

**POSTGRADUATE INSTITUTE OF SCIENCE  
UNIVERSITY OF PERADENIYA  
SRI LANKA**



**PGIS RESEARCH CONGRESS 2021  
PROCEEDINGS  
29<sup>th</sup> – 31<sup>st</sup> October 2021**

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## PGIS Research Congress 2021

### Message from the Director, Postgraduate Institute of Science



The Postgraduate Institute of Science (PGIS) of the University of Peradeniya was founded in 1996 to promote, encourage, and coordinate postgraduate education and training in the sciences on a national and global platform. Since its inception, PGIS has been a unifying resource for the community, a symbol of hope and optimism for students, and an innovative leader in science education. Compared to the many leading educational and research institutions worldwide, 25 years is a short time in the history of any postgraduate institute. However, PGIS has established itself as the leading institute in Sri Lanka and worldwide on a wide array of topics in a

brief period.

The PGIS offers a range of postgraduate degree programs designed to prepare high-quality graduates for careers to meet the country's requirements or further studies. The academic programmes of the PGIS are conducted through 11 Boards of Study — Biochemistry & Molecular Biology, Biomedical Sciences, Chemical Sciences, Environmental Science, Earth Sciences, Mathematics, Physics, Plant Sciences, Science Education, Statistics & Computer Science and Zoological Sciences. The programs offered by the Institute are PhD, MPhil, MSc and Masters Degrees as well as Postgraduate Diploma and Certificate courses. The research at the Institute also has outstandingly high societal impact and is of high international quality.

The PGIS Research Congress, which is conducted annually, is one of its key research events. Congress of this year will be recognized for making a mark while celebrating the 25th anniversary of PGIS. A conference of this magnitude relies on the efforts of many scholars, organizations, and well-wishers, and I would like to express my gratitude to the organizing committee members and referees for their invaluable support during the review process. I thank all authors who committed their work to the conference and congratulate those who are presenting their findings.

With great pleasure and satisfaction, I extend a heartfelt greeting and appreciation to all dignitaries, academics, delegates, and other stakeholders attending RESCON 2021. I firmly believe that your participation will add glamour to this historic occasion.

**Professor H.M.T.G.A. Pitawala**  
*Director/Postgraduate Institute of Science*



## **PGIS Research Congress 2021**

### **Message from the Congress Chairman**



The Postgraduate Institute of Science (PGIS), University of Peradeniya, celebrates its 25<sup>th</sup> Anniversary in 2021. On behalf of the Organizing Committee, I am honoured and delighted to welcome you to the 8<sup>th</sup> Annual Research Congress (RESCON) of the Postgraduate Institute of Science. The RESCON brings a tremendous and rich diversity of academics, research scientists and postgraduate students from world-renowned Universities and Institutes and provides an excellent opportunity to present their innovative research, scholarly contributions and share new ideas on future research trends.

We are honoured to have His Excellency Holger Seubert, Ambassador of the Federal Republic of Germany to Sri Lanka, as the Chief Guest and Prof. Sagarika Ekanayake, Department of Biochemistry Faculty of Medical Sciences, University of Sri Jayewardenepura, Sri Lanka as our distinguished keynote speaker.

It is very pleasing to note that 183 research papers will be presented under five themes: Earth and Environmental Science, Information & Communication Technology, Mathematics and Statistics, Life Sciences, Physical Sciences and Science Education.

Behind the successful organization of the congress lies the talents, dedication, collective and untiring efforts of many, including the volunteers and sponsors who extended us strong support. I greatly appreciate and acknowledge the tremendous support put in by Prof. HMTGA Pitawala, Director, PGIS, Dr Ashwini Amarasinghe, Secretary, RESCON 2021, Prof. Rupika Rajakaruna, Editor in Chief, all conveners and members of the subcommittees, reviewers of abstracts, invited speakers, session chairs, and the staff of the PGIS and the members of the Young Researchers Forum of the PGIS. The valuable support given by the Vice-Chancellor, University of Peradeniya and the Dean of the Faculty of Science, the services rendered by the public relations office, the security Department, the Maintenance Department, and the Health Centre of the University of Peradeniya are gratefully acknowledged. My special gratitude goes to the authors who submitted their outstanding research papers to the RESCON 2021. The great editorial assistance provided by Ms Mackrina Winslow since the receipt of abstracts until the completion of the proceedings is highly acknowledged.

I hope that you will find RESCON 2021 to be a highly valuable scientific venture.

**Professor RGSC Rajapakse**  
*Chairman/PGIS RESCON 2021*





## PGIS Research Congress 2021

### Message from the Editor-in-Chief



Change is the “*new normal*” for all of us today. When the 2020 COVID-19 pandemic forced a string of cancelled conferences, causing many organizers to shift meetings online, the PGIS held its first hybrid event of RESCON 2020— ushering a “*The show must go on*” motive. The 2020 event was a success. The novelty of virtual conferences has worn off now; however, they are likely to be here to stay, even as in-person events return. RESCON 2021 is again a hybrid event. Ease of attending from anywhere in the country or world is the major perk. It opened up an opportunity for many Sri Lankan students doing postgraduate studies abroad to showcase their work, raising the bar of diversity practice and bringing in more people around the world without having to “*fly around the world*”. The RESCON can continue to be virtual or have a virtual component after the pandemic ends. Thus, we can widen our kaleidoscope by extending the platform to a bigger global participation. At the same time, the virtual platform made the editorial task easier. It allowed the team to meet and discuss without compromising the teaching and research workload, numerous meetings or responsibilities as parents having kids. We all got “*Zoom fatigue*” sometimes but have learnt to appreciate the virtual platform and finish the work in time, although we missed the opportunity to meet and chat over a cup of tea with our favourite “*parrippu wade*” from the Faculty canteen. The editorial process is a daunting task. Ensuring a high-quality conference requires accepting papers that pass a rigorous review process. Each abstract in plenary sessions was reviewed by 2–3 reviewers with an acceptance rate of 76%. As the Editor-in-Chief, my biggest challenge was taking that critical decision “*to accept*” or “*not to accept*” when the reviewer comments were not black or white. Having a team of experts to share that burden was a huge relief. The untiring effort of the five theme coordinators and the editorial committee members was invaluable; I owe the team a lot. And a special thank you to the authors who submitted abstracts; the reviewers for their thoughtful comments and recommendations which were exceedingly helpful in assessing the novelty and quality of abstracts. I extend my appreciation to all who read, listen, watch, access, use and learn from RESCON content. The Secretary of the Congress, Dr Ashwini Amarasinghe, was a lifesaver; plus Mr Grammarly came in handy at the end too. I extend my humble gratitude to the Director PGIS, Prof. H.M.T.G.A. Pitawala and the congress Chair Prof. Sanath Rajapakse, for their continuous support and encouragement; thank you for the opportunity! Last but not least, our Editorial Assistant, Ms Mackrina Winslow, was an angel sent from heaven. We wouldn't have survived the journey without her. All in all, it is teamwork. So, as the saying goes, “*None of us is as smart as all of us.*”

My compliments, a very successful conference!

**Professor Rupika S. Rajakaruna**  
*Editor-in-Chief, PGIS RESCON 2021*



## **PGIS Research Congress 2021**

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## **PGIS Research Congress 2021**

### **A Brief Biography of Prof. Sagarika Ekanayake,**

#### **Keynote Speaker, RESCON 2021**



Sagarika Ekanayake is a senior professor in biochemistry at the University of Sri Jayewardenepura, Sri Lanka. She graduated from the University of Peradeniya, Sri Lanka and obtained her PhD in Applied Nutrition and Food Chemistry from the University of Lund, Sweden, in 2005. Her fields of expertise include Food Chemistry, Biochemistry, and Applied Nutrition.

Prof Ekanayake is an eminent researcher in various fields, with 47 publications in peer-reviewed indexed journals and more than 200 communications, including presentations at international/regional conferences and national annual scientific sessions of scientific organizations. Her research has been recognized with Presidential Awards (5 times), NRC Merit Awards, USJP Research Award, and other accolades. Her current research includes studies on nutritional value and glycaemic response of traditional Sri Lankan rice varieties, proximate and functional properties of composite flours, and nanocomposites and bioactivities.

As an academic, Prof Ekanayake has been active as an administrator as well as a supervisor. She was the President of the Institute of Chemistry, Ceylon, and Dean of the College of Chemical Sciences, from 2019 to 2020. Furthermore, she served as the Head of the Department of Biochemistry in the Faculty of Medicine, University of Sri Jayewardenepura, from 2011 to 2013. In addition, she has advised 6 PhD candidates, more than 15 MPhil/MSc candidates, and numerous undergraduates.

A grantee of more than 15 highly sought-after research grants, Prof Ekanayake is one of the most eminent scientists in Sri Lanka. She has been cited among leading professionals of the world (Marquis who is who in the world) and top 100 educators by International Biographical Centre, Cambridge, England, in 2014. As the organizing committee of RESCON 2021, we will be honoured to host Prof Sagarika Ekanayake as the keynote speaker of the Inauguration Ceremony.



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**VARIATION IN AVAILABLE PHOSPHORUS CONCENTRATION IN SOIL  
SAMPLES COLLECTED FROM PADDY LANDS IN SRI LANKA**

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Phosphorus (P) is an essential macronutrient required for the growth and development of plants. Plant-available P concentration in the soil varies due to the differences in soil mineralogy, physical and chemical properties such as texture and pH. It is also affected by agronomic practices adopted by the farmers. Knowledge on plant-available P concentration in soils is urgently needed to achieve sustainable P management. Rice (*Oryza sativa* L.) is the primary crop grown in Sri Lanka, covering many soils. Therefore, the objective of this study was to investigate the effects of the agro-climatic zone (ACZ), major water sources used for rice cultivation (major irrigation, minor irrigation or rainfed), and other crops grown in paddy fields on the variation of available P concentration in rice fields. A total of 1,200 soil samples were collected after harvesting the crop in *Yala* season 2019 and before the beginning of land preparation for *Maha* season 2019/2020, representing paddy lands across the country. Phosphorus concentration in soil samples was determined using the Olsen method. Available P concentration in soil samples varied from 2.1 to 220.1 mg kg<sup>-1</sup>. More than 25% of soil samples displayed P concentration less than 10 mg kg<sup>-1</sup> and 12% of soil samples exhibited P concentration more than 30 mg kg<sup>-1</sup>. Intermediate Zone soils had higher available P concentration (21 mg kg<sup>-1</sup>) than that in the Dry Zone (18 mg kg<sup>-1</sup>) and Wet Zone (15 mg kg<sup>-1</sup>) soils ( $p < 0.05$ ). Available P concentration in soils among major water sources used for cultivation was similar ( $p > 0.05$ ). Paddy fields used to cultivate vegetables in the previous season (*Yala* 2019) had a higher available P concentration (46 mg kg<sup>-1</sup>) than the fields used to grow other crops ( $p < 0.05$ ). The ACZ and crop rotation-based variation in soil P availability must be considered when managing P application to rice fields.

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**Keywords:** Agro-Climatic Zone, Available phosphorus, Olsen method, Paddy

**PREPARATION AND CHARACTERIZATION OF BIODEGRADABLE CASSAVA STARCH THIN FILMS USING MICROWAVE METHOD**

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Most petroleum-based polymers are non-degradable. Therefore, development of an environmentally friendly replacement for non-degradable plastics is of paramount importance. Thermoplastic starch (TPS) is a solution for non-biodegradable plastics. The gelatinization method is the most common practice in preparing starch-based thin films, and microwave heating can be used as a novel method. Microwave treatment can produce a higher amount of modified starch within a shorter period. In this study, the effect of microwave treatment on the properties of cassava starch thin films was studied. Microwave treatment was conducted at 10, 20, 30 and 40 s to obtain modified starch while the cassava starch-based thin films were prepared via the conventional casting method. The current study reports the effect of microwave time of cassava starch-based thin films using Fourier Transforms Infrared (FTIR) spectroscopy, tensile strength properties (ASTM D 882-02), biodegradability (aerobic compost environment test), and water absorption rate (ASTM D 570-98). FTIR studies showed the same bands for all samples, which are characteristics of starch. When the microwave treatment time increased from 0 s to 20 s, a significant increment ( $p < 0.05$ ) in tensile strength (6.67 MPa) could be observed. In the biodegradation test, all the microwaved thin films had shown significant ( $p < 0.05$ ) degradation within 15 days with respect to native cassava starch thin films. The lowest rate was achieved by the 20 s microwaved film. Therefore, microwave treatment time of 20 s was optimum in improving mechanical properties, water resistivity and reduced biodegradation. Also, these films can act as a substitute for petroleum-based inert plastics.

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**Keywords:** Cassava starch, Microwave treatments, Starch modification



**EFFECT OF PHTHALIC ACID ON STRUCTURAL, MECHANICAL AND WATER RESISTANCE PROPERTIES OF BIODEGRADABLE CASSAVA STARCH/POLYVINYL ALCOHOL THIN FILMS**

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This work focuses on producing and evaluating *green* multifunctional film materials based on a mixed eco-friendly thermoplastic starch (TPS)/Polyvinyl alcohol (PVA) matrix compatibilized with phthalic acid as a solution for non-degradable petroleum-based plastic waste accumulation. Most researchers have utilized maleic acid, succinic acid, borax and acetic acid to compatibilize TPS/PVA thin films. In the present study, TPS/PVA blended films were prepared using a solution casting with 0, 1, 2 and 5 wt% of phthalic acid as the compatibilizing agent with respect to TPS share while maintaining TPS/PVA weight ratio of 40/60 and 60/40, respectively. Fourier Transform Infrared (FTIR) spectroscopy, Scanning Electron Microscopy (SEM), and Powder X-ray Diffraction (PXRD), dynamic mechanical analysis (DMA) and Thermogravimetric Analysis (TGA) were used to characterize the samples. The tensile, water absorption and biodegradability tests were carried out according to ASTM D-882-02, ASTM-D-570-98, and aerobic compost environment tests. TGA results implied an enhanced homogeneity and better thermal stability of compatibilized blends compared to their non-compatibilized blends. Besides, the FTIR spectrums demonstrated that new hydrogen bonds had been formed in the presence of phthalic acid, causing increased interactions between starch and PVA macromolecules. According to the biodegradation test, the blended films except neat PVA showed a significant degradation after 30 days. Both the tensile strength and water resistivity improved with the addition of phthalic acid. This study demonstrated that these films with enhanced mechanical properties and water sensitivity could replace non-degradable packaging films for low water content.

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**Keywords:** Cassava starch, Compatibilized, Phthalic acid, Polyvinyl alcohol, Thin films

## ENHANCED PHOTOCATALYTIC ACTIVITY OF Fe DOPED ZnO NANOPARTICLES AND THE INFLUENCE OF CO-POLLUTANTS

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The release of dyes from various sources to water bodies has caused significant hazardous effects on the environment. This study evaluated the photocatalytic activity of the Fe doped ZnO nanoparticles synthesized by the co-precipitation method at different Fe concentrations: 0.025, 0.05, 0.075, and 0.1% respective to Zn. The effect of various co-pollutants on the photodegradation of methylene blue (MB) studied in this work was not reported elsewhere. Synthesized nanoparticles were characterized by Powder X-ray Diffractometry (PXRD) and Raman spectroscopy. PXRD patterns show the presence of ZnO crystal structure. Upon doping Fe, no significant changes in the PXRD peak positions and lattice parameters were observed, and peaks corresponding to oxide phases of iron were absent, revealing proper doping of Fe<sup>3+</sup> to ZnO lattice. Raman spectra of the 0.1% Fe doped and undoped ZnO nanoparticles were identical except for the slight shifts in the Raman shifts, which indicate proper doping of Fe<sup>3+</sup>. The Fe doped ZnO nanoparticles were more effective in photodegrading MB under sunlight than ZnO nanoparticles. Photocatalytic activity increased with increasing dopant concentration where the highest rate constant (0.03426 min<sup>-1</sup>) was obtained with 0.05% Fe doped ZnO. With a further increase in Fe concentration, photocatalytic activity decreased due to electron-hole pair recombination. The effect of co-pollutants on photocatalytic activity was investigated using Rhodamine B (RhB), Pb<sup>2+</sup>, PO<sub>4</sub><sup>3-</sup> and S<sub>2</sub>O<sub>3</sub><sup>2-</sup> ions. The presence of Rhodamine B slightly decreased the rate constant for the photodegradation of MB (0.01816 to 0.01341 min<sup>-1</sup>), and doped nanoparticles were effective in degrading RhB in addition to MB. The presence of Pb<sup>2+</sup> (0.01455 to 0.00572 min<sup>-1</sup>) and PO<sub>4</sub><sup>3-</sup> (0.02448 to 0.01497 min<sup>-1</sup>) ions significantly decreased the rate constants for the photodegradation of MB, while S<sub>2</sub>O<sub>3</sub><sup>2-</sup> ion has increased the photocatalytic activity (0.01983 to 0.02143 min<sup>-1</sup>). The presence of RhB resulted in an overall negligible decremented effect. Presence of Pb<sup>2+</sup> and PO<sub>4</sub><sup>3-</sup> ions showed a considerable inhibitory effect on the degradation efficiency. The Pb<sup>2+</sup> ion competes with MB for ZnO surface, PO<sub>4</sub><sup>3-</sup> neutralizes MB limiting the adsorption and S<sub>2</sub>O<sub>3</sub><sup>2-</sup> acts as an electron acceptor.

**Keywords:** Fe doped ZnO, Pb<sup>2+</sup>, PO<sub>4</sub><sup>3-</sup>, Rhodamine B, S<sub>2</sub>O<sub>3</sub><sup>2-</sup>

**AVIFAUNAL DIVERSITY ASSOCIATED WITH BENTOTA RIVER MANGROVE, SOUTHWESTERN SRI LANKA: IMPLICATIONS FOR CONSERVATION**

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Sri Lanka is a tropical country with mangrove cover found in most of its coastal zone, bordering lagoons, estuaries, and protected bays. Mangroves consist of rich biodiversity that provides habitats for numerous species. The Bentota River, located in the Galle District in the Southern Province, has a well-developed riverine mangrove forest. It adds biological and ecological values to this highly populated area. The present study focuses on enumerating the avifaunal diversity associated with Bentota riverine mangrove forest. A three-month survey from April to June 2021 was conducted in 500 m long transects to assess the avifaunal diversity. The Shannon Index (H), Shannon Evenness (E), and the Simpson's Index (D) were calculated. A total of 1,629 individuals of 69 species belonging to 30 families were recorded from the area. The Shannon Index, Shannon Evenness and Simpsons' Index were 3.69, 0.875, and 0.0318, respectively. Thus, the area represents considerable avifaunal diversity including six endemic birds; Crimson-fronted Barbet (*Megalaima rubricapillus*), Sri Lanka Green Pigeon (*Treron pompadora*), Sri Lanka Hanging Parrot (*Loriculus beryllinus*), Sri Lanka Jungle Fowl (*Gallus lafayettii*), Yellow-fronted Barbet (*Megalaima flavifrons*) and Sri Lanka Swallow (*Cecropis hyperythra*). Waterbirds recorded include White-breasted Waterhen (*Amaurornis phoenicurus*), Lesser Whistling Duck (*Dendrocygna javanica*), Common Kingfisher (*Alcedo atthis*), White-throated Kingfisher (*Halcyon smyrnensis*), Black-headed Ibis (*Threskiornis melanocephalus*) and Slaty-legged Crake (*Rallina eurizonoides*), a rare nationally threatened (Critically Endangered) waterbird. Several threats viz., habitat destruction by clearing mangroves, garbage dumping, and spreading invasive *Annona glabra* and *Dillenia suffruticosa* were recorded. Therefore, proper law enforcement, together with conservation measures, is recommended to protect this sensitive habitat.

**Keywords:** Avifaunal diversity, Bentota River, Conservation, Mangrove, Southwestern Sri Lanka

**DEVELOPMENT OF CASSAVA BAGASSE REINFORCED THERMOPLASTIC  
CASSAVA STARCH SHEETS**

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Due to awareness of environmental and sustainability issues, eco-friendly natural fibres have generated much interest as reinforcing agents in thermoplastic composites. Cassava starch-based composite sheets were prepared using cassava bagasse, which was passed through a 500-mesh sieve as filler, and it is a by-product of the cassava starch extraction process. Composite sheets were prepared through compression moulding technique using glycerol as the plasticizer, and three concentrations of cassava bagasse were incorporated during composite preparation. Then, the physical and structural properties of the composite sheets were investigated. According to the Scanning Electron Microscope (SEM) micrographs, composites with high fibres content (30% w/w) exhibited more heterogeneous surfaces and showed pull-out of fibres, which the presence of voids could be observed on the images of the composites with fracture. The concentration of bagasse had a significant influence on the physical properties of composite sheets. The tensile strength of composite sheets increased from 2.11 to 3.56, 3.93, and 11.78 MPa after adding 10, 20 and 30% (w/w) of cassava bagasse, respectively. However, the tensile strain at break decreased as the cassava bagasse material concentration was increased. Besides, the hardness of the composite sheets increased by about 74% as the cassava bagasse 10% (w/w) was added to the composite. All the composite sheets were biodegradable, and the water absorption of the composite sheets increased as the cassava bagasse material concentration was increased. The utilization of cassava bagasse as a reinforcement agent for cassava starch-based thermoplastic sheets added value to the waste produced during starch extraction while promising environmental sustainability.

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**Keywords:** Cassava bagasse, Cassava starch, Thermoplastic sheets

**USE OF BIOCHARS PRODUCED FROM PLANT MATERIALS TO INCREASE PHYSICOCHEMICAL PROPERTIES IN SLOPING LANDS SOILS**

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Soil degradation due to improper use of soil or poor soil management affects the productivity of agricultural lands and thereby threatens food security. Biochar has attracted attention for the rehabilitation of degraded soils. This study determined the effect of the application of biochar produced from different plant materials on the physicochemical properties in soils in sloping lands. Randomized Complete Block Design (RCBD) was used with four treatments and four replicates. Land plots were prepared with each type of biochar made from cones of *Pinus pinaster*, barks of *Eucalyptus tereticornis*, wood chips of *Camellia sinensis* and a control. They were incorporated into the soil on top 5 cm at the rate of 250 g/m<sup>2</sup> separately in each plot size of 1.5 m × 1.0 m. Soil samples were collected from top to 30 cm depth (root zone) using a core sampler once in two weeks after applying biochar for three months. Soil samples were analyzed for physicochemical properties such as pH, EC, bulk density, particle density, porosity, soil organic matter, total nitrogen, exchangeable potassium and available phosphorus. Duncan's multiple range test was carried out using SPSS 25.0. Results revealed that the application of biochar significantly increased the soil nutrients, organic matter content ( $p = 0.0001$ ), total nitrogen ( $p < 0.0001$ ), available potassium ( $p < 0.0001$ ), phosphorous ( $p = 0.0001$ ), porosity ( $p < 0.0001$ ) and significantly decreased the bulk density ( $p < 0.0001$ ). Moreover, a desirable range of soil pH (6.5 – 7.3) was obtained after incorporating biochar. The highest level of organic carbon (4.4%) was observed in the soil incorporated with *C. sinensis* biochar. Further, the highest amount of total nitrogen (6.6 ppm), exchangeable potassium (6.6 ppm), and available phosphorus (1.2 ppm) were also observed in soils incorporated with biochar produced from *C. sinensis*. In conclusion, biochar application could increase soil nutrient content and physical properties for tilth increasing in the sloping land soils.

**Keywords:** Biochar, *Camellia sinensis*, *Eucalyptus tereticornis*, *Pinus pinaster*, Sloping lands, Soil physicochemical properties

***Canna indica* AND *Eleocharis dulcis* ON BOD<sub>5</sub> AND COD IN DAIRY WASTEWATER THROUGH HORIZONTAL SUBSURFACE FLOW CONSTRUCTED WETLAND: COMPARATIVE STUDY**

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Wastewater discharged from industrial operations contains high concentrations of organic and inorganic substances causing environmental pollution. Green technologies are extensively applied in many countries in treating wastewater. Constructed wetlands (CW) are one such greener wastewater treatment technology practised worldwide over many decades. Among the different types of constructed wetlands, horizontal subsurface flow constructed wetlands (HSSFCW) are most widely used, thus becoming low impact alternatives to more conventional wastewater treatment processes. The study compared the influence of *Canna indica* and *Eleocharis dulcis* on Biological Oxygen Demand (BOD<sub>5</sub>) and Chemical Oxygen Demand (COD) in dairy wastewater through HCCFCW. The raw water was fed into each treatment ( $n = 4$ ) once in five days. The samples were collected in three days of hydraulic retention time from each treatment and control unit ( $n = 4$ ), where no plants were included before subjecting samples for laboratory analysis. The data from water samples from the inlet and outlet of treatments were analyzed using a Paired t-test. Significant differences among treatment means were separated using Duncan's multiple range test using SPSS 25.0 at  $\alpha = 0.05$  and confident interval (CI) = 95%. The results revealed that there was a significant difference between the inlet and outlet of each *C. indica* unit ( $p = 0.0030$ ) and its control unit ( $p < 0.0001$ ), *E. dulcis* unit ( $p = 0.0040$ ) and its control unit ( $p < 0.0001$ ) for BOD<sub>5</sub>. The highest reduction efficiency of BOD<sub>5</sub> in the control unit was 40.5%, whereas 91.7% was observed in the *C. indica* unit, and 72.3% was observed in the *E. dulcis* unit. Also, there was a significant difference between the inlet and outlet of *C. indica* unit ( $p = 0.0240$ ) and its control unit ( $p = 0.0150$ ), *E. dulcis* unit ( $p = 0.0040$ ) and its control unit ( $p = 0.0018$ ) regarding COD. The highest reduction efficiencies related to COD were 90.4%, 93.9% and 69.5% in the control unit, *C. indica* unit and *E. dulcis* unit, respectively. Further, there was a significant difference ( $p = 0.0030$ ) between the COD reduction efficiencies in both units where *C. indica* and *E. dulcis* were used. The results also revealed that the influence on the reduction of BOD<sub>5</sub> in both selected wetland species remained the same, and COD reduction efficiency in the *C. indica* unit was higher than that of *E. dulcis*. Hence, horizontal subsurface flow constructed wetlands through phytoremediation may be an effective green technology for treating dairy wastewater.

**Keywords:** BOD<sub>5</sub>, *Canna indica*, COD, *Eleocharis dulcis*, Horizontal subsurface flow constructed wetland

**BIOETHANOL PRODUCTION FROM *Chara globularis* USING YEAST AND YIELD IMPROVEMENT BY OPTIMIZATION OF CONDITIONS**

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The rising population, depletion of petroleum-based fossil fuel and atmospheric contaminations by fossil fuel combustion have opened avenues for alternative, eco-friendly and renewable energy sources. Bioethanol is an alternative and renewable substrate which has drawn attention due to environmental concerns and energy security. This study aimed to determine the best bioethanol producing freshwater flora abundantly available in the Northern Province of Sri Lanka using *Saccharomyces cerevisiae* and optimize the fermentation conditions to enhance the ethanol yield from *Chara globularis*. When freshwater flora such as *C. globularis*, *Cabomba caroliniana*, *Spirodela polyrhiza*, *Salvinia minima*, *Salvinia natans*, *Wolffia arrhiza* and *Wolffia globosa* were hydrolyzed with 1 M sulfuric acid solution, and the amount of reducing sugar was determined, *C. globularis* produced a higher amount of reducing sugar than other species tested. When pre-treatment of *C. globularis* was done with 1 M acid solutions (sulfuric acid, nitric acid and hydrochloric acid) and alkaline solutions (sodium hydroxide and potassium hydroxide), a higher amount of reducing sugar was obtained with sulfuric acid. When alcohol was produced from *C. globularis* using *S. cerevisiae* after three different hydrolysis methods, namely acid hydrolysis (1 M sulfuric acid), enzymatic hydrolysis (1% alpha-amylase) and a combination of chemical and enzymatic hydrolysis (1 M sulfuric acid and 1% alpha-amylase), a combination of chemical and enzymatic hydrolysis gave higher ethanol yield; thus this combination hydrolysis was selected. The conditions for fermentation of *C. globularis* substrate using *S. cerevisiae* were optimized sequentially by changing one factor at a time while keeping the other variables constant. After the optimization of fermentation time (24 h), operating temperature (35 °C), rotation speed (200 rpm) and sulfuric acid concentration for combined pre-treatment (0.75 M) with an inoculum size of 100 g/L, bioethanol yield was increased by two times compared with the non-optimized condition.

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**Keywords:** Alpha-amylase, *Chara globularis*, Hydrolysis, Optimization, Sulfuric acid

**SPATIO-TEMPORAL DISTRIBUTION OF CHLOROPHYLL-A OF  
PHYTOPLANKTON BIOMASS IN SOUTHWESTERN OCEAN OF SRI LANKA  
CONCERNING DIFFERENT MARITIME ZONES AND MONSOON PATTERNS**

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Marine phytoplankton plays a vital role as a primary producer. However, their spatiotemporal distribution has not been described well within the Sri Lankan waters. This study assessed the anomalies of chlorophyll-a concentrations representing phytoplankton biomass in the southwestern coast of Sri Lanka during different monsoon patterns and maritime zones over six years (2015 – 2020) using remote sensing. To obtain chlorophyll-a concentrations, the moderate Resolution Imaging Spectroradiometer (MODIS) aqua images were daily analyzed by SeaDAS 7.5.3. ArcGIS 10.8 was used to clip reprojected raster layers as per different isobath zones (continental shelf, 1,000 m, and 2,000 m), which were demarcated by Google Earth pro 7.3.3 and legalized zones (Territorial Sea and Exclusive Economic Zone (EEZ)) in the southwestern region. According to two-way ANOVA, mean chlorophyll-a concentrations significantly differed in isobath zones, legalized zones and monsoon patterns. The highest mean chlorophyll-a value, 3.89 mg/m<sup>3</sup> was observed during the southwest monsoon period in the continental shelf, and the lowest (0.14 mg/m<sup>3</sup>) was in the EEZ in the first inter-monsoon period. When concerning the total study area, the highest mean chlorophyll-a values were recorded in the southwest monsoon (2.87 mg/m<sup>3</sup>), followed by the second inter-monsoon (1.31 mg/m<sup>3</sup>), northeast monsoon (0.54 mg/m<sup>3</sup>), and the first inter-monsoon (0.43 mg/m<sup>3</sup>). The mean chlorophyll-a values gradually declined towards the open ocean as the continental shelf, territorial sea, 1,000 m isobath, 2,000 m isobath, and EEZ consecutively. These fluctuations with chlorophyll-a could be due to the uplifting of nutrients drained from terrestrial runoff during the activated monsoon periods and associated upwelling processes. However, further studies are needed to evaluate the nutrient loading with terrestrial runoffs and levels of trace elements that are required for the growth of phytoplankton.

**Keywords:** Chlorophyll-a concentration, Isobath zones, MODIS, Monsoon patterns, Plankton blooms



**SOCIOECONOMIC DETERMINANTS OF CROP CHOICE IN VEGETABLE FARMING AT KALPITIYA, SRI LANKA**

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More farmers have shifted to vegetable farming from other crops in recent years, cultivating a wide array of vegetables even without assessing the production and marketing in agriculture, creating sustainability issues in the long run. This study aimed to identify key socio-economic determinants of farmers that affect the choice of the vegetable crop. The study adopted exploratory research methods. A sample of 130 vegetable farmers (pumpkin,  $n = 14$ ; beet,  $n = 99$ ; cabbage,  $n = 17$ ) in the Kalpitiya Divisional Secretariat division was selected for the study. A pre-tested, structured questionnaire survey with focus group discussions was used to gather data. Multinomial Logistic Regression (MLR) was employed to elicit the relationship between the choice of crop and selected socio-economic variables: gender, age, education of the farmer, extent, average yield, unit selling price, average fertilizer usage, number of families and hired labour. SWOT analysis was also used to assess the production and marketing risk in vegetable farming. Results indicated, farmers tend to select pumpkin aiming a higher selling price per unit over beet ( $p < 0.05$ ) and cabbage ( $p < 0.01$ ). However, farmers tend to choose beet ( $p < 0.05$ ) and cabbage ( $p < 0.01$ ), aiming for a higher yield prospect over pumpkin. Female farmers ( $p < 0.01$ ) tend to select pumpkin over beet due to easiness in harvesting. Farmgate prices and the average yield are the only deciding factors for selecting a particular vegetable crop. Frequent price volatility was reported for vegetable produce. However, farmers obtained better returns and faster cash recovery from vegetable cultivation. Hence, production and marketing risk was not considered by the farmers. In addition, information asymmetry between producers and markets creates lapses in spatial price linkages. Creating better market linkages with sufficient information could be a possible solution to introduce alternative agriculture activities among farmers to develop sustainable farming practices within the selected community.

*Financial assistance from the Accelerating Higher Education Expansion and Development AHEAD DOR is acknowledged.*

**Keywords:** Choice of crop, Socioeconomics, Vegetable farming

**REMOVAL OF LEAD IONS IN WASTEWATER USING THERMALLY REGENERATED DIATOMACEOUS EARTH FROM SPENT DIATOMACEOUS EARTH**

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This study describes a method of removal of lead ions in wastewater using a thermally regenerated diatomaceous earth (DE) formed from spent diatomaceous earth (SDE) under 400 °C (SDE-400 °C) and 800 °C (SDE-800 °C). SDE is mainly generated from food processing and brewery industries as industrial waste. This work also reports the effectiveness and efficiency of lead (Pb<sup>2+</sup>) ions removal from aqueous solution by the adsorbent of SDE. The surface morphology of SDE dry form was obtained by Field Emission Scanning Electron Microscopy (FE-SEM) and indicated a well-arranged porous structure with some particles on the surface. Nitrogen adsorption-desorption analysis was performed at -196 °C for the dry form of SDE and found that it contains 2.22 m<sup>2</sup> g<sup>-1</sup> of specific surface area and 0.015 cm<sup>3</sup> g<sup>-1</sup> of the total pore volume. The favourable conditions for Pb<sup>2+</sup> adsorption onto SDE were determined. The maximum lead adsorption was obtained when the adsorbent dosage of 50 mg and contact time of 180 min at pH of 4.8, maintained for 50 mL of lead solution at 25 °C. The Langmuir and Freundlich adsorption isotherm models were used to interpret the equilibrium data of the investigated systems. The Langmuir model best described the adsorption characteristics of Pb<sup>2+</sup> on SDE, SDE-400 °C and SDE-800 °C with maximum adsorption capacities of 163.93, 208.33, 322.58 mg g<sup>-1</sup>. Moreover, the present study suggests the favourable application of SDE-800 °C as an effective material for removing Pb<sup>2+</sup> from aqueous solutions for industrial wastewater treatment than the other two adsorbents due to the presence of chemisorption and physisorption.

**Keywords:** Adsorption, Isotherm, Lead(II), Spent diatomaceous earth, Thermal regeneration

**TREES TO CAPTURE AIRBORNE PARTICLES IN URBAN ENVIRONMENTS**

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Urban landscaping provides an emerging avenue to transform densely populated environments into more eco-friendly landscapes by applying effective designing techniques to ensure ecological and aesthetic aspects. Appropriate plants could enhance the quality of the landscape, and trees are one such softscape material that can be effectively incorporated in landscaping. However, in Sri Lanka, the texture of plants is underutilised in landscaping. Hence, the objectives of this study were to identify different textural classes of trees and to relate their usability in urban environments, especially for intercepting pollutants such as particulate matter. Thirty-nine tree species were selected for the study, and seven quantitative and eight qualitative morphological characters contributing to the plant texture were coded. The data were analysed by hierarchical cluster analysis, thus grouping tree species into three distinct textural classes: 20 fine-textured, five medium-textured and 14 coarse-textured species. The trees that belonged to the fine-textured group recorded shorter internodal and petiole length and smaller leaf area, which resulted in a dense canopy. The coarse-textured species recorded longer internodal and petiole length and larger leaf area result in a loose canopy. Apart from these characters, the presence of hairs on leaves further contributes to a coarse texture. The coarse-textured tree species have a higher potential to intercept airborne particulate matter than fine and medium-textured species. Hence, these species can be recommended for urban landscape designs to reduce atmospheric pollution.

**Keywords:** Landscaping, Morphological characters, Particulate matter, Texture, Trees

**BIOLOGICAL AND ECOLOGICAL ASPECTS OF THE INDIAN CRESTED PORCUPINE (*Hystrix indica*) POPULATION AT UDAWATTEKELE FOREST RESERVE IN KANDY, SRI LANKA**

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The Indian Crested Porcupine (*Hystrix indica*) ranges freely in Southern Asia and is found across the Middle East, Pakistan, Bhutan, India and Sri Lanka. Their home range includes forests and shrublands, urban settings, rocks, crevices, hilly ridges, and mounds. Porcupine density is related to vegetation, the availability of food and predator activity. Since it has a large geographical distribution, porcupines are adapted to various habitats. However, due to habitat destruction, the porcupine density is fluctuating. *Hystrix indica* population was studied from September 2019 to May 2021 at the Udawattekele Forest Reserve, Kandy, Sri Lanka (7.2989 °N, 80.6424 °E), spanning 104 ha, for 18 months. Seven transects (T) within the reserve T1 (1 km), T2 (1.55 km), T3 (0.83 km), T4 (0.32 km), T5 (0.65 km), T6 (0.1 km) bordering the reserve on the North, and T7 (0.58 km), were used to study the population. Four persons undertook data collection, two walking on parallel transects at a given time to avoid double counting. Observations were made twice a week at dusk from 05:00 – 06:00 h, at night between 20:00 – 22:00 h, and at dawn from 04:00 – 05:00 h, four times a month. The data was truncated using Distance 7.3 computer application into 3-month intervals due to the relatively small population of 20± individuals. The porcupines' elusive nature rendered night-time counts almost impossible yet provided valuable insight into nocturnal behaviour, mating and foraging patterns. The adult population was biased toward sows (3 females:1 male), and annual survival rates were greater for adult females than for males. Despite being monogamous, adult males preferred to forage alone, increasing their risk of falling prey to traps and succumbing to road kills. Birth rates of reproductively mature females averaged 0.82 annually during the 18-month study period, while a mean reproductive rate of 0.41 young females, based on birth rates and the pup sex ratio, was calculated. The estimated population drop rate of 0.034 indicated that the study population might be declining; however, further investigation is needed to clarify this trend. Several factors have contributed to the decline of the porcupine population at Udawattekele: the scarcity of food within the reserve forced the porcupines to venture beyond the reserve's borders to scavenge garbage disposal bins and private gardens, often falling victim to dogs and human traps. The Indian crested porcupine is rendered an agricultural pest due to its ability to destroy crops with its frontal incisors and sharp, strong front claws. Yet, several anthropogenic threats, including poaching for its meat, have reduced its population at an alarming rate. Thus priority should be given to the conservation of the species before it reaches an endangered level.

**Keywords:** Indian crested porcupine, Conservation, Population, Udawattekele

**CONTAMINATION STATUS AND EFFECT OF TRIBUTYL TIN (TBT) ON  
REPRODUCTIVE IMPAIRMENT OF MOLLUSCS**

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Xenobiotic tributyltin (TBT) is an organotin compound widely used in various consumer and industrial products such as pesticides, antifouling paints for ship hulls, aquaculture facilities, and other structures exposed to marine waters. However, it adversely affects and interrupts steroid metabolism by converting testosterone to estradiol 17 $\beta$  in biota. TBT exposure on female molluscs causes reproductive impairment known as imposex which is used as a biomarker of TBT pollution in an aquatic environment. The present study aimed to quantify TBT in water, sediment and marine molluscs collected from the coastal belt of Sri Lanka. The Solid-Phase Micro Extraction method was used to quantify the TBT in five species of molluscs: *Crassostrea madrasensis*, *Crassostrea cucullate*, *Perna viridis*, *Perna perna* and *Thais clavigera*, which are used as seafood. Mollusc samples were collected within the premises of ten fishery and four commercial harbours in Sri Lanka. The TBT concentration in water ranged from  $303 \pm 7$  ng L<sup>-1</sup> to  $25 \pm 4$  ng L<sup>-1</sup> and in sediment from  $107 \pm 4$  ng Kg<sup>-1</sup> to  $17 \pm 1$  ng Kg<sup>-1</sup>. The highest TBT concentration was recorded in *P. viridis* ( $234 \pm 3$  ng Kg<sup>-1</sup>) collected from Dikkowita fishery harbour, where the highest number of boats operated in the Southern coast. TBT concentration of *T. clavigera* ranged from  $32 \pm 2$  ng Kg<sup>-1</sup> to  $134 \pm 2$  ng Kg<sup>-1</sup>; this species was selected as the bioindicator based on the availability of the organisms to study imposex development. Relative Penis Length Index (RPLI) of affected females varied from 15.5% to 24.8%. *T. clavigera* with the highest RPLI (24.8%) and highest imposex affected frequency (17.0%) was recorded in the Dikkowita harbour. Imposex affected females of *T. clavigera* increased with increasing TBT concentrations in the marine environment ( $p < 0.05$ ). TBT may be a significant factor that impacts the reproductive impairment of molluscs. Therefore, TBT may be a plausible factor that causes the decline of marine molluscs via producing sterile females.

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**Keywords:** Bioindicator, Fishery and commercial harbours, Imposex, *Thais clavigera*, Tributyltin

**POTENTIAL OF HEAVY MINERALS AROUND THE KOKKILAI LAGOON OF  
NORTHEAST SRI LANKA**

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Extractable mineral sand deposit at Pulmoddai extends about 7.2 km along the beach from Arisimale to the Kokkilai lagoon mouth of the northeastern coast of Sri Lanka. The exploiting rate of minerals is higher than the replenishing rate; therefore, it is important to investigate the source of deposits or any other alternative deposits. Thus, geochemical and mineralogical studies were carried out to assess the heavy mineral potential around the Kokkilai lagoon region. Sixteen surface sediment samples were collected from the perennial river inputs of the Kokkilai lagoon, lagoon bottom and along the coast of the lagoon mouth. Mineralogical studies with X-ray Diffraction (XRD) revealed the heavy minerals rutile, ilmenite, monazite and zircon from all samples. The XRD graphs showed a high percentage of rutile and ilmenite for the perennial river inputs. X-ray Fluorescence (XRF) technique identified the available oxide contents of each sample, and a significant amount of Fe<sub>2</sub>O<sub>3</sub>, TiO<sub>2</sub> and ZrO<sub>2</sub> were recognized from the river inputs and lagoon bottom compared to the most other riverine sediments of the country, including the Mahaweli River. The Kokkilai lagoon river inputs flow through the Wannai Complex rocks, characterized by thick sequences of orthogneisses comprising amphibolite-grade migmatitic, granitic, and granodioritic gneisses, charnockites and calc-silicate rocks. These particular rock types included higher percentages of heavy minerals that may be the reason for the presence of above oxides and high content of heavy minerals. Wave activities of the beach have sorted with its characteristic specific gravity and piled up the heavy minerals along the coast than the river inputs and lagoon bottom of the Kokkilai lagoon. Hence, the perennial rivers of the Kokkilai lagoon might be the primary agents for the heavy minerals in the northeastern coast that earlier postulated aeolian origin. The high concentrations of heavy minerals recorded in the Kokkilai lagoon region can replenish the coastal deposits in the future, which needs to be further investigated.

**Keywords:** Heavy minerals, Kokkilai lagoon, Northeastern coast

**VARIETAL RESPONSE OF CHILLI (*Capsicum annum*) TO LOW CONCENTRATIONS OF NITROGEN UNDER *IN VITRO* CONDITIONS**

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Nitrogen (N) is a constraining factor for the growth and yield performance of crops. Excessive application of N fertilizers increases the cost of production while negatively impacting the environment by polluting the groundwater, as reported in the Kalpitiya area. Thus, the crop varieties that can efficiently respond to lower N concentrations than the recommended doses are equally beneficial for the farmers and the environment. Therefore, a two-factor factorial in Completely Randomized Block was conducted to test four commercial chilli varieties (MICHHY F1, MI *Waraniya*, MI 2 and KA 2) for different N concentrations. Chilli seeds were cultured onto the half-strength Murashige and Skoog (MS) media supplemented with four NH<sub>4</sub>NO<sub>3</sub> concentrations, 875.00 (control), 656.25, 437.50, 218.75 mg L<sup>-1</sup> under *in vitro* conditions. Thirty replicates were used for each treatment. Vegetative parameters of seedlings, including leaf and root number and shoot and root length, were compared after 30 days of culture initiation. The N concentrations ( $p < 0.05$ ) and the genotypes ( $p < 0.0001$ ) influenced the growth performance of the seedlings significantly, but an interaction effect was not observed. KA 2 performed better for leaf number and shoot length, whereas MICHHY F1 was the best for root length. Both varieties performed better for root number. The performance of an individual variety for different N concentrations indicates their stability for the nutrient stress. The comparable root and shoot growth of MICHHY F1 under all N concentrations indicated its adaptability. However, the leaf number decreased significantly after the concentration of 656.25 mg L<sup>-1</sup> NH<sub>4</sub>NO<sub>3</sub>. MI *Waraniya* and KA 2 also showed lower sensitivities for the reduced N supplement. MI 2 was highly sensitive to the N concentration, where significant reductions were observed in all parameters. Therefore, MICHHY F1, MI *Waraniya* and KA 2 were selected as the tolerant genotypes for the reduced N supplement.

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**Keywords:** Genotype, *In vitro*, Nitrogen, Sensitivity, Tolerance

**SYNTHESIS OF  $\gamma$ -Fe<sub>2</sub>O<sub>3</sub> COATED SAND FOR ADSORPTIVE REMOVAL OF FLUORIDE IONS FROM DRINKING WATER**

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The presence of fluoride in water has become a major problem across the planet. More than 200 million people worldwide consume drinking water with fluoride concentrations that exceed the WHO guideline of 1.5 mg/L. Excess intake of fluoride can cause health impacts, like dental fluorosis and skeletal fluorosis. Much attention has been paid to removing fluoride ions from drinking water, and adsorption is an effective way of removing fluoride. In this study  $\gamma$ -Fe<sub>2</sub>O<sub>3</sub> coated sand was synthesized using river sand and  $\gamma$ -Fe<sub>2</sub>O<sub>3</sub> nanoparticles by pouring 40.00 cm<sup>3</sup> of 2.0 mol dm<sup>-3</sup> FeCl<sub>3</sub> solution and 1.00 cm<sup>3</sup> of 10.0 mol dm<sup>-3</sup> NaOH, over 100 g of cleaned and dried sand and heated at 110 °C for 5 h and then at 400 °C for 4 h. After repeating this procedure, the coated sand was washed with deionized distilled water and dried at 100 °C for 6 h. Formation of  $\gamma$ -Fe<sub>2</sub>O<sub>3</sub> on the sand surface was confirmed by Raman Spectroscopic measurements since the characteristic maghemite peaks occurred at 649 cm<sup>-1</sup> and Fourier Transmission Infrared measurements as Fe-O-O-H vibration peaks at 690 cm<sup>-1</sup> and 790 cm<sup>-1</sup>. 41% of fluoride ions from 50 mL of 2.5 mg dm<sup>-3</sup> NaF solution was removed by 0.2 g of synthesized  $\gamma$ -Fe<sub>2</sub>O<sub>3</sub> coated sand at pH 2. The point of zero charge of the iron oxide coated sand was 8.80, and below this value, the surface contained positively charged active sites.  $\gamma$ -Fe<sub>2</sub>O<sub>3</sub>- fluoride interaction was strong, and fluoride is well chemisorbed to the  $\gamma$ -Fe<sub>2</sub>O<sub>3</sub> coated sand surface, and Raman shift at 465 cm<sup>-1</sup> confirms the formation of Fe-F bonds. The adsorption data for the removal of fluoride ions fitted with Langmuir isotherm for all concentrations. The reaction kinetics showed that the mechanism of removal fitted with second-order kinetics.  $\gamma$ -Fe<sub>2</sub>O<sub>3</sub> coated sand can be used as an efficient and low-cost filter material to remove fluoride ions in drinking water.

**Keywords:**  $\gamma$ -Fe<sub>2</sub>O<sub>3</sub> nanoparticles, Adsorbent, Adsorption, Fluoride, Coated sand



**IMPACT OF GEM MINING BY RIVER BED DREDGING IN THE UPPER CATCHMENT TRIBUTARIES OF KALU GANGA, SRI LANKA**

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River bed dredging is one of the conventional gem mining methods in Sri Lanka. The unregulated river dredging process frequently causes channel deepening or bank erosion, as evidenced in the main rivers of *Kelani*, *Kalu*, *Nilwala*, and *Deduru Oya*. As a result, such rivers get eroded to compromise the sand budget of the river beds, and the natural sedimentation process in the upper catchments of these rivers is disturbed. This study aimed to analyse the adverse effect of gem mining by dredging on the natural river bed of the *Kalu Ganga* river basin, Sri Lanka. Initially, field investigations were carried out in *Wey Ganga* and *Hangamu Ganga*, tributaries of the *Kalu Ganga*, which are considered productive gem mining areas of Sri Lanka. Thirty-five stream sediment samples were collected from the middle of both rivers considering the flow patterns and mining locations. Eighteen sampling locations were about 2 km downstream from the selected dredging sites, whereas other sampling locations were evenly distributed upstream from the dredging points. Grain Size Distributions (GSD) were determined for all the sediment samples, and the results were statistically analysed. Seventeen sampling sites were selected along the *Hangamu Ganga*, and of that, six were dredging sites. The average GSD of mining sites indicated 37% of gravels, 61% of sands, and 2% of fines, whereas non-mining sites indicated 7% of gravels, 92% of sands, and 1% of fines. Similarly, 12 sampling sites of dredge mining areas of *Wey Ganga* indicated 38% of gravels, 62% of sands with the absence of finer fractions. The non-mining sites of *Wey Ganga* showed 16% of gravels, 82% of sands, and 2% of finer fractions. The increased amounts of gravel compared to the sand fraction in mining regions were significant in both rivers. The finer fractions of the bedload were very few in all conditions, and it may be due to the high flow rates of the young stage of a river. Despite the sampling area, the sorting or skewness of the samples did not show any significant variations. However, the kurtosis indicated platykurtic nature for mining sites and mesokurtic or leptokurtic nature for natural river flows. The study found that the artificial dredging on the bedload has been reworked, and hence the river beds are disturbed by the mixing of coarse fractions. However, there was no continuous effect on the river bed sedimentation due to the sizes of grains except in suspended load, which needs to be further studied.

**Keywords:** Grain Size Distribution, *Kalu Ganga* basin, River dredging

**LOSS OF KOTTE MARSHLAND: CAUSES AND ITS IMPACT ON ENVIRONMENT**

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The Colombo Metropolitan Region is enriched with wetlands and has been accredited as RAMSAR wetland site. Wetlands in the Colombo Metropolitan Region can be subdivided into several segments, of which Kotte marsh is one of the significant segments. The land use pattern of Kotte has changed over time. This study was carried out to determine the change in the extent of the Kotte marshland and its impact on the environment from 2004 to 2021. Direct observation and field discussion with the public were used to obtain primary data on the status of the Kotte marshland and verification of the boundary. Satellite images from Google Earth Pro and Open Street mapping were used to assess the extent of the Kotte marshland. The assessment has been done by georeferencing and digitizing satellite images of Kotte marsh using GIS tools (Arc Map 10.4). As per the analysis, the extent of the marsh in 2004 was 57.21 ha, and in 2021 it was 45.07 ha. It was reduced by 12.14 ha within 17 years. These wetlands have been rapidly deteriorated. The health of the wetland is gradually declining from time to time as a result of incorrect extraction of uses and misconceptions forwarded to wetlands. Urbanization is a significant cause of this wetland loss in Sri Jayewardenapura Kotte. Filling of the marsh for industrial purposes, reclamation, water pollution, garbage disposal in the surroundings of the marsh, and water regulation are affecting the quality of the wetland. Marshland reduction increases the probability of flood hazards in Sri Jayewardenapura Kotte. The Kotte marshland loses its ability to control floods because it lost reed beds through the filling process. The marsh was a habitat for *Prionailurus viverrinus* (fishing cat); however, the animal in the marshland habitat is now diminished. It is currently the area's most important metropolitan wetland. It delivers a variety of ecosystem services on a local, city, and regional scale. Hence, it is essential to make the public aware of the importance of wetlands and the proper implementation of wetland management strategy plans for urban development to protect the wetlands.

**Keywords:** Colombo Metropolitan Region, Ecosystem, Kotte marshland, Wetlands

**GEOTECHNICAL CHARACTERIZATION OF CLAY SOILS FROM SOUTHERN TO EASTERN LOWLANDS OF SRI LANKA: IMPLICATIONS FOR INDUSTRIAL APPLICATIONS**

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Clay-based industries have been prevailing since ancient times in Sri Lanka despite the scientific input to identify and improve the quality of the materials has been insignificant. Thirteen soil samples employed in various clay-based businesses were collected from the southern and eastern lowlands of Sri Lanka (Ampara to Matara). The geotechnical properties of these soil samples were determined and assessed to check their suitability in different industries. The natural water content, grain size distribution (GSD), specific gravity (Gs), liquid limit, and plastic limit of all samples were determined as per the ASTM standards. A high variation of water content as recorded for the soil samples indicating the minimum at Thanamalwila (4.9%) in the Dry one of Sri Lanka, whereas the maximum at Kamburupitiya (29.5%), which is in the Wet Zone. The high water content may be due to the high water absorption capability of the soils and the climate condition of the particular area. The majority of the soils contained sand with an average of 60.6% (49.5 – 69.5%) and less gravel (0.1 – 26.6%). The average bulk finer fraction is 31.4% and showed a discrepancy in different locations indicating high silt contents (17.5 – 40.8%) than the clays (3.5 – 8.2%). The average Gs of the samples was 2.67 (2.59 – 2.78), indicating a strong influence of inorganic contents on the composition. Based on the Unified Soil Classification system (USCS), nine samples were classified as ‘silty sands’, and the rest as ‘clayey sands’. Eight collected soil samples were low plastic; four samples were medium plastic, whereas only one showed high plastic soil based on their Atterberg limits. The soils' low to medium plastic nature suggests their moderate to high standing capacity in applied load; however, this needs further testing. In conclusion, the acquired clay industrial soils of the region have favourable geotechnical characteristics, suggesting their suitability for industries such as bricks and roof tiles rather than soft industries such as pottery and porcelain.

**Keywords:** Clay characterization, Clay industrial soils, Geotechnical properties

**DEVELOPING A RELIABLE MONITORING FRAMEWORK TO DETECT ENVIRONMENTAL CHANGES NEAR MINING AREAS: A REMOTE SENSING APPROACH**

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Agriculture and mining are two key industries that govern the growth of the socio-economic systems of a country. Detrimental effects on the socio-environment during mining activities are unavoidable. Hence, a proper balance between social, environmental, and economic aspects needs to be promoted in mining industries. Developing robust real-time monitoring systems will prevent overexploitation of resources, negative impact on the socio-environmental system, illegal mining activities, and abandoned mines without proper reclamation. This study aims to recommend utilising no-cost satellite data to assess effects on the environment due to mining. Further, the machine learning approach in this study is expected to lead to an autonomous real-time monitoring mechanism. Based on accessibility and stakeholder interest, a cluster of abandoned and operating quarry sites in the Anuradhapura District, Sri Lanka, was selected as the study area. Freely available high spatial resolution satellite images were obtained from Google Earth and Copernicus Open Access Hub (Sentinel 2 satellite data). Imageries acquired were subjected to object-based land cover classification. Machine learning algorithms, namely, Decision Tree, Random Forest, and Support Vector Machine, were used in the classification process. The best performing algorithm in land cover classification was chosen for multi-temporal analysis of the area of interest. In addition, false colour composites and spectral indices were generated using Sentinel 2 images to differentiate human-induced negative impacts and natural changes. The results show that Support Vector Machine outperformed other algorithms in classifying land cover near mining areas. Further, multitemporal analysis of land cover changes using this algorithm implies autonomous monitoring using satellite data was viable. Additionally, auxiliary information such as false colour composites and spectral indices confirmed that the increased proportion of water bodies in the area was due to leaving the abandoned mines without proper rehabilitation. This study provides evidence that the fusion of machine learning based classification with spectral indices helps develop robust monitoring systems.

**Keywords:** Machine Learning, Mining, Multitemporal analysis, Real-time monitoring, Satellite Data

**USE OF REMOTE SENSING DATA TO IDENTIFY TEMPERATURE VERTICAL STRUCTURE OF WATERS AROUND SRI LANKA**

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Temperature is one of the most significant parameters in descriptive oceanography. The ocean can be divided into three layers: surface, thermocline, and deep layer based on the temperature. The upper layer is known as the mixed layer, where the temperature is almost equal to the surface water temperature. The deep layer also has a constant temperature throughout. The thermocline is the layer between the mixed and deep layers, where a rapid temperature drop can be seen. This study embodies the temperature structure around Sri Lankan waters using ocean modeled data based on satellite observations. Vertical temperature data were obtained from the Copernicus Marine Environment Monitoring Service (CMEMS) for two years, from 2018 to 2019. These data were in daily composites of 0.25-degree spatial resolution within an area of latitudes between 0 °N – 20 °N and longitudes between 70 °E – 90 °E. Parameters included in the dataset were the date, latitude, longitude, depth and seawater temperature. R statistical language was used to read the data and to plot the temperature maps. The results showed that the surface mixed layer spans up to 50 m while its temperature fluctuates between 25 – 30 °C. The seasonal variability of thermocline depth varies between 60 – 175 m deep. The temperature at thermocline varies between 19 – 23 °C, and the warmer water penetrates more than 75 m depth throughout the year.

**Keywords:** Ocean temperature, Remote sensing, Thermocline

**HUMAN-LEOPARD CONFLICT IN SELECTED TEA PLANTATION ECOSYSTEMS IN HILL COUNTRY OF SRI LANKA**

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Human-leopard conflict is a rising issue in the upcountry of Sri Lanka, especially where tea cultivations are the dominant vegetation type. The Sri Lankan Leopard (*Panthera pardus kotiya*) is an endangered species, and most of these conflicts result in human-caused deaths of leopards. Hence the objective of this research was to assess the human-leopard conflict in selected tea estates in the upcountry wet zone. The study was conducted from January 2016 to February 2019, focusing on 15 estates in the Kandy and Nuwara Eliya districts. Data were collected through questionnaires and personal interviews from 225 respondents. Tea estate managers, employees, estate communities and school teachers were the target group. The data were analysed to generate information on trends and patterns of the conflict. The relationship between the frequency of attacks and distance to the nearest forest was analysed using regression analysis. Results indicate that the majority of respondents experienced the conflict, severity depending on study areas. Attacks on dogs were recorded in 13 estates. Attacks on humans were recorded from Panmoor, Hatton, Rosita and Kotagala estates. These happened unexpectedly and resulted in non-fatal injuries only. There was no significant correlation between the distance to the nearest forest and the frequency of attacks ( $p > 0.05$ ). 80% of respondents ( $n = 214$ ) indicated that the leopard killings were due to snares targeted at wild boar (*Sus scrofa*). Misidentification of leopards by estate communities leads to the unintentional killing of fishing cats (*Prionailurus viverrinus*), another endangered species. Most of the community (84%) had a negative attitude towards leopard conservation due to fear and lack of awareness of the role played by the leopard in the ecosystems. Awareness programs for the plantation community on the importance of wildlife conservation may help to conserve not only leopards but also fishing cats. They will help improve the sustainability of tea ecosystems which are required to obtain tea estate certifications such as Rainforest Alliance UTZ and Fair Trade. Avoiding deforestation and planting native trees in deforested areas will increase prey availability for leopards; thus, it may help in reducing conflict rates in the long run.

**Keywords:** Fishing cat, Human-Leopard conflict, Leopard, Panmoor, Rosita

**GEOCHEMICAL AND MICROSTRUCTURAL CHARACTERIZATION OF GALLBLADDER STONES: IMPLICATION FOR BIOMINERALIZATION**

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Stone formation in the gallbladder is one of the growing health issues reported throughout the world. However, the studies on the characteristics of gallbladder stones (GBS) in the Sri Lankan community are scarce. Investigating the composition and microstructures of GBS is important for identifying the causative factors. The present study examined the compositional and structural characteristics of GBS in Sri Lankan patients. Twenty-three patients who were admitted for GBS removal surgery were selected for the study. The socio-demographic information was collected from patients using a structured questionnaire. The GBS removed from the surgery were analyzed by Fourier Transformed Infra-Red Spectrometer (FTIR) and Inductively Coupled Plasma Mass spectroscopy (ICP-MS) to investigate the functional groups and chemical composition. Microstructural and morphological features of GBS were observed by Scanning Electron Microscope (SEM) and stereo polarizing microscope. Selected samples were analyzed in duplicate. The most common type among the studied samples was “Mixed GBS”(n = 10, 43.5%) comprising cholesterol and bilirubinate followed by the “Pigment GBS”(n = 7, 30.4%), which contain bilirubinate. The “Pure cholesterol GBS”, which comprised only cholesterol, was the least common type of GBS. Calcium was identified as the main constituent in GBS together with Cu, Mn, Fe, Mg, Zn, and Ni. The Pigment GBS contained higher concentrations of these elements compared to the other two types. The core region and the crust were enriched with Ca compared to the central part of the stone. Concentric layers of alternating dark and light colour bands observed in the crust reflect the compositional difference in bile involved in the GBS formation. The SEM imaging confirmed lightly stacked cholesterol with plate- and needle-like crystals and irregularly arranged clumps of bilirubinate. The Ca-rich core of GBS confirmed that the Ca-salt precipitation possibly provided a nucleus for the GBS formation.

**Keywords:** Bilirubinate, Cholesterol, Gallbladder stones, Microstructure, Trace elements

**RAPID SYNTHESIS OF GRAPHENE OXIDE USING SRI LANKAN NATURAL VEIN GRAPHITE**

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Due to its excellent purity and high crystallinity, Sri Lankan natural vein graphite is a viable contender for industrial-scale applications. Graphene oxide has gained widespread attention in the scientific and industrial communities during the last two decades. However, more attention is needed to introduce and develop new rapid methods in graphene oxide synthesis. This study aimed to synthesize graphene oxide from Sri Lankan natural vein graphite using a modified rapid Tour's method for the first time. Natural vein graphite powder (< 53 μm) of shiny slippery fibrous morphology was added to the mixture of H<sub>2</sub>SO<sub>4</sub> and H<sub>3</sub>PO<sub>4</sub> (acid ratio 9:1) in an ice bath. Then, KMnO<sub>4</sub> was added and stirred for one hour at 50 °C. The mixture was then poured into ice together with 30% H<sub>2</sub>O<sub>2</sub>. Prepared graphene oxide was characterized by Raman spectroscopy and FTIR-ATR spectroscopy. The oxidation of graphite is confirmed by the development of the strong D band and the disappearance of the 2D band, as well as the broadening of the G band and the blue shift of the G band in the Raman spectrum. The presence of the bands of hydroxyl, epoxy and other functional groups in the FTIR-ATR spectrum also confirms the successful synthesis of graphene oxide. Accordingly, this approach could produce graphene oxide in less than two hours, which has a high potential for industrial applications. This modified rapid Tour's method can be introduced as a simple and time-efficient method to prepare the graphene oxide.

**Keywords:** Carbon precursors, Graphene oxide, Rapid Tour's method



**IDENTIFICATION OF DRINKING WATER WELLS WITH HIGH FLUORIDE ION CONCENTRATIONS IN HAMBANTOTA DISTRICT, SRI LANKA**

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Excessive levels of fluorides in drinking water may cause dental fluorosis. According to the WHO guidelines, fluoride ions (F<sup>-</sup>) in drinking water should be between 0.5 mg dm<sup>-3</sup> – 1.5 mg dm<sup>-3</sup>. This study investigated the fluoride ion concentration in drinking water wells and other selected water quality parameters in three Grama Niladhari divisions (GNDs): Medamulana, Galsiyambalayaya and Warayaya areas with a high incidence of dental fluorosis in the Hambantota District. As an initial study, water samples were collected monthly from seven drinking water wells in September and October 2020 and January, March, and April 2021. Temperature, total dissolved solids (TDS), salinity, pH, electrical conductivity (EC) were measured onsite by PCSTestr 35 multi-parameter. The measured values ranged as follows: Temperature 27.3 °C – 32.0 °C, TDS 323 mg L<sup>-1</sup> – 1340 mg L<sup>-1</sup>, salinity 233 mg L<sup>-1</sup> – 947 mg L<sup>-1</sup>, pH 7.8 – 8.6, and EC 453 μS cm<sup>-1</sup> – 1886 μS cm<sup>-1</sup>. The F<sup>-</sup> concentrations in the three GNDs measured by ion chromatographic technique ranged from 1.0 mg L<sup>-1</sup> to 3.6 mg L<sup>-1</sup>, with most wells exceeding the WHO accepted levels. The concentration of Ca<sup>2+</sup> in the above locations ranged from 22.6 mg L<sup>-1</sup> to 312.3 mg L<sup>-1</sup>, with most wells exceeding the WHO guideline value of 100 – 300 mg L<sup>-1</sup>. The concentration of Mg<sup>2+</sup> ranged from 12.3 mg L<sup>-1</sup> to 83.6 mg L<sup>-1</sup> and most wells exceeded the WHO threshold value of 30 mg L<sup>-1</sup>. Accordingly, the hardness values from 114.6 mg L<sup>-1</sup> to 1058.7 mg L<sup>-1</sup> also exceeded the WHO threshold value of 180 mg L<sup>-1</sup>. Therefore, drinking water consumption from dug wells in the investigated area may be a reason for the observed dental fluorosis incidents. Not only the fluoride ions but also TDS, EC and total hardness values have exceeded the WHO acceptable limits. Therefore, the water quality in the investigated area does not meet the acceptable standards and may cause hazardous health effects. This project will continue to observe whether there is a continuous deterioration of the water quality, and possible causes will be investigated.

**Keywords:** Dug wells, Fluoride, Ion chromatography, Warayaya

**CHLOROPHYLL CONTENT AND PEROXIDASE ACTIVITY AS BIOMARKERS IN SCREENING RICE VARIETIES AGAINST IRON (Fe<sup>2+</sup>) TOXICITY**

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Iron toxicity is one of the widely distributed nutritional disorders that affect rice production negatively. Therefore, the identification of efficient biomarkers for screening rice varieties with tolerance to excess Fe<sup>2+</sup> is important. However, leaf bronzing has been widely used as a phenotypic biomarker in screening rice varieties against Fe<sup>2+</sup> toxicity. Hence, this study aimed to investigate the applicability of chlorophyll content and peroxidase activity (POD) as biomarkers for screening rice varieties against iron (Fe<sup>2+</sup>) toxicity. Two rice varieties recommended for the low-country Wet Zone (LCWZ) of Sri Lanka were identified as iron tolerant (Ld408) and susceptible (Ld365) by the initial study before being used in the experiments. Seven-day old seedlings of both varieties were exposed to different levels of Fe<sup>2+</sup> [150 mg L<sup>-1</sup>(Control), 450 mg L<sup>-1</sup>, 650 mg L<sup>-1</sup>, 850 mg L<sup>-1</sup>, 1,050 mg L<sup>-1</sup> and 1,250 mg L<sup>-1</sup>] at pH 5.5 for seven days. A randomized block design (RBD) was employed with three replicates per treatment and control, and the experiment was carried out in a modified flood and drain hydroponic system. At the end, the total chlorophyll content and POD activity were measured. All data were analyzed through two-way ANOVA followed by Tukey's posthoc test using the statistical software MINITAB 17. Ld408 showed Fe<sup>2+</sup> level-dependent significant ( $p < 0.050$ ) increase in the total chlorophyll content and POD activity with the increase in Fe<sup>2+</sup> concentration. In contrast, Ld365 indicated a significant reduction ( $p < 0.050$ ) in the total chlorophyll content and POD in the treatments with the Fe<sup>2+</sup> concentration higher than 450 mg L<sup>-1</sup> and 650 mg L<sup>-1</sup>, respectively. Further POD activity of Ld408 showed a lower rate in all treatments compared to Ld365. The observed decreases in the chlorophyll content and increasing POD activity of Ld365 infer that the exposed plants to Fe<sup>2+</sup> treatments are under the stressful condition compared with plants of Ld408 under the same treatments. The overall results indicate the variety-specific sensitivity of both chlorophyll content and POD towards Fe<sup>2+</sup> concentration, highlighting higher tolerance of Ld408 than Ld365 for the excess Fe<sup>2+</sup>. According to our preliminary data, it may be possible to apply total chlorophyll content and peroxidase (POD) activity as biomarkers for screening tolerant rice varieties to Fe<sup>2+</sup> toxicity at the early growth stage.

**Keywords:** Chlorophyll, Iron toxicity, Ld365, Ld408, Peroxidase activity

**POTENTIAL OF USING INVASIVE *Petiveria alliacea* FOR FEEDING GOATS IN TOTAL MIXED RATIONS**

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*Petiveria alliacea* is a perennial herb invasively spreading in Kandy and Mathale districts and has already become a troublesome weed in the farmlands. The present study assessed the biological value of tannins in *P. alliacea* and its potential to include in total mixed rations (TMR) for feeding goats. *Panicum maximum* was used as a control plant. Both *P. alliacea* and *P. maximum* at the boot stage were harvested from the Peradeniya University Experimental Station field in Dodangolla, dried, ground, and analyzed for proximate composition. Further, the *in vitro* organic matter digestibility (*in vitro* OMD), metabolizable energy (*in vitro* ME) and biological effect of tannins were determined using *in vitro* gas fermentation assay. Two isonitrogenous (16.4 and 16.8% CP) and isoenergetic (7.44 and 7.25 ME MJ/kg DM) total mixed rations (TMR) were formulated using different levels of *P. alliacea*, *P. maximum* and coconut meal (0:46:54 and 35:33:32, respectively). Using Sannan male goats (13-month, 23.7 ± 1.19 kg), a feeding experiment consisting of two weeks of adaptation period followed by one week of collection period was conducted according to a Latin Square Design (*n* = 6). The crude protein (CP) content of *P. alliacea* (15.33 ± 0.32%) was greater (*p* < 0.05) compared to *P. maximum* (7.61 ± 0.11%). Despite the significant (*p* < 0.05) effect on the biological value of tannins, *P. alliacea* had significantly greater *in vitro* OMD and *in vitro* ME compared to *P. maximum* (*p* < 0.05). The use of *P. alliacea* in TMR formulation did not influence the feed intake, *in vivo* dry matter digestibility and *in vivo* OMD. *Petiveria alliacea* herb is a protein and energy-rich, more digestible forage than *P. maximum* and can be included at 35% in TMR formulation for feeding goats. The ration with *P. alliacea* can be cheaper as it replaced 22% coconut meal (54 vs 32%) of the ration.

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**Keywords:** Tannins, Digestibility, Metabolizable energy, Proximate composition, *Petiveria alliacea*

**DIVERSITY AND ABUNDANCE OF WATERBIRDS IN DELFT ISLAND, JAFFNA, SRI LANKA**

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Delft, an isolated island in the Northern Avifaunal region of Sri Lanka (9°29'50" N; 79°42'00" E), is not yet a popular destination for tourists. However, its location in the Indian Ocean, close to India, within a major flyway of migratory birds, makes it a unique place for waterbirds. The objective of this study was to assess the waterbird diversity and abundance in Delft Island. Twenty locations were selected within the island and investigated for waterbird diversity from June to December 2020. Shannon-Weiner Diversity Index (H'), Shannon Evenness (E), and Simpsons' Diversity Index (D) were calculated. A total of 6,837 individuals belonging to 50 genera, 75 species, and 17 families were encountered. The Shannon-Wiener index was 3.44, Evenness was 0.797, and Simpsons' Index was 0.947. The highest Shannon Index (H' = 3) was shown at the 20<sup>th</sup> point. Seven species including little tern (*Sternula albifrons*; 13.7%), great crested tern (*Thalasseus bergii*; 9.9%), lesser crested tern (*Thalasseus bengalensis*; 6.4%), Caspian tern (*Hydroprogne caspia*; 5.9%), gull-billed tern (*Gelochelidon nilotica*; 5.1%), sooty tern (*Onychoprion fuscatus*; 4.9%), and bridled tern (*Onychoprion anaethetus*; 4.2%) were recorded with a high relative abundance. Further, two Vulnerable (VU) bird species were recorded during the study, viz. little ringed plover (*Charadrius dubius*), and Kentish plover (*Charadrius alexandrinus*). Among the threats identified within the island, the illegal hunting of birds and egg collection were common. These threats may affect rare and threatened species. The results showed that the island has high waterbird diversity, and therefore, it is suitable for promoting ecotourism activities as some species are restricted to the northern avifaunal zone. Community-based ecotourism may reduce the threats to the birds as well.

**Keywords:** Abundance, Delft Island, Diversity, Northern avifaunal region, Waterbirds

**CATCH COMPOSITION OF SHRIMP TRAWL LANDING OFF THE COAST OF GURUNAGAR, JAFFNA**

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Shrimp trawl fishery is one of the major fishing activities in Gurunagar fishing community. There are around 150 mechanized fishing boats actively engaged in shrimp trawling. The bycatch and discards are common and have detrimental effects on shrimp trawling due to their low selectivity. A portion of the catch is discarded from shrimp trawls for many reasons, including small size, damaged organism, lower market price and lack of space onboard. Besides, shrimp is a commercially valuable species brought to the landing site, and the remaining catches are discarded at sea. To date, there have been no detailed studies on bycatch estimation in shrimp trawling in Jaffna. This survey was carried out from six shrimp trawlers operated in coastal waters off Gurunagar, Jaffna, from January to December 2020 to assess the quantity and monthly variation of shrimp, commercial valuable bycatch and discards. The number of discards was quantified onboard before discarding to the sea. The average ratio of shrimp: bycatch was 8%:92%. The mean monthly total bycatch generated from shrimp trawling varied from 87.9% to 92.4%. The average shrimp: commercial bycatch: discards composition ratio was 8:23:69. Commercial bycatch ranged from 20% to 30% of a catch, with a comparatively higher amount of commercial bycatch in April and December. The mean monthly shrimp catch ranged from 300 to 570 kg/month. Mean monthly bycatch generated by shrimp trawling ranged from 4,425 to 6,150 kg/month and in different months with an overall average of  $5,268.75 \pm 128.81$  ( $n = 12$ ) kg/month. The obtained data will be an important tool for fishery management measures. Bycatch is unavoidable in shrimp trawling, and fishers will always be under pressure to reduce the bycatch. However, with responsible fishing, fishers can be educated to ensure the health of the marine environment and species diversity.

**Keywords:** Bycatch, Discards, Shrimp, Shrimp trawling, Total catch

**VALLAI AND THONDAMANARU AREAS AS NATURE-BASED ECOTOURISM DESTINATIONS IN JAFFNA PENINSULA, SRI LANKA**

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Ecotourism is responsible travel to natural areas that foster environmental understanding, promote conservation, and sustain local communities' culture and well-being. Vallai and Thondamanaru areas are situated in the northern part of the Jaffna Peninsula, associated with the Thondamanaru lagoon. The objective of the present study was to assess the ecotourism potential of these two areas using Geospatial analysis based on studies undertaken from 2013 to 2018. Multi-Criteria Decision Method and criteria ranking method in GIS were used for suitability analysis. The evaluation process for potential sites was conducted based on several selected criteria viz. bird species diversity, tourist preferences, proximity to residential areas, proximity to tourists' accommodation, distance from main roads, scenic beauty, density and distribution, and facilities (factors selected according to literature and expert opinion). Suitability analyses were based on four aspects: greater flamingo, other waterbirds, mangroves, and beaches. These considered criteria are not the same for each category. The ranking levels were applied within the criterion and between the criteria. A suitability map was produced through overlaying criteria based thematic maps. From the Jaffna sites' ranking analysis, the potential status of study areas was derived. The study revealed that Vallai and Thondamanaru areas have high potential based on greater flamingos and other waterbirds. On the other hand, Akkarai Beach and mangroves within the study area represent low potential. Of the study areas, Thondamanaru recorded 3,281 individuals belonging to 58 bird species, and Vallai recorded 17,045 individuals belonging to 83 species. At least 4,612 individuals of greater flamingo were recorded from Vallai and 736 from Thondamanaru. Even though these areas have great potential for ecotourism, which should be promoted from a sustainable point of view, lack of investments, promotional activities and infrastructure facilities negatively impact ecotourism development of the study areas.

**Keywords:** GIS, Multi-Criteria analysis, Nature-based tourism, Thondamanaru, Vallai

## COMPREHENSIVE GEOCHEMICAL ASSESSMENT OF GROUNDWATER IN YAN OYA RIVER BASIN, SRI LANKA

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The quality of drinking water is important as deteriorating water quality threatens human health. Yan Oya is the fifth-longest river in Sri Lanka, with a total length of 142 km, and its catchment covers 1,538 km<sup>2</sup>. This catchment encompasses several major hotspots of Chronic Kidney Disease of unknown aetiology (CKDu), such as Padaviya, Kebitigollewa and Horowpothana. Since groundwater quality has received much attention as one of the main factors influencing the disease, we conducted a detailed geochemical investigation covering the entire Yan Oya drainage basin. A total of 90 groundwater samples were collected from both shallow dug wells (< 10 m) and deep tube wells (> 10 m), which are used for drinking purposes. The samples were analyzed for anions and cations using standard procedures. The major cations of groundwater ranged in the order Na > Ca > Mg > K while anions varied in the order HCO<sub>3</sub><sup>-</sup> > Cl<sup>-</sup> > SO<sub>4</sub><sup>2-</sup> > F<sup>-</sup> > NO<sub>3</sub><sup>-</sup> > PO<sub>4</sub><sup>3-</sup>. Among the trace elements Sr, Ba, Fe, and Mn were relatively higher in groundwater while Al, Zn, Cd, Cu, Pb, Ni, Co, Cr, and As were below 0.01 µg L<sup>-1</sup>. The fluoride concentration of water varied from 0.10 to 5.30 mg L<sup>-1</sup> with a mean value of 1.2 mg L<sup>-1</sup>, while water hardness ranged from 25 to 1207 mg L<sup>-1</sup> with a mean value of 301 mg L<sup>-1</sup>, both exceeding the WHO permissible limits for drinking water. Geochemical data indicated that the main groundwater type of the region is Ca<sup>2+</sup>-Mg<sup>2+</sup>-HCO<sub>3</sub><sup>-</sup> facies. As indicated in Gibb's Plots, rock weathering and ion exchange processes control groundwater quality. In the cluster analysis, fluoride, hardness, and alkalinity were clustered together with a 88% similarity level, mainly in the lower segment of the catchment where CKDu prevalence is high.

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**Keywords:** CKDu, Dry zone, Groundwater facies, Hydrogeochemistry, Yan Oya

**GEOLOGICAL FACTORS AND THEIR EFFECT ON CUT SLOPE INSTABILITIES:  
A CASE STUDY AT BELIATTA ON SOUTHERN EXPRESSWAY**

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The Southern Expressway is a highway from Colombo to Mattala. There are several cut slopes along this road. Due to the high rainfall in the area, some of these slopes become unstable during rainy seasons. One such location at Beliatta (Chainage 19+000 km on the Southern Expressway extension) was chosen as the study site where the moderately to highly weathered rock was exposed due to soil erosion leading to slope instability. Understanding the factors causing the slope instabilities can reduce the risks involved with suitable mitigation measures. Here we analyzed the geological factors which govern these slope instabilities. The analysis relied on two types of data: borehole data and discontinuity data. Twelve boreholes were selected out of 20 boreholes drilled on both sides of the slope at the Beliatta site. The groundwater level and soil column, moisture content, grain size distribution, Atterberg limits and Standard Penetration Test (SPT) values were measured. The Dips software (version 6.008) was used to analyse the discontinuity data, and a kinematic analysis was performed. The occurrence of a pegmatite body and the high plasticity of the soil were identified as the main geological factors governing slope instability. Weathered pegmatite is rich in clay, which is impermeable, and therefore pore water pressure increases in that area, affecting slope stability. The stability of the slope has been influenced by the weak zone developed on shear zone at the location. There is a possibility for an occurrence of a wedge failure in the moderately weathered rock mass. Other types of failures are at a low possibility. By kinematic analysis, it was found that when the slope angle is reduced to 34°, the probability of occurring planar sliding, wedge sliding, direct toppling, and flexural toppling become zero. The slope mitigation designs can be improved by using the findings of this study, and it can be further improved to find the particle size distributions and shear strength values.

**Keywords:** Borehole data, Discontinuities, Kinematic analysis, Soil parameters, Southern Expressway



**EFFECTS OF IMPURITIES OF ROCK PHOSPHATE DEPOSITS IN SRI LANKA  
ON THE PRODUCTION OF FERTILIZER FOR SHORT TERM CROPS**

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Rock phosphate deposits formed by weathering of carbonatites are found at Eppawala and Kawisigamuwa, Sri Lanka. Both deposits are made up of the same types of primary and secondary phosphate minerals. Currently, rock phosphate mining occurs only at Eppawala deposits to produce phosphate fertilizer for long-term crops. After sorting the primary apatite crystals, high-grade rock phosphate fertilizer is produced, and the remaining materials are used to make low-grade fertilizer. Although several studies have measured the major and minor element contents of parent carbonatites, the geochemistry of secondary ore bodies important for mining and beneficiation is still not well-known. This research aimed to comprehend the chemical compositional variation of the secondary ores to evaluate their beneficial potential as fertilizers. Herein, major and minor element contents of representative ore samples ( $n = 28$ ) were measured using an Inductively Coupled Plasma-Optical Emission Spectrometer and Inductively Coupled Plasma-Mass Spectrometer. According to the results, the major components of the ores were  $P_2O_5$ , CaO,  $Fe_2O_3$ ,  $SiO_2$ ,  $Al_2O_3$ , and  $TiO_2$ , having weight percentages of 2.80 – 39.81, 2.38 – 52.13, 5.47 – 48.88, 0.27 – 47.09, 1.44 – 22.68, and 0.06 – 2.73, respectively. The average concentrations of  $Na_2O$ , MnO,  $K_2O$ , and MgO were below 1 wt%. The U and Th content were below the detection limit. Therefore, any impacts from the radioactive elements may be negligible. Since major elements showed high variations in distribution, the ore bodies were highly heterogeneous in terms of chemical composition due to the mixing of weathered material in a karst environment. Even though some areas were highly enriched with  $P_2O_5$ , impurities such as  $Fe_2O_3$ ,  $SiO_2$ , and  $Al_2O_3$  were intense.  $R_2O_3$  content ( $Fe_2O_3+Al_2O_3$ ) of the matrix was in the range of 6.91 – 51.74 wt%, which exceeded the maximum allowable level (5 wt%) for the fertilizers. Elevated levels of  $R_2O_3$  are toxic to plants if they become bioavailable. Direct application of this matrix without any purification process may be harmful to long-term crops. Furthermore, such impurities may have a significant impact when used to produce fertilizer for short-term crops. As a result, physical separation of such contaminants from the phosphate matrix is recommended before beneficiation.

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**Keywords:** Fertilizer, Impurities, Rock phosphate,  $R_2O_3$ , Secondary ore

**ENRICHMENT OF RARE EARTH ELEMENTS IN RELATION TO MINERAL PARAGENESIS IN WEATHERED CARBONATITE ENVIRONMENT**

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Increasing demand for Rare Earth Elements (REEs; Lanthanides + Sc and Y) driven by the hundreds of high-tech applications has led to the search for new economic sources. The majority of the world's REEs are associated with carbonatite rocks and their weathered derivatives. Since the REE content of the basement carbonatite rocks at Eppawala, Sri Lanka, has been reported to be high, there is a high potential for REE concentration in their weathered crust to be several orders of magnitude higher than in the parent rock. Identifying REEs enriched zones in weathered profiles using chemical methods is costly because of the high inhomogeneity developed during karstification. Here we aimed to study the relationship between the REEs composition and the mineral paragenesis in phosphate ores. Mineralogical compositions of the weathered carbonatite samples were determined using X-Ray powder diffraction analysis to identify the REEs bearing phases. Other than the primary minerals derived from the carbonatite body, the common secondary phases present in the weathered zones include different generations of secondary fluorapatite, carbonated fluorapatite, crandallite, gorceixite, florencite, and goyazite mineralized during the development of the weathering products. Further, iron oxyhydroxide minerals such as goethite formed by oxidation of iron oxide minerals were abundant in the intensively leached zones of the ore. Aluminosilicates such as kaolinite and montmorillonite can be found in the lateritic layers of the profile. Hydrated aluminium silicates and secondary phosphate minerals such as crandallite, gorceixite, florencite, goyazite, and goethite have a high propensity to scavenge REEs. In particular, aluminophosphate minerals have more affinity for light REEs. As a result, locations rich in certain minerals have an increased tendency for accumulating REEs and are hence appropriate for mining. Therefore, understanding the mineralogy is a facile and low-cost approach to identifying the REEs enriched zones compared to the expensive and complex geochemical analyses.

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**Keywords:** Eppawala, Mineral paragenesis, Rare earth elements, Weathered carbonatite

**EFFECTIVENESS OF *Monochoria vaginalis* TO TREAT DAIRY WASTEWATER IN ALUM SLUDGE-BASED CONSTRUCTED WETLAND SYSTEM**

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Wastewater is one of the major environmental problems worldwide. Industrial wastewater such as dairy wastewater contains a high level of organic and inorganic matter, oil and grease, and phosphate. The constructed wetland (CW) concept has been used as a treatment method for various types of wastewater. In this study, an alum sludge-based CW system consisting of two steps as a sedimentation tank and the CW was created to treat dairy wastewater. An alum sludge layer was applied as a substrate layer to the CW to increase the effectiveness of removing phosphorus from the dairy wastewater. The *Monochoria vaginalis* plant was selected as a macrophyte for this CW system. Twenty-five litres of dairy wastewater flowed through the following: a) CW system, b) CW without the alum sludge layer, and c) CW without the *Monochoria vaginalis*. The samples were collected before and after sending through the system, and the following parameters: pH, conductivity, turbidity, nitrate, phosphate as P, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Total Solids (TS) and oil and grease were measured. Results showed that average removal efficiencies of the complete CW system were 30% for pH, 15% for conductivity, 75% for turbidity, 73% for nitrate, 65% for phosphate, 95 – 99% for oil and grease, 25% for TS, 15 – 20% for TDS and 60% for TSS. Further, the results showed that the alum sludge substrate layer could significantly reduce the amount of phosphorus in the wastewater. In this CW system, physical, chemical and biological processes have been involved in wastewater treatment. Therefore, the CW system developed in this study can be identified as an effective, eco-friendly and cost-effective small-scale constructed wetland unit.

**Keywords:** Alum sludge, Constructed wetland, Dairy wastewater, *Monochoria vaginalis*

**COMPARISON OF ANTIBIOTIC RESISTANCE IN BACTERIA IN POLLUTED AND UNPOLLUTED SOIL**

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Antibiotic resistance is a major global health threat. Soils can be polluted by antibiotics with the addition of antibiotic-containing wastes. The current study investigated and compared the antibiotic sensitivity of soil bacteria isolated from polluted soil (PS) from the Gohagoda dumping site and unpolluted soil (UPS) from a restored area in Hanthana. Soil samples from polluted ( $n = 5$ ) and unpolluted ( $n = 5$ ) areas were collected, and a dilution series were prepared using 1.0 g of soil from each sample. Dominant soil bacterial isolates from PS and UPS were subcultured. Antibiotic sensitivity tests were performed using seven antibiotics commonly used in Sri Lanka (amikacin, amoxicillin-clavulanate, ciprofloxacin, cefotaxime, imipenem, meropenem, ticarcillin-clavulanate). The diameter of the zone of inhibition produced by each antibiotic was measured. Statistical analyses were performed at 5% significance level using Minitab 18.1. With all antibiotics, the mean diameters of zones of inhibition obtained for isolates from UPS were higher compared to those from PS. The values for UPS were significantly higher for all antibiotics except meropenem. The percentage of antibiotic-resistant bacteria was higher in PS than in UPS. Results showed significantly higher values for all antibiotics except amikacin and cefotaxime. The findings confirm the higher prevalence of antibiotic-resistant bacteria in soil in the Gohagoda dumping site, in comparison to an unpolluted area, emphasising that unsafe disposal of antibiotic-containing wastes can cause environmental and health risks. Understanding antibiotic resistance in bacteria in landfills will be useful in managing sanitation practices among landfill workers to avoid health risks. Further, these antibiotic-resistant bacteria need to be investigated for pathogenicity.

**Keywords:** Antibiotic sensitivity, Landfill area, Restored area, Soil bacteria, Zone of inhibition

**MEAN SEA LEVEL VARIATION FROM TIDE GAUGE AND ALTIMETRY DATA  
IN COLOMBO, SRI LANKA**

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The ocean thermal expansion related to ocean warming has contributed to the global mean sea-level rise. The sea-level fluctuations are conventionally measured by tidal stations around the globe with long records. However, tidal stations are sparse and distributed randomly. With the advent of satellite altimetry (SA) missions like TOPEX/Poseidon, Jason-1, Envisat, and more recent missions like Jason-2 and Jason-3, an effective technique of measuring global sea-level fluctuations by merging tide gauge (TG) and SA data are possible with remarkable accuracy. However, altimetry measurements, which can measure the ranges within a few centimetres, are absolute and geocentric, whereas tide gauge measurements are relative and referenced to the Earth's crust. The Earth's crust may be affected by vertical crustal movements (VCM) detected by long-term Global Positioning System (GPS) measurements. The main objective of this study is to assess the mean sea level (MSL) rise by merging TG and SA measurements with continuous GPS data. Long-term records of SA and TG (from 1993 to 2018) and continuous GPS data from 2012 to 2020 (average velocity  $0.05 \pm 1.03$  mm/yr) were used for the analysis. The linear trend analysis of continuous GPS data showed no VCM effects and subsidence in the Colombo tide gauge location. The SA and TG variations showed a similar linear trend which implicitly validates the effectiveness of SA for analyzing the MSL variations. A combined solution from long-term TG and SA data revealed that the MSL rise in the Colombo tide gauge location is around 3 mm per year.

**Keywords:** Mean Sea level, Satellite altimetry, Tide gauge, Vertical crustal movement

**EFFECTIVENESS OF CONSTRUCTED WETLAND IN TREATING LIVESTOCK WASTEWATER**

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Livestock wastewater is a type of agricultural wastewater that includes dairy wastes and animal wastes. When it is mismanaged, it directly impacts the environment, including air, soil, surface water, and groundwater. Constructed wetlands are treatment systems that use natural processes involving wetland vegetation, soils, and associated microbial assemblages to improve water quality. The objective of this study is to compare the purification ability of the laboratory scale system, which consists of a sedimentation tank, constructed wetland and a tank with a seeds layer, to reduce pH, nitrate, turbidity, electrical conductivity, ammonia, Total Solids (TS), Total Suspended Solids (TSS) and Total Dissolved Solids (TDS). The ability of five macrophytes to survive in livestock wastewater for nine days was tested. Based on the results, *Commelina diffusa* was selected as the best macrophyte. The efficiency of *Strychnos potatorum* seeds in treating livestock wastewater was investigated separately. Then, a purification system was constructed, and 15 L of the diluted livestock wastewater was flown through the system, measuring the parameters after each step. The total purification efficiencies of the system were around 10% for pH, 25% for turbidity, 55% for TS, 80% for TSS, 90% for nitrate and 50% for ammonia. Furthermore, the treated water had better colour and odour than the raw livestock wastewater. The cycling of nutrients and other materials of wastewater by macrophytes may affect this result. Treated water can be utilized for cleaning purposes like washing livestock farm premises. The treatment capacity of the constructed wetland was around 5,500 mL m<sup>-2</sup> h<sup>-1</sup>. This purification system requires low capital, low energy, and less maintenance to treat the livestock wastewater. Therefore, this purification system can be introduced to manage wastewaters of local livestock farms.

**Keywords:** *Commelina diffusa*, Constructed wetlands, Livestock wastewater, *Strychnos potatorum*

**APPLICATION OF FACTOR ANALYSIS IN GROUNDWATER CLASSIFICATION  
IN NEETIYAGAMA, ANURADHAPURA**

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Groundwater is generally free from pathogens but contains chemical pollutants—high salinity and fluoride in groundwater result from geogenic factors. Therefore, groundwater classification is highly desired. Piper trilinear diagrams based on major ions in water are conventionally used to elucidate different water types. The major limitations of this method are: a) classification is made using major ionic species, b) only fourteen water types can be identified, and c) chemical species cannot be accounted for the classification. This study aimed to develop an improved geochemical classification method to address these limitations. We developed a classification based on multivariate statistics that can include water quality parameters without imposing an upper limit. R-mode factor analysis has proven highly effective in studies of groundwater quality. The technique can identify the hidden factors behind observed variables. We collected thirty-six groundwater samples from Neetiyyagama village (X-181018, Y-347127 Anuradhapura) in the dry season to determine major and minor constituents in water by ICP-OES, IC and multi-parametric analyzer. Groundwater types were classified using Piper diagrams, and factor analysis was performed for only major ions ( $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{HCO}_3^-$ ,  $\text{Cl}^-$ ,  $\text{SO}_4^{2-}$ ) by R studio 3.4.3. The correlations among the major ions were analysed using Bartlett's test of sphericity and identified the significant correlations. The four-factor model was suggested based on the Parallel Analysis. After rotating the factors, the final factor model with respective ion concentrations was selected and mapped. Factor 1:  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{HCO}_3^-$ ,  $\text{Cl}^-$ , Factor 2:  $\text{Na}^+$ , Factor 3:  $\text{K}^+$ , and Factor 4:  $\text{Ca}^{2+}$  and  $\text{SO}_4^{2-}$ . Piper diagram classification also showed that four water types are predominant in this area (NDC - $\text{HCO}_3^-$  – 50%, Ca- $\text{HCO}_3^-$  – 44%, Mg-  $\text{HCO}_3^-$  – 3%, Na+K-  $\text{HCO}_3^-$  – 3%). Both classifications prove that  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Na}^+$ ,  $\text{K}^+$  are the major ions controlled by the water chemistry in this area and are mainly influenced by basement geological conditions.

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**Keywords:** Factor analysis, Groundwater, Multivariate classification, Piper trilinear diagrams

**RARE EARTH ELEMENTS IN TEA GROWING SOILS FROM DIFFERENT AGRO-CLIMATIC REGIONS OF SRI LANKA**

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There is a growing concern about the accumulation of rare earth elements (REE), particularly light REE, in tea growing soils. Therefore, this study investigated the distribution of REE in tea growing soils from different agro-climatic zones of Sri Lanka. Eighty sampling locations were selected from five tea growing agro-climatic zones, namely Mid-Country Intermediate (IM), Up-Country Intermediate (IU), Low-country Wet (WL), Mid-Country Wet (WM), and Up-Country Wet Zone (WU). Two samples were collected from each location at depths of 0 – 15 cm and 15 – 30 cm. REE in soils were quantified by ICP-MS after microwave-assisted digestion. The mean total REE concentrations ( $\Sigma$ REE) in IM, IU, WL, WM and WU zones were 268 ( $\pm$  78.5), 195 ( $\pm$  42.5), 158 ( $\pm$  71.7), 211 ( $\pm$  58.4) and 182 ( $\pm$  65.7) mg/kg, respectively. The light REE (La to Eu) concentrations were higher in all five zones than the heavy REE (Gd to Lu and Y) and Sc. Approximately 84% of the  $\Sigma$ REE in soils were accounted for by light REE. Post-Archean Australian Shale (PAAS) normalized REE pattern showed a very similar distribution in all study zones. However, the pronounced positive Ce anomaly in the mid-country wet zone and the positive Gd anomaly in all five zones indicated anthropogenic input of these elements. Further studies are required to confirm the anthropogenic sources of the soils.

*Financial assistance from the Tea Research Institute of Sri Lanka (Grant No. B. 125) is acknowledged.*

**Keywords:** Agro Climatic Zones, ICP-MS, Rare Earth Elements, Soils, Tea estates



**GEOSPATIAL TECHNIQUES TO IDENTIFY THE RELATIONSHIP AMONG NDBI, NDVI AND LAND SURFACE TEMPERATURE: CASE STUDY IN COLOMBO DISTRICT, SRI LANKA**

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Sri Lanka has a high population growth and is urbanizing rapidly. Colombo is the most urbanized district. Colombo city is the commercial capital of the country and is the largest city in terms of population. According to census and statistics, the population of Colombo city represents 77.6% of the total urban population of the Western Province. Many studies have indicated that there is an impact of urbanization on the increase of atmospheric temperature. This case study was carried out to identify the relationship between *Land Surface Temperature (LST)* with *Normalized Difference Built-up Index (NDBI)* and *Normalized Difference Vegetation Index (NDVI)*. There are several indices for the analysis of built-up area and vegetation cover. The Colombo district's land use/land cover detection has been employed based on the NDVI ranges. Data was acquired using *Landsat 8 satellite images* on 13<sup>th</sup> January of 2017. *NDBI*, *NDVI* and *LST* maps were produced for the study area and compared the relationship. Pearson correlation coefficient results revealed a positive correlation between *NDBI* and *LST* ( $r = 0.75454$ ) and a negative correlation between *LST* and *NDVI* ( $r = -0.44302$ ). Therefore, it can be concluded that the *LST* values increased as the built-up environment increased with a less green cover. In contrast, the *LST* values were lower when the green cover was dense in the built-up environment of the Colombo District.

**Keywords:** Colombo District, Geospatial techniques, Land surface temperature, Urbanization

**DEVELOPMENT OF ACID SULFATE SOILS IN COLOMBO SUBURBS IN SRI LANKA**

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Acid sulfate soils (ASS) are abundant in submerged, tidal, anaerobic coastal areas and inundated inland areas. ASS consist of pyrite as the major constituents, and jarosite, pyrrhotite, marcasite, mackinawite, goethite, natrojarosite, and schwertmannite as minor or accessory minerals. It has been reported that 12.6 million hectares of land worldwide are affected by sulfuric acidity due to ASS. The wetlands predominantly in the western coastal belt have been subjected to massive urbanization and probably may lead to developing ASS due to exposures of peaty layers to the atmosphere. Thus, the identification and mitigation of impacts of ASS are more important than the amelioration methods during the construction. This study aims to identify the potential acid sulfate sites in Colombo and its suburbs, including Thalangama Tank, Kotte Marsh, Kollonnawa Marsh, Diyatha Uyana, and Muthurajawela. Sixty-five soil and water samples were collected and analyzed at Ecotech Industrial Solutions (Pvt.) Ltd. Titration method was used to measure total actual acidity, total potential acidity, total sulphidic acidity, whereas pH, conductivity, iron, aluminium, chloride, and sulphate concentrations were measured by spectrophotometry. A method adapted from the Australian Acid Sulphate guideline was followed to measure the pH and peroxide of soil samples. According to the action criteria based on Australian ASS guidelines, soils containing more than 6 moles H<sup>+</sup>/ton are ASS. The results revealed that the potential acid sulfate soils are highest in Muthurajawela and Thalangama wetlands, and values range from 45 moles H<sup>+</sup>/ton to 280 moles H<sup>+</sup>/ton. Tested soil samples from other sites showed various acid values between 11 moles H<sup>+</sup>/ton and 165 moles H<sup>+</sup>/ton. Muthurajawela soil samples had high peroxide reaction rate and those samples showed pH less than 1 after the oxidation process indicating sulphate acidity. But normal soils show mild reaction rate in peroxide oxidation and soil pH can range 5-8 after peroxide oxidation. Tested water samples from several points except from few points in Thalangama wetland showed concentration of sulphate ion to chloride ion ratio above 0.5. It is an indication of presence of ASS according to Australian guidelines. Further investigations are required to assess the behaviour of this ASS.

**Keywords:** Acid Sulfate Soils, Pyrite, Sulfuric acidity, Wet zone, Sri Lanka

**GEOCHEMICAL EVIDENCE OF HUMAN-ENVIRONMENT INTERACTIONS IN SOUTHERN COASTAL AREA OF SRI LANKA FROM MID TO LATE HOLOCENE EPOCH**

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The effects of coastal changes associated with sea-level fluctuations on past human behaviour during the Holocene Epoch in Sri Lanka is poorly understood. The main hindrance is the lack of multidisciplinary studies. Sediment samples collected from Pallemalala, Mini-Athiliya, Bundala, Kalamatiya, and Henagahapugala were used to investigate the paleoenvironmental evolution and anthropogenic impact on the littoral area. Sediments from recent lagoonal and beach environments were also collected. Vertical variations of major and trace elements, paleo salinity levels, and organic matter content of sediments were used as geochemical tracers to interpret paleoenvironmental changes. The downcore variations of Sr/Ba ratios, paleo-salinity levels, Ga, V and PO<sub>4</sub><sup>-3</sup> in Pallemalala, Mini-Athiliya and Kalamatiya depicted an increasing trend except for Ga, which declined in Kalamatiya. In contrast, Sr/Ba ratios, Ga and V displayed a decreasing trend while PO<sub>4</sub><sup>-3</sup> exhibited an increasing pattern in Henagahapugala. Conversely, in Bundala, Sr/Ba ratios, paleo-salinity levels and V increased downwards instead of the decreasing trend of PO<sub>4</sub><sup>-3</sup> and Ga. These geochemical parameters indicate that Pallemalala, Mini-Athiliya and Kalamatiya experienced mixed marine and fluvial/terrestrial influence. Henagahapugala displays comparatively strong marine influence. The persistent anthropogenic geochemical signals suggest that prehistoric populations frequented these sites despite the elevated marine influence. However, Bundala was less favoured. The findings indicate that the prehistoric communities successfully exploited a diverse range of coastal habitats during the Holocene.

*Financial assistance from the National Science Foundation (Grant No. NSF/SCH/2018/11) is acknowledged.*

**Keywords:** Anthropogenic impact, Holocene, Palaeoenvironment, Sea level changes



**ADOPTION OF RIDGE ESTIMATOR IN POISSON-MODIFICATION OF QUASI LINDLEY REGRESSION MODEL TO OVERCOME MULTICOLLINEARITY**

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The generalised linear model approach of a mixed Poisson regression (MPR) model is a remedial measure to solve the over-dispersion problem in the Poisson regression model. The Poisson-Modification of the Quasi Lindley (PMQL) regression model is one of the MPR models. The maximum likelihood estimator (MLE) is used to estimate its regression coefficients by applying the iterative weighted least square (IWLS) algorithm. However, the variance of the MLE is inflated when multicollinearity exists. In this study, we adopt the ridge regression method in the PMQL regression model to combat multicollinearity. The performance of the MLE and PMQL ridge regression estimator ( $RE_{PMQL}$ ) are compared in terms of scalar mean square (SMSE) criterion by using an extensive Monte Carlo simulation study. To estimate the ridge parameter in  $RE_{PMQL}$  we adhere to eight notable classical and modified ridge parameter estimators proposed for the ordinary linear regression model. High correlation coefficients (0.90, 0.95, 0.99) were considered to generate the covariates with several degrees of multicollinearity in the simulation study. The results of the simulation study show that the  $RE_{PMQL}$  performs better than the MLE to estimate the regression coefficients of the PMQL regression model in the presence of multicollinearity. The performance of the different estimators reviewed in this study is affected by the factors of degrees of correlation among the covariates ( $\rho$ ), the sample size ( $n$ ), the value of the intercept ( $\beta_0$ ), the number of covariates ( $p$ ), and the values of the over-dispersion parameters of the PMQL regression model ( $\alpha, \delta$ ).

**Keywords:** Multicollinearity, Over-dispersion, PMQL regression, Poisson regression, Ridge estimator

**LONG SHORT-TERM MEMORY NETWORK TO PREDICT DAILY PLATTS  
PRICE PER BARREL OF AUTO DIESEL**

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Auto diesel is one of the primary sources of energy consumed worldwide, and its price movements are subject to fluctuations in the global economy. Several studies have highlighted that fuel price prediction is challenging because the price fluctuation is dynamic, nonlinear and complex. This creates room for researchers to identify methods that predict price fluctuations accurately. The objective of the study is to forecast the daily Platts price per barrel of auto diesel using the Long Short-Term Memory (LSTM) network. The daily Platts price spans from January 2010 to March 2021 was collected from the Ceylon Petroleum Corporation of Sri Lanka. Firstly, descriptive statistics were obtained to explore the price fluctuations. Secondly, the LSTM approach was used to forecast daily Platts price as it is well-suited to capture long-term dependencies in time series data than conventional and standard recurrent neural network methods. Data were preprocessed to improve the model performance and then split into two for training (70%) and testing (30%) the model. The LSTM network was trained until convergence using the Adam optimisation algorithm, and the Mean Squared Error (MSE) was used as the loss function. Finally, prediction accuracy was evaluated using the Root MSE (RMSE), the Mean Absolute Error (MAE) and the Mean Absolute Percentage Error (MAPE). It is revealed that the daily prices oscillate significantly and deviate from a normal distribution. Moreover, the minimum and the maximum price per barrel were \$20.75 and \$144.37, respectively. The network convergence was attained after 40 epochs with a batch size of 60. Further, the forecast accuracy of LSTM was high, which was evident from RMSE (0.0125), MAE (0.0077) and MAPE (1.79%). Therefore, predictions from the LSTM network can be used to make better decisions to minimise the risk associated with price volatility.

**Keywords:** Auto diesel, Fluctuation, LSTM, Platts price

**ANALYSIS OF COLOMBO STOCK EXCHANGE AND BUILDING RISK  
MINIMISED PORTFOLIOS THROUGH CAPITAL ASSET PRICING MODEL AND  
MARKOWITZ PORTFOLIO THEORY**

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Small to medium-range capital market investors in Colombo Stock Exchange (CSE) usually tend to invest without proper analysis, predominantly based on rumours by stock market manipulators. This study focuses on applying theoretical mathematical models (Capital Asset Pricing Model - CAPM and Markowitz Portfolio Theory - MPT) to manage investment portfolios and improve profitability even for retail investors. The main objectives of this study are to identify the beta value (which represents risk) for a company share through CAPM and build a risk minimised portfolio according to the investor's risk appetite while proving the concept of asset diversification through MPT. CAPM was applied to listed companies in CSE with share prices, All Share Price Index (ASPI) values, and government treasury-bill rate (risk-free rate). MPT was also applied with CSE data for selected two companies, and a share portfolio was created by plotting the efficient-frontier graph. The share portfolio represents the return fluctuation according to the risk, and an investor can select the minimised risk portfolio according to the Sharpe ratio. Risk-free assets (treasury bills) were included for the analysis by plotting the capital market line to further reduce the portfolio risk according to the investor's risk appetite. Findings of the CAPM study have shown the beta value for the selected share (2.16 for AEL.N) and can be used to find the expected return of the share. MPT study shows the importance of asset diversification to improve profitability according to the investor's risk appetite. Here the treasury-bill rate was assumed to be 0.5%. Weights of the optimised share portfolio (86% of AEL.N and 14% of GHLL.N) or risk-free asset included portfolio can be derived through the calculation. The investor's capital can be invested accordingly. These techniques can be applied to shares of all the listed companies and build a better portfolio according to the investor's risk appetite.

**Keywords:** Capital Asset Pricing Model, Efficient frontier, Markowitz Portfolio Theory, Risk appetite, Sharpe ratio

**TRANSFER LEARNING FOR PLANT LEAF DISEASE CLASSIFICATION WITH CONVOLUTIONAL NEURAL NETWORKS**

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Many farmers use the traditional approaches for plant leaf disease detection. However, it requires significant time and continuous monitoring of the field resulting in unforeseen losses. Computerised cultivating practices can be a solution for effectively and rapidly recognising plant leaf diseases. This research analyses the transfer learning approaches and how the transfer learning techniques can increase the performance of neural network architecture with predefined models. Two well established convolutional neural network (CNN) models, VGG 19 and GoogLeNet (InceptionV3), were used to find the best model for plant leaf detection in terms of loss and accuracy metrics. All the models have been configured with consistent hyperparameter values. The technique is applied on plantVillage Kaggle datasets of potato, bell pepper, and tomato leaves to investigate the disease of unhealthy leaves. 70% of the dataset was used for training with the 5-fold cross-validation, and 30% was used for testing. Next, the feature extraction and classification process were performed in dataset images to detect leaf diseases using VGG 19 and GoogLeNet (InceptionV3) models by applying image processing. The experimental results confirm the effectiveness of the study, with an overall accuracy of 94.8% of VGG 19 and an overall accuracy of 95.6% of InceptionV3. The results illustrate that the leaf image classification can be achieved with high accuracy using the transfer learning technique without deep knowledge in image processing. Among the two architecture models, InceptionV3 performs well with the validation accuracy of 96%, validation loss of 19.2%, and training loss of 11.9%, where augmentation, dropout, and early stopping techniques are applied. This study confirms that the proposed model can be effectively utilised to identify potential diseases in plant leaves.

**Keywords:** CNN, Image augmentation, Leaf disease, Transfer learning



**NOVEL COMPARATIVE MACHINE LEARNING APPROACH FOR AIR QUALITY FORECASTING**

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Air quality forecasting which provides reliable information on future pollution status, is useful in managing effective air pollution and planning preventive measures. However, air quality forecasting is a challenging task due to rapidly changing weather and pollutant levels. Therefore, accurate forecasting algorithms are needed to regulate the air quality for mitigation plans and early warning purposes. Among the various air pollutants, fine particulate matter with an aerodynamic diameter lesser than  $2.5 \mu\text{m}$  ( $\text{PM}_{2.5}$ ) has been associated with adversarial health effects and a major threat to the living environment. A comparative study is presented using deep learning models to forecast surface  $\text{PM}_{2.5}$  concentration. The study was divided into two categories: standard deep learning models and hybrid deep learning models. Multivariate Long Short-Term Memory (LSTM), Gated Recurrent Unit (GRU), and Convolutional Neural Network (CNN) models were chosen as the standard models. Subsequently, two hybrid models, namely CNN-LSTM, which combines 1D-CNN and LSTM, and CBGRU, which combines 1D-CNN and Bidirectional GRU, are established for forecasting  $\text{PM}_{2.5}$  concentration. The experiment was carried out using the air quality dataset in Beijing, China. Model evaluation was carried out on multiple evaluation metrics such as Root Mean Squared Error (RMSE) and the Mean Absolute Error (MAE). The hybrid models outperformed the standard models. Research findings signify that the model CBGRU (RMSE = 27.12, MAE = 13.95) provided an accurate prediction performance with the lowest errors by efficiently extracting the inherent feature trends of the latent air contaminants and meteorological input data associated with  $\text{PM}_{2.5}$ .

**Keywords:** Air quality forecasting, Convolutional Neural Network, Deep Learning, Gated Recurrent Unit

**LINEAR PROGRAMMING MODEL FOR WATER RESERVOIR MANAGEMENT**

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Water reservoir management is one of the important topics in operations research due to its practical necessity. This study presents a linear programming model for a water release plan in water reservoir management, mainly to satisfy the irrigation water needs. A linear programming model is built to determine which proportions of the lands should be used for the cultivation of crops according to the available water. The proportions of crop cultivations are also addressed in the proposed model for crops with varying water consumption. While maximising the proportions of lands to be cultivated, the constraints, storage continuity, maximum and minimum capacities of the storages, linking constraints, water demand constraints, and lower bounds for crop cultivation proportions are considered in the model. A case study of the Udawalawe irrigation scheme is considered to demonstrate the applicability of the proposed model. Udawalawe reservoir is mainly used for irrigation purposes. There are two main canals of Udawalawe reservoir, and in this study, we focus on the left bank irrigation scheme and assume that the water release for the left and right banks are equal. Evaporation losses and spillage are not considered. The left bank canal feeds about 10,065 hectares of paddy and other crops, mainly sugarcane and banana. For the case study, 64 tanks, including reservoirs, 75 regions (lands) for crop cultivations are considered. A linear programming model with 2,805 variables, 600 inequality constraints, and 1,063 equality constraints was obtained and solved using MATLAB®. By solving the proposed model, the optimum proportions of lands to be used for cultivation and the proportion of paddy and other crop cultivation were obtained. With the proposed model, decision-makers in the related field are benefitted from providing a cultivation plan according to the availability of water.

**Keywords:** Crop water allocation, Linear programming, Water reservoirs

**APPROXIMATE ANALYTICAL SOLUTION FOR KORTEWEG-DE VRIES EQUATION VIA THE METHOD OF DIRECTLY DEFINING INVERSE MAPPING**

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In this study, we develop and apply a semi-analytical method called the Method of Directly Defining the inverse Mapping (MDDiM) to obtain a series solution for the Korteweg-de Vries (KdV) equation arise in the study of long solitary waves in lakes and estuaries. KdV is a mathematical model of waves on shallow water surfaces. Here, we obtained an eight-order approximate series solution for the elongation of the shallow water wave. The square residual error of the eight-order series solution was accurate up to eleven decimal places. Further, our results agreed with the exact solution, the solution obtained by Optimal Homotopy Analysis Method (OHAM), and the results available in the literature, obtained by several numerical methods. In MDDiM, we have the freedom to choose an inverse linear map, which saves computation time because we no longer need to solve systems of differential equations but systems of equations. Further, it is an open problem to apply this novel method to solve fuzzy partial differential equations and investigate various nonlinear partial differential equations arising in science and engineering.

**Keywords:** Korteweg-de Vries equation, Method of Directly Defining the inverse Mapping, Series solutions

**TIME SERIES MODELLING AND FORECASTING OF DENGUE INCIDENCE IN  
JAFFNA DISTRICT, SRI LANKA**

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Dengue hemorrhagic fever is one of the frequently chronicled epidemiological scenarios worldwide in the past and ongoing time frame. The number of cases of the recent outbreaks seems partially deviate compared to the existing pattern. Moreover, the dengue incidence has been more marked in the Northern Province, where among the five districts of the Northern Province, a significant increase has been recorded in Jaffna. Hence, forecasting dengue incidence is an essential aspect. Studies have shown that the number of dengue incidences depends on the weather factors such as rainfall and the number of rainy days. This study aimed to find an appropriate time series forecasting model for the number of dengue incidence recorded in Jaffna district Sri Lanka by using Seasonal Auto-Regressive Integrated Moving Average (SARIMA) and SARIMA with rainfall an exogenous variable (SARIMAX) model. The secondary time series data were collected with the period of January 2010 to December 2020. Further, forecasting accuracy measures, Akaike Information Criterion, Root Mean Square Error and Mean Absolute Error were used to identify the best forecasting model based on the lowest measure of accuracy. According to the data, the highest dengue incidence (2763) was reported in December 2019, and the lowest reported dengue incidence (10) occurred in May 2011. Moreover, the average monthly dengue incidence was 242. The SARIMA (2,1,1)(0,1,1)<sub>12</sub> and SARIMAX (2,1,1)(0,1,1)<sub>12</sub> were selected as the best models to forecast the Dengue incidence in Jaffna district. Overall, the SARIMAX model outperforms the SARIMA model. The outcomes of the analysis would be useful to the health authorities when taking preventive measures to minimise the dengue outbreak during a season.

**Keywords:** Dengue Forecasting, SARIMA, SARIMAX

**ENERGY-AWARE SELF CONFIGURATION FOR SCHEDULED IOT DEVICES  
BASED ON DEEP SLEEP FOR EFFECTIVE LOAD BALANCING**

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Most of the devices in the modern industrial environments are interconnected and provide a wide range of services such as collecting data, taking actions and providing alerts. The Internet of Things (IoT) plays a major role in modern industrial environments that help make critical decisions based on the analysed data generated by many interconnected devices. Manufacturers and service providers always make efforts to minimise the configuration and management of devices. They want the devices to self-evolve and take decisions without involving a centralised system. The main purpose of this study is to introduce an energy-aware self-configuration for scheduled IoT devices based on deep sleep for effective load balancing. The proposed method helps IoT devices decide their deep sleep time-frequency by themselves by considering the remaining operational time, battery life, and current deep sleep time duration. Usually, self-configurable devices take actions based on the analytics provided by a centralised server. However, it requires extra energy to send an additional network call for each cycle. The proposed method can update the deep sleep frequency by skipping a one-time cycle at a time. Spanning of the time cycle improves the performance of the load balancing as well. Because it avoids the additional communication with the server for each cycle and calculates the critical values itself, the proposed method can save energy around 150 times more than a single network call over Wi-Fi. Moreover, since it skips a time cycle to save energy at a time, when necessary, the performance of the scheduling mechanism will also be improved.

**Keywords:** Deep sleep, Energy efficiency, Load balancing, Scheduling, Self-configurable devices

**ACCEPTANCE OF MOBILE BANKING SERVICES OFFERED BY SRI LANKAN COMMERCIAL BANKS**

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Mobile banking services empower customers to conveniently patronage financial services through smart mobile devices. Present research analyses the impact of subjective norms (SN), security of e-services (SoES) and interaction effect on mobile banking adoption (AoMB) of students at the University of Kelaniya. Students participating in the weekend study programs and are using mobile banking services have been considered for sample selection. Finally, 287 duly completed self-administered questionnaires were utilised for the data analysis process. The technology acceptance model has been adopted by means of incorporating the subjective norms variable and security of e-services variable. ANOVA, ANCOVA and Hierarchical Linear Model (HLM) were considered for data analysis. Empirical evidence supported all three hypotheses, which state that SN, SoES and interaction effect predict AoMB. Correspondingly, it was noted that SN and SoES are determinant factors towards AoMB. In accordance with the final HLM, it could be noted that mobile banking adoption, upon controlling for SoES, was comparatively lower for the respondents who had SN bearing in mind perceived usefulness than those who had SN in view of perceived ease of use. The cross-sectional nature and constrained sample were limitations of the study. Findings of the research could be used by the commercial banks and IT vendors developing banking applications, regulators and connected stakeholders to enhance the mobile banking adoption level through the country. Perceived social pressure along with secure mobile banking service delivery may drive greater financial inclusion for the betterment of the society at large whilst unveiling considerable profitability and performance expectations for the Sri Lankan banking fraternity for mutually rewarding long term relationships. The originality of the research is that the particular HLM analysis and incorporation of associated models, given the specific research context. Future research could be performed in quest of varied findings in the wide-ranging country and societal contexts by integrating relevant models and perspectives.

**Keywords:** E-Services, Mobile banking, Online banking, Subjective norms, Technology adoption.

**CLUSTER-FIRST ROUTE-SECOND HEURISTIC ALGORITHMS FOR  
CAPACITATED VEHICLE ROUTING PROBLEM**

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The Capacitated Vehicle Routing Problem (CVRP) is a combinatorial optimisation problem that determines the optimum routes for a given homogeneous fleet of vehicles located at a single depot. The objective of CVRP is to determine the set of routes with the minimum total travel distance that start and terminate at the depot while satisfying the demands at every customer point. Since CVRP is NP-Hard, heuristic algorithms have received broad interest to solve large-scale CVRPs. Generating feasible clusters of customer points with a subsequent Traveling Salesman Problem (TSP) for each generated cluster, called cluster-first route-second, is the most prominent heuristic approach to solve CVRP in the literature. In this study, a novel clustering heuristic algorithm and two improvements for the Nearest-Neighbor (NN) algorithm: Modified NN (MNN) and Improved NN (INN), using the best-fit regression lines for solving TSP are proposed. The Sweep Algorithm and the proposed Novel algorithm for clustering phase and original NN algorithm, MNN, INN, Genetic Algorithm, and Greedy Algorithm for TSP solving are considered to compare the performances of the proposed algorithms. By combining the aforementioned two clustering algorithms and five TSP solving algorithms, ten cluster-first route-second heuristic algorithms are formed and implemented in the MATLAB environment. Then the effectiveness of the proposed algorithms is compared statistically using a set of 100 benchmarked problems in which the number of customer nodes ranges from 100 to 1000. These instances are solved using the ten algorithms, and CPU time and the total travel distance are recorded. One-way ANOVA ( $\alpha = 0.05$ ) test was used to compare the performance of ten algorithms. The statistical analysis revealed that the proposed clustering algorithm is significantly better than the Sweep Algorithm, and performance is increased when the number of customer nodes is increased. Moreover, both MNN and INN algorithms generate competitive TSP solutions.

**Keywords:** Capacitated vehicle routing problem, Cluster-first route-second algorithm, Improved nearest-neighbour algorithms

**EMPIRICAL AND MULTIVARIATE EPIDEMIOLOGICAL ANALYSIS ON  
COVID-19 PANDEMIC**

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The spreading pattern of COVID-19 differs greatly across the countries based on different country-level factors, quarantine measures, and government policies. This study examines definite clusters of countries that exhibit similar patterns in the time series of COVID-19 daily confirmed cases per million worldwide. The country-level demographic, socioeconomic, and meteorological variables associated with the trend patterns were studied, and finally, the geographic and temporal distribution of the countries within each identified cluster were examined. The data set consists of 155 affected countries in the world as of August 7, 2020. Multivariate analysis techniques, principal component analysis, factor analysis, and cluster analysis in data mining were used to explore the hidden features of the COVID-19 merged dataset. Three distinct clusters of daily confirmed cases per million across the world were identified using time series clustering, and three univariate time series models were fitted for the average values of the series within each cluster by assuming countries within each cluster follow a similar distribution. An explanatory model was applied to identify the association of meteorological, demographic, and socioeconomic variables with each cluster pattern, and then the cluster solutions were validated. Assorted county-level meteorological, demographic, and socioeconomic variables appeared to have significant relationships with identified three clusters. The findings of this study can be used to determine the disease spread in countries with similar distributions and underlying factors.

**Keywords:** Cluster analysis, Data mining, Factor analysis, Principal component analysis, Time series



**MATHEMATICAL MODELLINGS FOR FINGERING PHENOMENON OF INCLINE OIL LAYERS WITH AND WITHOUT CONSIDERING MASS FLOW RATES AND THEIR SOLUTIONS USING THE METHOD OF DIRECTLY DEFINING INVERSE MAPPING**

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In this study, we develop mathematical models for the fingering phenomenon, with and without considering the mass flow rates of oil and water when incline occurs through a homogeneous porous media. The fingering phenomenon transpires through the secondary oil recovery process using a water injection well. Further, we develop and apply a semi-analytical method called the Method of Directly Defining inverse Mapping (MDDiM) to obtain series solutions for derived mathematical models. MDDiM was first discovered by S. Liao in 2016; later, in 2018, Vajravelu et al. took the lead to extend it to address systems of nonlinear ordinary differential equations. Recently, MDDiM was further extended to solve nonlinear single and coupled partial differential equations. Here, for each model, we obtained third-order approximate series solutions for the water saturation in the presence of different inclinations. The obtained results, with minimum errors, are presented graphically and discussed. The results we obtained here agreed very well with the results available in the literature, which were obtained by the variational iteration method. Further, it is investigated that fast convergence in MDDiM compared to the variational iteration method. By looking at graphs, it is further investigated that water saturation increases with the distance for any inclination, and higher water saturation level with the existence of the mass flow rate.

**Keywords:** Fingering phenomenon, Homogeneous porous media, Inclined flow, Method of Directly Defining the inverse Mapping, Saturation of water

**NEW CLASS OF HYBRID THIRD-ORDER APPROXIMATIONS FOR FRACTIONAL DERIVATIVES AND APPLICATIONS**

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Higher-order approximations for fractional derivatives (FDs) and integrals have recently been of great importance for numerous real-world applications in many branches of science and engineering, including fractal phenomena, anomalous diffusion, viscoelasticity, and biological population models. In contrast to the classical derivatives, FDs play a leading role in describing memory and hereditary properties of materials and processes; for example, the anomalous diffusion model is described by the continuous random walk in a stochastic process. The shifted Grünwald approximation (ShGA) with shift  $r = 1$  is well-known to be of first-order accuracy for approximation of FDs. Recently, a second-order accurate Grünwald type approximation with arbitrary shift (ShGTA) was constructed in the literature and proved to be reliable with shifts  $r = -1, 1$  for stability and consistency with numerical verifications for FDs of order  $\alpha \in \{1, 2\}$ . In this study, a new class of hybrid third-order approximations was established. The approximation formula for this class was obtained from a hybrid convex combination of one ShGTA with shift  $r$  and a convex combination of two ShGAs with two distinct shifts  $r_1$  and  $r_2$ . This class includes 18 different third-order approximations corresponding to a shift combination  $(r, r_1, r_2)$  with  $r, r_1, r_2 \in \{-1, 0, 1\}$ . We apply them for the fractional boundary value problem of order  $\alpha$ . Numerical test examples are accomplished to verify the accuracy and convergence order of each approximation. The numerical results confirm that the accuracy and the convergence order of each approximation except the case where  $r = -1, r_1 = 1$  and  $r_2 = -1$ . The analysis of stability properties of the class is the next step of our study.

**Keywords:** Fractional derivatives, Second-order approximation, Shifted Grünwald approximation

**NOVEL IMPROVEMENT IN RSA ALGORITHM**

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In 1977, Rivest, Shamir, and Adelman proposed a new public key cryptosystem known to the world now as the RSA algorithm. This system has become one of the acclaimed members of the cryptography family due to its secure and hard to break cornerstone, the factoring problem. However, many researchers are proposing new variants of the original RSA algorithm to overcome its drawbacks. In this study, we propose a new cryptographic scheme based on the textbook RSA algorithm associating the concept of continued fractions. The algorithm was designed under the three primary steps of key generation, encryption, and decryption. The key generation of the system is improved to generate a large encryption key without affecting the decryption key. In this new scheme, the string of plaintexts to be encrypted was taken as a partial quotient of a finite continued fraction representation and the corresponding rational number was calculated. The denominator and the numerator of the rational number should be in their lowest forms. Continued fractions give an additional advantage as it encrypts a string of plaintexts by encrypting only two integers optimising the time and the memory consumption. The encryption and the decryption processes are similar to that of the standard RSA algorithm; insomuch the implemented algorithm does not affect the security of the RSA algorithm, which depends on the factoring problem. In addition, as the algorithm uses a large encryption key, it has been proven that the system is secure against Wiener's attack.

**Keywords:** Continued fraction, Factoring problem, RSA Cryptosystem, Wiener's attack

**LEADING CONTRIBUTORY FACTORS FOR ROAD TRAFFIC ACCIDENTS IN SRI LANKA**

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According to the records of traffic headquarters, road traffic accidents are increasing at an alarming rate in Sri Lanka. Number of deaths and critical injuries report due to road traffic accidents are unbearable to a country like Sri Lanka. The data set used for the current study includes traffic accident information collected from traffic headquarters from January 1, 2014, through December 31, 2014. An exploratory analysis was conducted followed by factor analysis to identify the factors that significantly affect the severity of accidents. Moreover, Hotspots are used to identify the divisions and places more prone to accidents followed by cluster analysis to identify the factors that contribute to accidents. Circular statistical analysis was used to detect circular variables in data and their behavior, Hierarchical and K-modes clustering to cluster data, and GIS mapping to map data concerning DS (Divisional Secretariats) divisions and police stations. Among 35,964 accidents in 2014, 2260 deaths, 19,851 severe injuries, and 13,853 damages were reported. Most of them were in the 30-50yrs age group. The highest number of accidents were in Western provinces. Also, high in *Colombo, Nugegoda, Kelaniya, Gangawatakorale (Kandy) and Gampaha* DS divisions. Cities such as *Kurunduwatta, Maharagama, Kadawatha, Kandy and Gampaha* are more prone to accidents. More accidents were reported in rural areas than the urban area. From January to December, there is a noticeable increase in the number of accidents. Days of the week, months on year show the same circular accident counts throughout the respective time. In addition, the *A-grade* roads are the most vulnerable to accidents and not safe for drivers/pedestrians. Neither clustering algorithm was able to produce a viable clustering structure. However, factors that can influence accident severity, which are Environmental factors (road surface, light condition, weather condition, and location type), Driver/rider age limit, driver/rider gender, human factor, pedestrian factor, vehicle factor, alcohol test, and traffic control were identified. Circular data, hourly, monthly, daily, weekly, and direction wise gave the same pattern throughout the year. Finally, we have a plethora of knowledge regarding Sri Lankan road traffic accidents, which we can use to develop better data collection methods that will assist reduce traffic accident statistics.

**Keywords:** Circular Statistics, Exploratory Factor Analysis, Hierarchical Clustering, Hotspot Identification, Road accidents and Traffic

**CONNECTIVITY MATRIX REPRESENTATION OF GRAPHS OBTAINED BY GRAPH OPERATIONS ON COMPLETE BIPARTITE GRAPHS**

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The connectivity matrix is an adjacency matrix with the property that each cell representing the connection between two nodes receives a value of one. Each cell that does not represent a direct connection gets a value of zero. Connectivity matrices are used in real-world applications such as finding the network tolerance of a network and brain connectivity. Our study mainly focuses on obtaining simple matrix representations for resulting graphs of finite summation and multiplication of  $K_{m,m}$ . In our previous work, we have shown that the resulting graph of the product of  $n$  copies of complete bipartite graphs  $(K_{m,m})^n$  is also a complete bipartite graph, and the number of edges adjacent to each vertex is given by  $2^{n-1} \times m^n$  and the summation of  $n$  copies of  $K_{m,m}$  is not a complete bipartite graph, and the number of edges adjacent to one vertex is given by  $m(2n - 1)$ . These resulting graphs are complicated. In our work, we have shown that the matrix representation of  $K_{m,m}$  is the  $m \times m$  square matrix  $(M_m)$  with all entries equal to  $M$ , where  $M = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$  which is the matrix representation of  $K_{1,1}$ . Matrix representation of  $(K_{m,m})^n$  is a square matrix of order  $(2^{n-1}m^n \times 2^{n-1}m^n)$  with all entries equal to  $M$  and this result is proved by mathematical induction where  $m$  is the number of vertices in one partite set or degree of one vertex and  $n$  represents the number of copies of  $K_{m,m}$ . The matrix

representation of the graph obtained by adding  $n$  copies of  $K_{m,m}$  is, 
$$\begin{bmatrix} M_m & J_{2m} & \cdots & J_{2m} \\ J_{2m} & \ddots & \cdots & J_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ J_{2m} & J_{2m} & \cdots & J_{2m} \end{bmatrix},$$

where  $J_{2m}$  is the  $2m \times 2m$  matrix with all entries equal to 1. This result is also proved using mathematical induction. As an application, we plan to apply these theorems to prepare aeroplane routing plans.

**Keywords:** Bipartite graph, Connectivity matrix, Matrix product, Matrix summation

**ALTERNATIVE APPROACH FOR ANTIMAGIC LABELLING OF A WHEEL GRAPH USING THE CONCEPT OF A PATH GRAPH**

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In 1989, Hartsfield and Ringel introduced the idea of antimagic labelling. Antimagic labelling of a graph  $G$  with  $m$  edges and  $n$  vertices is a bijection from the set of edges to the set of integers  $\{1, \dots, m\}$  such that all  $n$  vertex summations are pairwise distinct. Here the vertex summation is defined as the summation of the labels assigned to edges incident to a vertex. Hartsfield and Ringel conjectured that all simple connected graphs except  $K_2$  are antimagic. In our research, we found an alternative antimagic labelling method for a wheel graph. A wheel graph is a simple graph that contains a cycle of length  $n - 1$  and for which every vertex in the cycle is connected to one other vertex known as the hub or the middle vertex. The edges of a wheel that connect to the hub are called spokes. We labelled the Wheel graph using the concept of the antimagic labelling method of the path graph  $P_{n-1}$ . We removed the middle vertex of the wheel graph and created a path graph using the vertices in the outer cycle of the wheel graph. Then the spokes of the Wheel graph were represented by adding one edge to each vertex. We labelled all the edges using antimagic labelling of the path graph  $P_{n-1}$ . Finally, we calculated the vertex sum for each vertex and proved that every vertex sum was distinct, and the middle vertex takes the highest value, resulting in the complete proof of the theorem.

**Keywords:** Antimagic labelling, Path graph, Wheel graph

**EFFECT OF MAGNETIC FIELD ON BOUNDARY LAYER FLOW OF NANOFLUID USING THE METHOD OF DIRECTLY DEFINING INVERSE MAPPING**

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Magnetic nanofluid constitutes a particular class of nanofluids that exhibit both magnetic and fluid properties. Most researchers have used this magneto nanofluid concept to investigate the thermodiffusion effect on boundary layer flow due to its extensive industrial applications. Most of the studies on the thermodiffusion effect on magneto nanofluid were based on linear stretching of the sheet. However, in reality, stretching is not necessarily linear. Therefore, researchers began to investigate the nonlinearity of the stretching sheet in the boundary layer flow of nanofluid. One of such is the thermodiffusion effect on the boundary layer flow of nanofluids over a nonlinear stretching sheet. Nevertheless, this study was conducted in the absence of a magnetic field. In this study, we hope to extend that earlier study in the presence of a magnetic field and solve the problem analytically. In that case, the Method of Directly Defining inverse Mapping, which is the most recent analytical technique we can use to find approximate solutions within the first few terms, is employed. The analytical results of this study are compared with numerical solutions and found to be in good agreement. Also, the variation of the velocity profile and the skin friction coefficient is examined with different values of magnetic field parameters, and thereby concluded that the velocity decreases with increases in the magnetic field parameter.

**Keywords:** Magneto nanofluid, Method of Directly Defining inverse Mapping, Thermodiffusion effect

**AN ALTERNATIVE METHOD OF CONSTRUCTING SYMMETRIC HADAMARD MATRICES OF ORDER  $2(q + 1)$ , WHERE  $q \equiv 1(\text{mod } 4)$**

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A square design with parameters  $(v, k, \lambda)$  with  $v = 4m - 1, k = 2m - 1$  and  $\lambda = m - 1$  for integers  $m \geq 2$ , is called a *Hadamard design* and the corresponding incidence structure determines a square matrix of order  $4m$  with  $\pm 1$  entries when 0 is replaced by  $-1$  and first row and column with entries 1 is added. This matrix is called a Hadamard matrix. Hadamard introduced his matrices when studying how large the determinant of a square matrix can be. A matrix  $H$  of order  $n$  with entries  $\pm 1$  and satisfying  $HH^T = nI_n$ , where  $H^T$  is the transpose of  $H$  and  $I_n$  is the identity matrix of order  $n$ . It is conjectured that a Hadamard matrix of order  $n$  exists if and only if  $n = 1, 2$  or  $n \equiv 0(\text{mod } 4)$ . Still there are unknown Hadamard matrices of order of multiple of 4. In the present study, we propose an alternative method of constructing symmetric Hadamard matrices. This method is easy to understand and apply. A symmetric Hadamard matrix  $H$  of size  $2(q + 1)$  can be constructed using quadratic non-residues over a finite field and the general form of the proposed method is provided. Let  $H = \begin{bmatrix} A + I & A - I \\ A - I & -A - I \end{bmatrix}$ , where  $A = \begin{bmatrix} R & j \\ j^T & 0 \end{bmatrix}$  with  $j$  being a column vector of length  $q$  with all entries 1 and  $R$  is a Symmetric matrix of order  $q$  constructed by using  $\overline{\chi(a)}$ . The quadratic character  $\overline{\chi(a)}$  indicates whether the given finite field element  $a$  is a perfect square. If  $\overline{\chi(a)} = 0, \overline{\chi(a)} = -1$  if  $a = b^2$  for some non-zero finite field element  $b$ , and  $\overline{\chi(a)} = 1$  if  $a$  is not the square in  $GF(q)$ . The element  $a$  in  $GF(q)$  is said to be a quadratic residue if it is a perfect square in  $GF(q)$ , otherwise  $a$  is a quadratic non-residue. As a future work, we are planning on implementing a computer programme to construct large Hadamard matrices of order  $2(q + 1)$ .

**Keywords:** Quadratic non-residues, Quadratic residues, Symmetric Hadamard matrices



**A METHOD OF CONSTRUCTING HADAMARD MATRICES OF ORDER  $2^{n+1}(q + 1)$  FOR  $q \equiv 1(\text{mod } 4)$**

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A Hadamard matrix  $H$  of order  $n$  with entries  $\pm 1$  satisfying  $HH^T = nI_n$ , where  $H^T$  is the transpose of  $H$  and  $I_n$  is the identity matrix of order  $n$ . If  $H = H^T$ , then  $H$  is called a symmetric Hadamard matrix. The French mathematician Jacques Hadamard proved that such matrices could exist only if  $n$  is 1, 2, or a multiple of 4. There are many properties and features that define a Hadamard matrix. Two Hadamard matrices are said to be equivalent if one can be obtained from the other by a combination of elementary row operations and column operations. Hadamard matrices can be constructed in many ways such as Sylvester Construction, Paley Construction, Kronecker product construction, Williamson construction etc. In this study, we propose an alternative method to construct inequivalent symmetric Hadamard matrices. A symmetric Hadamard matrix  $(H_{2^{n+1}(q+1)})$  of order  $2^{n+1}(q + 1)$  can be constructed by

replacing all 0 entries of  $H_{2^{n+1}(q+1)} = \begin{bmatrix} 0 & j^T \\ j & R \end{bmatrix}$  by the matrix

$A_{2^{n+1}} = \begin{bmatrix} A_{2^n} & -A_{2^n} \\ -A_{2^n} & -A_{2^n} \end{bmatrix}$ , where  $A_2 = \begin{bmatrix} 1 & -1 \\ -1 & -1 \end{bmatrix}$ , and all  $\pm 1$  entries by the matrix

$\pm B_{2^{n+1}} = \pm \begin{bmatrix} B_{2^n} & B_{2^n} \\ B_{2^n} & -B_{2^n} \end{bmatrix}$ , where  $B_2 = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$  and  $j$  is a column vector of length  $q$  with

all entries 1. Here,  $q \equiv 1(\text{mod } 4)$  for a positive integer  $n$ . Moreover,  $R$  is a Symmetric matrix of order  $q$  and it is constructed by using  $\overline{\chi(a)}$ , where

$$\overline{\chi(a)} = \begin{cases} -1 & \text{if } a \text{ is a non zero quadratic residue in } GF(q), \\ 1 & \text{if } a \text{ is a quadratic non - residue in } GF(q), \\ 0 & \text{if } a = 0. \end{cases}$$

The quadratic character  $\overline{\chi(a)}$  indicates whether the given finite field element  $a$  is a perfect square. If element  $a$  in  $GF(q)$  is said to be quadratic residue if it is a perfect square in  $GF(q)$  otherwise  $a$  is a quadratic non-residue. Furthermore, these Hadamard matrices and the Hadamard matrices constructed by using the Sylvester construction are inequivalent. As future work, we plan on implementing a computer programme to construct large inequivalent symmetric Hadamard matrices of order  $2^{n+1}(q + 1)$ .

**Keywords:** In-equivalent, Quadratic non-residue, Symmetric Hadamard matrices

**NUMERICAL SOLUTIONS OF STEADY FREE FLOW OVER POROUS MEDIA  
USING COMSOL MULTIPHYSICS**

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Flow simulations in porous media have a wide range of environmental and industrial applicability. This process is a vital tool in groundwater hydrology, civil engineering, automotive industry, and textile engineering. Most research focus on modeling the physics of the flow through porous media. Recently, due to new findings in biology, blood flow in a capillary can be modeled as flow over a porous media. However, only a few studies have developed governing equations of motion for flows over porous media. Our previous work found analytical and self-similar solutions for the velocity distribution of free flow over porous media. This work presents the numerical solutions of free flow over porous media by using COMSOL Multiphysics. We consider a channel where the bottom of the channel was occupied by porous media and the top of the channel was occupied by a free flow region. The motion in the channel was governed by the coupled incompressible Navier-Stokes Equations and the Brinkman Equations. The flow between the channels was assumed to be steady-state and Newtonian. Further, the velocity profiles for the flow in the channel were examined for different values for parameters such as permeability, porosity, and input velocity. We observed that the velocity distribution in the channel depended on these parameters. Moreover, the contribution of the porous layer to the volumetric flow rate was discussed at different permeability values and input velocities. Results showed that the volumetric flux rate decreased as the permeability of the porous medium increased, and the volumetric flux rate increased as the input velocity increased. The results were validated with analytical results.

**Keywords:** COMSOL Multiphysics, Darcy-Brinkman equation, Navier-Stokes Equations, Porous media

**PARAREAL-RADIAL BASIS FUNCTION-FINITE DIFFERENCE (RBF-FD)  
FRAMEWORK FOR SOLVING TIME-DEPENDENT PARTIAL DIFFERENTIAL  
EQUATIONS**

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This study combines the Parareal time solver algorithm with the Radial Basis Function-Finite Difference (RBF-FD) space discretisation to create a computationally efficient approach for solving large-scale partial differential equations (PDEs). The Parareal algorithm utilises a combination of coarse and fine standard ODE solvers to simultaneously approximate solutions at different time intervals. The RBF-FD is a mesh-free method used to discretise PDEs in space. The Polyharmonic Spline RBF is commonly used in RBF-FD computations; however, any other RBF could be used as well. The RBF methodology is similar to the method of lines approach, where the space discretisation would transform a time dependent PDE into a system of ordinary differential equations (ODEs). Therefore, to solve a time-dependent PDE, one could discretise the PDE in space using the RBF-FD method and use the Parareal algorithm to solve the system of ODEs. However, there are several issues when it comes to pairing the RBF-FD differentiation matrices with ODE solvers. Firstly, the RBF-FD differentiation matrices could have spurious eigenvalues that may fall outside the stability region of the ODE solver. To stabilise the algorithm, one needs to use unacceptably small-time steps, which increase computational costs. Secondly, the higher degree polynomials used in RBF-FD discretisation to achieve higher-order convergence increased the computational cost, especially in large-scale problems. The novelty of our work is that we address these issues by pairing a coarse and fine RBF-FD space discretisation with a respective coarse and fine time solver in the Parareal algorithm. We show that the coarse RBF-FD stencil preserves the higher-order convergence of the fine RBF-FD stencil through error analysis. Furthermore, we show the finite step convergence of the Parareal algorithm for various test cases, including the shallow water equations.

**Keywords:** Higher-order convergence, Parallel Time Solvers, Parareal, RBF-FD, Spurious Eigenvalues

**ACYCLICITY OF COMPLEMENTS OF  $\sigma$ -COMPACT WEAKLY  
INFINITE-DIMENSIONAL SUBSETS IN HILBERT CUBE**

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Acyclicity properties of subsets in the Hilbert cube are a subject of intensive study in infinite-dimensional topology. The complement of a compact, finite-dimensional subset in the Hilbert cube is acyclic. This result was generalised to compact  $C$ -spaces, and compact  $trt$ -dimensional spaces. The final generalisation of the above result was proved for weakly infinite-dimensional compact subspaces of the Hilbert cube. It is a well-known fact that the Hilbert cube cannot be made disconnected by removing a weakly infinite-dimensional (not necessarily closed) subspace. Some strongly infinite-dimensional compacta can separate the Hilbert cube. Further, a previous study proved that the complement of a weakly infinite-dimensional subset of the Hilbert cube is continuum connected. However, path-connectivity of the complement of a non-compact weakly infinite-dimensional subspace in the Hilbert cube is not established. In 2017, a result on the homology of complements of compact weakly infinite-dimensional spaces was proved. In particular, this showed that the complement of a weakly infinite-dimensional compact subspace of the Hilbert cube is path-connected since it has trivial 0-dimensional homology. In this research, we have generalised this result to complements of  $\sigma$ -compact weakly infinite-dimensional spaces. We prove that if  $X = \bigcup_{i=1}^{\infty} X_i$  is a  $\sigma$ -compact weakly infinite-dimensional subspace of  $Q$ , where each  $X_i$  is compact, then the complement of  $X$  has trivial 0-dimensional Steenrod homology. This argument is based on using Milnor's short exact sequence for Steenrod homology to the sequence of spaces  $K_i$ , which are closed tubular neighbourhoods of paths in the complement of  $X_i$ . Since there are continuum connected spaces with non-trivial 0-dimensional Steenrod homology, the above theorem is a generalisation of the continuum connectedness theorem proved in literature.

**Keywords:** Acyclicity, Hilbert cube, Steenrod homology, Weakly infinite-dimensional subspace

**ON CONNECTEDNESS PROPERTIES OF COMPLEMENT OF CLOSED HAUSDORFF WEAKLY INFINITE-DIMENSIONAL SUBSET IN THE MODULI SPACE OF ALL COMPLETE RIEMANNIAN METRICS ON THE PLANE**

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In Riemannian geometry, introducing geometric concepts to smooth manifolds is done via selecting an appropriate Riemannian metric. We define  $R_{\geq 0}(R^2)$  to be the space of all complete Riemannian metrics of non-negative curvature on the plane. The Lie group  $Diff(R^2)$  of all self diffeomorphisms onto  $R^2$  acts on  $R_{\geq 0}(R^2)$  by pulling back metrics. Denote the moduli space of all complete Riemannian metrics of non-negative curvature on the plane by  $M_{\geq 0}(R^2)$ , it is the quotient space of  $R_{\geq 0}(R^2)$  by the  $Diff(R^2)$  action via pullback. The moduli space  $M_{\geq 0}(R^2)$  is not a manifold since different Riemannian metrics may have isometry groups of different dimensions. A topological space  $X$  is said to be weakly infinite-dimensional if for every family  $\{(A_i, B_i): i \in N\}$  of pairs of disjoint closed subsets of  $X$ , there exist separators  $D_i$  between  $A_i$  and  $B_i$  such that  $\bigcap_{i=1}^{\infty} D_i = \emptyset$ . The connectedness properties of the space  $R_{\geq 0}(R^2)$  and  $M_{\geq 0}(R^2)$  were first studied by Belegardek and Hu, and they proved that the complement of every finite-dimensional subset of the space  $R_{\geq 0}(R^2)$  is continuum-connected. It was later proved that the complement of every closed, finite-dimensional subset of  $R_{\geq 0}(R^2)$  is path-connected and that the complement of a subset of  $M_{\geq 0}(R^2)$  is path-connected if the subset is countable, or it is closed, metrisable and finite-dimensional. The results for  $R_{\geq 0}(R^2)$  were generalised to show that complement of every closed, weakly infinite-dimensional subset of  $R_{\geq 0}(R^2)$  is path-connected. Further, a partial generalisation on  $M_{\geq 0}(R^2)$  was obtained to prove that the complement of a closed Hausdorff space with Haver's property  $C$  of  $M_{\geq 0}(R^2)$  is path-connected. In this research, we prove that the complement of every closed Hausdorff weakly infinite-dimensional subset of  $M_{\geq 0}(R^2)$  is path-connected, with an argument using a dimension theoretic argument on the dimensionality of a paracompact preimage of a fully closed map onto a weakly infinite-dimensional space. With this result, we conclude the series of theorems of connectedness properties of  $R_{\geq 0}(R^2)$  and  $M_{\geq 0}(R^2)$ .

**Keywords:** Moduli space, Riemannian metrics, Weakly infinite-dimensional

**PROVIDE A RECOMMENDATION TO THE FEMALE FASHION INDUSTRY  
BASED ON SOCIAL MEDIA USING DEEP LEARNING**

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The fashion industry has extremely dynamic trends pursuing profit and growth. This dynamic factor can be used to create new value for the female fashion industry and the economy of the world. This research proposes a platform to give a conclusive idea about the current female fashion trend of clothing types and colours to the fashion industry. The images of celebrities, models, and other trendsetters were considered for data collection. These real-time data sets were downloaded via Instagram using a Web scraping technique with the puppeteer library of Node.js. Classification of gender, cloth type, and colour was performed using three different Convolutional Neural Networks (CNNs). The CNN used to filter the female images has 'rmsprop' optimiser with six layers with relu and max pooling. Cloth type was also categorised using a similar CNN that applied the 'adam' optimiser. 'sgd' optimiser used in the CNN which used to classify cloth colour with 'categorical\_crossentropy' loss function. The trained CNN for gender classification was done with 82.0% accuracy, followed by 83.2% and 80.2% for clothing type and colour. To take the accuracy test, a programme was used to test the test data set. Predictions were stimulated using a Graphical User Interface (GUI) for convenient accessibility. The predictions were made in 0.49 seconds. Therefore, the proposed system is a user-friendly, computationally efficient method for predicting current trends in the female fashion industry.

**Keywords:** Convolutional Neural Networks, Image processing, Keras, Numpy array, Web scraping

**IDENTIFICATION OF IMPACT OF DISTRIBUTION CHANNEL DYNAMICS ON ASSORTMENT PLANNING OF AUTOMOTIVE PRODUCTS**

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The original equipment manufacturers' (OEMs) current situation is that they carry overly complex order catalogues for configurable products such as automobiles, which results in high development, management, and supply chain costs. Our study aims to control the complexity of OEMs' configuration catalogue to decrease development and supply chain costs while improving profitability, achieving sales objectives, and maintaining strong distribution channels. Assortment planning literature is yet to account for the dynamics of the distribution channels properly, the focus of our study. We consider the impact of dealer density, customer choice complexity, and regional heterogeneity on key performance metrics such as profit, sales, revenue, and inventory levels. Our assortment planning models are developed considering both stockout-based substitution and assortment-based substitution. In addition, we include the multiple substitution behaviour of customers to generate a more realistic scenario. We used several criteria that impact customer substitution behaviour, such as commonality between substitutable products, price similarities, and customer utility when substituting. We also extend the model to consider trades among dealers. Our demand model is based on multinomial logit models widely used in assortment planning literature, which provide a closed-form solution for the probability of directly choosing any individual configuration from the OEM order catalogue. The analytical model is developed for dealers to identify the set of configurations offered in the assortment and inventory replenishment policy to optimise the dealer level profits. Moreover, we conducted simulation experiments using the model parameters to validate the results from the analytical model and expand the studies to understand the impact of trades between dealers on the overall assortment size, inventory levels, and profitability in the dealer network. In conclusion, the study showed that although individual dealers prefer large territories to have higher profits, as OEM, it is crucial to identify the optimal size of the dealer network to have better sales. Further, this study shows that the heterogeneity of dealer network impacts increasing OEM level assortment, affecting assembly line balancing and demand forecasting of productions.

**Keywords:** Assortment-based substitution, Assortment planning, Dealer trades, Optimisation, Stockout-based substitution

**PRIME LABELLING OF SKELETON OF A SPIDER GRAPH**

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Graph labelling is an important area of research in graph theory. There are many graph labelling techniques such as graceful labelling, magic labelling, antimagic labelling, prime labelling. Graph labelling is used in many applications such as coding theory, radar, and astronomy. If vertices of a simple graph can be labelled with distinct integers from the set  $\{1, 2, \dots, n\}$  in such a way that the labels of any two adjacent vertices are relatively prime, it is called prime labelling. A graph that admits prime labelling is called a prime graph. Around the 1980's the concept of prime labelling was introduced by Roger Entringer where he stated the conjecture that every tree is prime, which remains unsolved. The theory was developed and discussed by A. Tout et al. in 1982. Recent work on prime labelling involves known graphs. Vaidya and Prajapati introduced the concept of  $k$  prime labeling in 2011 and probed some results relating to it. The present work focuses on prime labeling of a skeleton of the spider-like graph with the result of the consecutive  $k$ -cyclic prime labelling method of a ladder graph. In this labelling, first, we label legs considering as a ladder using the  $k$ -cyclic prime labelling. Whenever consecutive integers are not relatively prime, such integers will be shifted to its antenna. This way, we can label for any length of a leg of a spider. Furthermore, prime numbers and their behaviour are not easy to identify because there are arbitrarily large gaps in the sequence of prime numbers. However, in this work, the prime labelling method was used primarily to get an idea about a particular application of the prime numbers. As future work, we aim to find a generalised prime labelling method for these types of spider graphs.

**Keywords:**  $k$ -prime labelling, Prime graph, Spider graphs



**LSTM NEURAL NETWORK MODEL TO FORECAST TEMPERATURE**

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In the past few decades, many urban areas worldwide have suffered from severe air pollution resulting in many health hazards and an increase in global temperature. Several studies investigated the effect of temperature changes that could lead to changes in the chemical composition of the atmosphere. Nevertheless, how an increase in temperature affects air pollution during heatwaves is still unclear. This study aims to identify whether the air pollution indicators could predict the temperature. Here we discuss two methods to forecast the daily temperature using air pollutant concentration levels such as ground level O<sub>3</sub>, CO, NO<sub>x</sub>, PM<sub>2.5</sub> and PM<sub>10</sub> as exogenous predictors. Delhi, one of the top 30 cities in the world with the worst air pollution, is considered in the study. Daily temperature and air pollution data for more than five years since 2015 were considered. The temperature in Delhi displayed a cyclic pattern with more variations in recent years. The forecasting ability of traditional Auto-Regressive Moving Average (ARMA), a time series regression model, and a popular neural network model, Long Short-Term Memory (LSTM), were evaluated. The results indicated that the forecast errors of the LSTM model were very low compared to that of the ARMA model. The LSTM model with all the air pollutant concentrations was the best model to forecast the temperature in Delhi with a mean squared error of 6.91 and a mean absolute error of 3.28. Moreover, the LSTM model captured the extreme points and the deviating points more accurately than ARMA. Overall results indicated that the accuracy of forecasting the temperature could be improved by accommodating the air pollution indicators in an LSTM model. The findings would help the environmental and climate scientists study the combined contribution of air pollution and temperature in the global warming issue.

**Keywords:** ARMA, LSTM, Neural Network, Time Series Regression

**GLOBAL TRENDS IN DATA SCIENCE INDUSTRY**

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The hiring of employees depends on several factors, such as academic qualifications and social factors. Recognising the patterns of these factors of employees is important for companies when recruiting new employees. The main objective of this study was to explore and identify varying clustering patterns among employees around the world. A publicly available dataset on a survey conducted by Kaggle during 2017 – 2020 was considered. As missing values were present in this dataset, a data imputation method for categorical data was used to process a complete dataset. The most appropriate variables for a cluster analysis were selected using the forward selection method. Considering the Gower distance as the dissimilarity measure, the k-medoids algorithm was used to partition the dataset into clusters. Preliminary analysis revealed that most companies prefer to accommodate male employees between 22 – 29 years old, which has been a consistent factor over the years. The propensity to hire individuals with Master's or Doctoral degrees has declined over time, and now the companies tend to hire individuals with Bachelors or professional degrees. In addition, the number of students and the number of Indians/Asians working in the industry has increased dramatically over the years. These results are an indication of companies trying to increase their workforce for a low cost. Eight clusters were identified in cluster analysis for each year separately. Each year, a cluster of 18 – 21 years old individuals, with most of them being males who possess a Bachelor's degree, is present. Also, almost all the employees with a Doctoral degree are 30 – 39 years old or older where many of them are males. Most of the female data scientists with a Master's degree were between 22 – 29 years of age. The 30 – 39 years old employees with a Master's degree were clustered together, with the majority being males, but only in 2019, they were scattered in higher age categories. Most of the data scientists above 40 years were either Bachelor's or Master's or other professional qualification holders. However, in 2020, a considerable number of Doctoral degree holders were added to this cluster. The insights provided by this study would mainly be useful to companies in recruiting Data scientists based on their academic qualifications and demographic characteristics.

**Keywords:** Academic qualification, Cluster analysis, Data imputation, Gower distance

**TINY SUSPICIOUS OBJECT DETECTION IN SECURITY SURVEILLANCE**

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Computer vision-based security surveillance with automated CCTV cameras helps identify criminals and reduce the crime rate. It has been widely used in defence, transportation, and public places like airports, harbours, and bus terminals. The tiny object detection is essential for providing complete real-time surveillance in high-security zones. In real-time object detection, execution time is vital to provide adequate security. However, tiny object identification is often difficult because of a wide range of backgrounds, background congestion, and small objects with fewer pixels. This study proposes a method that aims to detect tiny suspicious objects for real-time security surveillance. The proposed method includes three main steps. In the first step, background modelling makes the system more efficient at detecting objects with the help of preprocessing techniques such as auto orient, static crop and auto-adjust contrast. In the second step, suspicious tiny objects images are annotated and labelled under 13 object classes, including a pocket-knife, lighter, metal nail and others collected from surveillance videos. In the last step, the developed dataset is trained with Tiny YOLOv4 and YOLOv4 models. The trained module with YOLOv4 took 4 h for training and 54 ms per image for detecting on a system with Tesla T4 GPU in the Google Colab environment and achieved a detection accuracy of 82.4%. Similarly, Tiny YOLOv4 algorithms took 1 h for training and 13 ms per image for detecting and achieved a detection accuracy of 74.6%. Thus, experimental results show that Tiny YOLOv4 performs faster than YOLOv4 while maintaining an accuracy of 74.6%, making it more suitable for real-time surveillance. Also, the lightweight architecture of Tiny YOLOv4 is more appropriate to install on embedded security surveillance devices. Our study explored the difficulties in real-time security surveillance of small suspicious objects. The proposed model will help detect small suspicious objects in public security surveillance.

**Keywords:** Computer vision, Deep Learning, Suspicious Tiny Object Detection

**WITH-IN-HOST MATHEMATICAL MODELING FOR COVID-19**

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Two mathematical models are proposed to represent the within-host dynamics of the SARS-CoV-2 virus. The first proposed model contains the interaction between interferon responses, host cells, and viral dynamics of the SARS-CoV-2 virus. The second model considers the innate and adaptive immune responses against the viral infection, a more detailed version of the first model. We developed two-compartment models using ordinary differential equations to represent the rate of change of host cells, viral load and immune responses. Data fitting and numerical simulation show that viral replication below the detectable level, 18 – 22 days after onset of symptoms. We considered different starting times of infection to maintain high accuracy. The parameters were estimated using a fit-model function in the python package to best fit the actual viral load data of two infected patients. The results show that the second model, including innate and adaptive immune responses, best fit the available data. Two sets of parameters for each model were estimated using the available viral load data of the two patients. Hence, four sets of parameters and four basic reproduction numbers were calculated as 4.383, 4.635, 8.892 and 8.841 using these two proposed models. The resulted reproduction numbers show that the SARS-CoV-2 virus had higher cellular level infectivity inside the host. Both the model with interferon responses and the model with immune responses predict that the virus may clear after 28 – 33 days from the onset of symptoms.

**Keywords:** COVID-19, Immune response, Interferon, Mathematical modeling, Within-host dynamics

**INTELLIGENT LECTURE RECORDING USING HUMAN AND GESTURE  
RECOGNITION**

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Today, e-learning platforms are used for knowledge transfer through electronic media to address several learning contexts, ranging from conventional classroom delivery to online and offline distance learning. This study proposes a system to capture and record a lecture with all student and teacher interactions and screen sharing using artificial intelligence techniques. The recording is performed using multiple PTZ cameras and microphones connected wirelessly. In the human detection module, an IP camera setup is used to detect and track the lecturer. Specific hand gestures are defined for the lecturer to capture the audience, the whiteboard, and the computer screen view. The gesture recognition module recognises these special hand gestures using a trained TensorFlow Lite MobileNetV2-based SSD deep learning model with a 0.5 depth multiplier included in the Google MediaPipe model. The deep learning model evaluates 21 3D coordinates of the hand to identify gestures. Multiple camera setup automatically moves towards the lecturer, audience and computer view according to the identified hand gesture. The recording module performs the recording of the video and saves it in the cloud. The proposed system also includes a Learning Management System (LMS) and an archive of lecture videos that the students can view. The human detection and hand gesture modules were evaluated using 100 people and the hand gesture datasets since the whole system is dependent on the accuracy of those modules. The hand gesture dataset includes three types of hand gestures made using both left and right hands. The human detection module achieved an accuracy of 90% with a Haar classifier-based model. Also, an average precision of 95.7% for palm detection and an accuracy value of 90% were achieved for gesture detection, respectively. The performance of the human and hand gesture detection methods indicates that intelligent video recording with student and teacher interactions can be achieved.

**Keywords:** Deep learning, Gesture recognition, Human detection, Intelligent video capturing, PTZ Camera Control

**MODELING OF THE DENGUE OUTBREAK USING MODIFIED SEIR MODEL IN  
JAFFNA DISTRICT**

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Dengue fever is a mosquito-borne viral disease transmitted to humans through the bite of infected *Aedes* mosquitoes, mostly *Aedes aegypti*. In the Jaffna District, about 200 cases of dengue fever per 100,000 people in 2019 was reported. A better understanding of the transmission dynamics of the dengue disease epidemic in Jaffna is vital for public health. Mathematical modeling is a useful technique for analysing transmission dynamics. This research aims to improve the theoretical understanding of dengue transmission through a simulation and the related changes in the dengue epidemic in the Jaffna District. The four-compartment (susceptible ( $S_h$ ), exposed ( $E_h$ ), infected ( $I_h$ ), and removed ( $R_h$ )) (SEIR) models for human and two compartment (susceptible ( $S_v$ ), exposed ( $E_h$ ), and infected ( $I_v$ )) model for vectors with seven nonlinear differential equations were used to formulate a mathematical model. Relevant data from 2019 were collected from Jaffna regional health authorities and analysed with the developed model. Two equilibrium points were found: the first point was locally asymptotically stable, and the other was focus asymptotically stable. Moreover, the reproduction number  $R_0 > 1$ . The proposed model shows that the focus of dengue fever would be stable in the Jaffna District except in some specific places.

**Keywords:** Dengue fever, Equilibrium, Reproduction number, SEIR model, Stability

**CHARACTERIZATION OF EXTRACELLULAR POLYMERIC SUBSTANCES OF CYANOBACTERIAL, FUNGAL AND BACTERIAL BIOFILM COMPLEXES BY LIQUID CHROMATOGRAPHY-MASS SPECTROMETRY AND FOURIER TRANSFORM INFRARED SPECTROSCOPY**

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Biofilms are complex communities of multiple microbial species that are attached to surfaces or interfaces in nature. They secrete self-produced extracellular polymeric substances (EPS) for their structure and protection. Such biofilms can also be developed *in vitro* using beneficial microbes for biofertilizers, pharmaceuticals, fuels and electricity. Resident microbes in biofilms establish EPS biochemical-based complex network interactions that govern their functioning. The EPS is considered the “dark matter of biofilm” due to its complexity. Identifying the EPS biochemicals and understanding their contribution to the network interactions is important to achieve improved qualitative productivity and innovation in this field of research. Therefore, a study was designed to analyze biochemical parameters of fungal-bacterial biofilms (FBBs), fungal-cyanobacterial biofilms (FCBs), cyanobacterial-bacterial biofilms (CBBs), and fungal-cyanobacterial-bacterial biofilms (FCBBs). Microbes used were *Aspergillus niger*, *Nostoc* sp., and gram (-) *Stenotrophomonas maltophilia* and gram (+) *Bacillus subtilis*, as fungal (F), cyanobacterial (C) and bacterial (B) counterparts, respectively. ATR-FTIR and LCMS were used to characterize the EPS produced by the different biofilms. Results revealed that FCBBs were at the forefront of producing lipids, proteins, and polysaccharides. In FCBBs, gram (-) *S. maltophilia* was more productive than the gram (+) *B. subtilis*, and the EPS production was affected by the F:C:B ratio of the inoculum. In addition, ecologically and industrially important three biochemicals, i.e. Rescinamine, Colchicine, and Syrosetin, were found in biofilm-EPS. In conclusion, the productivity of biofilms can be improved by manipulating microbial composition. Further research is needed to develop more productive (75 – 95%) biofilms for various biotechnological applications. Also, LC-MS and ATR-FTIR spectroscopy can be recommended as effective tools in comparative studies in evaluating structural and functional properties of fungal, bacterial and cyanobacterial biofilm complexes.

**Keywords:** Biofilms, EPS biochemicals, Network interactions

**STRESS TOLERANT RHIZOBIAL STRAINS INHABITING *Clitoria ternatea* L. IN ANURADHAPURA DISTRICT, SRI LANKA**

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Biological Nitrogen Fixation (BNF) is a process in which atmospheric nitrogen gas is fixed by microorganisms such as rhizobia that live in nodules of the legume plant roots. *Clitoria ternatea* L. is a perennial herbaceous legume that grows naturally in a wide range of soil and gets successfully nodulated even under harsh climatic and soil conditions. This study was conducted to isolate rhizobia from *C. ternatea* grown in different locations of Anuradhapura district, Sri Lanka and to characterize their stress tolerance to identify highly tolerant strains. The root nodules from *C. ternatea* were collected from seven sites in the Anuradhapura District. Twenty-eight pure rhizobial colonies were isolated in ½ Lupin Agar medium. They were separately grown in ½ Lupin broths and subjected to four physiological conditions of pH (3 – 9), temperature (25 – 45 °C), salinity (NaCl concentrations of 0.1 – 3.0%) and drought [Polyethylene glycol-8000 (PEG) concentrations of 0.1 – 0.4%]. The rhizobial strains which showed high tolerance to extreme physiological conditions were subjected to a combination of physiological stress conditions such as pH (8.0), temperature (36 °C), NaCl (3.0%), and PEG (0.4%) to mimic the prevailing environmental conditions in the Anuradhapura District. DNA was extracted from these stress-tolerant rhizobial strains and subjected to PCR-based ERIC fingerprinting, and the genetic diversity was assessed. Of the 28 pure rhizobial colonies, 12 isolates showed high tolerance to at least two extreme physiological conditions. The optimum pH, salinity and temperature range for the growth for the isolates were found between 5 – 8, 0.1 – 1.0% and 30 – 35 °C, respectively. Almost all the isolates grew well in the 0.2% PEG concentration. AP-2 (Anuradhapura urban site) showed the highest tolerance at pH 3.0 and 9.0 and 3.0% NaCl concentration. The isolates KH-3 (Kahatagasdigiliya site) and MH-3 (Mihintale site) showed the highest survival at 45 °C and 0.4% PEG concentration, respectively. PG-1 (Palugaswewa site) showed the highest tolerance to combined physiological stress. The ERIC profile confirmed the high genetic diversity, and 11 clusters were found at 69.9% of the similarity level. These stress-tolerant strains could be used for further studies on cross inoculation of crop legumes as a solution for the high usage of chemical nitrogen fertilizers.

**Keywords:** BNF, *Clitoria ternatea*, ERIC fingerprinting



**TEMPORAL VARIATION IN TERRESTRIAL PEST GASTROPOD COMMUNITIES  
IN AGRICULTURAL LANDS IN NUWARA ELIYA DISTRICT, SRI LANKA**

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Population fluctuations of terrestrial pest gastropods (TPG) are important aspects when developing pest control strategies. Nuwara Eliya District (NED) has the highest production of upcountry vegetables in Sri Lanka and recorded the highest TPG infestations. The study evaluated changes in TPG populations during both the rainy (RS) and non-rainy (NRS) seasons in the Nuwara Eliya District. Eighty agricultural lands were sampled from 2017 to 2019 during RS and NRS, establishing ten 1 m<sup>2</sup> sampling plots per location. A total of 5,758 individuals belonging to 13 species and seven families and 1,325 individuals belonging to nine species and five families were encountered during RS and NRS, respectively. Species abundance and density ( $t = 4.69$ ,  $p = 7.15 \times 10^{-6}$ ) were higher in the RS. The relative abundance and densities of each species except *C. chenui* were higher in RS. These differences were significant for *Bradybaena similaris* ( $t = 3.79$ ,  $p = 2.2 \times 10^{-16}$ ), *Deroceras reticulatum* ( $t = 2.64$ ,  $p < 2.2 \times 10^{-16}$ ), *Lissachatina fulica* ( $t = 2.90$ ,  $p = 0.0005$ ), *Mariella dussumieri* ( $t = 4.25$ ,  $p < 2.2 \times 10^{-16}$ ) and *Macrochlamys indica* ( $t = 1.96$ ,  $p = 0.0001$ ). However, TPG eggs and estivating gastropods were found within the soil and under decaying organic matter during the NRS, indicating that these species breed during the NRS while the young hatch during the RS leading to a sudden increase in the population. Diversity of TPG (Shannon-Wiener,  $H'$  and Simpson dominance,  $D_s$ ) were higher in RS ( $H' = 1.60$ ;  $D_s = 0.70$ ) than NRS ( $H' = 1.45$ ;  $D_s = 0.69$ ). The similarity of TPG communities between the two seasons was 57%. This population dynamics of TPG can be utilized to devise pest management actions. Here we recommend that the control measures are not limited to the RS but also implemented during the NRS when the TPG populations are relatively low, ultimately reducing the farmers' economic losses.

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**Keywords:** Agricultural lands, Nuwara Eliya District, Population dynamics, Terrestrial pest gastropods

**BIOFILM BIOFERTILIZER MITIGATES HEALTH RISKS ASSOCIATED WITH POTENTIALLY TOXIC TRACE ELEMENT ACCUMULATION IN RICE GRAINS**

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In Sri Lanka, the annual per capita consumption of rice fluctuates around 100 kg. However, rice is often contaminated with potentially toxic trace elements (PTTE), which may lead to many health complications in the long run. The use of chemical inputs [e.g. chemical fertilizers (CF)] has been the main reason. As microbes reduce the bioavailability and mobility of these PTTE, implementing microbial interventions in rice cultivation is a need of the hour. In the present study, the Department of Agriculture (DOA) recommended fertilizer practice (100% CF), 66% CF + Biofilm biofertilizer (66% CF + BFBF), and 66% CF alone were used as treatments. In each treatment, the heavy metal content in rice grains was compared using ICP-OES. According to the results, concentrations of PTTE showed in the order of Zn > Cu > Ni > Cr > As in all three treatments. The least amount of Cadmium (Cd) and Co were in 66% CF + BFBF and 100% CF practices, respectively. The BFBF application decreased the heavy metal concentrations in rice grains compared to the 100% CF application. This could be attributed to the immobilization of PTTE by soil microbes through enzymatic microbial detoxification, production of sulfides and carbonates enhancing the precipitation of toxic metal ions, cellular sequestration, and bio-adsorption. Furthermore, the results indicated that the BFBF practice with reduced CF could lower Cd to impose the lowest estimated daily intake. The hazard quotient (HQ) of As was 1.8 in the 100% CF (DOA practice), indicating potential health risks, while in the BFBF practice with reduced CF, it was reduced down to 0.4. In addition, the hazard index was decreased from 3.7 to 1.6, indicating a lesser likelihood of adverse health effects with 66% CF + BFBF practice. Therefore, it can be concluded that the addition of BFBF with a reduced CF can provide a healthier plate of rice than the use of 100% CF.

**Keywords:** BFBF, Hazard index, Hazard quotient, Potentially toxic trace elements, Rice grains

**POTENTIAL OF BIOFILM TREATED K-FELDSPAR AS A BIO-MINERAL FERTILIZER IN ORGANIC AGRICULTURE**

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Being one of the essential macronutrients for plants, potassium (K) plays a vital role in plant growth and health. In organic agriculture, we cannot use any chemical inputs; therefore, K-rich minerals like K-feldspar will be suitable for replacing muriate of potash (MOP). Unfortunately, K-feldspar is not capable of releasing a sufficient amount of K due to its lower solubility. In the present study, K-feldspar was treated with a biofilm formulation (BF) developed from soil fungi and bacteria to form a bio-mineral fertilizer, i.e. Biofilm-feldspar, and analyzed for its solubility. Here, six treatments *viz.* (a) feldspar, (b) Biofilm-feldspar, (c) autoclaved (121 °C) Biofilm-feldspar, (d) heat-treated (200 °C) Biofilm-feldspar, (e) MOP, and (f) control (no fertilizer) were compared in a leaching column experiment up to four weeks. Results show that the Biofilm-feldspar released K (ca. 100 ppm) comparable to MOP at the end of four weeks, indicating a potential to replace MOP. In addition, the solubility of Biofilm-feldspar was further increased with the heat treatment. The highest release of K (ca. 115 ppm) was observed in feldspar heated at 200 °C followed by BF treatment. From the heat treatment, microscale cracks might have formed and facilitated the microbial action on the mineral structure. The study revealed the potential of using Biofilm-feldspar as a bio-mineral fertilizer in agriculture. However, further studies should be conducted to evaluate Biofilm-feldspar in soil-plant systems under farmers' field conditions.

**Keywords:** Biofilm formulation, Bio-mineral fertilizer, Potassium feldspar

***Lactobacillus fermentum* AS A BIOCONTROL AGENT AGAINST FOODBORNE PATHOGEN *Listeria monocytogenes***

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Overuse and misuse of antibiotics are major drivers for the emergence and evolution of antibiotic resistance in commensal and human pathogens. The spread of acquired antibiotic resistance in the environment mainly occurs via the food chain. The resistance of pathogenic bacteria to currently available antibiotics presents a possible challenge to human health. As a solution to this prevalent global issue, alternatives for antibiotics are in search, and biological control is at the forefront. *Listeria monocytogenes* is a foodborne human and animal pathogen that causes listeriosis, while *Lactobacillus* spp. are generally regarded as safe and possess the GRAS status. In this study, three strains of *Lactobacillus fermentum* ( L-12, L-15, and L-18 ), previously isolated from spontaneously fermented buffalo milk from Kantale, Sri Lanka and molecular identification was carried out earlier, were tested *in vitro* for their possible biocontrol efficacy against *L. monocytogenes* (NTCT 11994). The antagonistic activity was screened using the agar well diffusion method. *Lactobacillus fermentum* supernatants were transferred to wells on *L. monocytogenes* agar plates containing BHI. Sterile MRS broth was used as the negative control. The experiments were conducted in triplicate, and the diameter of inhibitory zones was determined. All three strains of *L. fermentum* demonstrated antagonistic activity against *L. monocytogenes*. The antagonistic performance was highest in L-12, followed by L-18 and L-15, respectively. Strain L-12 had the highest mean zone diameter of 13.8 mm. Results showed that the antagonistic behaviour is highly strain-specific. *In vitro* study supports the possible usage of *L. fermentum* strains as biological control agents to inhibit *L. monocytogenes*. Further, fermented buffalo milk (buffalo curd) can be introduced as a functional food with a natural antibacterial effect.

**Keywords:** Antagonistic activity, Antibiotics, Biocontrol, *Lactobacillus fermentum*, *Listeria monocytogenes*

**ANTAGONISTIC ACTIVITY OF *Lactobacillus fermentum* AGAINST *Aspergillus* SPECIES OBTAINED FROM PASTEURIZED FRUIT SYRUP**

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According to the WHO, a particular bacterium must possess specific characteristics to be considered a probiotic bacterium used in the food industry. Antagonistic activity against other microorganisms by producing antimicrobial substances is one such character. This study investigated the *in vitro* antagonistic activity of two naturally isolated *Lactobacillus fermentum* strains against spoilage of *Aspergillus* spp. isolated from pasteurized fruit syrup. *Lactobacillus fermentum* strains were isolated from spontaneously fermented buffalo milk. Molecular identification of *L. fermentum* (strain L-18 and T5d) and *A. foetidus*, *A. flavus*, *A. oryzae* and *A. elegans* was carried out by the authors previously. For the assay, each *L. fermentum* strain was streaked as one line in a modified MRS agar plate and incubated anaerobically at 37 °C for 48 h. A fungal agar block was placed on an incubated MRS agar plate, maintaining a distance of 2 cm from the *L. fermentum* streaked line and incubated aerobically at 28 °C for up to seven days. The area of the fungal mycelium in photograph images was transferred to square pixels using Adobe® photoshop C6 (13.0 - 64bit) software kit. The square pixels were then converted to square centimetres by using MS Excel 2019. The ability of antifungal activity by the two strains of *L. fermentum* was detected by comparing the growth area of each tested fungal mycelium corresponding to the same mycelium without the bacterium (positive control). Both *L. fermentum* strains showed positive antagonistic effects against all four tested *Aspergillus* species. Zero growth of *A. foetidus* indicated 100% control by both *L. fermentum* strains, while the growth of *A. elegans* was controlled close to 100%. *Aspergillus flavus* and *A. oryzae* were moderately controlled. The study identified two potential *in-vitro* antifungal *L. fermentum* isolates, exhibiting the benefit of consuming traditional buffalo curd and its potential to be used as a probiotic food source.

**Keywords:** Antagonistic effect, *Aspergillus* spp., Fermented foods, Food preservation, *Lactobacillus fermentum*

**EFFECT OF pH ON EARLY EMBRYO DEVELOPMENT OF ZEBRAFISH, *Danio rerio***

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Water pollution has become a leading environmental problem faced by today's world. It has been reported that the pH in water bodies has changed critically in past years along with the increasing land-use practices, industrial discharges and anthropological activities. Extreme acidic and alkaline pH levels affect the early embryo development of fish in lethal and sub-lethal levels, inducing low hatching rates and morphological abnormalities. Zebrafish (*Danio rerio*) is an ideal model for studying environmental and toxicological effects on early embryo development due to the small body size, transparency and ex-utero development of the embryo. The present study evaluated the hatching rate, hatching time, morphological abnormalities and mortality rates of zebrafish embryos exposed to pH ranging from 1 to 12. Desired pH solutions were prepared using 1 M HCl and NH<sub>4</sub>OH at 27 °C. Distilled water (pH 7) was used as the control. All experiments were carried out up to 96 hpf (hours post-fertilization) with ten embryos per pH value and triplicated using different batches. Variations in hatching rate, time and mortality rate were obtained in different pH solutions compared to the control. The pH values of 3 and 10 were identified as lethal levels with 100% mortality, where embryos were turned opaque within 1 h. A hatching rate of 100% was observed from 6 – 8 pH range, and it ranged from 60 – 80% at pH of 4, 5 and 9. The highest hatching time of 78 ± 1.15 hpf was recorded at pH 4, where the lowest was at pH 7 at 68 ± 0.58 hpf. Embryo hatching occurred around 72 hpf. There were no morphological abnormalities detected in surviving embryos. The results show that zebrafish embryos can tolerate a wide range of pH, and the effect is minimal at pH 6 – 8 while having a 100% survival rate with a low hatching time.

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**Keywords:** Embryo development, Hatching rate, Mortality, Zebrafish

**ECTOPARASITES IN PETS AND LIVESTOCK IN UDUNUWARA  
DIVISIONAL SECRETARIAT DIVISION IN CENTRAL PROVINCE  
OF SRI LANKA**

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Ectoparasites are a major health concern of both humans and animals. They act as vectors of many economically important and zoonotic diseases, and in-depth studies on species diversity are important in controlling and preventing infestations. The objective of the study was to survey ectoparasite species in domestic animals and collect socio-ecological data from households having infested domestic animals within the Udunuwara Divisional Secretariat Division in the Central Province of Sri Lanka. Households were visited using a snowball sampling method, and ectoparasites were collected through visual appraisal. Seven hundred eighty ectoparasites were collected from 151 host animals, including dogs, cats, cattle, rabbits, goats, domestic fowls, turkeys, pigeons, lovebirds, and a buffalo in 42 Grama Niladhari divisions within the area. The collection comprised of ticks ( $n = 311$ , species = 13), lice ( $n = 196$ , species = 11), fleas ( $n = 256$ , species = 2), and mites ( $n = 17$ ). Among the tick species, the cattle tick *Rhipicephalus microplus* (30%) was the most abundant, followed by the brown dog tick *Rhipicephalus sanguineus* (29%) and *Rhipicephalus haemaphysaloides* (17%). Among the louse species, *Menacanthus stramineus* (28%) was the most abundant, followed by *Damalinia caprae* (15%) and *Lipeurus caponis* (14%). The dog flea *Ctenocephalides canis* (82%) was the most abundant, while *Ctenocephalides felis* was found in cats and dogs. The rabbit fur mite: *Leporacarus gibbus* and another two Analgoidea mites were recorded from rabbits, domestic fowls, and lovebirds, respectively. Households with low sanitation, close contact with the wild animals, feeding livestock with cut grass like *Panicum maximum* (Guinea grass), and poor veterinary care were socio-ecological factors presumably creating a conducive environment for infestations. Moreover, the household members lacked awareness about ectoparasites, ectoparasite-related complications, and zoonotic potential of ectoparasites. Domestic animals were infected with a wide range of ectoparasites. Island-wide surveys on ectoparasite fauna are required to understand the distribution and ecology of these parasite taxa.

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**Keywords:** Domestic animals, Fleas, Lice, Mites, Ticks

**GASTROINTESTINAL PARASITES OF DOGS IN A REMOTE TEA-GROWING AREA IN TALAWAKELLE: A POTENTIAL PUBLIC HEALTH PROBLEM**

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Gastrointestinal (GI) parasites cause severe illness in dogs and humans, particularly in socio-economically challenged communities with large stray dog populations. Most of these GI parasites of dogs are zoonoses. Since dogs play a pivotal role in the epidemiology of human infections, investigating the types of GI parasites and prevalence are important in assessing their public health significance. Fresh faecal samples from stray dogs in two tea estate communities ( $n = 50$  from each) in Talawakelle were collected and analysed following a modified Sheather's sucrose floatation method. The common dog hookworm *Ancylostoma* was further investigated using the molecular marker *ITS1-5.8S-ITS2* for species identification and phylogeny. Of the 100 stray dogs examined, 97.0% were positive for GI parasites. Mixed infections (85.6%) were more common than single infections (14.4%). Sixteen GI parasite species were detected using egg morphology and morphometry, all of which were zoonotic. *Entamoeba* sp. (58.0%) was the most prevalent infection, followed by *Ancylostoma* sp. (45.0%) infection. Overall, helminth prevalence was significantly higher in female dogs (92.5%,  $n = 37$ ) than male dogs (73.3%,  $n = 44$ ), potentially due to the immune suppression during pregnancy and lactation. Puppies ( $n = 15$ ) harboured higher parasitic burdens than adults ( $n = 82$ ), of which the prevalence and burden of *Toxocara canis* (68.8%;  $p < 0.001$ ) was significantly higher, possibly due to vertical trans-mammary or trans-placental transmission of infective larvae. This study depicts the first record of the parasite *Hymenolepis* from dogs in Sri Lanka. This study also signifies the first molecular characterisation of *Ancylostoma caninum* in Sri Lanka. The local variant was phylogenetically unique and 99.2% similar to the variant identified from India. The presence of zoonotic GI parasites with public health significance highlights the importance of improving community sanitation, proper veterinary care for dogs, and public awareness of zoonotic diseases.

**Keywords:** *Ancylostoma caninum*, Dogs, Molecular characterisation, Prevalence, Zoonoses



**SILVER NANOPARTICLES INCORPORATED POLYMER-BASED  
ELECTROSPUN SKIN SCAFFOLD FOR BURN WOUNDS**

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Polymeric electrospun nanofibrous scaffolds with enhanced antimicrobial properties have become a suitable substitute for artificial scaffolds in tissue engineering applications, including skin scaffolds, in the recent past. This is because of the ability to mimic the anatomical architecture of extracellular matrices by facilitating cell growth and proliferation. Silver nanoparticles (AgNP) are known to have antibacterial activity. In this study, AgNP and Graphene oxide (GO) incorporated PolyCaproLactone/ PolyEthylene Glycol (PCL/PEG) based electrospun fibrous mesh was prepared, characterized and tested *in vitro* for use as wound dressings. Silver nanoparticles were synthesized by reducing Ag<sup>+</sup> using trisodium citrate and characterized using UV-Vis spectrophotometry. Different fibrous scaffolds were prepared, including PCL+PEG, PCL+AgNP, PCL+PEG+AgNP and PCL+PEG+AgNP+GO using an electrospinning apparatus. The scaffold discs were loaded with prepared AgNP solutions (0.05 M, 0.1 M, 0.2 M) for the antimicrobial assay. The morphology of fabricated scaffolds was evaluated by optical microscopic studies and by XRD studies. Finally, water absorption capacity and antibacterial assays (by disc diffusion method) were performed using Ciprofloxacin 0.50 mg /disc as the positive control. The water absorption studies showed that the scaffold could absorb water by seven folds of its initial weight. The scaffold showed promising antibacterial activity against both Gram-negative bacteria (*Escherichia coli*, *Pseudomonas aeruginosa*) and Gram-positive bacteria (*Bacillus cereus*, *Staphylococcus aureus*, *Staphylococcus epidermidis*), which can be predominantly seen in burn wounds. The results show that the prepared biodegradable and biocompatible electrospun fibrous scaffold may be useful as an effective tissue-engineered artificial extracellular matrix for burn wounds since it can absorb high amounts of exudate with an antimicrobial action against the above-mentioned bacteria.

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**Keywords:** Burn wounds, Electro spinning, Polymers, Silver nanoparticles, Skin scaffold

## PERFORMANCE OF CHILLI, *Capsicum annum* L. UNDER DIFFERENT FOLIAR TREATMENTS

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The general technique of supplying nutrients to plants is the application of fertilizer to the soil. However, foliar applications are practised to offset the rapid nutrient requirements of plants. This study evaluated the growth and yield performances of MI-Green chilli variety under Department of Agriculture (DOA) recommendation over different foliar applications. This experiment was laid out in a Randomized Complete Block Design (RCBD) with five foliar spray treatments viz., cow dung (T1), compost tea (T2), urea (T3), urea+ mono-ammonium salt f (T4), urea+ sucrose (T5), and a control (DOA recommendation; T6). Here, T1 and T2 were used as pesticides rather than fertilizers. Results disclosed the highest plant height ( $53.5 \pm 6.8$  cm) on 90 DAS (Days after sowing) in T4 whereas the lowest ( $38.9 \pm 4.6$  cm) in T2. The highest number of flowers at 60 DAS ( $21 \pm 3$  flowers) was recorded in T4, whereas the least ( $8 \pm 2$  flowers) was in T3. The highest number of pods per plant was in T4 ( $15 \pm 3$  pods), whereas the least was in T3 ( $6 \pm 2$  pods). The maximum pod length ( $6.8 \pm 2$  cm) was in T4, while the least ( $4.4 \pm 3$  cm) was in T3. The highest seeds/pod ( $87 \pm 12$  seeds) was in T4, and the least ( $47 \pm 13$  seeds) was in T3. Among the treatments, T4 recorded the highest average pod weight (12.5 g), and the lowest (5.1 g) was in T3. The highest yield per plant (2.8 g) was in T4, whereas the least (2.1 g) was in T3. The highest final yield was in T4 (5.6 t/ha), whereas the lowest was in T3 (4.2 t/ha). There was a significant ( $p < 0.05$ ) difference in T4 with control ( $\tau_1 - \tau_2 = 0.8 > \text{LSD} = 0.6$ ). Hence urea+ mono-ammonium salt foliar spray was the best foliar treatment that can apply under the DOA recommendation to get better growth and yield performance in MI-Green chilli.

**Keywords:** Chillies, Compost Tea, Cow dung spray, Foliar-Feeding, Urea and sucrose spray

**HERBICIDAL PROPERTIES OF INVASIVE ALIEN PLANTS *Ageratina riparia* AND *Austroeupatorium inulifolium* AGAINST *Brassica juncea***

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Synthetic herbicides cause harmful effects on human health and the environment, and therefore, the importation of agrochemicals has been banned recently in Sri Lanka. Invasive alien plants (IAPs) spread aggressively, threatening ecosystems, biodiversity and crops. A strategy to resolve the problems of synthetic herbicides and the uncontrolled spread of IAPs is to develop eco-friendly plant-based herbicides from IAPs. Accordingly, two IAPs, *Ageratina riparia* (Regel) R.M. King & H. Rob. and *Austroeupatorium inulifolium* (Kunth) R.M. King & H. Rob. were evaluated for their herbicidal properties against *Brassica juncea* (L.) Czern. The dry leaf powders, prepared from the two IAPs, were separately extracted into dichloromethane-methanol (1:1) using a bottle extractor. The leaf powders and the concentrated leaf extracts were tested for their inhibitory effects on seed germination and early seedling growth (shoot length, root length and biomass) of *B. juncea* in a Petri dish assay using 2-methyl-4-chlorophenoxyacetic acid (MCPA) and glufosinate ammonium as positive controls and distilled water and aqueous dimethyl sulfoxide as negative controls. Each treatment was carried out on 25 seeds in four replicates in three trials. The IC<sub>50</sub> values of *A. riparia* and *A. inulifolium* leaf powders were  $0.81 \pm 0.07$  mg cm<sup>-2</sup> and  $0.60 \pm 0.13$  mg cm<sup>-2</sup>, respectively; the corresponding values for *A. riparia* and *A. inulifolium* leaf extracts, in equivalent leaf powder, were  $0.48 \pm 0.04$  mg cm<sup>-2</sup> and  $0.52 \pm 0.04$  mg cm<sup>-2</sup>, respectively. Leaf powders (at 1.76 mg cm<sup>-2</sup>) and extracts of *A. riparia* (at 0.95 mg cm<sup>-2</sup> equivalent leaf powder) and *A. inulifolium* (at 0.74 mg cm<sup>-2</sup> equivalent leaf powder) were more potent than the commercial herbicides glufosinate and MCPA (at concentrations recommended for field use). Growth parameters of *B. juncea* seedlings decreased with increasing amounts of leaf powders and extracts of both IAPs. The two IAPs *A. riparia* and *A. inulifolium* are potential sources for developing plant-based herbicides.

Financial assistance from the Sri Lanka Council for Agricultural Research Policy (Grant No. NARP/16/UP/PGIS/01) is acknowledged.

**Keywords:** *Ageratina riparia*, *Austroeupatorium inulifolium*, Herbicidal, Invasive alien plants

**ESTABLISHMENT OF A PROTOCOL FOR GENOMIC DNA EXTRACTION FROM HUMAN SALIVA**

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Extraction of sufficient quantities of high-quality DNA is a prerequisite for genetic research and clinical diagnostic studies. Obtaining patient compliance for invasive and painful sample collection procedures is difficult. Saliva is a non-invasive source of DNA; however, the lack of standardized protocols that do not rely on overnight incubations or expensive kits has greatly limited its usage. Hence, the present study aimed to set up a protocol for isolating high-quality genomic DNA from saliva collected from 21 healthy volunteers belonging to two age groups. Unstimulated whole saliva was collected from the participants and subjected to a modified phenol-chloroform DNA extraction method. The effects of the time of sample collection, storage conditions, and sample volume on the quality of extracted DNA were determined by repeating the protocol under the respective non-standard conditions. Each DNA extraction was followed by DNA purity and concentration estimation, agarose gel electrophoresis, and PCR amplification using primers specific for the common periodontal pathogen, *Porphyromonas gingivalis*. The proposed protocol was able to produce DNA of mean purity values >1.700 and mean concentrations >100 µg mL<sup>-1</sup>. Moreover, PCR amplification revealed the absence of *P. gingivalis* in all samples. The statistical analysis using SAS 9.00 revealed that sample collection 15 min after a meal significantly reduced the quality of extracted DNA. In contrast, saliva storage for 48 h at -20 °C before DNA extraction produced no such difference ( $P < 0.05$ ). The novel protocol also produced high-quality DNA from a minimum of 0.1 mL of saliva. Overall, this optimized protocol allows the successful economic isolation of high-quality genomic DNA from human saliva using readily available reagents and laboratory conditions, suitable for diagnostics and large-scale population-based studies.

**Keywords:** Non-invasive, PCR amplification, Phenol-chloroform method, *Porphyromonas gingivalis*

## DISTRIBUTION OF OXALATE IN DIFFERENT TISSUES OF STAR FRUIT

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Star fruit (*Averrhoa carambola*) is a popular fruit with a high concentration of oxalate. Therefore, prolonged and regular consumption of star fruits can lead to urinary calcium oxalate crystal formation, nephrolithiasis and chronic kidney diseases. Data are scarce on the distribution of oxalate in star fruit tissues. The present study determined the oxalate concentration in different parts of the fruits of the small sour wild and large sweet hybrid cultivars. The oxalate concentrations in the flesh, peel and ridges of mature unripe and ripe fruits were determined by titrating with KMnO<sub>4</sub>. The results show that the mean total oxalate concentration (mg/100 g) in the flesh, peel and ridges of the small sour ripe fruits were 40.2 ± 5.2, 73.0 ± 5.1 and 125.6 ± 6.1, respectively, and that of the unripe fruit of the same cultivar were 29.9 ± 1.1, 70.5 ± 18.4 and 110.9 ± 19.9, respectively. In large sweet ripe fruits, the mean total oxalate concentration in flesh, peel and ridges were 31.7 ± 11.7, 60.2 ± 16.9 and 107.9 ± 28.7, respectively, and that of the unripe fruit of the same cultivar were 28.8 ± 7.3, 56.4 ± 18.4 and 110.6 ± 28.2, respectively. The results revealed that the mean total oxalate concentration in ridges on all four treatments was significantly ( $p < 0.05$ ) higher than the other parts of the fruit, while the lowest content was observed in the flesh. Comparatively, the concentration of oxalate was higher in the small sour fruits than the large sweet fruits. The unripe fruits of both cultivars contain a relatively lower content of oxalate than ripe fruits. The results suggest that consuming the large sweet star fruit is safer than consuming small sour fruits, and removing the peel with ridges before consuming star fruits is recommended.

**Keywords:** *Averrhoa carambola*, Large sweet fruits, Oxalate content, Small sour fruits, Star fruits

**ANTIBIOTIC SUSCEPTIBILITY OF BACTERIA CAUSING EAR INFECTIONS:  
CROSS-SECTIONAL STUDY AT NATIONAL HOSPITAL OF SRI LANKA**

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Bacterial isolates from patients with ear infections have exhibited resistance to one or more antimicrobial agents. Only a few studies have been carried out on the antibiotic susceptibility of bacteria causing ear infections in Sri Lanka. This has imposed a significant burden on clinicians when choosing the right antibiotic for treating ear infections. Hence, a cross-sectional study was carried out to determine the antibiotic susceptibility of bacteria in ear infections. Ear swabs were collected from patients from August through October 2018 by the microbiology laboratory at the National Hospital of Sri Lanka (NHSL). The antibiotic sensitivity test (ABST) was performed on bacteria following protocols published by the Clinical Laboratory Standard Institute (CLSI). SPSS software was used to analyse data. Of the patients who visited the ENT clinic during the study period, 146 suspected cases with ear infections had been reported to the microbiology laboratory. Out of them, 138 patients (94.5%) were positive for pathogenic bacteria. Six pathogenic bacterial species were identified from the ear swabs. *Pseudomonas aeruginosa*, coliforms, *Staphylococcus aureus*, MRSA, *Proteus* sp., and *Acinetobacter* were the most common pathogens causing ear infections. The most frequently isolated species from ear swabs was *P. aeruginosa*, whilst the least commonly isolated species was *Proteus* sp. Our findings indicated that ampicillin had the highest overall resistance followed by erythromycin and cefuroxime, whereas most bacterial isolates exhibited susceptibility to vancomycin, teicoplanin, imipenem and ceftazidime. Thus, antibiotic resistance should be considered in prescribing the right antibiotics when treating patients with ear infections.

**Keywords:** Antibiotic Sensitivity Test, Antimicrobial agents, Ear infections, Pathogenic bacteria

## OPTIMIZATION OF TOTAL RNA EXTRACTION FROM HUMAN URINARY SEDIMENT

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Urine is the best choice to identify biomarkers for metabolic and renal disorders because it is readily available, and samples can be obtained non-invasively from patients. However, RNA isolation from voided urine is challenging due to the presence of RNases and cell scarcity. This study aims to optimize a protocol for RNA extraction from urine samples in gene expression studies. Twenty urine samples were collected from healthy controls (HC) ( $n = 11$ ;  $49 \pm 5$  years) and chronic kidney disease (CKD) patients ( $n = 9$ ;  $62 \pm 3$  years) and were centrifuged at 3,000 g for 30 min at 4 °C. Then, 500  $\mu$ L of the lysis buffer was added to the pellet, vortexed and kept on ice for 5 min. Next, 100  $\mu$ L of sodium acetate (pH = 4.0) and 500  $\mu$ L of water-saturated phenol were added and mixed well. After that, 200  $\mu$ L of chloroform: isoamyl alcohol (49:1) was added, vortexed and centrifuged. An equal volume of cold isopropanol was added to the aqueous phase and incubated at -20 °C for 1 h to precipitate RNA. The pellet was washed with 75% ethanol, air dried, and resuspended with 12  $\mu$ L nuclease-free water. Finally, the RNA was quantified and reverse transcribed into cDNA to be used in RT-qPCR. Mean urine volume was  $82.5 \pm 41.9$  mL. Serum creatinine and estimated glomerular filtration rate of CKD patients were  $3.0 \pm 0.2$  mg dL<sup>-1</sup> and  $19.2 \pm 4.8$  mL min<sup>-1</sup> 1.73 m<sup>-2</sup>, respectively. The total yield of RNA from CKD and HC samples were  $873 \pm 523$  ng and  $735 \pm 291$  ng, respectively, and a statistically significant difference was not observed between the two study groups ( $p > 0.05$ ). The  $\beta$ 2 microglobulin gene could be successfully amplified using samples even with a low cDNA concentration (0.625 ng). This modified phenol-chloroform based urinary RNA isolation method is less expensive, does not require RNA clean-up kits and provides a higher yield of RNA with less inhibition which is sufficient for downstream applications than column-based techniques.

**Keywords:** Chronic kidney disease, RNA isolation, Urinary sediment

**POTASSIUM AND PHOSPHORUS CONCENTRATIONS OF RICE GRAINS COLLECTED FROM DIFFERENT AGRO-CLIMATIC ZONES OF SRI LANKA**

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Rice (*Oryza sativa* L.) grains serve as a key source of essential mineral elements such as phosphorus (P) and potassium (K) in the Sri Lankan diet. The effect of agro-climatic conditions and agronomic management factors on the P and K concentration in rice grains in Sri Lanka is unknown. This study investigated the P and K concentrations in rice grains by collecting 100 rice grain samples countrywide using stratified random sampling approach. The P and K concentrations were assessed using protocols coupled with spectrophotometry, and flame photometry, respectively. Grain K and P concentrations collected from different agro-climatic zones (ACZs), water sources used for rice cultivation, fields used to grow other crops in the previous season were compared using analysis of variance. Grain P concentrations ranged from 0.55 to 1.75 mg g<sup>-1</sup> DW, while grain K concentrations were in the range of 1.68 and 4.53 mg g<sup>-1</sup> DW. The concentrations of the two minerals were not significantly ( $p > 0.05$ ) affected by different irrigation water sources, i.e., major irrigation, minor irrigation, and rainfed. Grain K concentration was similar among ACZs ( $p > 0.05$ ). However, grain P concentration in Wet zone Low country was significantly lower than those observed in other ACZs ( $p < 0.05$ ). Rice fields used to cultivate paddy, other field crops (e.g., mung bean, cowpea, maize) or fallow in the previous season showed significantly lower grain K concentration than those from the fields used to grow banana ( $p < 0.05$ ). However, grain P concentration was not affected by the crops grown in the previous season ( $p > 0.05$ ). Overall, there was high variability in P and K concentrations of the rice grain samples collected from different regions in Sri Lanka. The ACZ and crops grown in rotation are important determinants of grain P and K concentrations in rice and thus need to be considered in the fertility management in rice-based cropping systems in Sri Lanka.

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**Keywords:** Agroclimatic zones, Irrigation methods, Phosphorus, Potassium



**IN VITRO CYTOTOXICITY OF *Carica papaya* CRUDE LEAF EXTRACT**

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Plant-based compounds are an option for the development of new antiviral drugs. Asians commonly use papaya (*Carica papaya*) leaves to treat dengue without an understanding of its toxicity, if any. The objective of the study was to screen *in vitro* cytotoxicity of *C. papaya* leaf extract against normal African green monkey kidney epithelial cell line (Vero) cells. CytoTox 96® Non-Radioactive Cytotoxicity Assay (Promega, USA) is a colourimetric assay, which quantitatively measures lactate dehydrogenase (LDH) released upon cell lysis. *Carica papaya* leaf extract was prepared in a two-fold dilution series. Two, 96 well assay plates, were prepared with Vero cells and, the assay was set up with an analytical system based (i) Negative control - without Vero cells, (ii) Vehicle control - untreated cells, (iii) Positive control - lysis solution with four replicates. *Carica papaya* extract was added to the test wells at different concentrations and, one set of plates was incubated for 5 h at 37 °C and the other set for 24 h at 37 °C. The absorbance data were measured using a standard 96-well plate reader (Labtech LT-4500, Singapore) and the percentage cytotoxicity was calculated for each concentration tested. Colour intensity and the absorbance values decreased with the decrease of concentration of leaf extract. The percentage cytotoxicity for dilutions, 1/4, 1/8, 1/16, 1/32, 1/64, 1/128, 1/256, 1/512, 1/1024 was 95.60, 71.53, 74.77, 82.16, 79.91, 40.25, 7.37, 0.16, -1.24, respectively, for the 5 h and 141.61, 133.24, 127.78, 121.88, 109.79, 106.67, 30.64, 22.67, 25.39, respectively for 24 h. Higher concentrations of the extract caused higher cell lysis showing cytotoxic effects Vero cells at dilutions < 1/256. The information about the cytotoxicity levels helps select the minimum toxic concentrations of *C. papaya* leaf extract against the antiviral activity of the dengue virus.

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**Keywords:** *Carica papaya*, Crude leaf extract, Cytotoxicity, Vero cells

**IN VITRO ANTIMICROBIAL ACTIVITY OF PANCHAVALKALA, AN AYURVEDIC HERBAL FORMULA: PRELIMINARY STUDY**

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*Panchavalkala* is a water extract of a combination of barks of five medicinal plants, widely used to treat wounds in Ayurvedic medicine. Three different combinations are commonly used as *Panchavalkala* in Sri Lanka. This study evaluated the *in vitro* antimicrobial activity (AMA) of three different combinations of *Panchavalkala* against common pathogens: *Escherichia coli*, *Pseudomonas auregenosa*, *Staphylococcus aureus*, methicillin-resistant *Staphylococcus aureus* (MRSA) and *Candida albicans*. The combinations of *Panchavalkala* were prepared using pure raw materials according to the ayurvedic formulae. They were named A, B, and C and 60 g of total weight was used for water extraction and concentrated into 8:1 by boiling from each combination. Screening of AMA for each sample was carried out using the agar well diffusion assay in quadruplicate. Zones of inhibition of samples A, B, C against *S. aureus* and MRSA were  $4.81 \pm 0.26$  mm,  $4.69 \pm 0.26$  mm,  $4.25 \pm 0.27$  mm,  $3.88 \pm 0.23$  mm,  $5.12 \pm 0.23$  mm,  $4.50 \pm 0.38$  mm, respectively. Growth of *S. aureus* was significantly inhibited by sample C compared to amoxicillin used as a positive control ( $p = 0.01$ ). Samples A and C showed a significant effect against MRSA compared to vancomycin ( $p = 0.01$ ). None of the above combinations of *Panchavalkala* had an inhibitory effect on *E. coli*, *P. auregenosa* and *C. albicans*. All three combinations were effective against *S. aureus*, including MRSA *in vitro*. Further studies are recommended to explore the AMA of *Panchavalkala* used in Sri Lanka.

**Keywords:** Anti-microbial activity, Methicillin-resistant *Staphylococcus aureus*, *Panchavalkala*, *Staphylococcus aureus*, Water extraction

**MORPHOLOGICAL DIVERSITY OF EXTERNAL MALE GENITALIA OF SEVEN MOSQUITO GENERA IN SRI LANKA**

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Structural variations of external male genitalia are promising identification features of mosquitoes. The present study was aimed to determine the generic and species-specific variations of male genital structures of common mosquito species in Sri Lanka. Larvae and adult mosquitoes were sampled from September to November 2020 from selected sites in the Kandy district. Larvae were reared to adult, and male mosquitoes were separated from the colony. Light trap samples were carefully observed to separate male mosquitoes. Standard taxonomic keys were used for identification. Genitalia of 52 male mosquitoes belonging to seven genera and 15 species were separated and slide-mounted using Canada Balsam. Detailed images of mounted genitalia were photographed using a micro-image system. Structural variations were reported from the basal lobe, basistyle, claspette, phallosome and dististyle of male genitalia. *Aedes* mosquitoes were characterized by the clump of setae present in the basal lobe. Filament and row of setae in the claspette were used to differentiate *Aedes albopictus*, *Aedes aegypti* and *Aedes greenii*. Globular structure in the dististyle was unique to *Aedes vittatus*. Genus *Anopheles* was characteristic of the spines present at the base of the basistyle. Globular structure in the claspette end was a distinctive feature of *Anopheles maculatus*. *Armigeres* mosquitoes were characterized by the presence of tooth-like structures along the dististyle. Dense setae on the basistyle was specific to *Armigeres subalbatus*. Outward curved dististyle was a prominent feature of *Coquilletidia crassipes*. A crown-like structure with a comb of teeth in the tenth sternite and appendages on the subapical lobe was characteristic of *Culex*. *Orthopodomyia* species were distinguished with the number of spines on the basal lobe. The structure of the phallosome was unique to *Toxorynchites* mosquitoes. Generic and species-specific features of male genitalia reported from this study are essential in identifying mosquito species complexes in Sri Lanka.

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**Keywords:** Basistyle, Claspette, Dististyle, Identification, Phallosome

**POST-DISPERSAL SURVIVAL AND GERMINATION OF SEEDS OF  
*Pterocarpus marsupium* AND *Elaeocarpus ganitrus***

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*Pterocarpus marsupium* (native) and *Elaeocarpus ganitrus* (exotic) are two tree species that produce a large number of fruits every season. However, the seed germination of these two species is poor or delayed. This study evaluated the survival and germination of seeds of the two species after dispersal. Fresh, healthy fruits filled with seeds at dispersal were collected. Seed germination (SG) of *P. marsupium* with and without mechanical scarification was tested under laboratory conditions (20 × 5 seeds per treatment). In *E. ganitrus*, germination of intact seeds and seeds exposed by breaking the endocarps was tested in distilled water and 500 ppm gibberellic acid (GA<sub>3</sub>) (10 × 5 seeds per treatment). Data were recorded weekly for four weeks. Four replicates of 50 and 25 fruits of *P. marsupium* and *E. ganitrus*, respectively, were buried at two depths (0 and 3 cm) in plastic mesh containers filled with soil. Seedlings that emerged were recorded after three months, and surviving seeds were exhumed, and SG was tested. Initially, the seeds present per 100 fruits (SF<sub>100</sub>) of *P. marsupium* and *E. ganitrus* were 73 and 100, respectively. Mechanical scarification increased SG of *P. marsupium* (93%) compared to non-scarified seeds (12%;  $p < 0.05$ ), however, none of the *E. ganitrus* seeds were germinated. In the burial experiment, SF<sub>100</sub> of *P. marsupium* had declined to 24 (16 germinated after scarification) and six (five germinated after scarification;  $p < 0.05$ ) at 0 and 3 cm depths, respectively producing < 20 seedlings per 100 fruits. In *E. ganitrus*, SF<sub>100</sub> was 88 at 0 cm, out of which 66 (75%) germinated in 500 ppm GA<sub>3</sub> after breaking the endocarp. At 3 cm depth, SF<sub>100</sub> was 86, of which 50 (58%) germinated in 500 ppm GA<sub>3</sub> after breaking the endocarp. The post dispersal survival of seeds was low in *P. marsupium* compared to *E. ganitrus* and was higher at the soil surface (0 cm depth).

**Keywords:** *Elaeocarpus ganitrus*, *Pterocarpus marsupium*, Seed burial, Seed germination, Seed survival

**RICE BLAST DISEASE OUTBREAK IN 2020/2021: CROSS-SECTIONAL ANALYSIS**

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Annually, over 30% of rice harvest is lost due to blast disease caused by *Magnaporthe oryzae* worldwide. In 2020, the “Maha” season reported a blast outbreak in the country. This analysis aimed to assess the damage due to the blast outbreak in terms of disease incidence and severity. Infected fields were studied in six districts: Kilinochchi, Anuradhapura, Kandy, Ampara, Gampaha, and Monaragala. Two fields were studied from each district using three 1 m<sup>2</sup> randomly selected quadrats. Damage due to the disease was estimated based on standard protocols and farmers interviews. During the interviews, farmers claimed that the disease condition coincided with wet weather. They explained that from the first symptom, which was “*sudu karal*” or “whiteheads” that randomly cropped up among healthy bushes, the entire fields appeared “burnt” within 24 to 48 h. Due to fast disease development, the curative application of fungicides was neither practical nor successful. Cultivars grown in the sites: BG 367, BG 300, BG 359, and BG 1/94 were susceptible to panicle blast, and the yield loss can be up to 100%. Wherever the disease severity was low between zero to four scale, disease incidence was also low at 25%. However, the same cultivar in severely infected fields on a six to nine scale showed a high disease incidence of 40% to 80%. Furthermore, fields adjacent to severely infected fields, where the same cultivar was grown but with three to a seven-day difference in growth stage, did escape the disease. Therefore, other than the susceptibility of the cultivar, prevailing weather conditions and the crop growth stage or other factors can critically affect disease incidence and severity. Thus, while the results highlight the importance of crop calendar and good agricultural practices (GAPs), further studies on the climate factors and the development window that triggers the disease can help accurate disease forecasting.

*Financial assistance from the National Research Council (Grant No. 18-091) is acknowledged.*

**Keywords:** Disease incidence, Disease severity, *Magnaporthe*, Yield loss

**INCREASED INTESTINAL ABSORPTION OF CHLOROGENIC ACID  
PROMOTED BY COCONUT OIL REDUCES MACROMOLECULAR DAMAGE IN  
HUMANS**

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Antioxidants in the body can reduce oxidative stress. Reports indicate that medium-chain fatty acids (MCFAs) absorb small polar drug molecules. Coconut oil has a high percentage of MCFAs. Our previous studies indicate that coconut oil enhances the absorption of antioxidants such as caffeic acid in rats and chlorogenic acid in humans. The present study was conducted with human volunteers to study the effect of enhanced absorption of chlorogenic acid on the oxidation of macromolecules (lipids and proteins). Ethical clearance for the study was obtained from the Ethics Review Committee of the University of Kelaniya. The study involved three groups with 30 volunteers in each group. Group 1 received a gelatinous capsule with chlorogenic acid (450 mg) and coconut oil (1.00 mL), while Group 2 received a gelatinous capsule with chlorogenic acid (450 mg) and soybean oil. The control group received a gelatinous capsule containing only chlorogenic acid (450 mg). The control group reflects the baseline of the chlorogenic acid absorbed from food. Based on previous studies, blood samples were collected one hour after the oral administration of the capsule. Inhibition of lipid peroxidation in plasma was assessed by Thiobarbituric acid reactive substances (TBARS) assay. TBARS level of Group 1 ( $0.003 \pm 0.001 \mu\text{mol/mL}$ ) was significantly different ( $p \leq 0.05$ ) from that of Group 2 ( $0.007 \pm 0.001 \mu\text{mol/mL}$ ) and the control group ( $0.010 \pm 0.001 \mu\text{mol/mL}$ ). Inhibition of protein oxidation in plasma was assessed by protein carbonyl assay. Protein carbonyl level in Group 1 ( $0.98 \pm 0.11 \text{ nmol/mL}$ ) was significantly different ( $p \leq 0.05$ ) from those of Group 2 ( $2.06 \pm 0.13 \text{ nmol/mL}$ ) and control group ( $2.49 \pm 0.29 \text{ nmol/mL}$ ). The results indicate that the intestinal absorption of chlorogenic acid improves the antioxidant status of blood, thus protecting lipids and proteins from oxidative damage.

**Keywords:** Chlorogenic acid, Coconut oil, Soybean oil

ACCUMULATION OF ESSENTIAL AND TOXIC ELEMENTS IN  
SRI LANKAN RICE (*Oryza sativa* L.)

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Rice is the staple food in many Asian countries, including Sri Lanka, and has a high demand because it provides essential carbohydrates, protein, and minerals. Among essential minerals, zinc (Zn) and iron (Fe) are globally deficient and are more common among rice-consuming populations. Rice plants also accumulate toxic elements, especially arsenic (As) and cadmium (Cd), which can cause serious health issues. Close attention is currently given towards cultivating high-quality rice that is less in toxic elements and high in nutrient values. However, there is a lack of information on trace element accumulation of Sri Lankan traditional rice genotypes. Therefore, a glasshouse experiment was conducted using genetically diverse ten rice cultivars with three replicas to assess toxic and essential elements in rice grains, and rice grains were analyzed using an ICP-MS. The varietal difference in Fe accumulation was significant, and the highest accumulation was observed in *Beheth heenati*, while At 362 and Bg 300 were identified as lower Fe accumulating varieties. The highest Zn accumulation was shown by *Kahawanu*, followed by *Pachchaperumal* and *Beheth heenati*. The native variety, *Behethheenati*, accumulated a higher amount of essential trace elements, including Zn, Fe, Mn, Ni, Co, V, Mo, and Cu. The highest Cd accumulation was observed in At 362 while Bg 300 showed the lowest, followed by *Madathawalu* and *Kahawanu*. Arsenic has shown a significant difference in their accumulation in different varieties. The highest As accumulation was observed in *Kalu heenati*, while the lowest was found in At 362, followed by *Kahawanu* and Bg 300. Among the cultivar tested, *Kahawanu* and Bg 300 were identified as relatively lower in both As and Cd concentrations in grains. As a result, these genotypes can be used in further studies on developing varieties with high nutrients and low toxic elements while achieving other desired characteristics.

**Keywords:** Essential nutrients, Genetically diverse rice cultivars, Toxic elements

**NUTRITIVE VALUE OF GRASS SPECIES PALATABLE TO  
SAMBAR DEER (*Rusa unicolor*) IN HORTON PLAINS NATIONAL PARK**

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Sambar deer (*Rusa unicolor*) is classified as a browser since it secretes viscous saliva and consists of the relatively less stratified rumen. However, they often gathered in herds for communal grazing in Horton Plains National Park (HPNP) grasslands dominated by native *Chrysopogon zeylanicus* and introduced *Pennisetum cladestinum* and *Pennisetum glabrum* species. The present study investigated the nutritional value of more palatable grass species for sambar in HPNP grasslands. Grazing sambar was observed along a transect from Pattipola entrance to Ohiya in HPNP at three observation circles (100 m radius) from 6:00 to 8:00 hours and 15:00 to 18:00 hours on three consecutive days of every month during 2020. The grass patches where sambar grazed in higher numbers were assumed to contain more palatable grass species. In each observation circle, those grass patches were marked, and the species composition was recorded using a quadrat ( $n = 6$ ). The most common grass species was *P. cladestinum* followed by *P. glabrum*, *C. zeylanicus*, *Garnotia exaristata*, and *Andropogon lividus*. Edible plant matter of the most common five grass species was collected ( $n = 6$ ), and proximate composition, organic matter digestibility (OMD), and metabolizable energy content (ME) were estimated. The most palatable *P. cladestinum* had the highest ( $p < 0.05$ ) crude protein (CP) percentage ( $10.46 \pm 0.37$ ), followed by *P. glabrum* ( $8.27 \pm 0.57$ ). The CP percentages of less palatable *C. zeylanicus*, *G. exaristata*, and *A. lividus* ( $7.46 \pm 0.23$ ,  $6.60 \pm 0.15$ , and  $6.73 \pm 0.14$ , respectively) were lower than *P. cladestinum* ( $p < 0.05$ ). The native grass species in HPNP, *C. zeylanicus* had the lowest ( $p < 0.05$ ) OMD ( $33.51 \pm 1.43\%$ ) and ME ( $4.9 \pm 0.21$  MJ/kg). The results suggested that high CP percentage in *P. cladestinum* caused sambar in HPNP to shift from browsing to grazing, and further studies are needed for confirmation.

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**Keywords:** Browser, Crude protein, Digestibility, Energy, Grazer, *Pennisetum* spp.



***Pyricularia oryzae* ISOLATES REGARDLESS OF THEIR ORIGIN FROM DIFFERENT SYMPTOMATIC ORGANS CAUSED NECK BLAST IN INOCULATED RICE PLANTS**

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Rice blast disease caused by *Pyricularia oryzae* is attributed to 30% annual yield loss. Although the pathogen infects the whole plant, neck blast is the most destructive. During a recent island-wide blast outbreak, the fields were completely infected with neck blast, and there were only a few or no leaf blast symptoms. Therefore, this study aimed to determine the nature of symptom development by *P. oryzae* on the leaf, leaf collar, panicle, neck and rachis. Disease samples were collected from infected fields at Waththegama (Kandy District). *Pyricularia oryzae* was isolated from typical blast symptoms on a leaf, leaf collar, panicle, neck and rachis. Characteristic conidial morphology was used to confirm the identity of the pathogen following sporulation induction treatments. Suspensions of the mycelium of each isolate were evenly sprayed on aerial parts of rice plants cultivar BG 1/94 in triplicate. Two and half months-old rice plants raised in pots were used for inoculation. The plants were kept inside humidity chambers at ambient conditions until the development of the disease. The rice plants inoculated with different isolates showed neck blast symptoms, but none of the other organs was infected. The outcome of the study indicated possible infection by *P. oryzae* isolated from different organs. Furthermore, the results showed possible associations between disease development, plant developmental stage, environmental conditions or others. The observation affirms the importance of robust screening programs at different host development stages for effective varietal screening. Since sporulation of blast fungus is limited to artificial media, spraying with mycelia can be recommended as a simple and efficient method for pathogenicity testing for breeding programs.

*Financial assistance from the National Research Council, Investigator Driven Grant (18-019) is acknowledged.*

**Keywords:** Blast disease, Inoculation, Rice, Resistance, Screening

**EFFECT OF MICROPLASTICS ON GROWTH OF *Solanum lycopersicum* AND SOIL ARBUSCULAR MYCORRHIZAL FUNGI**

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Microplastic (MP) contamination of agricultural soils is a major concern today. Here we investigated the effects of MPs on the growth of *Solanum lycopersicum* and Arbuscular Mycorrhizal Fungi (AMF) abundance. A pot experiment was conducted in a glasshouse using garden soil mixed with two types of MPs, microfibers (MFB) and microfilms (MFL), to achieve MP concentrations, 0.0, 0.4, 2.4, 4.4, 6.4 and 8.4%. Ten seedlings of *S. lycopersicum* were raised per pot from seeds and left only two seedlings per pot. Six replicates were used for each treatment. Plant height was measured weekly for 13 weeks before harvesting destructively. Relative growth increment (as a percentage of the initial height), relative growth rate (RGR), root weight ratio (RWR) and root: shoot ratio (RSR) were calculated. Chlorophyll levels were quantified spectrophotometrically using randomly selected mature leaves. The AMF spores were quantified by extracting spores using the wet sieving and decanting method. Irrespective of the MP type, a concentration-dependent reduction in growth increments over time was detected compared to the control (with no MPs). After 13 weeks, the RGR also showed a similar reduction in the presence of MPs ( $F = 13.74$ ;  $p \leq 0.0001$ ). The RSR gradually declined with the increasing levels of MPs. The decline in RSR was due to reduced biomass allocation to above-ground parts (55 and 40% decline with MFL and MFB, respectively) compared to a 6 and 22% decline in root allocations (compared to control plants). Plants grown with MFBs had significantly higher chlorophyll content than MFLs ( $F = 18.33$ ;  $p \leq 0.0001$ ). Despite the type, MPs also significantly reduced the AMF spore density ( $F = 108.1$ ;  $p \leq 0.0001$ ), confirming their negative role on soil microbes. The smallest and the largest spores ( $< 45 \mu\text{m}$  and  $> 500 \mu\text{m}$ ) were notably more prevalent in soils without MPs than soils with MPs. Overall, results suggest that MPs negatively influence the vegetative growth of *S. lycopersicum* and the abundance of AMF spores. Understanding the impacts of MPs on the soil-plant system is imperative to minimise risks posed by soil MPs in agriculture.

**Keywords:** AMF, Microfibers, Microfilms, Tomato, Vegetative growth

**COMPARATIVE EVALUATION OF PHYTOCHEMICAL CONSTITUENTS IN LEAVES OF FOUR SELECTED MEDICINAL PLANTS**

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Diabetes mellitus is a major epidemic worldwide. The anti-diabetic activity of medicinal plants is due to the presence of phytochemicals and other ingredients which demonstrate hypoglycemic activity. Some individuals prefer traditional medicines for diabetes as they believe these have fewer side effects. The present study analysed the phytochemical constituents in leaves of four selected medicinal plants: *Murraya koenigii*, (Curry leaf) *Tinospora cordifolia* (Moonseed), *Enicostemma axillare* (Indian whitehead) and *Gymnema sylvestre* (Cow plant), known for their anti-diabetic properties. The leaves of medicinal plants were collected, and their identification was authenticated at the National Herbarium, Royal Botanic Gardens Peradeniya. The shade dried leaves were powdered and extracted with ethanol using the cold extraction technique. The ethanolic extracts of each medicinal plant leaf powder were used to detect the presence of phytochemicals. The total phenolic, tannin and flavonoid contents were evaluated by the colourimetric method. Tannin, saponins, alkaloid, glycosides, steroids, phenols and coumarins were found in leaf extracts of all plants. Terpenoids, quinone and anthraquinones were only found in *M. koenigii* and *E. axillare*. Total phenolic contents (mg GAE/g) varied from  $325.60 \pm 23.84$  (*T. cordifolia*) to  $1960.70 \pm 66.88$  (*M. koenigii*), Flavonoid contents (mg GAE/g) ranged from  $15.03 \pm 1.42$  (*T. cordifolia*) to  $22.270.86$  (*E. axillare*). The total tannin content (mg/ml) of all four varieties is almost similar ( $1.24 \pm 0.01$ ). Higher alkaloid content was found in *M. koenigii* ( $19.42 \pm 0.26\%$ ). This study revealed that the ethanolic extract of leaves of all plant species contains basic phytochemicals, and *M. koenigii* is richer with important phytochemicals, followed by *E. axillare*. Therefore, *Enicostemma* and *Murraya* species can be used as nutraceuticals in traditional medicine.

**Keywords:** *Enicostemma axillare*, Leaves, Medicinal Plants, *Murraya koenigii* Phytochemicals

**IN VITRO ANTIOXIDANT AND ANTIHYPERGLYCEMIC ACTIVITIES OF PLANT EXTRACTS OF *Garcinia zeylanica***

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*Garcinia zeylanica* (*Kaha goraka/Ela goraka*), belongs to the genus *Garcinia*, Family Clusiaceae and is among the five endemic *Garcinia* species in Sri Lanka. It is also a globally endangered plant. This species shows similar morphology to *G. quaesita* (*Rath goraka*). The dried fruits of both species are used in Ayurveda and as a savoury agent in cooking. However, very little attention has been given to *G. zeylanica* compared to the *G. quaesita* in the scientific exploration of biological activities. Hence, we studied the *in vitro* antioxidant and antihyperglycemic activities of the fruits (F), leaves (L) and bark (B) of *G. zeylanica*. Nine crude extracts were obtained by sequential extraction of plant parts with hexane (HX-L, HX-F, HX-B), ethyl acetate (EA-L, EA-F, EA-B) and methanol (MT-L, MT-F, MT-B). The presence of antioxidants in all plant parts was confirmed by qualitative evaluation using the TLC bioautography method, and all nine plant extracts showed the presence of antioxidant compounds in varying degrees. The antioxidant potential was evaluated quantitatively using DPPH radical scavenging assay. The antihyperglycemic activity was evaluated using the  $\alpha$ -amylase inhibition assay. Nonpolar extracts showed a very high free radical scavenging ability compared to polar plant extracts, while the MT-B showed a significantly low IC<sub>50</sub> (13.81  $\pm$  0.13) mg L<sup>-1</sup> despite being polar. HX-F extract showed very high antioxidant activity (13.53  $\pm$  0.02) mg L<sup>-1</sup> compared to that of HX-L (46.57  $\pm$  2.93) mg L<sup>-1</sup>, and HX-B (44.86  $\pm$  0.01) mg L<sup>-1</sup> extracts, and it also showed a very low IC<sub>50</sub> with a closer value to the ascorbic acid (7.30  $\pm$  0.75) mg L<sup>-1</sup>, which is the standard. HX-F showed the lowest IC<sub>50</sub> value (28.08  $\pm$  1.09) mg L<sup>-1</sup> in  $\alpha$ -amylase inhibition assay indicating very high antihyperglycemic activity compared to the HX-L and HX-B. These empirical data showed that there is significant antioxidant activity and antihyperglycemic activity in *G. zeylanica*.

**Keywords:**  $\alpha$ -amylase, Bioactivities, DPPH assay, *Garcinia zeylanica*

**ISOLATION OF HALOTOLERANT FUNGI FROM PICKLED FOOD AND THEIR GROWTH PERFORMANCES IN DIFFERENT SALINE CONDITIONS**

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Highly concentrated salt is one of the oldest food preservation techniques used by communities worldwide for centuries. A high concentration of salt makes an unfavourable environment for microbial growth by creating a water stress environment. Pickling is one of the widely used food preservation methods based on the use of high salt concentrations. But the most pliable food pathogens like fungi can still contaminate salt-persevered food. Fungi that can tolerate high salt concentrations are known as halotolerant fungi. Most of the salt-tolerant fungal species belong to the phyla Ascomycota and Zygomycota. *Penicillium* is one of the well-studied fungal genera, while the genus *Mucor* has many industrial applications. These fungi are reported as processed food spoiling fungal genera. Most of the species belonging to the genus *Penicillium* can tolerate higher salt concentrations, closer to 20% NaCl. Most of the species that belong to the genus *Mucor* can tolerate 3% NaCl without distracting their enzymatic activities. In this study, a few halotolerant fungal species responsible for contaminating pickled lime were isolated and identified based on colony characteristics and reproductive morphology. Furthermore, the salt-tolerant ability of the isolated fungi was tested using a modified PDA medium consisting of different salt concentrations. The NaCl concentration series was designed from 0.0 mold m<sup>-3</sup> to 1.0 mold m<sup>-3</sup> with 0.2 intervals. Based on the colony characteristics and microscopic features, the isolates were identified as *Penicillium* sp. and *Mucor* sp. *Penicillium* sp. recorded the highest growth in 1.0 mold m<sup>-3</sup> NaCl medium, and it was more stable than *Mucor* sp. at higher salt concentrations. *Mucor* sp. showed the optimum growth at 0.2 mold m<sup>-3</sup> NaCl, and the growth decreased with the increasing salt concentration.

**Keywords:** Morphology, *Mucor*, *Penicillium*, Pickled food, Salt-tolerant

**BIOFILM BIOFERTILISER ENHANCES THE COMPOSITION AND CAPACITY OF ANTIOXIDANTS IN RICE GRAINS**

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Rice (*Oryza sativa* L.) is the staple food in Sri Lanka, and it is an important source of vitamins, minerals, fibres and antioxidants. Rice antioxidants influence the cellular redox status of human plasma, which could offer protection against chronic diseases such as cancers and diabetes, those known to be associated with oxidative stress. However, there is a dearth of information about the effects of biofertilisers on antioxidant composition and capacity in rice grains. The available evidence suggests a higher prevalence of antioxidants in organic rice than in rice grown with chemical fertiliser. Therefore, this study investigated the effect of Biofilm biofertiliser (BFBF) on antioxidants and antioxidant capacity of rice grains. Rice seed samples ( $n = 90$ ) were collected at the harvest from 18 farmer-managed paddy fields that were under two different fertiliser applications; 100% chemical fertiliser (CF) practice (425 kg NPK/ha) and 50% CF practice + BFBF (2.5 L/ha) in the Ampara District. The samples were analysed for total phenolic content (TPC), total flavonoid content (TFC) and total antioxidant capacity (TAC). The data were statistically analysed using a *t*-test following the confirmation of normal distribution. Pearson correlation coefficients (*r*) were calculated to determine the relationships among TPC, TFC and TAC using Minitab 17 version. The results revealed that the application of 50% of CF practice + BFBF significantly increased ( $p < 0.05$ ) the production of TPC by 67%, TFC by 45%, and TAC by 80% in rice grains over 100% CF practice. Furthermore, TAC was found to be positively correlated with TPC ( $r = 0.871$ ;  $p > 0.0001$ ) and TFC ( $r = 0.868$ ;  $p < 0.0001$ ). Thus, the results confirmed that the application of BFBFs increased the content and the capacity of antioxidants in rice grains.

**Keywords:** Antioxidants, Biofilm biofertiliser, *Oryza sativa*

**BIOACTIVITY AND WOUND HEALING PROPERTIES OF SELECTED PLANTS**

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Herbs as traditional therapy for wound healing and skin regeneration is common in Asian countries such as China, India and Sri Lanka. The phytochemicals in these herbs may possess antioxidant, anti-inflammatory, antibacterial activities, and cell migration and proliferation properties to provide tissue remodelling, which helps heal wounds. The aim of this research was to investigate the wound healing properties of *Coffea arabica* (coffee), *Murraya koenigii* (curry leaves), and *Tabernaemontana dichotoma* (poison nut) leaves. The extracts were prepared using dried, powdered leaves where water and water-acetone (v/v 1:1) extracts were obtained using a bottle shaker and hot water extracts by Soxhlet extraction. Nine extracts were prepared and assessed for antioxidant activity by DPPH radical scavenging assay and FRAP assay. Their anti-inflammatory activity was determined by heat-induced hemolysis assay and antibacterial activity by broth microdilution assay against six bacterial strains representing gram-positive and gram-negative strains. Water-acetone extracts exhibited the highest activities, amongst which coffee leaves water-acetone extract showed the best activity. Coffee leaves water-acetone extract showed the lowest IC<sub>50</sub> value of  $27.44 \pm 1.12$  ppm in DPPH assay, the highest FRAP value of  $24.25 \pm 0.98$  mmol dm<sup>-3</sup> g<sup>-1</sup> in FRAP assay, the lowest IC<sub>50</sub> value of  $280.00 \pm 19.88$  ppm in anti-inflammatory assay and the lowest MIC values ranging from 25.00 mg ml<sup>-1</sup> to 6.25 mg ml<sup>-1</sup> against the six bacterial strains tested. Coffee leaves water-acetone extract showed the highest activities in antioxidant, anti-inflammatory and antibacterial assays suggesting that it may possess the highest wound healing properties among the nine extracts investigated in this study.

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**Keywords:** Antibacterial, Anti-inflammatory, Antioxidant, Wound healing

**IDENTIFICATION OF A LIPOLYTIC *Trichoderma* sp. AND CHARACTERISATION OF ITS EXTRACELLULAR LIPASE**

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Fungal lipases are used in many industries due to their low production cost, catalytic activity, ability to tolerate polar organic solvents and stability at high temperatures. The demand for lipases has kept researchers exploring new lipolytic fungi. However, the success of such studies lies in the optimisation of the growth conditions to maximise lipase secretion and characterisation of the enzyme activity. Therefore, the current study aims to characterise the crude enzyme extracted from a lipolytic *Trichoderma* sp. and identify the fungus to species level. The *Trichoderma* sp. was isolated from soil, and the lipolytic activity was determined qualitatively and quantitatively. The growth medium of the lipolytic *Trichoderma* sp. was optimised for carbon source, nitrogen source, and pH. The effect of pH, temperature, cations, and anions for the crude lipase activity was analysed. Total genomic DNA was extracted for species-level identification, and Internal Transcribed Spacer (ITS) region was amplified using ITS 1 and ITS 4 primers and sequenced. The results of the study revealed the dependence of extracellular lipase production on growth conditions. Maximum lipase secretion was observed with olive oil as the carbon source and ammonium sulfate as the nitrogen source at a pH of 7.0. The crude lipase activity was high at a pH of 6.0 and 40 °C. The significant lipase activity at high temperatures revealed the potential applications in industries. Moreover, Ca<sup>2+</sup> and NO<sub>3</sub><sup>-</sup> enhanced the crude lipase activity. Database analysis of the sequenced DNA region revealed the fungus as *Trichoderma longibrachiatum*. The study showed that the lipolytic *T. longibrachiatum* could be improved for industrial applications. Furthermore, the enzyme characterisation revealed the industrially important properties of the crude lipase extracted from the lipolytic *Trichoderma* sp.

**Keywords:** Fungal lipase, ITS, Lipase activity, *Trichoderma longibrachiatum*



**IDENTIFICATION OF CELLULOLYTIC *Penicillium* sp. AND PRODUCTION AND CHARACTERISATION OF ITS ENZYME**

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Cellulase is an enzyme complex consisting of exoglucanase, endoglucanase and  $\beta$ -glucosidase that acts synergistically to degrade cellulose matter. Fungal cellulases are widely used in industrial applications due to their high activity, availability and high stability. *Trichoderma*, *Penicillium* and *Aspergillus* are the most reviewed cellulolytic fungi, while *Trichoderma* is used in commercial level cellulase production. However, recently *Penicillium* sp. has gained attention as an efficient cellulase producer that might even outperform *Trichoderma* sp. Therefore, this study aimed to identify a soil cellulolytic *Penicillium* sp., characterise its extracellular cellulase, and optimise the growth media for the secretion of the enzyme. Pure fungal colonies were obtained, and initial screening for cellulolytic ability was carried out using Congo red and Gram's Iodine methods. Crude cellulase was characterised for optimum pH, temperature and effect of ions on cellulase activity. The fungal growth medium was optimised with respect to a carbon source, nitrogen source and pH, for cellulase production. Identification of the fungal species was carried out using morphological and molecular methods, where Internal Transcribed Spacer (ITS) based PCR amplification followed by sequencing was performed. Based on sequence similarity, the cellulolytic fungal species was identified as *Penicillium sumatraense*. The crude enzyme showed the highest activity at pH 4.0 and 60 °C, while the addition of  $Mn^{2+}$  ions increased the enzyme activity significantly. The fungus secreted high levels of enzyme when cellulose and  $NaNO_3$  were used as carbon and nitrogen sources, respectively, and the pH of the medium was 6.0. Further studies related to the thermostability of *Penicillium sumatraense* cellulase and its efficiency compared to other cellulolytic fungi have to be performed.

**Keywords:** Filter paper assay, Fungal cellulase, Industrial cellulases, ITS based fungal identification, *Penicillium sumatraense*

**Careya arborea STEM BARK: SOURCE OF POTENTIAL THERAPEUTIC AGENTS**

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Natural products originating from plants and microorganisms have been widely used to treat many diseases. Many records have shown the use of such substances by humans for thousands of years. *Careya arborea*, commonly known as wild guava, is a medium-sized deciduous tree that belongs to the Family Lecythidaceae. The stem bark is used in the treatment of tumours, bronchitis, epileptic fits and skin diseases. It is also used as a remedy for diarrhoea dysentery with bloody stools and ear pain. *Careya arborea* stem bark was air-dried and powdered using a grinder. The powdered sample was sequentially extracted with ethyl acetate (EtOAc) and methanol (MeOH) using a sonicator. Removal of the solvents afforded EtOAc and MeOH extracts. The two extracts were subjected to silica gel, Sephadex LH-20 and reversed-phase silica gel columns to yield five compounds Lupeol caffeate (1), Epigallocatechin-3-gallate (2), Galocatechin (3), Epigallocatechin (4) and Lupeol (5). All the compounds were subjected to enzyme inhibitory assays;  $\alpha$ -amylase,  $\alpha$ -glucosidase, acetylcholinesterase and lipase. Compounds were screened for antioxidant activity using DPPH radical scavenging method, antifungal activity against *Cladosporium cladosporioides*, phytotoxicity by lettuce seed germination assay and toxicity against brine shrimp, *Artemia salina*. Compound 2 showed moderate brine shrimp lethality (LD<sub>50</sub> 71.29 ppm). Strong antioxidant activity against DPPH radical was observed for all five compounds, and strong  $\alpha$ -glucosidase inhibitory activity was observed for compounds 2, 3 and 4 (IC<sub>50</sub> 0.89, 3.80 and 0.25 ppm, respectively). Moderate acetylcholinesterase inhibitory activity was exhibited by compound 2 (IC<sub>50</sub> 85.92 ppm) and compound 5 (IC<sub>50</sub> 90.33 ppm), while compound 3 showed strong acetylcholinesterase inhibitory activity (IC<sub>50</sub> 9.51 ppm). Out of all, compound 3 exhibited mild  $\alpha$ -amylase inhibitory activity (IC<sub>50</sub> 111.81 ppm), and compound 2 showed lipase inhibitory activity (IC<sub>50</sub> 179.85 ppm). These results suggest that *C. arborea* could be a potential source for the isolation of new therapeutic agents.

**Keywords:** Antioxidants, *Artemia salina*, *Careya arborea*, Enzyme inhibitors

**BIOACTIVITY OF METABOLITES FROM *Piper longum***

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Plant-derived extracts and compounds have been widely used to treat many diseases. *Piper longum* L. (Piperaceae), commonly known as long pepper, is widely distributed in the tropical and subtropical regions of the world. Dried fruits of *P. longum* are slender and aromatic. They are commonly used to treat stomach aches, bronchitis, cough and tumours. They are also applied externally to soothe and relieve muscular pains, rheumatism, paralysis and inflamed skin. Fruits of *P. longum* (400 g) were air-dried, powdered using an electric grinder and extracted successively with ethyl acetate (EtOAc) and methanol (MeOH) using a sonicator. Removal of the solvent afforded 12 g of EtOAc and 21 g of MeOH extracts. It was subjected to silica gel, Sephadex LH-20 and reversed-phase silica gel columns and resulted in three UV active compounds guineesine (1), pipatalin (2) and 4',7-dimethylapigenin (3). All the compounds were subjected to enzyme inhibitory assays  $\alpha$ -amylase,  $\alpha$ -glucosidase, acetylcholinesterase and lipase. They were also screened for antioxidant activity using DPPH radical scavenging method, antifungal activity against *Cladosporium cladosporioides*, phytotoxicity by lettuce seed germination assay and brine shrimp toxicity against *Artemia salina*. All compounds showed moderate brine shrimp lethality with IC<sub>50</sub> of 66.71 ppm, 30.53 ppm and 35.63 ppm, respectively. Strong antioxidant activity was observed for compound 1 against DPPH radical with IC<sub>50</sub> 0.03 ppm. Compound 2 showed both root and shoot inhibition of lettuce seedlings at 243.58 ppm and 169.43 ppm, respectively. Moderate  $\alpha$ -glucosidase and weak  $\alpha$ -amylase inhibitory activities were observed for compound 3 at 58.12 ppm and 667.28 ppm, respectively. None of the above compounds exhibited acetylcholinesterase,  $\alpha$ -amylase and lipase enzyme inhibitory activities and antifungal activity. These findings suggest *P. longum* fruits could be a potential source for new therapeutic agents.

**Keywords:** Antioxidant, Enzyme inhibitors, *Piper longum*

**METABOLITES OF ENDOPHYTIC FUNGI ASSOCIATED WITH  
*Syzygium aromaticum***

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Plant endophytic fungi are an important source of renewable and environmentally friendly novel bioactive compounds. Hence, the present study investigated the chemistry of endophytic fungi isolated from leaves of *Syzygium aromaticum* L. (Myrtaceae), commonly known as cloves, a popular condiment plant used in indigenous medicine in Sri Lanka. They are commercially used for many medicinal purposes and in the perfume industry. In addition, clove is considered as one of the spices that can be potentially used as preservatives in many foods to replace chemical preservatives due to their antioxidant and antimicrobial properties. Fresh leaves of *S. aromaticum* were collected from the Central Province of Sri Lanka. Small segments (5 mm × 5 mm) of triple sterilised leaves were placed on Potato Dextrose Agar (PDA) and kept for incubation at room temperature (27 °C) for five to seven days in the dark until the appearance of fungal mycelium. The emerging fungus was subcultured to obtain pure cultures. Molecular identification of the isolated endophytic fungus is in progress. The pure fungal culture was inoculated into Potato Dextrose Broth (PDB), which was kept for 21 days with shaking at room temperature. The medium was filtered after 21 days, and the filtrate was partitioned with EtOAc (1:1). The residual mycelium was crushed and extracted with EtOAc. Both EtOAc extracts were combined based on the similarity of TLC. The chromatographic separation (silica gel column followed by Sephadex LH-20 and PTLC) of EtOAc extract resulted in campyrone C (1), campyrone A (2), campyrone B (3), pyrophen (4), 6-(1-hydroxy-2-methylbutyl)-4-methoxy-2H-pyran-2-one (5), carbonarone A (6), dianhydroaurasperone C (7), fonsecinone D (8) and asperpyrone A (9). Therefore, endophytic fungi can be a promising source for isolating bioactive compounds beneficial for agriculture, industry and medicine.

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**Keywords:** Condiment plants, Endophytic fungi, *Syzygium aromaticum*

**SURFACTANT MODIFIED NANO-MONTMORILLONITE AS SLOW-RELEASE NITRATE FERTILISER**

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The application of chemical fertiliser is the most straightforward way to increase crop yields. However, the overuse of fertilisers causes serious environmental hazards and human health problems. Most chemical fertilisers are inefficient because their nutrient release dynamics do not synchronise with plant nutrient uptake. As a result, most applied fertilisers tend to escape through leaching, adsorption, degradation, and surface runoff. We hypothesise that developing a biologically synchronised slow-release nano fertiliser (BSSRNF) will further improve nutrient use efficiency. Nitrogen (N) is the most important nutrient for all plant species, and it is primarily taken up in the forms of  $\text{NH}_4^+$  and  $\text{NO}_3^-$ . Surfactant modified montmorillonite (SMM) was developed as a carrier molecule to slow down the release of  $\text{NO}_3^-$ . MMT's surface area was increased to retain  $\text{NO}_3^-$  by treating with a cationic surfactant hexadecyltrimethylammonium bromide (HDTMA). Scanning electron microscopy, Fourier transform infrared analysis, X-ray diffraction, and thermogravimetric analysis were used to characterise the material's surfactant modification. Further, MMT was modified by using different combinations of HDTMA and the maximum ratio of  $\text{NO}_3^-$  to HDTMA absorbed was determined. It demonstrated that the material modification increased the surface capacity by a factor of nine when compared to the unmodified MMT. Also, the sorption of nitrate can be well described by the Langmuir sorption isotherm. It further demonstrated that the supply of  $\text{NO}_3^-$  from fertiliser-loaded SMM was available after 60 days of continuous leaching. These findings indicate that SMM can be adopted to deliver  $\text{NO}_3^-$  in a synchronised, slow-release manner and thus has enormous potential to improve plant fertiliser N use efficiency in cropping systems.

**Keywords:** Fertilizer, Montmorillonite, Nitrate, Slow-release, Surfactant

**PHYTOTOXICITY OF SOLVENT EXTRACTS FROM AN ENDOPHYTIC FUNGUS ISOLATED FROM *Cardiospermum halicacabum***

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Endophytic fungi are a promising source of bioactive substances. Naturally derived secondary metabolites from endophytic fungi may provide a source of environmentally friendly weedicides. This study investigated the phytotoxic activity of solvent extracts from an endophytic fungus isolated from fresh, mature leaves of *Cardiospermum halicacabum* (Sapindaceae) collected from the Central Province of Sri Lanka. Endophytic fungus KS/CH/F was isolated from triple sterilized leaf segments placed on potato dextrose agar (PDA). Pure fungal strains were cultured on a large scale in potato dextrose broth (PDB) medium for five weeks. The resulting culture broth was filtered, and broth and mycelium were separately extracted with Ethyl acetate (EtOAc). The freshly filtered broth was used for broth spraying assay for three-week-old cucumber (*Cucumis sativus*) plants, and observations were taken until seven days. The two EtOAc extracts were combined based on thin-layer chromatography and screened for phytotoxicity using lettuce (*Lactuca sativa*) seed germination inhibition bioassay and leaf puncture assay using two-week-old cucumber leaves. The combined EtOAc extract was subjected to column and thin-layer chromatography (silica gel column followed by Sephadex LH-20 and PTLC) to give seven compounds. Broth spraying assay showed wilting symptoms, and leaf necrosis appeared from day one of spraying and most of the plants were completely wilted by day three, with others having leaf necrosis. Leaf puncture assay for the EtOAc extract at 1000 mg L<sup>-1</sup> showed increased leaf necrosis from 24 to 72 h. The EtOAc extract showed 100% root inhibition and 99.2% shoot inhibition at 1,000 mg L<sup>-1</sup> with IC<sub>50</sub> value of 97.05 mg L<sup>-1</sup> and 241.46 mg L<sup>-1</sup> for root and shoot inhibition, respectively. Molecular identification of the fungus and structure elucidation of the isolated compounds are in progress. The present work has demonstrated that solvent extracts from this endophytic fungus show phytotoxic activity and could be used to develop eco-friendly weedicides.

*Financial assistance from the National Research Council (Grant No. NRC/EWC/18-03) is acknowledged.*

**Keywords:** *Cardiospermum halicacabum*, Endophytic fungi, Phytotoxicity

**COMPARISON OF ANTIOXIDANT AND ANTIMICROBIAL ACTIVITIES OF SRI LANKAN STINGLESS BEE PROPOLIS (*Tetragonula iridipennis* AND *Tetragonula praeterita*) USING TWO EXTRACTION METHODS**

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Propolis is a resinous product of stingless bees. The composition and bioactivity of propolis extracts depend on the bee species, ecosystem and extraction method. Sri Lankan propolis has not been investigated. Therefore, this study aimed to compare the antioxidant and antimicrobial activity of propolis of two bee species: *Tetragonula iridipennis* (TI) and *T. praeterita* (TP) collected from Kandy, Sri Lanka. Ethanol extracts of the two propolis samples were prepared using Soxhlet (TI-SOX, TP-SOX) and sonication (TI-SONI, TP-SONI) methods, and percentage extraction yields were determined. Antioxidant and antimicrobial activity of the extracts were determined in triplicates using 1,1-diphenyl-2-picrylhydrazyl (DPPH) assay and agar dilution method by determining minimum inhibitory concentrations (MIC), respectively. Soxhlet method gave a higher percentage extraction yield for both propolis samples. TI-SONI and TI-SOX showed significant antioxidant activities (IC<sub>50</sub> of 9.805 ± 0.270 and 5.942 ± 0.046 mg L<sup>-1</sup>, respectively) with values closer to the IC<sub>50</sub> of L-ascorbic acid (5.210 ± 0.059 mg L<sup>-1</sup>). IC<sub>50</sub> of TP-SONI and TP-SOX were 269.2 ± 6.741 and 411.0 ± 9.302 mg L<sup>-1</sup>, respectively. Antimicrobial activity was tested against three gram-negative (*Pseudomonas aeruginosa*, *Escherichia coli*, *Klebsiella pneumoniae*), three gram-positive (*Staphylococcus aureus*, methicillin-resistant *Staphylococcus aureus*-MRSA and *Enterococcus faecalis*) bacterial strains and *Candida albicans* within the concentration ranges of 16 – 128 mg L<sup>-1</sup>. All extracts were inactive against *C. albicans*. TP extracts did not show antibacterial activity. TI extracts were only active against gram-positive bacterial strains (MIC values of 16 – 32 mg L<sup>-1</sup>). Therefore, the bee species and extraction method have an impact on the extraction yield and bioactivity. TI extracts show remarkable antioxidant and antibacterial activity against gram-positive bacteria and would be a potential source of antibacterial and antioxidant compounds.

**Keywords:** Minimum inhibition concentration, Sonication method, Soxhlet method

**ISOLATION OF PCR AMENABLE DNA FROM PROCESSED SANDALWOOD SAMPLES FOR MOLECULAR AUTHENTICATION**

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Sandalwood (*Santalum album* L.) is a highly prized commercial plant species appreciated worldwide for its sweet, persistent aroma. Due to its scarcity and high prices in the market, sandalwood is adulterated with plant sources similar in appearance or fragrance during the trade. This has health implications for end-users, owing primarily to their use as herbal drugs. Highly dried and processed samples of sandalwood products available on the market pose difficulties in using morphological methods of adulterant detection. Chemical detection methods of chemo-profiling fail when the chemical composition of plants is affected by environmental variations and the close genetic relationship of plants. The application of molecular tools provides promising ways of standardization over physical and chemical methods for adulterant detection. DNA barcoding combined with High-Resolution Melting (Bar-HRM) is a novel technique for detecting adulterants. We aimed to develop a robust molecular tool using the Bar-HRM to detect sandalwood adulteration. Towards this end, DNA isolation from heartwood samples is extremely challenging due to the low amounts of preserved DNA within the heartwood. We successfully developed a modified CTAB protocol for PCR amenable DNA extraction from the available market samples of sandalwood. The CTAB method was modified by extending the incubation period of the sample with the buffer at 65 °C to 2 h to release more DNA, and overnight incubation for DNA precipitation at -20 °C with a sodium acetate mixed isopropanol solution. The isolated DNA gave the desired PCR bands with universal primers for the *rbcL* gene region. The ‘uMELT’ simulated melting profile for the designed DNA barcodes for sandalwood and its adulterants produced expected differentiated curves, affirming the success of the project being developed. The current results warrant further studies on running High-Resolution Melting (HRM) analysis to authenticate sandalwood from its adulterants.

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**Keywords:** Bar-HRM, CTAB, DNA, PCR, Sandalwood



**PCR SCREENING REVEALS THE EXISTENCE OF QUINOLONE RESISTANCE GENES IN ANTHROPOGENICALLY AFFECTED WATERWAYS OF BADULLA AND KANDY DISTRICTS**

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Aquatic ecosystems serve as reservoirs for the emergence and dissemination of antibiotic resistance genes. Though fluoroquinolone resistance is of global concern, data from Sri Lanka is scattered and sparse. Therefore, we aimed to investigate the presence of quinolone resistance genes in two districts: Badulla and Kandy, to understand the magnitude of the distribution of fluoroquinolone resistance in the environment. We used molecular tools such as PCR amplification, DNA sequencing, and phylogenetic trees to evaluate the evolutionary relationship of the detected operational taxonomic units. We detected *quinolone resistance (qnr)* genes; *qnrA*, *qnrB*, and *qnrS* using PCR screening of environmental DNA samples collected from human-interacted waterways in those districts, using a convenient sampling method. Six out of 30 (20.0%) sites in the Kandy district and five out of 30 (16.7%) sites in the Badulla district harboured *qnr* genes. In both districts, the detection frequency of *qnrB* genes was relatively high compared to *qnrA* and *qnrS* genes. Two-sample-proportion tests conducted at a significance level of 0.05 showed no statistical difference between the *qnr* gene detection proportions observed between the two districts. The *qnr*-positive sites in the Kandy district were confined only to the samples from waterways adjacent to hospitals. However, in the Badulla district, we detected *qnr* genes from the waterways adjacent to dairy farms, agricultural fields, and hospitals. The presence of environmental bacteria comprised of antibacterial resistance genes is a significant health risk toward humans' wellbeing. Therefore, in-depth studies based on the One-Health approach are required to understand whether there is an interaction between intensive agriculture practice and the emergence of fluoroquinolone resistance in the environmental microbiome. The PCR protocols used during the study can be used as a rapid screening tool to detect *qnr* genes in countrywide environmental DNA samples.

**Keywords:** Aquatic ecosystem, Environmental DNA, Fluoroquinolones, Plasmid-mediated quinolone resistance (*qnr*), Rapid screening tool

**PHENOLIC CONTENT AND ANTIOXIDANT ACTIVITIES OF RAW AND PROCESSED *Artocarpus nobilis* (CEYLON BREADFRUIT) SEEDS IN COMPARISON WITH ALMOND, PISTACHIO AND CASHEW**

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Tree nuts are a rich source of phytochemicals, particularly polyphenols are reported in higher concentrations. Nuts are excessively investigated as these compounds directly influence human health. Seeds of *Artocarpus nobilis* are underutilized in Sri Lanka and are yet to be explored for their bioactive properties. This study evaluated the total phenolic content (TPC), total flavonoid content (TFC), and antioxidant activity of raw and processed (roasted, microwaved, and boiled) *A. nobilis* seeds in comparison with almond, pistachio, and cashew. TPC and TFC of methanol extracts were determined by folin-ciocalteu and aluminum chloride colourimetric assay, respectively. Antioxidant activity was determined using the following *in vitro* assays: 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity, Trolox equivalent antioxidant capacity (TEAC) by 2,2-azino-bis (3-ethylbenothiazoline-6-sulphonic acid; ABTS), ferric reducing antioxidant power (FRAP), and oxygen radical absorption capacity (ORAC). According to the data, roasted *A. nobilis* seeds had the highest TPC ( $25.28 \pm 0.29$  mg of gallic acid equivalent per g of defatted sample) and TFC ( $20.08 \pm 0.42$  mg of catechin equivalent per g of defatted sample), while raw-almond seed extract had the lowest. Seeds of *A. nobilis* had significantly higher TPC, TFC, and antioxidant activity than the commonly consumed pistachio, almond, and cashew nuts. Considering the effect of processing, roasting and microwaving significantly ( $p < 0.05$ ) improved the TPC, TFC, and TEAC by ABTS in *A. nobilis* seeds, where boiling reduced it significantly. Strong positive correlations were observed between antioxidant activity measured by ABTS ( $r = 0.979$ ), ORAC ( $r = 0.852$ ), and FRAP ( $r = 0.964$ ) assays with the TPC of the studied samples. These results suggested that phenolic and flavonoids in *A. nobilis* seeds may be responsible for the antioxidant activity of studied seed samples. The current study concluded that *A. nobilis* seeds are a potential source for a natural antioxidant agent.

**Keywords:** Antioxidant activity, *Artocarpus nobilis*, Phenolic and flavonoid content, Processing method

## **HERBAL MEDICINE FOR COVID 19: A REVIEW**

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The COVID-19 infection is caused by a newly discovered coronavirus, SARS-CoV-2. At present, there are no exact curative treatment principles or pharmaceutical products for the safe and effective treatment of COVID-19. According to the World Health Organization, around 80% of the world population depends on herbal medicine for their primary health care needs. Herbal medicine has played an essential role in preventing and controlling infectious diseases in the past. This literature review was conducted to obtain information on the possible effectiveness of herbal medicine in treating COVID-19 based on outcomes of preclinical and clinical studies. This review was done through 28 reviewed articles and clinical reports, short case studies and case series in indexed journals published during the past 30 years. Articles published before 1990 and other peer-reviewed articles were excluded. The review mainly identified the basic mechanisms of pharmacological action that may be related to potential anti-COVID-19 herbal medicines. Such mechanisms of action included inhibiting coronavirus at a structural level, inhibiting RNA synthesis and replication of coronavirus and inhibiting various virulence factors of the coronavirus. *Tribulus terrestris*, *Withania somnifera*, *Curcuma longa*, *Ocimum sanctum* and *Phyllanthus emblica* are primarily observed as promising medicinal plants against COVID-19.

**Keywords:** Coronavirus, COVID-19, Herbal medicine

**PHYTOTOXIC COMPOUNDS FROM AN ENDOPHYTIC FUNGUS RESIDING IN  
*Vernonia cinerea***

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Fungi are eukaryotic living organisms that produce a large number of novel secondary metabolites. Endophytic fungi residing in internal plant tissues, resulting from the recombination of host plant genes, can produce the same vital and rare bioactive compounds produced by the host plant. The objective of this study was to isolate compounds produced by endophytic fungi associated with *Vernonia cinerea* (Syn. *Cyanthillium cinereum*), which is a small herb belonging to the family Asteraceae known to produce many bioactive compounds. *Vernonia cinerea* was collected from Hanthana (7.2681 °N, 80.6355 °E). An endophytic fungus isolated from triple sterilized leaf segments (5 × 5 mm) of *V. cinerea* was cultured in 90 flasks containing 400 mL of potato dextrose broth medium. Flasks were shaken continuously on a laboratory shaker after ten days of inoculation until extraction. After three weeks of incubation, the broth was filtered. Freshly filtered broth (5 mL for each plant) was sprayed on two-week-old cucumber seedlings (*Cucumis sativus*). Observations were taken daily for five days. Necrotic symptoms were observed on the leaves after 24 h, and some plants died after three days. Rest was extracted with EtOAc. Lettuce seed germination bioassay for phytotoxicity evaluation was performed in triplicates. After five days of incubation at room temperature at dark conditions, root and shoot length were measured. The EtOAc extract showed 82% and 64% inhibition of root and shoot growth, respectively, in the assay at 1000 ppm. Abscisic acid was used as a positive control. The EtOAc extract was subjected to chromatographic separation over silica gel, Sephadex LH-20, PTLC and HPLC to furnish five known compounds, 2-hydroxy-6-methyl benzoic acid, its (1*S*,5*R*,6*R*)- and (1*R*,5*R*,6*R*)-5,6-dihydroxy-3-(hydroxymethyl)-2-oxo-3-cyclohexene-1-yl esters, epoxydon and a 2,4-pyrrolidinedione derivative, PF1052. Determination of phytotoxic compounds and identification of endophytic fungus is in progress.

Financial assistance from the National Research Council (Grant No. NRC/EWC/18-03) is acknowledged.

**Keywords:** Endophytic fungi, Phytotoxic activity, *Vernonia cinerea*

**METABOLITES OF AN ENDOPHYTIC FUNGUS FROM A COMMON WEED**  
*Acalypha indica*

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Weeds are the worst agricultural and environmental pests worldwide. The use of synthetic weedicides has become a major issue in health and day-to-day living. Hence, the introduction of eco-friendly weedicides will be beneficial. We focused on isolating phytotoxic compounds from the fungi associated with common weeds found in Sri Lanka. These weeds can grow in harsh conditions and establish in any environment; hence, the fungi associated with *Acalypha indica* were studied. An endophytic fungus was isolated from the triple sterilized healthy leaf segments (5 × 5 mm) of *A. indica*. Pure cultures were inoculated into potato dextrose broth media (400 mL × 90), allowed to stand for seven days and then incubated at room temperature for another 14 days while shaking every other day on a laboratory shaker. After 21 days, the fungal broth was filtered to separate the mycelium. The filtered broth was sprayed onto two-weeks old cucumber plants, and observations were recorded every 24 h up to 5 days. No visible necrotic symptoms were observed despite slight growth retardation. The broth was extracted with ethyl acetate (EtOAc). The mycelium was sequentially extracted with EtOAc and methanol (MeOH). The crude EtOAc and MeOH extracts were subjected to phytotoxic assay against lettuce seed germination inhibition assay in triplicates (five days in dark conditions). Abscisic acid was used as a positive control. The broth EtOAc extracts showed 83% and 79%, while the mycelium EtOAc extract showed 44% and 97% shoot and root inhibition, respectively, at 1000ppm. The broth EtOAc extract was subjected to chromatographic separation over column chromatography, PTLC and HPLC to furnish two new compounds, (4*E*,6*E*)-undeca-4,6,10-triene-2,8,9-triol and (6*E*,8*E*)-9-(3-hydroxy-(2-hydroxymethyl)phenyl) nona-6,8-diene-2,4,5-triol, in addition to known compounds, 19,20-epoxycytochalasin C, methyl (2*E*)-3-(4-methoxyphenoxy)-2-propenoate, clonostachydiol and (4*E*,6*E*,10*E*)-trideca-4,6,10,12-tetraene-2,8-diol.

Financial assistance from the National Research Council (Grant No. NRC/EWC/18-03) is acknowledged.

**Keywords:** *Acalypha indica*, Endophytic fungi, Phytotoxicity, Weedicides

**VARIATIONS IN NUTRITIONAL COMPOSITION AND FRUIT QUALITY OF POPULAR BANANA CULTIVARS IN JAFFNA**

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Banana cultivars of *Kathali*, *Kappal* and *Etharai* are very popular in the home gardens of Jaffna. Mature green fruits of the three cultivars were harvested from home gardens, and ripe fruits were used to assess free sugar, total sugar, protein, fat and polyphenol compounds. Fresh weight, moisture content, total soluble solids, pH, titratable acidity and firmness of ripe fruits were also measured. These parameters were compared with the mature green fruits purchased from the Thirunelveli market and ripened at ambient conditions. Free sugar, protein and fat contents of all three cultivars showed significant difference ( $p = 0.05$ ), and total sugar content was observed to be high in *Etharai*. There was no significant difference in the total sugar content of *Kathali* and *Kappal* fruits. The fat content of fruits of these three cultivars was low and varied from 0.18 to 0.22%. *Kappal* fruits showed a high value of fat content among the three cultivars. Bioactive compound polyphenol was observed to be high in *Etharai* with the value of 0.06 mg equivalent of Gallic acid/g fresh weight of the pulp. The fresh weight and firmness of fruits were high in *Etharai*, low in *Kathali*, with no significant difference ( $p = 0.05$ ) observed in fresh weight, moisture content, total soluble solids and titratable acidity of *Kappal* and *Etharai* fruits. The total soluble solids and pH value of fruits were high in *Etharai*, and the values recorded were 27.33 °Brix and 4.86, respectively. Ash content of *Kathali*, *Kappal* and *Etharai* fruits was 3.19 – 3.28%. No significant difference ( $p = 0.05$ ) was observed in total soluble solids, titratable acidity, and firmness of *Etharai* fruits obtained from home gardens and collected from the market. Based on the study, *Etharai* fruits with high sugar and ash content were more suitable for desserts. It was also suitable for the export market due to the high firmness index. Among these three cultivars, promoting *Etharai* cultivar will give high economic returns to Sri Lanka. The results provide important information to the food industry to select suitable cultivars for the export market and value-added processing products.

**Keywords:** Banana cultivars, Polyphenol, Proteins, Quality parameters, Total sugars

**ISOLATION AND CHARACTERIZATION OF PHENOLIC COMPOUNDS FROM  
ANTIDIABETIC PLANT, *Costus speciosus***

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The medicinal plant *Costus speciosus* (Koen) Sm. or crepe ginger, *Thebu* in Sinhala, belongs to the Family *Costaceae* and inherits a range of pharmacological activities, antidiabetic effect being reported as of great importance. The plant is also well known for its antioxidant, antibacterial, anthelmintic, anticancer, anxiolytic, anti-inflammatory, antipyretic, hepatoprotective and diuretic properties. Phenolic compounds are highly significant plant secondary metabolites that exert various health benefits in humans, including antioxidant effects, chemopreventive properties and anti-inflammatory activity. Therefore, the current study focused on isolating phenolic compounds in the leaf extracts of *C. speciosus*. Dried, powdered leaves were subjected to sequential extraction with hexane, ethyl acetate and methanol through ultrasound sonication. Ethyl acetate and methanol extracts were combined, re-dissolved in dichloromethane and partitioned with aqueous sodium bicarbonate followed by aqueous sodium hydroxide. Aqueous layers were re-extracted with ethyl acetate after neutralization, and the ethyl acetate extract was fractionated via silica gel column chromatography and size exclusion chromatography (Sephadex LH-20) and PTLC. Isolated compounds were characterized via <sup>1</sup>H NMR and <sup>13</sup>C NMR spectroscopy. This approach furnished *trans*-cinnamaldehyde, *p*-coumaric acid, 4-hydroxybenzoic acid, vanillic acid, ferulic acid, indole-3-carboxaldehyde, kaempferol-3-*O*- $\beta$ -D-glucopyranoside, sitosterol glucoside and (*E*)-1,3-bis(4-hydroxy-3-methoxyphenyl) prop-2-en-1-one. These compounds possess several bioactivities, including antioxidant, antibacterial and anti-inflammatory activities. Dissolving phenolic compounds into a basic aqueous layer and re-extraction with organic solvent after neutralization seems to be an efficient method to isolate phenolic compounds from plant extracts.

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**Keywords:** *Costus speciosus*, Phenolic compounds, Leaf extracts

## RENAL-TOXICITY OF CYLINDROSPERMOPSIN IN WISTAR RATS

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A naturally-derived cyanotoxin, Cylindrospermopsin (CYN), has a wide spectrum of toxicity on biological activity in animals and humans. Hepatotoxicity, genotoxicity, cytotoxicity and carcinogenic effects on animals and humans have been recorded. The present study aimed to determine the possible toxic effects of CYN on mammalian kidneys using male Wistar rats as an animal model. Thirty-five Wistar rats were randomly divided into five groups ( $n = 7$ ), and rats were orally treated with different concentrations of cyanotoxin; CYN (0.175  $\mu\text{g}/\text{kg}$ , 0.140  $\mu\text{g}/\text{kg}$  and 0.105  $\mu\text{g}/\text{kg}$ ) with a control group treated with distilled water for 90 days. The fifth group received water contaminated with Cylindrospermopsin at 0.161  $\mu\text{g}/\text{kg}$ , collected from a well from Padaviya. Blood samples were collected from the lateral tail veins at 0, 7, 14, 28, 42, 60, 90 days, and serum creatinine was analyzed. Urine was collected from each rat at 0, 7, 14, 28, 42, 60, and 90 days using the individual metabolic cages and urine creatinine was analyzed. Kidney Injury Molecule-1 (KIM-1) level was quantified using the ELISA weekly. After 90 days, the kidney of each exposed rat was taken and fixed for histological evaluation. The results showed that the mean body weight of treated and control group rats gradually increased until the 90<sup>th</sup> day. The absolute and relative weights of kidneys of the treated groups were significantly less ( $p < 0.05$ ) than the control group. A significant ( $p < 0.05$ ) increase of serum creatinine concentration from  $0.62 \pm 0.01$  to  $0.89 \pm 0.03$  mg/dL,  $0.64 \pm 0.02$  to  $0.86 \pm 0.01$  mg/dL,  $0.64 \pm 0.02$  to  $0.85 \pm 0.02$  mg/dL,  $0.61 \pm 0.02$  to  $0.83 \pm 0.01$  mg/dL were detected for 0.175  $\mu\text{g}/\text{kg}$ , 0.140  $\mu\text{g}/\text{kg}$ , 0.105  $\mu\text{g}/\text{kg}$ , 0.161  $\mu\text{g}/\text{kg}$  doses of the CYN treated compare to the control ( $0.60 \pm 0.01$  to  $0.70 \pm 0.01$  mg/dL) at 90 days of exposure. Decrease of urine creatinine level from  $55 \pm 1$  to  $33 \pm 1$  mg/dL,  $54 \pm 1$  to  $35 \pm 2$  mg/dL,  $54 \pm 2$  to  $38 \pm 1$  mg/dL,  $53 \pm 1$  to  $32 \pm 2$  mg/dL were recorded for CYN exposed rat groups of 0.175  $\mu\text{g}/\text{kg}$ , 0.140  $\mu\text{g}/\text{kg}$ , 0.105  $\mu\text{g}/\text{kg}$ , 0.161  $\mu\text{g}/\text{kg}$  respectively compare to the control ( $54 \pm 1$  to  $47 \pm 1$  mg/dL). The highest KIM-1 concentrations were recorded in the 0.175  $\mu\text{g}/\text{kg}$  treatment dose. Histologically, kidney changes included luminal protein, focal nuclear pyknosis and a single case of glomerular collapse. Thus, the study showed the prolonged exposure to CYN contaminated water leads to kidney injuries.

**Keywords:** Cylindrospermopsin (CYN), KIM-1, Serum Creatinine, Urine Creatinine, Wistar Rats



**ASPECTS OF HATCHING AND INCUBATION OF RELOCATED SEA TURTLE EGGS IN THE GALBOKKA HATCHERY KOSGODA, SRI LANKA**

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In Sri Lanka, sea turtle hatcheries are privately-owned, profit-making ventures relying on tourists for viability. However, many do not conform to prescribed guidelines, and hence their contribution towards sea turtle conservation is questionable. This study examined the hatching success and incubation duration of relocated sea turtle eggs in the Galbokka Sea Turtle Conservation and Research Center, Kosgoda, on the southwestern coast of Sri Lanka. Fifty egg clutches (5,537 eggs) were relocated, including 42 green turtles and eight olive ridley turtles. The hatching success of green turtles and olive ridley turtles was 72.1% and 80.0%, respectively. The mean incubation duration of green turtle egg clutches was  $59.3 \pm 12.9$  days ( $n = 28$ , range 42 – 90), and that of the olive ridley turtle was  $55.8 \pm 6.6$  days ( $n = 8$ , range 49 – 64). The value recorded here for the green turtle for both hatching success and incubation duration was comparable with those recorded for natural nests of the same species. There was no correlation between clutch size and incubation duration in both species. Clutch size was positively correlated with the number of live ( $r = 0.57$ ,  $p = 0.002$ ) and dead ( $r = 0.49$ ,  $p = 0.007$ ) hatchlings of the green turtle. In the green turtle clutches, the incubation period was negatively correlated with hatching success ( $r = 0.62$ ,  $p < 0.001$ ). Incubation duration was positively correlated with non-viable eggs of green turtles ( $r = 0.526$ ,  $p = 0.001$ ) while no correlation in olive ridley turtles ( $r = -0.537$ ,  $p = 0.272$ ). Although hatching success of relocated and natural nests is comparable, it is important to determine the sex ratios as hatchery incubated clutches are known to produce highly female-biased populations.

*Financial assistance from the Nagao Natural Environment Foundation 2019 is acknowledged.*

**Keywords:** Green turtle, Hatching success, Incubation duration, *In-situ* conservation, Olive Ridley turtle

**BIOACTIVITIES OF *Melicope lunu-ankenda* FROM SEETAWAKA BOTANIC GARDEN, AWISSAWELLA, SRI LANKA: A PRELIMINARY STUDY**

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*Melicope lunu-ankenda* is an important medicinal plant of the family Rutaceae, commonly distributed in the mid-country wet and montane zones in Sri Lanka and tropical regions of Asia. Previous studies have displayed the chemistry and bioactivity of the plant found in various regions in Asia. This study focuses on the bioactivities of the leaf and bark of the plant from the Seetawaka region, the Western Province of Sri Lanka. Leaves and bark of the plant collected were washed, air-dried, ground and subjected to sequential extraction with dichloromethane followed by methanol. The antioxidant activity was determined using DPPH radical scavenging assay and IC<sub>50</sub> values obtained for dichloromethane leaf (DL), dichloromethane bark (DB), methanol leaf (ML) and methanol bark (MB) extracts were 143.06, 188.17, 49.25 and 70.17 mg L<sup>-1</sup>, respectively. The LC<sub>50</sub> values obtained using brine shrimp (*Artemia salina*) lethality assay for DL, DB, ML and MB extracts were 89.52, 74.28, 17.32 and 114.95 mg L<sup>-1</sup>, respectively. The total phenolic content of the ML and MB extracts were 232.26 and 263.22 mg (GAE) g<sup>-1</sup> of plant extract, respectively. The antimicrobial activities of the extracts were tested against *Staphylococcus aureus* (*S. aureus*), *Escherichia coli* (*E. coli*), Methicillin-resistant-*staphylococcus aureus* (MRSA) and *Candida albicans* (*C. albicans*) using agar disk diffusion assay. Dichloromethane extracts showed antimicrobial activity against *S. aureus*, and MRSA strains, while methanol extracts showed antibacterial activity against *S. aureus* strain only. Antifungal activity was shown only by the ML extract. Minimum inhibitory concentration (MIC) was determined using agar plate dilution assay and microplate method. DB showed the highest MIC value, above 2,500 mg L<sup>-1</sup> against *S. aureus*, *E. coli* and *C. albicans* strains, while ML showed the highest against MRSA strain, above 2,500 mg L<sup>-1</sup>. The respective tests on extracts confirmed the presence of carotenoids, flavonoids, tannins, terpenoids and triterpenoids. Results showed moderate antioxidant activity, cytotoxicity and antimicrobial activity in the leaf and bark of the plant from Seetawaka, which could make the species a therapeutic agent for some diseases. Thus, the isolation of bioactive compounds can be used as drugs and in cosmetic formulations in the future.

**Keywords:** Antimicrobial, Antioxidant, Cytotoxicity, *Melicope lunu-ankenda*, Polyphenol content

**SUPPORTIVE CARE FOR WOMEN WITH RECURRENT PREGNANCY LOSS:  
PREFERENCES OF JAPANESE WOMEN**

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Women who had miscarriage/stillbirth are likely to have anxiety, depression, grief, and guilt. Tender loving care (TLC) is important to ease women's stress with recurrent pregnancy loss (WWRPL), but it is still an ill-defined concept. This study aimed to clarify the specific contents of TLC preferred and experienced by the WWRPL. Women who visited outpatient clinics in two hospitals in Okayama and Hiroshima to receive treatments for recurrent pregnancy loss (RPL) ( $n = 146$ ) from June-September 2019 were studied. Awareness of TLC, preferences and experience regarding 26 supportive care options, the number of doctors consulted, and frequency of ultrasound examinations were assessed using a questionnaire survey. Responses from 142 were analysed, and  $< 10\%$  were aware of TLC. Six categories were developed based on the supportive care options, and category-wise, testing, guidance and advice, and a friendly atmosphere was highly preferred. Out of 26, 14 supportive care options were preferred by  $> 70\%$  of WWRPL. Sufficient tests to find the cause of RPL (97.2%), provide medical information and necessary explanations (96.5%), explain the pregnancy condition (95.8%) and an environment where you can ask questions freely (95.8%) were highly preferred. First, three options of the above four had the highest experience rates as well. History of  $> 4$  miscarriages/stillbirths was significantly associated ( $p < 0.05$ ) with the preferences related to sensitivity and empathy. The majority preferred to consult one doctor (43%) and perform ultrasound examinations once a week (54.9%). In conclusion, preferences for TLC ranged widely among WWRPL. It is necessary to identify the background and requirements of each patient and provide tailor-made care, paying attention to highly requested care options. WWRPL preferred a patient-centred care plan incorporating emotional support, psychological care, sensitivity and empathy involving one doctor with an ultrasound examination performed once a week in the first trimester of their subsequent pregnancies.

**Keywords:** Psychological support, Recurrent miscarriage, Tender loving care, Unexplained pregnancy loss

**CONSISTENCY OF BEHAVIOUR IN TWO FISH SPECIES, *Poecilia reticulata* (GUPPY) AND *Nannoperca vittata* (WESTERN PYGMY PERCH)**

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Behavioural traits often show consistent covariation among individuals of the same species. This covariation can have clear consequences for fitness and the evolution of life histories. Here we used several testing setups (open field test, emergence test, novel object test, mirror test) to evaluate the consistency of behavioural traits in western pygmy perch (*Nannoperca vittata*) and guppy (*Poecilia reticulata*) with a week of resting period between the first and the second trials for a total of four trials across the experimental timeline. Forty-eight fish from each species were used for the study regardless of their sex. Track length (TL), time spent in the risky zone (RZ) were measured in an open field test, while time to emergence (ET) was measured in the emergence test. Latency to approach a novel object (LA) and time spent close to the object (TS) were measured in novel object test and aggression and sociability test/mirror test, time spent close to a mirror (CV), and the number of attacks (AT) launched at the mirror was measured. A monochrome camera was mounted above the experimental arena and recorded the fish movements. Videos were analyzed using video tracking software. Repeatability (consistency) was calculated as the intra-class correlation coefficient (ICC), based on within individual and between individual variance components. ICC is the fraction of behavioural dissimilarity used to measure the differences of behavioural traits between and among individuals of the same species. ICC was higher than zero for all traits except for the number of attacks in *N. vittata*. Only TL, RZ, CV and ET were repeatable in *N. vittata* ( $p < 0.05$ ), while all traits except LA and attacks are significantly repeatable in *P. reticulata* ( $p < 0.05$ ). The results suggest that the individuals have some traits that contribute to reacting differently towards biotic and abiotic environmental stressors. Moreover, the results provide an idea of which behavioural traits can be used as guides in upcoming studies. In general, traits measured in the open field and emergence tests can be used in future studies as they have shown significant repeatabilities in both fish species.

**Keywords:** Behavioral traits, Between individual variance, Consistent covariation, *Nannoperca vittata*, *Poecilia reticulata*

**HEAVY METAL ACCUMULATION AND ANTIMICROBIAL ACTIVITY OF SOME COMMON BRYOPHYTES IN KADUGANNAWA AREA OF SRI LANKA: CASE STUDY**

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Bryophytes occupy a pivotal position in the land plant phylogeny as the first plant group that evolved on land. They are used as biomonitoring agents of environmental pollution and antimicrobial agents due to their unique characters. Although Sri Lanka harbours a rich diversity of bryophytes, their application as biomonitors and antimicrobial agents have not yet been researched. The present study explored the heavy metal accumulation capacity and antimicrobial activity of some common bryophytes at Kadugannawa in the Central Province of Sri Lanka. Fresh specimens of bryophytes were periodically collected over two months along the roadside in Kadugannawa (a polluted environment) and identified up to the genus/species level. Identified samples were assessed for metal composition using X-ray fluorescence spectrometry (XRF). Specimens were assessed to check the accumulation capacity of heavy metals, including Mn, Pb, Cu, Ni, Cr, and Cd, through the acid digestion method using Atomic Absorption Spectroscopy (AAS) and Atomic Emission Spectroscopy (AES). Data were presented at a significance level of  $p < 0.05$ . The antimicrobial potential was tested against pathogenic microorganisms *Staphylococcus aureus*, *Escherichia coli* and *Candida albicans* using well diffusion method. Five species, including *Dumortiera hirsuta*, *Marchantia papillata*, *Plagiochasma rupestre*, *Riccia billardieri* and *Philonotis* sp. were identified. Among the heavy metals tested, Mn and Cr were the highest in concentration in *M. papillata*. *Plagiochasma rupestre* showed the highest accumulation of Ni and Pb while *Philonotis* sp. showed the highest accumulation of Cd and Cu. *Marchantia papillata* and *D. hirsuta* showed a high degree of inhibition of *S. aureus*. All species displayed inhibition of *E. coli*. *M. papillata*, *D. hirsuta* and *R. billardieri* showed antifungal activity against *C. albicans*. The present study emphasizes the need for further research in polluted and unpolluted areas to assess the potential use of bryophytes as biomonitoring agents and their use in the production of antimicrobial agents in Sri Lanka.

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**Keywords:** Antimicrobial activity, Biomonitoring, Bryophytes, Heavy metals

**PROXIMATE COMPOSITION ANALYSIS OF HAND-MADE AND MACHINE-MADE HYBRID SWEET SORGHUM SILAGES**

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Hybrid Sweet Sorghum-HSS [*Sorghum bicolor* (L.) Moench] is a rapidly growing annual crop cultivated as a good quality forage in the livestock industry worldwide. Nutrient composition of forage is a crucial factor to be concerned in ration formulation. Hence, the present study aimed to assess the proximate composition of hand-made and machine-made HSS silage produced in the Vavuniya and Mullaitivu Districts in the Northern Province of Sri Lanka. First, a survey was conducted among farmers to collect information on major HSS silage users. Then 15 hand-made and five machine-made silage samples were collected from 20 medium-scale dairy cattle farmers (5–25 cows/herd) in each district. The proximate composition of the silage samples was determined following the Association of Official Agricultural Chemists (AOAC). The results of the survey showed that most farmers (75%) in the two Districts used hand-made HSS silage due to the lack of chopping machinery and low cost, while the rest of the farmers used machine-made HSS. The content of dry matter (DM), acid detergent fibre (ADF) and neutral detergent fibre (NDF) in both silages were significantly different ( $p < 0.05$ ). However, the content of ash and crude protein did not differ significantly ( $p > 0.05$ ). A higher amount of DM (28.2%) was recorded in hand-made HSS silage, while ADF (35.9%) and NDF (70.6%) contents were higher in machine-made HSS silage. When preparing hand-made HSS silage, the sorghum was harvested 90 days after planting, while in machine-made silage, sorghum was found to be harvested at different growth stages and processed simultaneously. The results of this study revealed that hand-made HSS silage would be a better option as forage than machine-made HSS silage in terms of proximate composition.

**Keywords:** Acid detergent fibre, Crude protein, Hybrid Sweet Sorghum, Neutral detergent fibre, Silage

**INFLUENCE OF CULTURE ON PAIN PERCEPTION IN PATIENTS WITH  
CHRONIC PAIN: A REVIEW**

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Chronic pain is a universal experience that can be explained using physiological, psychological, socio-cultural and spiritual aspects. The culture would largely influence one's pain perception. Hence, health professionals have to be cognizant of meeting the needs of culturally diverse patient populations when developing psychological interventions for chronic pain. The objective of this paper is to review current evidence of cultural influence on pain perception of patients with chronic pain. The five-step review guidelines: (1) framing a question, (2) identifying relevant work, (3) assessing the quality of studies, (4) summarising the evidence and (5) interpreting the findings were used. The literature search was performed using databases: PubMed, Scopus, PsycINFO and MEDLINE. The search was performed with the keywords "chronic pain", "cultural influence", and "pain perception" combined by Boolean operators OR/AND (culture AND pain perception), (chronic pain AND culture) and (cultural sensitivity OR cultural difference). A total of 75 studies published between 2000 to 2020 were identified. Fourteen studies were included in the analysis. Studies involving adult patients ( $\geq 18$  years old) with persisting pain for more than three months measured on a Visual Analogue Scale ( $\geq 40$  on a 100 mm scale) were included. Full-text articles published other than in the English language were excluded. The studies related to acute pain, oncological pain and non-peer-reviewed articles were excluded. The analysis of research findings yielded three main themes (1) pain expressiveness versus stoicism, (2) the propensity for using traditional remedies and prayers, and (3) language and literacy. It can be concluded that there is evidence regarding the differences in pain perception among different races, ethnicities and cultures. Hence, developing socio-culturally sensitive psychological interventions is crucial to reduce the cultural disparities in the treatment of chronic pain. The study limitations might be the use of different measurement tools of pain perception, the comparisons of various populations and the inconsistent control for confounding variables. A clinical implication of the review is to enhance clinicians' cultural awareness and encourage them to develop socio-culturally applicable interventions.

**Keywords:** Chronic pain, Culture, Disparities, Pain expressiveness, Pain perception

NON-LETHAL MARGINAL TRACES IN RECENT AND FOSSIL  
CYPLEASTEROID ECHINOIDS FROM FLORIDA

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Decapod crustaceans and some benthic fish produce non-lethal predatory traces or marginal traces on sand dollar (Echinoidea: Clypeasteroidea) tests in modern environments. Comparable marginal traces are also observed in fossil sand dollar specimens. These non-lethal marginal traces are underexplored, and they may provide quantifiable data on biotic interactions affecting both recent and fossil sand dollars. In this study, non-lethal marginal traces were characterised using SCUBA sampled live-collected sand dollars from the northeastern Gulf of Mexico. These include four species: *Encope aberrans* ( $n = 67$ ), *Encope michelini* ( $n = 304$ ), *Clypeaster subdepressus* ( $n = 401$ ), and *Mellita tenuis* ( $n = 409$ ). The traces were cusped in shape, healed, and located along the ambitus of the tests, rarely extending into the petals. The frequency of traces was higher in sand dollars with flatter tests (53.7% for *E. aberrans*, 79.3% for *E. michelini*, and 59.7% for *M. tenuis*) than sand dollars with thick-margined tests (9.3% for *C. subdepressus*). Traces comparable to the non-lethal traces documented in recent specimens were also observed in fossil sand dollars from Florida repositated at the Invertebrate Paleontology Division at the Florida Museum. The fossil species include *Clypeaster sunnilandensis*, *Clypeaster rosaceus*, *Encope aberrans*, *Encope tamiamensis*, and *Mellita acclinensis* from the Pliocene portion of the Tamiami Formation, *Abertella carlsoni* from the Late Oligocene of the Arcadia Formation, *Wythella eldridgei* from the Early Oligocene of the Bumpnose Limestone, and *Clypeaster rogersi* from the Early Oligocene of Florida. Several live-collected sand dollars were X-ray imaged and nano-CT scanned to determine the nature of the test damage. The scanned images suggest that the traces are of predatory origin, not a result of a growth deformation. The characteristics of modern traces provide a protocol to identify non-lethal marginal traces on fossil sand dollars and help us better understand the evolutionary history of biotic interactions, specifically non-lethal predation in the echinoid fossil record.

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**Keywords:** Biotic interactions, Predation, Predatory traces in the fossil record, Sand dollars, Sub-lethal predation



**FAST AND EFFICIENT METHOD TO SYNTHESISE CHITOSAN FROM PRAWN SHELLS**

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Chitin is the second most abundant of all polysaccharides and is found in the shells of crustaceans and the cell walls of certain fungi and algae. Chitin is insoluble in water, and deacetylation yields chitosan. Chitosan is a natural biopolymer with non-toxic, antibacterial, biodegradable, and biocompatible properties. Due to these properties, it is widely applied in biomedical applications such as drug delivery, tissue engineering scaffolds, wound dressings, and antibacterial coatings. However, the reported procedures to extract chitin from prawn shells and subsequent conversion into chitosan involve lengthy processes which take 52 – 110 h. Therefore, this study attempted to synthesise chitosan from prawn shells by optimising the individual steps involved. Extraction of chitin and conversion of chitin to chitosan consists of four main steps: deproteination, decolouration, demineralisation, and deacetylation. The deproteination step was optimised by varying the reaction time (1 to 5 h) and reaction temperatures [Room temperature (RT) to 70 °C] with 5% NaOH. The demineralisation step was optimised by varying the concentrations of HCl (1% w/v to 5% w/v) and reaction time (2 to 24 h) at RT. Time taken for decolouration was optimised using acetone and H<sub>2</sub>O<sub>2</sub> at RT. It was found that with 5% (w/v), 2 h of reaction time and RT were the optimum conditions for deproteination and 5% (w/v) was the optimum concentration of HCl, and 2 h of reaction time at RT were the optimum conditions for demineralisation. Decolouration was done with H<sub>2</sub>O<sub>2</sub> at RT for 2 h. Finally, the product was deacetylated with 25% (w/v) NaOH for 2 h at 100 °C. The extracted chitosan was characterised by FTIR analysis. FTIR characterisation data confirmed the successful synthesis of chitosan, and it was obtained in 7 h in 13% of yield. These results indicate that this method is a fast and efficient method to synthesise chitosan from prawn shells.

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**Keywords:** Chitosan, Extraction, Natural biopolymer

**DIFFERENTIAL EXPRESSION OF MXYR GENE CLUSTER OF  
*Mycobacterium tuberculosis* IN THE PRESENCE OF CARBOHYDRATES**

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MxyR, a multiple antibiotic resistance regulator (MarR) family transcriptional regulator in *Mycobacterium tuberculosis*, is reported as a Mycobacterial Xylan Regulator. Gene *mxyR* is divergently oriented from a hydrolase (Rv3094c), oxidoreductase (Rv3093c) and an ABC transporter (Rv3092c) and convergently oriented with xylanase (Rv3096). Our previous studies revealed that MxyR is a carbohydrate responsive transcriptional regulator where specific carbohydrates act as natural ligands. Carbohydrate bound MxyR has the potential to change the expression levels of the respective gene cluster. Here, the different expression levels of the gene cluster in the presence of different carbohydrates have been investigated. Corncob (CC) xylan, glucose, galactose and arabinose were incorporated into the mid-log phase of *M. tuberculosis* culture to determine the influence of carbohydrates in expression levels of gene cluster Beechwood (BW) xylan. After incubating for one hour, the total RNA of the cultures was extracted separately and subjected to cDNA synthesis and quantitative RT-PCR. The data were analysed using the comparative C<sub>T</sub> ( $2^{-\Delta\Delta C_T}$ ) method. The expression levels of each gene fluctuated in the presence of different carbohydrates. Carbohydrates including BW xylan, CC xylan and arabinose up-regulated the expression of the whole gene cluster, while galactose down-regulated the expression. Further, higher up-regulation of the xylanase gene was observed in the presence of BW xylan (25 times) and CC xylan (57 times). Significant up-regulation of oxidoreductase was observed in the presence of arabinose (17 times) and BW xylan (12 times). In conclusion, xylan shows a significant fold change in the expression level of the gene cluster. Unravelling the regulation of mycobacterial metabolic pathways is a major challenge and current work aids in understanding the carbohydrate-mediated gene expression.

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**Keywords:** Carbohydrates, MxyR, *Mycobacterium tuberculosis*

**COMPARISON OF LEAF AND STEM TRICHOMES OF RICE VARIETIES PTB33 AND BG380: EVIDENCE FOR RESISTANCE TO BROWN PLANTHOPPER**

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The Rice Brown Planthopper (BPH), *Nilaparvata lugens* (stal.) is a serious monophagous insect pest in rice-producing countries worldwide. BPH can reduce rice yield and also perform as a vector for viral diseases. The use of resistant rice varieties is a perfect means for managing BPH. Among host plant resistance mechanisms, morphological factors provide a natural barrier for BPH attack. Very little is known on the use of morphological markers to distinguish BPH resistant and susceptible rice varieties. This study aimed to recognise and compare the characteristics and distribution of trichomes in highly resistant (*Ptb33*) and susceptible (*Bg380*) rice varieties and understand the effect of surface morphology on resistance against BPH. Paddy seeds collected from Rice Research and Development Institute, Bathalagoda, were germinated and transferred into pots in a plant house. Images of stem and leaf samples (2 months old) were analysed using a scanning electron microscope (SEM) under  $\times 500$  and  $\times 250$  magnification. Approximate trichome surface density was calculated for  $1\text{ cm}^2$  by counting trichomes on six different places of the image, using a  $1'' \times 1''$  grid. The mean density of macro-hairs on the adaxial surface of leaf Bg380 and Ptb33 was  $50\text{ cm}^{-2}$  and  $83.3\text{ cm}^{-2}$ , respectively. Angular prickles were present only in the abaxial surface Bg380 ( $83.3\text{ cm}^{-2}$ ); instead, Ptb33 had macro hairs with a mean density of  $66.6\text{ cm}^{-2}$ . Unbarbed prickles were high in Bg380 ( $800\text{ cm}^{-2}$ ) while low in Ptb33 ( $550\text{ cm}^{-2}$ ). Curved barbed prickles were observed on Bg380 stem ( $183\text{ cm}^{-2}$ ), while pointed, barbed prickles were observed on Ptb33 ( $633\text{ cm}^{-2}$ ). Short hard stiff macro-hairs were observed in both Bg380 and Ptb33 ( $317\text{ cm}^{-2}$ ,  $450\text{ cm}^{-2}$ ). Dense, long macro hairs on leaves, pointed barbed prickles, and short stiff and pressed macro hairs on the stem of Ptb33 may affect the adult settling, finding ovipositioning sites, and reducing suitable feeding sites. At the same time, curved barbed prickles may facilitate nymphs' retention on Bg380. Thus, this study suggests that the stem and leaf morphological features such as density and length of trichomes could positively correlate with the resistance of rice varieties against BPH.

**Keywords:** Brown Planthopper, Morphology, SEM analysis, Trichomes

**LENGTH-WEIGHT RELATIONSHIP AND CONDITION FACTOR OF *Anguilla bicolor bicolor* AND *Anguilla nebulosa nebulosa* IN SELECTED PERENNIAL RESERVOIRS OF ANURADHAPURA DISTRICT, SRI LANKA**

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Catadromous freshwater eels migrate between freshwater and offshore spawning grounds to complete their life cycle. Globally, 19 species belong to the genus *Anguilla*. Two Sri Lankan species, *Anguilla nebulosa nebulosa* and *Anguilla bicolor bicolor*, were collected from the landing sites of eight perennial reservoirs in the North Central Province, namely Kalawewa, Rajanganaya, Nachcaduwa, Nuwarawewa, Mahakanadarawa, Mahavilachchiya, Padaviya, and Huruluwewa. A total of 138 eels were collected to ascertain the length-weight relationship and condition factor from July 2019 to January 2021. All statistical analyses were assessed at a 5% level using Microsoft Excel (2013). The total length and weight of the eels were measured to the nearest 0.01 g and 0.1 mm, respectively. Morphological identification was based on previously published body colouration and anodorsal parameters studies. Among the eels collected, most (111) of them was *A. nebulosa nebulosa* while the rest ( $n = 27$ ) was *A. bicolor bicolor*. The mean total length and body weight of *A. nebulosa nebulosa* were  $71.1 \pm 13.3$  cm and  $824.5 \pm 519.8$  g, respectively, whereas those of *A. bicolor bicolor* were  $66.0 \pm 11.8$  cm and  $663.4 \pm 362.8$  g, respectively. The length-weight relationship of *A. nebulosa nebulosa* was  $TW = 0.0052 \times TL^{2.7803}$  and that of in *A. bicolor bicolor* was  $TW = 0.0181 \times TL^{2.4894}$ . Estimated  $r^2$  and  $p$  values of *A. nebulosa nebulosa* and *A. bicolor bicolor* were 0.7719, >0.05 and 0.8683, <0.05, respectively. Estimated "b" values (regression slope) of *A. nebulosa nebulosa* and *A. bicolor bicolor* were 2.7803 and 2.4894, respectively. The present results indicate an isometric growth in *A. nebulosa nebulosa* and negative allometric growth in *A. bicolor bicolor*. The relative condition factor ( $K_n$ ) for *A. nebulosa nebulosa* and *A. bicolor bicolor* were  $1.0559 \pm 0.7002$  and  $1.0140 \pm 0.1895$ , respectively. Results of the present study show that  $K_n$  values of both species lie between 1 and 1.5, indicating fatness and good growth conditions in the two species.

**Keywords:** Anguillid eels, Condition factor, Fisheries management, Length-weight relationship, Stock assessment

**PROGNOSTIC GENETIC MARKERS IN PRE- AND POSTMENOPAUSAL BREAST  
CANCER PATIENT COHORT FROM A TERTIARY CARE CENTER IN  
SRI LANKA**

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Breast cancer is one of the major causes of morbidity among women in Sri Lanka, of which management is challenging due to the limited accuracy of existing classical prognostic markers. Therefore, prognostic molecular biomarkers for precise breast cancer diagnosis are vital. Dysregulated apoptosis plays a critical role in the pathogenesis of breast cancer. The members of the B-cell lymphoma 2 (*BCL2*) gene family are reported to have a prognostic significance in breast cancer. Epithelial-to-mesenchymal transition (EMT) is important in breast cancer metastasis. Epithelial Cadherin coded by *CDH1* is a marker for EMT. This study aimed to assess the expression of *BCL2*, *BAD* (*BCL-2* associated agonist of cell death) and *CDH1* genes in a breast cancer patient cohort in Sri Lanka. Gene expression analysis was carried out using Real-time quantitative PCR (RT-qPCR) in triplicates for 68 breast tumour specimens obtained from patients with histologically confirmed breast carcinoma in Sri Lanka. The gene expressions with the menopausal status and primary clinicopathological parameters were statistically analysed. Our results showed that only *CDH1* expression was significantly associated with the menopausal status ( $p < 0.05$ ) and highly expressed in postmenopausal tumours. The *BCL2* expression was significantly associated with estrogen receptor (ER) status and tumour grade, while the *BAD* expression was associated with the ER status ( $p < 0.05$ ). Moreover, *CDH1* expression was associated with human epidermal growth factor receptor 2 (HER2) status ( $p < 0.05$ ). Therefore, *CDH1* may be suitable for prognosis based on menopausal status and HER2 status in Sri Lanka. *BCL2* may be suitable for ER status and tumour size-associated prognosis, while *BAD* may be suited for ER status-associated prognosis. However, analysis of patient survival data and an increased cohort size are required for establishing the suitability of these genes in the prognosis of breast cancer in Sri Lanka.

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**Keywords:** *BCL2* gene family, EMT markers, Prognostic biomarkers, Real-time quantitative PCR

**COMPARATIVE STUDY OF *IN VITRO* ANTICOAGULANT ACTIVITY OF RAW, BOILED AND HONEY FERMENTED *Allium sativum* (GARLIC) USED IN SRI LANKA**

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Sri Lankans consume garlic as raw, cooked and honey-fermented. Anticoagulant properties of garlic vary with different preparations. Here we analysed the *in vitro* anticoagulant activity of aqueous extracts of raw, boiled and honey-fermented garlic to determine the anticoagulant activity. Aqueous extracts of raw, boiled, and honey-fermented garlic preparations at different concentrations (10, 50, 250 and 500 mg ml<sup>-1</sup>) were prepared. *In vitro* anticoagulant activity was analysed by replicating prothrombin time (PT) of pooled plasma diluted with different garlic extracts four times. Independent sample *t*-test and Mann Whitney U test compared the PT values among each preparation. Mean PT values with aqueous extract of honey fermented garlic (25.8 ± 0.5, 27.8 ± 0.5, 30 ± 0.0 and 30 ± 0.0 s) were significantly higher compared to control (24 ± 0.0 s) at all concentrations (*p* < 0.05). The mean PT values with aqueous extract of raw garlic (25 ± 0.0 and 28.3 ± 0.5 s) and boiled garlic (25.3 ± 0.5 and 26 ± 0.0 s) were significantly higher compared to control only at high concentrations (250 & 500 mg mL<sup>-1</sup>; *p* < 0.05). The PT values increased with an increasing concentration of garlic extract. Honey fermented garlic had significantly higher PT values than the other two preparations (*p* < 0.05). Raw garlic had significantly high PT values than boiled garlic at high concentrations (*p* < 0.05). The boiling of garlic prevented the formation of organosulfur compounds, which are major compounds responsible for its anticoagulant activity. Honey has an effect on platelet aggregation. All three preparations of garlic have inhibitory effects on blood coagulation. Honey-fermented garlic has higher anticoagulant activity than the other two preparations. The anticoagulant activity increased with an increasing concentration of garlic extract.

**Keywords:** Boiled garlic, Honey fermented garlic, *In vitro* anticoagulant activity, Raw garlic

**ANTIOXIDANT POTENTIAL AND NUTRITIONAL COMPOSITION OF PEEL AND SEEDS OF *Flacourtia indica* FRUIT**

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*Flacourtia indica* is a valuable natural product used to treat various diseases and functional disorders. Few studies have been carried out on the antioxidant potential of the fruit flesh, but nothing has been reported on the non-edible portion. Hence, here we analysed the antioxidant properties and nutritional composition of fruit seeds and peels. The methanolic extracts were prepared. Antioxidant activity was determined by 2,2-diphenylpicrylhydrazyl (DPPH) assay, ferric reducing antioxidant power (FRAP), total phenol (TPC), total flavonoid (TFC), total anthocyanin (TAC) and proanthocyanidin (ProAc) contents were also determined. Under the proximate analysis, moisture, ash, lipid, fibre, protein, carbohydrate, and calorie contents were evaluated. IC<sub>50</sub> and TPC, FRAP values of the peel were found as 0.9518 mg L<sup>-1</sup>,  $1.884 \times 10^3 \pm 3.31$  mg Gallic acid per 100 g,  $33.258 \pm 0.613$  Fe<sup>2+</sup> mol dm<sup>-3</sup>, respectively. TAC and ProAc of peel were  $32.641 \pm 0.166$  (mg L<sup>-1</sup>) and  $8.3038 \pm 0.0293$  (mg CAE g<sup>-1</sup>), respectively. All the above values were higher than those in seeds. These data indicate that peel possesses a higher antioxidant capacity than seeds, and the literature reported values for fruit flesh. Moisture, lipid, ash, protein, carbohydrate contents and the calorie value of the peel were found as  $15.203 \pm 0.267\%$ ,  $9.277 \pm 0.165\%$ ,  $13.927 \pm 0.488\%$ ,  $22.411 \pm 0.535\%$ ,  $29.662 \pm 0.665\%$  and 291.785 kcal per 100 g, respectively and higher than those of seeds. The fibre content of the seed was found as  $50.960 \pm 0.484\%$  and higher than that in the peel. One-way analysis of variance (ANOVA) was performed using MINITAB 17 software. These findings reveal that the fruit peel of *F. indica* is a good source of natural antioxidants rich with nutrients that can be utilised as a value-added product with high therapeutic and nutritional value. Seeds can be utilised as a good source of fibre and can be developed up to an alternative food supplement.

**Keywords:** Antioxidant activity, *Flacourtia indica*, FRAP value, Nutritional composition

**AMYLASE ACTIVITY OF SELECTED BACTERIAL AND FUNGAL STRAINS**

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Enzymes are crucial for industrial applications as they are involved in various biological reactions. The present study determined the amylase activity of selected bacteria and fungus isolated from a municipal garbage dump near the Vincent Dias Stadium, Badulla. Twenty-seven bacterial (B1 – B27) and five fungal (F1 – F5) strains from a culture collection used in a previous study were used. Bacterial and fungal strains were cultured in Nutrient Agar medium and Potato Dextrose Agar medium, respectively. The bacterial and fungal strains were then re-cultured in Nutrient Broth (NB) and Potato Dextrose Broth (PDB), respectively, before performing an enzymatic assay. After four days, the culture medium was collected and centrifuged to obtain cell-free supernatants as crude amylase. Then, the activity of crude amylase was tested in a well-diffusion assay conducted in Starch Agar medium by following the CRD with triplicates. The NB and PDB were used as controls for bacterial and for fungal strains, respectively. The diameter of the halo zone around the wells was measured and analysed by ANOVA. The bacterial strain B8 showed the highest diameter among bacterial strains (3.40 cm), and F2 showed the highest diameter among fungal strains (3.13 cm). For testing amylase activity of B8 and F2 with time, B8 was re-cultured in NB, and F2 was re-cultured in PDB. The crude enzyme extracted from the subsamples collected from each medium within 6 h time intervals was used to digest starch. The amount of sugar formation after the starch digestion was evaluated by the DNSA method. The B8 showed the highest amylase activity (0.41 AU) at 30 and 54 h of incubation, whereas F2 showed the highest amylase activity (1.69 AU) at 78 h of incubation. Accordingly, the amylase activity of F2 is higher than that of B8. Therefore, among these 32 strains, F2 of this study can be recommended to extract amylase enzymes efficiently for industrial applications.

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**Keywords:** Amylase, Bacteria, Fungi



**ANTIMICROBIAL POTENTIAL AND CONSUMER ACCEPTANCE OF A HERBAL HAND SANITISER WITH *Mimosa pudica* LEAF EXTRACT AND MINIMAL ALCOHOL**

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Hand sanitisers (HS) prevent infections by transient microflora. The WHO-recommended HS are alcohol-based (75% isopropyl alcohol), which could cause dry skin. Previously, a herbal hand sanitiser (H-HS) was produced with 40% alcohol, adding a leaf extract of *Mimosa pudica* L. The current study aimed to determine the Minimum Inhibitory Concentration (MIC) of the prepared H-HS and conduct a sensory evaluation test to compare its consumer acceptability with WHO-HS and a commercial HS (C-HS). The MIC of H-HS was determined using 1,000-100,000 mg/L of the alcoholic extract of *M. pudica* with 40% isopropyl alcohol, by a well diffusion assay, against *Escherichia coli* ATCC25922, *Pseudomonas aeruginosa* ATCC27853, *Staphylococcus aureus* ATCC25923, *Candida albicans* ATCC10231 and *Candida tropicalis* ATCC13803. Organoleptic parameters (viscosity, colour, feel, aroma) and overall acceptability on 30 panellists (14 males and 16 females; aged 20 – 70 years) were determined using a hedonic scale: 9 = extremely like to 1 = extremely dislike. A Kruskal-Wallis test and a Mann-Whitney test were performed to determine significance and for median separation, respectively. The MIC against all test organisms was 10,000 mg/L. Its inhibition-zone diameters were significantly lower ( $p = 0.05$ ) than WHO-HS for the bacteria, while *Candida* spp. did not show a significant difference. The average median scores (range) for each organoleptic parameter were; colour 6 (5 – 8), 7 (5 – 9), 8 (6 – 9), feel 8 (6 – 9), 6 (5 – 9), 8 (5 – 9), aroma 8 (5 – 9), 7 (5 – 9), 8 (2 – 9) for H-HS, WHO-HS and C-HS, respectively. Colour, feel, and aroma were significantly different ( $p = 0.01$ ), with the H-HS having the lowest score for colour. Medians of feel and aroma were similar for C-HS and H-HS, while those of WHO-HS were significantly lower. The consumer acceptance of H-HS was similar to C-HS and higher than WHO-HS except for colour. In conclusion, the H-HS effectively inhibits all test organisms and is comparable to WHO-HS, while being consumer acceptable.

**Keywords:** Commercially available hand sanitiser, Organoleptic parameters, Sensory evaluation, Transient microflora, WHO-recommended hand sanitiser

**DIAGNOSIS PERFORMANCE OF CONVENTIONAL PCR VERSUS BLOOD SMEARS FOR HEMOPARASITES IN DOGS WITH OR WITHOUT CLINICAL SIGNS**

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Canine hemoparasites are a significant health problem among dogs globally. Current diagnosis relies mainly on microscopic examination of blood smears which may not detect the parasites in early infections and at low parasitemia. We assessed the diagnosis performances of conventional PCR vs blood smears in detecting hemoparasites in dogs with or without clinical signs. Blood samples from 82 dogs were collected, comprising 20 military dogs of the Sri Lanka Air Force (ten with signs), 32 free-roaming (two with signs), and 30 privately-owned dogs (ten with signs). Giemsa stained blood smears were prepared, and the results were compared with PCR amplified 18S rDNA gene of *Babesia* and *Hepatozoon* and 16S rDNA gene of *Ehrlichia* and *Anaplasma* and kDNA gene of *Leishmania*. Results showed that 37 dogs were infected with hemoparasites, comprising 27 *Babesia* spp., five *Ehrlichia canis*, one *Hepatozoon canis*, two *Anaplasma platys* and two *Leishmania* sp. infections. Among *Babesia*-infected dogs, only 37% showed clinical signs, of which 90% were both smear and PCR positive, while 63% were without signs, of which 47% were both smear and PCR positive and 53% were smear-negative but PCR positive. A high number of stray dogs showed smear-negative but PCR positive results. All five dogs infected with *E. canis* showed signs. Of which, two dogs with signs (40%) had both smears and PCR positive results while three (60%) had only smear-positive results. The two dogs infected with *A. platys* showed symptoms. Of which, one was both smear and PCR positive and the other was smear-positive but PCR negative. *Leishmania* and *H. canis* infected dogs showed signs; both smear and PCR results were positive. Of the two methods, the conventional PCR method gave a higher sensitivity for *Babesia* infections, especially in those stray dogs that did not show clinical signs but may act as reservoirs of infections.

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**Keywords:** Canine hemoparasites, Diagnosis, Polymerase Chain Reaction.

**FERTILITY PRESERVATION OPTIONS FOR PATIENTS WITH CANCER**

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Cancer incidences have an increasing trend worldwide, causing a global burden. Intense chemotherapy or radiotherapy has increased the cancer survival rate but with the expense of gonadal function in many cases. Therefore, oncofertility is becoming an essential aspect of supportive cancer care. Fertility preservation (FP) can impose a social, economic, ethical, and psychological impact on society. This review aimed to fill the information gap and provide an update of oncofertility care to the Sri Lankan scientific community and increase the awareness related to FP options and Clinical Practice Guidelines (CPG) for cancer patients. A Literature search under "oncofertility" and "fertility preservation" was performed in the PubMed and Google scholar databases. Ten original research articles, 20 review articles, and seven CPG were used to update oncofertility care. Different FP alternatives and strategies are available for both male and female patients. Embryo cryopreservation is considered the best option for married people. Cryopreservation of oocytes (mature or immature) is possible for married and unmarried women. Ovarian tissues cryopreservation is the only option available for prepubertal girls and unmarried women with cultural backgrounds. Sperm cryopreservation is recommended for postpubertal males while preserving testicular tissue might be the only option for prepubertal boys though it is still experimental. These techniques use either slow freezing methods or vitrification. According to the recommendations, oncologic health care providers should discuss infertility as a potential risk of therapy as soon as the cancer diagnosis is made and formulate a treatment plan. However, Sri Lanka has not joined such a society or practised FP methods for cancer patients yet. It is time to bring oncologists, gynaecologists, urologists, radiologists, paediatricians, surgeons, and psychologists to one table, discuss, share the knowledge, and make the mindset to advise eligible cancer patients on fertility issues and take actions.

**Keywords:** Cryopreservation, Embryo, Oocytes, Ovarian tissue, Sperm



**ANTIFUNGAL WALL COATING BASED ON Ca(OH)<sub>2</sub> MIXED WITH MgO AND TiO<sub>2</sub> NANOPARTICLES**

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Slaked lime (mainly composed of calcium hydroxide) is a commonly used building material applied on wall surfaces. This lime layer can be subjected to bio-deterioration due to the colonisation of different micro-organisms, with fungi being the main one. In this work, TiO<sub>2</sub> and MgO nanoparticles with sizes of 60 nm and 40 nm, respectively, were prepared using a hydrothermal method. They were mixed with Ca(OH)<sub>2</sub> particles in different proportions to form a series of suspensions. Powder X-ray diffraction analysis showed that MgO nanoparticles existed in the cubic phase while TiO<sub>2</sub> nanoparticles belonged to the anatase phase. The antifungal activities of these suspensions were tested in two different methods against *Aspergillus niger*, isolated from deteriorated wall surfaces. First, a preliminary assay was conducted by incorporating the nanoparticles mixture in the Potato Dextrose Agar medium with a fungal inoculum. In the second method, the suspensions were coated on glass Petri dishes. Then an inoculum of *A. niger* was introduced to the surface of this coating. Fungal growth on the coatings was observed under a natural photoperiod cycle and relative humidity of 80%. The study revealed that the Ca(OH)<sub>2</sub>-MgO, Ca(OH)<sub>2</sub>-TiO<sub>2</sub> and Ca(OH)<sub>2</sub>-MgO-TiO<sub>2</sub> systems inhibited the germination and mycelial growth of *A. niger*. In contrast, the pure Ca(OH)<sub>2</sub> system was readily colonised. However, pure MgO based coatings showed the highest antifungal activity, and pure TiO<sub>2</sub> based coatings showed the lowest. MgO-TiO<sub>2</sub> mixtures exhibited an intermediate performance that gradually increased with the percentage (w/w) of MgO added. These nanoparticles can be used in pure or mixed form with Ca(OH)<sub>2</sub> to prepare an antifungal coating.

**Keywords:** Antifungal coating, *Aspergillus niger*, Ca(OH)<sub>2</sub> particles, MgO nanoparticles, TiO<sub>2</sub> nanoparticles

**ISOLATION OF CHROMIUM(III) SEQUESTERING BACTERIA FROM  
TANNERY EFFLUENTS**

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Large amounts of chromium salts are used in the tannery industry, and wastewater containing heavy metals is discharged into natural water resources. Heavy metals are toxic and lead to carcinogenic effects on human and aquatic organisms. Consequently, the removal of chromium from contaminated water before discharging is essential. The use of bacteria provides an effective chromium removal method from an aqueous solution as bacteria have the ability for biosorption, intracellular sequestration, extracellular sequestration and reduction of heavy metal ions. This study investigates quantitative aspects of chromium resistance capability and chromium sequestering ability of isolated bacteria species. The isolated bacterium with chromium sequestering capability can be used in many industries to remove chromium species from the wastewater. First, nine samples were collected from two tanneries in the Colombo District and then physical and chemical parameters of the collected samples were determined. Pure bacterial colonies were isolated through culturing and sub-culturing processes. Chromium resistance of isolated bacteria species at different chromium(III) concentrations; 1000 mg L<sup>-1</sup> to 0 mg L<sup>-1</sup> was determined using a standard point method. The sequestered chromium amounts at different chromium(III) concentrations were measured using atomic absorption spectrophotometry. Five bacteria species were isolated from tannery effluents. All the isolated bacteria species grown on nutrient agar plates showed a higher growth rate in the presence of chromium than in the absence of chromium. They showed a poor growth rate when the chromium concentration was higher than 500 mg L<sup>-1</sup>. The maximum chromium removal percentage shown by a bacterium was 87.1%. Therefore, these isolated bacterial strains can be used to reduce the chromium concentration in chromium-contaminated aqueous solutions. This chromium removal method is more economically feasible when compared to physio-chemical methods. The isolated bacterial strains could be identified and explored for bioremediation purposes.

**Keywords:** Bacteria isolation, Chromium(III) removal, Metal resistance, Metal sequestration, Tannery effluents

**MATHEMATICAL MODELING AND SIMULATION OF ACOUSTIC PROPERTIES OF KNITTED FABRICS BACKED BY AN AIR CAVITY**

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Noise pollution has become a critical issue in the modern world of ever-increasing industries and machinery. Noise should be controlled due to the physical and psychological health effects associated with noise. Textiles as lightweight and cost-effective porous structures have received increasing interest for acoustic controlling applications. In-room acoustics, knitted fabrics represent a strong source of innovation due to drapability and aesthetic appearance. However, in general, the sound absorption performance of knitted fabrics is relatively low. Therefore, the primary goal of this work is to enhance sound absorption by introducing an air gap between the fabric and a solid wall. The diffuse incident sound absorption coefficient of knitted fabrics was mathematically modeled and simulated using basic equations of fluid dynamics where the fabric is acoustically described by its porosity, thickness, density and airflow resistivity. The air gap varied from 10 to 25 mm in 5 mm increments. Modeling predictions were compared with the experimental data obtained from the literature for sound absorption of knitted fabrics. The modeling predictions were in good agreement with the experimental data for different values of air gap thicknesses. The simulation results indicated that when the air layer thickness increases, the sound absorption coefficient of knitted fabrics increases significantly at low frequencies. The peak value of the sound absorption coefficient moves in the direction of a lower frequency. The sound absorption coefficient reached a maximum value of 0.45 at a resonance frequency equivalent to the quarter wavelength of the air layer thickness.

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**Keywords:** Acoustics, Airflow resistivity, Knitted fabrics, Porosity, Sound absorption

**DETECTION AND CHARACTERISATION OF WHISTLERS AND SFERICS**

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Naturally occurring radio signals from lightning discharges produce whistlers and sferics that can be prospectively used in the analysis of the middle atmosphere, especially the D-region of the ionosphere because of its ability to travel into the particular region. The initial portion of this study focused on developing a magnetic loop antenna and a high gain very low frequency (VLF) amplifier. Magnetic loop antennas are more favourable in this research area due to ease of construction and simplicity. In this study, a magnetic loop antenna of 1 m<sup>2</sup> was constructed on a wooden frame. Insulated copper wire with a diameter of 1 mm was wrapped 40 times around the frame to form the antenna. A high gain VLF amplifier was designed using the OP27 and the CA3140 integrated circuits and constructed using the ultra-violet (UV) exposure method. In the latter part of the study, sferics were observed throughout September 2019 till January 2020 in the University of Peradeniya premises using the constructed VLF receiver and the magnetic loop antenna. Obtained sferics were used to estimate the ionosphere D-region height, and the results were consistent with the theoretical values. D-region height estimated from the time difference between 1<sup>st</sup> and 2<sup>nd</sup> hop waves with the ground wave ranged from 35 to 57 km. Additionally, the frequency variation of the observed sferics was determined to be in the range of 3000 Hz – 8000 Hz. Also, the duration of the sferics was determined using the obtained amplitude vs time plots.

**Keywords:** Ionosphere, Magnetic loop antenna, Sferics, VLF amplifier, Whistlers



**FIRST HYPERPOLARIZABILITIES AND EXCITATION ENERGIES OF  
PORPHYRIN-BRIDGED RUTHENIUM COMPLEXES FEATURING  
NITROPHENYL ACCEPTOR: A DFT STUDY**

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The search for highly efficient nonlinear optical (NLO) materials has been accelerated in the past two decades due to their many potential applications, such as switching and optical signal processing. In the present study, density functional theory (DFT) and time-dependent DFT (TDDFT) calculations of a new family of nonlinear optical (NLO) metal complexes featuring both  $[\text{Ru}(\text{C}\equiv\text{CC}_6\text{H}_4)\text{Cl}(\text{H}_2\text{PCH}_2\text{CH}_2\text{PH}_2)_2]$  electron-donating and nitrophenyl electron-withdrawing groups fused to a porphyrin core via ethynyl or alkenyl linkers are reported. The calculated static first hyperpolarizabilities ( $\beta$ ) and low-lying linear optical data of these novel porphyrin-bridged Ru complexes were compared with those of ruthenium analogues with phenylene based bridges. The calculations showed that the porphyrin complexes show superior optical nonlinearity than the corresponding phenylene Ru complexes. The donor-bridge-acceptor structure leads to a significant increase in the calculated  $\beta$ , as expected. However, bridge lengthening by adding a phenyleneethynylene unit leads to a decrease in the static  $\beta$  value. Varying the bridge composition by replacement of the ethynyl linkages by an alkenyl group appears to have a reasonable impact on the optical nonlinearity for both structures. For the porphyrins, the hyperpolarizability decreased on replacing the yne linkage between the porphyrin unit and nitrophenyl acceptor by the *E*-ene group. For the acceptor containing porphyrins, the simulated UV/Vis spectrum features a significantly red-shifted Q band and an intense, high-energy B band, whilst calculations predict an intense optical band in the region of 350 nm – 450 nm for the Ru complexes with phenylene based bridges. For all the donor-bridge-acceptor Ru systems, the molecular orbital analysis revealed that the low-energy band shows substantial donor-acceptor charge-transfer character, thus making a significant contribution to the first hyperpolarizability  $\beta$ . The HOMO and LUMO energy gaps of the porphyrins are smaller than those of the Ru complexes with phenylene based bridges. As a result, the low-energy Q band (which results from the LUMO to HOMO) in the former is significantly red-shifted, which may explain the disparity in their  $\beta$  values.

**Keywords:** Computational chemistry, Metal alkynyls, Nonlinear optics, Porphyrins

## **CHANGES IN pH OF CONCRETE DURING HYDRATION**

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The pH value plays a major role in the concrete structure and its reinforcement. The corrosion of the concrete structure begins when its pH value falls below a specific level. Many studies have been performed to investigate the environmental factors that affect the pH of concrete. However, limited studies have been carried out on the pH changes in the concrete pore solution for some time. The present study investigates the pH changes of pore solution in the concrete during the hydration reaction up to three months. There is no standard procedure to measure the pH of cementitious structures. In this work, various analytical methods have been used, and the results were compared to find a correct way to measure the pH of concrete. Furthermore, the pH change pattern during the hydration reaction with time was also studied. Ex-situ leaching method with cold water extract methodology was used to extract the concrete pore solution. Various methods, including titration, direct measurement using a pH meter, reverse calculation, and thermodynamic modelling methods, were used to determine the pH of the extracted solutions. Due to the dilution effect of the added water, the methods used for measuring the pH value of the pore solution, such as direct pH measurement with a pH meter and titration method, underestimated the actual pH level. Moreover, both the reverse calculation of ionic activity of  $H^+$  in the concrete pore solution using titration method and the pH measurement using a pH meter cannot represent the actual ionic activity of  $H^+$  ion. However, the results obtained by modelling from the measured alkali concentrations showed acceptable results. This research outcome shows that the pH is increased nearly by 5% after a month of hydration of the concrete.

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**Keywords:** Alkalis, Concrete, pH, Pore solution, Thermodynamic calculations

**POTENTIAL OF BANANA (*Musa sp.*) PEELS AS SOURCE OF ELECTROLYTES IN VOLTAMMETRIC EXPERIMENTS**

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Banana (*Musa sp.*) is an electrolyte-rich fruit due to its high potassium content. Even though banana peel is considered a waste material, many studies have shown that it can be converted into value-added products. The ability of banana peels to function as electrolytes has not been extensively studied. This study aimed to explore the potential of banana peel extract as an alternative for expensive electrolytes utilised in electrochemical experiments. Extractions of three banana varieties: *Ambun*, *Embul*, and *Seeni* were prepared by blending and filtering the fresh peels. The electrical conductivity (EC) and total dissolved solids (TDS) in three extracts were determined using an electrical conductivity meter. *Ambun* peel extracts showed both the highest EC and highest TDS results. The mineral ion concentrations ( $Mg^{+2}$ ,  $Ca^{+2}$ ,  $Na^+$ ,  $K^+$ ) of three types of banana peel extracts were also determined with the flame atomic absorption spectrophotometer using a diluted extract series to confirm the presence of major electrolytes. In cyclic voltammetry (CV) experiments, baseline response of the banana peel extract was first investigated, and then cyclic voltammograms were recorded for  $0.001 \text{ mol dm}^{-3}$  ferrocene in dimethylformamide using banana peel extract as the supporting electrolyte with glassy carbon electrode as the working electrode; Pt wire as the counter electrode and calomel electrode as the reference electrode under  $N_2$  blanket. The results have exhibited the characteristic redox peaks of ferrocene with cathodic peak potential ( $E_{pc}$ ) at 0.23 V and anodic peak potential ( $E_{pa}$ ) at 0.38 V for at  $0.050 \text{ V s}^{-1}$  scan rate. Anodic and cathodic current ratio ( $i_{pa}/i_{pc}$ ), was 2.36 and peak separation ( $\Delta E_p$ ) was 0.15, which was higher than the results in a solution of a standard supporting electrolyte. None of these redox peaks of ferrocene was observed in the absence of banana peels extract. The results reveal that banana peels can be used as a source of electrolytes in CV experiments. Attempts were made to convert the extraction of the peel into a solid because solid electrolytes are more appropriate in electrochemical experiments. Further research on the development of solid electrolytes is underway.

**Keywords:** *Ambun* banana, Banana peel extract, Cyclic voltammetry, Electrolytes, Ferrocene

**DETECTION OF POLYCHLORINATED BIPHENYLS CONTAMINATED POWER TRANSFORMERS IN SRI LANKA**

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Polychlorinated biphenyls (PCBs) classified under persistent organic pollutants are a group I carcinogen. Aroclors were one of the widely used and most reported PCB commercial mixtures globally. Aroclor 1260, Aroclor 1254, Aroclor 1242, and Aroclor 1016 have been used in transformers. Sri Lanka is a signatory of the Stockholm Convention, where PCB usage has been curtailed since 2005. PCBs have mainly been used as insulating oil in transformers and capacitors. The elimination of PCBs by 2025 is a primary goal set by the convention. Accordingly, analysing and inventorying the transformers contaminated with greater than 50 mg kg<sup>-1</sup> PCBs in Sri Lanka is in progress. This study developed a method based on the ASTM D 4059 to determine the PCB content in insulating oils. PCBs in the sample were extracted with 2,2,4-trimethylpentane followed by interference removal using activated magnesium silicate. The extracted sample was allowed to stand for 10 min to settle the magnesium silicate particles, and 1.0 mL of the supernatant and 0.1 mL of hexachlorobenzene were mixed and analysed with gas chromatography- electron capture detection (GC-ECD). A matrix-matched calibration was used to address the intensity suppression due to the mineral oil, and ratios of uniquely identified well-resolved peaks were used in quantification by adding an internal standard to both calibrators and samples. The Ceylon Electricity Board inventory has more than 30,000 transformers, of which 2,500 were screened as suspected transformers to date. The confirmatory analysis was carried out in 329 samples by GC-ECD. Some of the samples (16.4%) contained total PCBs greater than 50 mg kg<sup>-1</sup>, out of which 16.1% had Aroclor 1260, and 1.5% contained both Aroclor 1260 and Aroclor 1254. The findings will be included in the national inventory facilitating PCB mitigation programs following the Stockholm Convention.

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**Keywords:** Aroclors, Insulating oil, PCBs, Stockholm Convention, Transformers

**ETHYLENE CARBONATE AND DIMETHYL CARBONATE COMPOSITION  
DEPENDENCE: A MOLECULAR DYNAMICS STUDY OF Li-IONS IN AN  
ELECTROLYTE**

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Li-ion rechargeable batteries (LIBs) have excellent durability, long cycling life and high specific density. Computational investigation of the effect of temperature, salt concentration and solid electrolyte interface on the Li-ion behaviour has been reported. However, computational studies on the composition dependence of ethylene carbonate (EC) and dimethyl carbonate (DMC) on the Li-ion behaviour are lacking. Here, we study the effect of the entire range of EC and DMC composition in the electrolyte to determine the optimum composition of EC and DMC in Li-ion rechargeable batteries. All systems were represented using the Generalised Amber Force Field (GAFF) and simulated using the LAMMPS code. The following properties were simulated and analysed; density, self-diffusion coefficient, ionic conductivity, cluster formation and ion pair lifetimes. Results showed that all mean square displacements, diffusivities and ionic conductivities increased with increasing DMC mole fraction ( $\chi_{dmc}$ ). Further, irrespective of  $\chi_{dmc}$ , the highest number of F<sup>-</sup> ions and carbonyl oxygen atoms were found, from 1.98 to 2.10 Å from Li<sup>+</sup> ions. This indicates the competition among PF<sub>6</sub><sup>-</sup> ions and EC and DMC molecules for Li-ions. The system with 0.2  $\chi_{dmc}$  showed the highest pair correlation of DMC with Li-ions, while 0.7  $\chi_{dmc}$  showed the lowest. The highest pair correlation for EC with Li-ions was observed for 0.4  $\chi_{dmc}$ . The incremental increase of  $\chi_{dmc}$  has increased the diffusivity of Li-ions and, hence the ionic conductivity. It has also shown that Li-EC pair correlation has increased with increasing  $\chi_{dmc}$  to 0.4, and a further increase in  $\chi_{dmc}$  has decreased the correlation with Li-ions, indicating that the 0.4  $\chi_{dmc}$  as the optimum EC/DMC composition.

**Keywords:** Dimethyl carbonate, Ethylene carbonate, Li-ion batteries, Molecular dynamics

**POLY (ACRYLIC ACID)/SAWDUST COMPOSITE FOR ADSORPTIVE REMOVAL OF SELECTED HEAVY METAL IONS FROM AQUEOUS SOLUTIONS**

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The synthesis of a novel adsorbent by grafting poly (acrylic acid) to sawdust to remove heavy metal ions from aqueous solutions is reported here. The ability of sawdust to adsorb heavy metal ions can be enhanced by grafting poly (acrylic acid) which increases the negative charge on the composite, making it a better adsorbent than sawdust. Poly (acrylic acid) was synthesised using potassium persulphate as the initiator by free-radical polymerisation of acrylic acid. *In-situ* polymerisation of acrylic acid on sawdust yielded the poly (acrylic acid)/sawdust composite (PAA/SD). Fourier Transform Infrared Spectroscopy (FTIR) was used to characterise sawdust, poly (acrylic acid) and PAA/SD. X-ray Fluorescence (XRF) was used to determine the metallic constitution of sawdust. The adsorption percentage of PAA/SD towards  $Pb^{2+}$ ,  $Ni^{2+}$ ,  $Cd^{2+}$ ,  $Zn^{2+}$  and  $Cr^{3+}$  was determined under conditions of a pH of 6, 60 min of shaking time, 60 min of settling time,  $(0.100 \pm 0.001)$  g dosage of PAA/SD composite of particle size of 200  $\mu m$  which was determined using a sieve plate. The procedure was repeated twice. The concentrations of heavy metals were determined using atomic absorption spectroscopy. Results indicate the successful synthesis of poly(acrylic acid) by free radical polymerisation of acrylic acid with a yield of 42%. FTIR characterisation affirms the synthesis of PAA/SD composite. XRF characterisation proves the absence of heavy metals tested in the analysis in sawdust, validating the sawdust sample used for composite preparation. The PAA/SD exhibited adsorption percentages of 51% for  $Pb^{2+}$ , 40% for  $Ni^{2+}$ , 60% for  $Cd^{2+}$ , 57% for  $Zn^{2+}$  and 55% for  $Cr^{3+}$  under the conditions studied. PAA/SD showed the highest adsorption towards  $Cd^{2+}$ . The novel PAA/SD composite is very effective in removing all tested heavy metals from aqueous solutions.

**Keywords:** Adsorption, Composite, Heavy metals, Poly(acrylic acid), Sawdust

**NUMERICAL STUDY OF THE EFFECT OF DELAFOSSITE  $\text{CuAlO}_2$  AND PEDOT:PSS AS HOLE TRANSPORT MATERIALS IN THE 3D/2D PEROVSKITE SOLAR CELL**

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Metal halide perovskite solar cells have shown good performance in photovoltaic. Methylammonium lead iodide ( $\text{CH}_3\text{NH}_3\text{PbI}_3$  or 3D-MAPI) is one of the most popular 3D metal halide perovskite materials. In this study, we numerically modelled metal halide perovskite solar cells having a p-i-n structure with intrinsic layers of 3D-MAPI and 2D monolayers of  $\text{CH}_3\text{NH}_3\text{PbI}_3$  (2D-MAPI). However, the hole transporting material of the p-i-n perovskite solar cell can control the performance of the solar cell due to the recombination in the hole transporting layer (HTL). We simulated and observed how the delafossite  $\text{CuAlO}_2$  and PEDOT:PSS (poly(3,4-ethylenedioxythiophene) polystyrene sulfonate) HTLs affect the solar cell model with the structure of Glass/p-PEDOT:PSS or p- $\text{CuAlO}_2$  (HTL)/i-3D-MAPI/i-2D-MAPI/n-PCBM (ETL)/Ag. The fullerene derivative (6,6)-phenyl-C61-butyric acid methyl ester (PCBM) was used as an electron transporting material (ETM). Firstly, the optimised solar cell model was simulated with a p-type PEDOT:PSS layer. Secondly, PEDOT:PSS was replaced with  $\text{CuAlO}_2$  to observe its performance. The one-dimensional Solar Cell Capacitance Simulator (SCAPS-1D) has been used to model these solar cells under the AM1.5G solar spectrum. We have first obtained the results, with the power conversion efficiency (PCE) of 20.17%, open-circuit voltage ( $V_{\text{OC}}$ ) of 1.10 V, fill factor (FF) of 76.08%, and short-circuit current density ( $J_{\text{SC}}$ ) of 24.17  $\text{mA cm}^{-2}$ . After replacing  $\text{CuAlO}_2$ , the solar cell performance improved, with the PCE of 23.17%,  $V_{\text{OC}}$  of 1.14 V, FF of 84.07%, and  $J_{\text{SC}}$  of 24.17  $\text{mA cm}^{-2}$  since  $\text{CuAlO}_2$  has shown high shunt-resistant value than PEDOT:PSS. Consequently, the 3D/2D metal halide perovskite solar cell model with  $\text{CuAlO}_2$  has numerically shown better power conversion efficiency than the solar cell model with PEDOT:PSS since the low carrier recombination at the  $\text{CuAlO}_2$  layer (HTL).

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**Keywords:** Hole-transporting material, Perovskite-based solar cells, Power-conversion efficiency, Recombination, SCAPS-1D

**PHOTOMETRIC ANALYSIS OF ECLIPSING BINARIES IN THE REGION OF HYDRA CONSTELLATION BY USING TESS MISSION DATA**

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Eclipsing binaries provide more reliable and accurate samples for studying stellar evolution. In this study, we considered four W UMa type eclipsing binaries to determine their stellar parameters and the physical nature of each system. The photometric data of target stars, EG Hya, V0404 Hya, V0452 Hya and V0483 Hya, were obtained from the TESS mission. The Lightkurve python package is used to extract light curves from TESS full-frame images. The stellar parameters were obtained using the PHOEBE 1 program based on Wilson-Devinney code modeling until the minimum values of residuals were obtained. We determined that all the stars had periods between  $0.61139 \pm 0.00001$  to  $0.29660 \pm 0.00009$  days, where EG Hya and V452 Hya have the highest and the lowest values, respectively. V0404 Hya and V0483 Hya recorded  $0.3096 \pm 0.0003$  and  $0.4075 \pm 0.0003$  days for the period of eclipses, respectively. Considering the mass ratio  $q$  of each system EG Hya and V0483 Hya had the lowest mass ratios of  $q = 0.1256 \pm 0.0002$  and  $q = 0.1058 \pm 0.0004$ , respectively, while V0404 Hya and V0452 Hya had the highest mass ratios of  $q = 0.5625 \pm 0.0006$  and  $q = 0.566 \pm 0.002$ , respectively. Depending on the value of the fill-out factor ( $f$ ), a totally eclipsing binary system EG Hya ( $f = 7.23\%$ ) and V0452 ( $f = 0.18\%$ ) were found to be marginal contact binaries, and V0404 Hya ( $f = 46.49\%$ ) and V0483 Hya ( $f = 14.58\%$ ) were identified as over-contacting binary systems. Further, system parameters such as inclination and effective temperatures were derived, and the physical model of each system was discussed.

**Keywords:** Lightcurve modeling, Marginal-contact binaries, Over-contact binaries, Wilson-Devinney



**METAL-ORGANIC FRAMEWORKS (MOF) SYNTHESISED FROM MONOMERS DERIVED FROM POST-CONSUMER POLY(ETHYLENE TEREPHTHALATE) BOTTLES**

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Metal-Organic Frameworks (MOFs) are organic-inorganic hybrid crystalline porous materials with a high surface area consisting of a regular array of positively charged metal ions connected by organic linker molecules. This study describes the synthesis of an aluminium-based MOF using bis-(2-hydroxyethyl terephthalate) (BHET), which has not been reported as a linker material to synthesise MOFs before. BHET was obtained by glycolysis of post-consumer polyethylene terephthalate (PET) bottles by reacting with ethylene glycol, followed by recrystallisation. The glycolysed product of PET bottles, BHET, was characterised using melting point, Fourier Transform Infra-red Spectroscopy (FTIR) and Powder X-ray Diffraction (PXRD) techniques. The synthesis of MOF was carried out by solvothermal method using different aluminium salts and BHET. The synthesised MOF was characterised using FTIR and PXRD techniques. The results of FTIR and PXRD analyses confirmed the formation of BHET as the glycolysed product of PET bottles, and synthesised MOF has a similar structure with MIL-53(Al) MOF. Further, it was found that the reaction between the linker BHET and the salt, Al (OH)<sub>3</sub>, results in the formation of the MIL-53(Al) MOF out of the tested aluminium salts. These results indicate that BHET obtained by recycling the post-consumer PET bottles by glycolysis can be used as a linker material to synthesise the MIL-(53) Al MOF.

**Keywords:** BHET, Glycolysis, MIL-53(Al), MOF, Poly(ethylene terephthalate)

## **CONSTRUCTION OF IONISATION CHAMBER TO DETECT ALPHA AND BETA PARTICLES**

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Ionising radiation cannot be observed directly with the naked eye. Therefore, there are various types of detectors available to detect them. An ionisation chamber is the simplest form among the gaseous detectors that can be constructed using inexpensive and readily available materials. The main objective of this research was to build an ionising chamber that can be used in the laboratory to detect alpha and beta particles separately—the design comprised of two components, so-called the detector segment and the measuring segment. The detector segment was constructed using an outer cylinder (anode) and an inner rod (cathode) made of aluminium. Two Teflon insulators were used to separate the electrodes at one end, and the other was kept open. Air at atmospheric pressure was used as the ionisation medium, and an external voltage was applied between the two electrodes. The measuring segment is comprised of a preamplifier and a current/voltage meter. A differential amplifier with four Darlington transistors was used along with an ARDUINO Uno microcontroller board and a voltage sensor to amplify and measure the output voltages from the detector segment. The ARDUINO board was connected to a computer interfaced program to obtain the real-time plot for quantitative analysis. Americium-241 (Am-241), Cesium-137 (Cs-137), and Strontium-90 (Sr-90) radiation sources were used to determine the ionisation region that the ionisation chamber operates and to identify alpha and beta particles by measuring their relevant output voltages over the same period. The ionisation region of the constructed chamber was found to be above the input voltage of 18 V. Background radiation was identified in the form of small fluctuations in the output voltage. The detection of beta particles was done using the radiation sources Cs-137 and Sr-90 where, Cs-137 is both a beta and gamma emitter, while Sr-90 is a pure beta emitter. The obtained output voltage due to the Cs-137 source increased very slightly (~0.05 V), while no significant increase was observed for Sr-90 with respect to the background radiation. This was mainly due to the low activity of Sr-90 compared to Cs-137 sources available at the laboratory. The detection of alpha particles was carried out by using the strong alpha emitter, Am-241. Output voltage due to this source had a significant increase of ~1.00 V compared to the background radiation. This is due to the high ionisation capability of alpha particles compared to beta particles. Hence, the study implies that the output voltage pulses from the constructed ionisation chamber can qualitatively identify alpha and beta particles.

**Keywords:** Alpha particle, Beta particle, Cosmic radiation, Ionisation chamber

**SCALE-UP OF ACID LEACHING PROCESS FOR VEIN GRAPHITE  
PURIFICATION: APPLICATION FOR LITHIUM-ION BATTERIES**

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With the rapid development of electrochemical energy storage systems, vein graphite has received significant attention as an anode material for Lithium-Ion Batteries (LIBs) due to enhanced power and energy density while maintaining excellent cycling stability in LIBs. The recently patented optimised acid leaching method is one of the well-identified methods for developing natural vein graphite (Sri Lankan Patent: 18729). However, this finding is based on a study conducted using a small sample (< 5.0 g), far less than industrial-scale production of battery anode materials. The present study investigates the feasibility of scaling up the acid leaching method used to purify the vein graphite at the laboratory level before designing an industrial-scale pilot plant. Varying ratios of graphite: acid weight and unit operations parameters were considered to obtain the optimum performance. The Carbon Content (CC) analysis and X-ray diffractogram obtained on the raw and purified scaled-up graphite samples successfully eliminated impurities while improving the CC by more than 99%. The electrochemical characterisation was carried out by assembling purified scaled-up graphite anode/LiPF<sub>6</sub>/Li cell configuration with CR 2032-coin cell type. Galvanostatic charge-discharge analysis of the LIB coin cells assembled with the scaled-up upgraded graphite as the anode material revealed a high and stable initial specific discharge capacity of 340 mA h g<sup>-1</sup> with high Coulombic efficiency of over 97%. Cyclic voltammetry and electrochemical impedance spectroscopy analysis revealed smooth diffusion and lithiation-delithiation process of Li-ion, an acquiescent formation of solid electrolyte interface and structural stability of scaled-up developed graphite anode materials by acid leaching method. The scale-up process in the laboratory shows similar results, despite the significant volumetric scale-up and slight differences of apparatus. Choosing the correct scale for the scale-up is crucial, and the process should be closely integrated into a multidisciplinary approach before designing the industrial-scale pilot plant.

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**Keywords:** Acid leaching, Anode of lithium-ion battery, Scale-up, Vein graphite

**NON-DESTRUCTIVE ULTRASONIC METHOD FOR DEFECT DETECTION IN  
WOODEN RAFTERS**

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Most ancient buildings in Sri Lanka are wood-framed. The wood components of antique buildings deteriorate with age. Insects and rapid changes in humidity are two of the most common causes of deterioration. Non-destructive testing (NDT) methods are required to preserve the wood components in old buildings. Various NDT methods such as X-ray, drilling resistance test, stress wave, and ultrasound are used to inspect the safety of antique wooden buildings. Among them, ultrasonic testing is simple, accurate, and inexpensive. Rafters are one of the main important components of antique buildings and are severely deteriorated. The main objective of this study was to develop a quantitative ultrasonic test methodology for detecting internal defects in wooden rafters of ancient wooden buildings. In addition, this study aimed to assess and evaluate the wood qualities such as acoustic velocities along longitudinal, radial, and tangential directions of wood and the modulus of elasticity (MoE) of wooden materials. Applying the ultrasonic test directly is challenging because of the connection between wooden parts or the contacted or hidden part by a wall or ceiling or other construction materials. Hence, an indirect ultrasonic testing method was required. Therefore, it was proposed to conduct ultrasonic tests with a newly developed prototype of an ultrasonic system. It is hard to make an artificial defect on the wooden rafter and quantify the amount of deterioration. Hence, a simple artificial slit was considered as an indicator of the deterioration. Regression models were proposed to describe the relationship between the artificial deterioration of the specimen and ultrasonic parameters. Time of flight amplitude (TOF-a), maximum amplitude, time of flight energy (TOF-e), energy value (EV) and pulse length (PL) were considered as the ultrasonic parameters. Ultrasonic parameters of the received ultrasonic signals were analysed using LabVIEW software. Correlation analysis of each ultrasonic parameter and the artificial slit depth showed that TOF-e and PL were proper ultrasonic parameters to predict the size of defects in wooden rafters. Multiple linear regression analysis was performed using TOF-e, PL and the artificial slit depth to establish a prediction equation. The established prediction equation showed a coefficient of determination of 0.77 for the wooden material of Teak. Therefore, the method was found to be effective to evaluate the deterioration in wooden rafters.

**Keywords:** Internal defects, MoE, Rafter, TOF (time of flight), Ultrasonic testing

**EVALUATION OF RADIATION SAFETY PROGRAMMES IN NUCLEAR  
MEDICINE FACILITIES IN SRI LANKA**

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Ionising radiation is vastly used in imaging and therapeutic fields in Nuclear Medicine (NM), where unsealed sources are used. The establishment of radiation protection is of paramount importance in these facilities for the safety of radiation workers, patients, and caretakers. Unintended exposure to ionising radiation and radioactive contamination can be possible if the radiation protection mechanism is not followed correctly. Although NM facilities in Sri Lanka are regulated, incidents occur due to a lack of radiation protection rules and guidelines locally and negligence and carelessness of employees. This study aimed to evaluate the existing radiation safety programmes and practices in NM facilities and then identify the gaps by comparing them with national and international standards to provide recommendations. Occupational exposure, medical exposure, public exposure, radioactive waste management, mitigation and prevention of accidents and safety of transport of radioactive materials are discussed. First, requirements and guidelines in the national and international standards were identified, and a sample radiation protection programme (RPP) was prepared. Secondly, facilities were visited to identify existing RPP. Two questionnaires were launched to collect data from medical practitioners, medical physicists, radiation protection officers (RPO), nurses and technologists in seven NM facilities in government and private hospitals and universities. The data were compared with prepared RPP. All facilities adhered to fundamental requirements. However, in facilities, essential needs such as local written rules, health surveillance, allocation of RPO's responsibilities, training for radiation staff, and maintenance of logbooks were not according to the guidelines. Accordingly, establishing a proper management system with a written RPP is recommended with special emphasis on the following: assigning responsibilities, preparing local rules written in all three languages, establishing a documented emergency plan, introducing proper radioactive waste management protocols, and developing a safety culture.

**Keywords:** Nuclear medicine, Protection officer, Radiation, Radiation Protection Programme

**IMPACT OF TEMPERATURE ON ACCURACY OF DRY RUBBER CONTENT MEASUREMENT AFFECTING THE MANUFACTURING PROCESS AND QUALITY OF CREPE RUBBER**

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Sri Lanka is the largest manufacturer and exporter of natural crepe rubber in the world. Dry rubber content (DRC) measurement of natural rubber latex is critical in the crepe rubber manufacturing process. It is used as the guide for standardising the latex and determining the quantity of sodium bisulphite added for the fractionation process. Currently, the DRC is measured through a density calculation using a hydrometer on a sample of diluted field latex. The hydrometer reading is compared with a standard chart published by the Sri Lanka Standards Institute and Rubber Research Institute of Sri Lanka (RRISL). This chart is based on a standard temperature of 29 °C. However, since the temperature has an inverse relationship with density, it affects the DRC value calculated. Incorrect DRC measurement leads to incorrect chemical dosages, improper standardisation, enhancing rubber wastages, and long process times. These result in inferior quality in the final crepe rubber sheets leading to rejections and price drops in the export markets and lower output yield impeding the returns for the manufacturer. This study focuses on the significance of accompanying the temperature with the current measurement method when calculating DRC. The error in measured DRC was calculated for a series of diluted field latex samples of different temperatures based on a temperature-corrected DRC chart by Kudaligama et al. The calculations indicated a significant error component involved in the DRC measurement using the standard chart when temperature variation in the field latex was considered. Due to this error component, DRC is underestimated for temperatures below 29 °C and overestimated for temperatures above 29 °C; with maximum error percentages of approximately 14% at 24 °C and 11% at 32 °C. Hence, this study strongly recommends accompanying a temperature measurement with the hydrometer reading and referring to the temperature-adjusted DRC chart instead of the standard chart. The adverse consequences of erroneous DRC measurements are further discussed, including a quantitative analysis of rubber wastages at different temperatures.

**Keywords:** Crepe rubber, Dry rubber content, Field latex, Temperature

**FUTURE ONSET OF DECELERATION OF THE EXPANDING UNIVERSE**

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The expansion of the Universe is one of the most important topics of discussion in cosmology. When the Universe is expanding, the expansion rate will change with cosmic time either through acceleration or deceleration. Hence, those changes can be discovered by using experimental data. Otherwise, it can be used as a suitable mathematical model related to the expansion of the Universe. The main purpose of this study is to explain the expansion of the future onset of deceleration with cosmic time. Robertson Walker metric and Einstein's field equations were used as major equations to obtain the relevant expressions. Non-vanishing Christoffel symbols and Ricci tensor components were obtained by using the Robertson Walker metric. Then, two independent equations with four unknown variables were obtained using modified Einstein's field equations. Here, the pressure of the Universe is considered to be zero (zero models) as the matter is distributed to space with the big bang. Moreover, the Universe is assumed to continue as a spherical shape throughout the expansion. All the calculations depended on four-dimensional space-time coordinates. Three boundary conditions were used to support calculations. The appropriate model solution of  $R$  (radius of the Universe) was used to explain the main objective of this study. The variation of expanding rate of the Universe graph was plotted using the second derivative of the model. Then, cosmic time of future onset of deceleration was obtained when  $\ddot{R} = 0$ . According to the calculations, the future deceleration of the expanding Universe will start from  $1.85 \times 10^{16}$  s (0.58 billion years) after the present epoch. Thus, the deceleration in the present, past and future can be explained using this model. The Supernovae observations are the evidence to verify this graphical explanation.

**Keywords:** Einstein's field equations, Expansion of the Universe, Onset of deceleration, Robertson Walker metric

**THERMOELECTRIC PROPERTIES OF COMMERCIAL ZINC OXIDE AND ALUMINIUM DOPED ZINC OXIDE**

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Most of the available machinery at operation generates excess heat, and hence a significant amount (around 66%) of the input fuel energy is wasted as heat. Therefore, waste heat recovery technologies such as thermoelectric generators are important to increase their overall energy efficiency. Thermoelectric generators are considered reliable technology that directly converts thermal energy into electrical energy. These devices are generally fabricated using alternative arrangements of suitable p-type and n-type semiconductors electrically in series and thermally in parallel. Zinc oxide (ZnO) is an inorganic n-type semiconductor that has received a great deal of attention to realise a high-temperature thermoelectric generator. In the present study, thermoelectric properties of pellets prepared using commercial ZnO and aluminium doped ZnO were observed at relatively lower temperatures. For this purpose, Al-doped ZnO was synthesised using a new chemical method. The successful synthesis of ZnO hexagonal wurtzite phase and doping were confirmed using powder X-ray diffraction pattern (JCPDF-01-079-0205). Pellets of synthesised Al-doped ZnO and commercially available ZnO powder were prepared at an applied uniaxial (non-isostatic) pressure of 295 MPa, which was lower than the pressures used in the literature, and their individual thermoelectric properties were observed at lower temperatures. The findings of this study are the synthesis method, low-pressure palletisation using wet ZnO and the generation of relatively high potential difference at low temperatures. The electrical conductivities of commercial ZnO and Al-doped ZnO were  $31.3 \text{ S m}^{-1}$  and  $35.6 \text{ S m}^{-1}$  (at 373 K). The thermal conductivities of these materials were  $2.38 \text{ W m}^{-1} \text{ K}^{-1}$  and  $1.40 \text{ W m}^{-1} \text{ K}^{-1}$  (at 373 K), respectively. Both materials showed negative Seebeck coefficient values of  $-165 \mu\text{V K}^{-1}$  and  $-225 \mu\text{V K}^{-1}$ , respectively, indicating the n-type semi-conductive behaviour. The dimensionless parameter figure of merit (ZT) characterises a material's ability to convert thermal energy into electricity. The ZT for ZnO and Al-doped ZnO were  $1.34 \times 10^{-4}$  and  $4.80 \times 10^{-4}$  (at 373 K), respectively. Commercial ZnO and Al-doped ZnO generated a potential difference of 14.9 mV and 19.9 mV, respectively, at a 90 K temperature difference across the hot and cold ends.

**Keywords:** Renewable energy, Seebeck effect, Semiconductors, Thermoelectricity



**NANO-STRUCTURED TiO<sub>2</sub>-B FOR LITHIUM-ION BATTERY APPLICATIONS**

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Many researchers have investigated electrode materials for the lithium-ion battery (LIB) industry in the past decade. Among them, titanium dioxide (TiO<sub>2</sub>) has attracted a great deal of attention due to its excellent properties, such as high operating potential, chemical and mechanical stability. However, the poor electrical conductivity and low ionic diffusivity are the main obstacles that hinder the production of high-performance LIBs with Titanium anodes. These drawbacks can be minimised by adding (a) conductive additives, (b) controlling the morphology, respectively. This work presents an extensive study of the TiO<sub>2</sub>-B nanobelts-based electrode with the reduced graphene oxide (rGO). As a conductive additive, rGO (~5 layers) was synthesised using Modified Hummer's method. The optimum hydrothermal temperature for growing TiO<sub>2</sub> nanobelt was noted as 176 °C. The length of the synthesised TiO<sub>2</sub>-B nanobelt was between 410 nm & 15 µm with an average width of 45 nm. The electrochemical performance of the TiO<sub>2</sub>-B/rGO composite anode was tested using constant current charge/discharge studies in the potential range of 1.0 – 3.0 V vs Li/Li<sup>+</sup>. The first discharging and charging capacities were 177.2 and 138.9 mA h g<sup>-1</sup>, respectively. The second discharge and charge capacities were 142.7 and 137 mA h g<sup>-1</sup>, respectively. The composite anode material of LIB's shows low cyclic performance and retained a low discharge capacity of 112 mA h g<sup>-1</sup> over 80 cycles, which is a significant capacity loss. A possible capacity fading mechanism will be discussed.

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**Keywords:** Hydrothermal temperature, Lithium-ion battery (LIB), Reduced graphene oxide(rGO), TiO<sub>2</sub>-B

**CHEMICAL REDUCTION OF GRAPHENE OXIDE USING L-ASCORBIC ACID**

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Chemical oxidation-reduction is one of the most promising and cost-effective methods for bulk production of reduced graphene oxide (RGO). The oxidation step causes the exfoliation of graphite to obtain graphene oxide (GO). The reduction process with several washing steps eliminates residual oxygen functional groups and metallic precipitates. The reduction procedure of GO significantly affects the structure as well as the morphology of RGO. In the reporting case, Sri Lankan natural graphite in powder form was used as starting material. The Hummers method with some modifications was used for the oxidation of graphite. During the oxidation process, ultrasonic treatment was carried out to peel off the oxidised outer graphite layers, allowing inner layers to undergo oxidation. The reduction process of GO was carried out at 95 °C for different time durations from 0.5 to 2.0 h using L-Ascorbic acid as the reduction agent. The surface morphology of products was studied using scanning electron microscopy (SEM), and structural analysis was done using powder X-ray diffraction (PXRD), Raman spectroscopy, and X-ray photoelectron spectroscopy (XPS). XPS analysis reveals that carbon to oxygen atomic ratio (C/O) decreases after oxidising graphite into GO from 23.4% to 2.3%. PXRD and Raman analysis exhibit the emergence of turbostratic disorder of layers and an increase in the level of disorder in GO compared to graphite. The minimum level of disorder and maximum crystallinity was exhibited by the GO sample reduced for 1.5 h. Compared to the GO sample, the RGO sample reduced for 1.5 h showed an increased C/O ratio (8.5%) and decreased d-spacing (3.62 Å), implying the elimination of some residual oxygen functionalities after the reduction step.

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**Keywords:** L-Ascorbic acid, Reduced graphene oxide, Reduction time, Structural study, Vein graphite

**EFFECT OF SEED LAYER ON MORPHOLOGY ENHANCEMENT OF CHEMICAL BATH DEPOSITED ZnO NANOWIRES FOR GAS SENSING APPLICATIONS**

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Metal oxide (MO<sub>x</sub>) semiconductor has stirred great attention in the gas sensors in the past decades due to the high sensitivity, fast recovery, low working temperature, and low cost. Nanowire-based MO gas sensors which possess a higher surface-to-volume ratio result in higher sensitivity and higher response to the chemical gases. However, it is crucial to synthesise long, thin MO<sub>x</sub> nanowires with uniform morphology to have superior sensing performance throughout the substrate. The chemical bath deposition (CBD) technique is a widely used technique to synthesise metal oxide nanostructures due to its relatively low-temperature growth conditions (< 100 °C), low cost, and scalability in the deposition. When considering the CBD technique, the seed layer is a significant concern for the well-growth of nanowires. Here, ZnO nanowires were grown on ZnO seeded silicon substrates, using the mixture of Zn(CH<sub>3</sub>COO)<sub>2</sub> and monoethanolamine as the initial solution. The study aims to obtain a uniformly distributed seed layer and understand the effect of seed layer thickness on nanowire formation. ZnO nanowires were synthesised on a seeded glass substrate via CBD. Two different samples were deposited using (a) spin-coated and (b) spray-coated seed layers before carrying out low-temperature CBD. An absorption edge at 378 nm, which corresponds to the ZnO nanoparticles, was observed in the UV-visible spectra of both the spin-coated and the spray-coated seed layers. Synthesised NWs showed an absorption edge at 376 nm, confirming the presence of ZnO NWs. The SEM images show that the spray-coated seed layer was uniformly distributed throughout the surface compared to the spin-coated. After the CBD process, the nanowires grown on the spray-coated substrates were well-aligned compared to those grown on the spin-coated seed layer. Nanowires with the spin-coated seed layer were not uniformly distributed, and random clusters were found to have formed on the top of the nanowires. Therefore, the spray-coated seed layer was selected as the better method. Seed layer thickness is a major factor for the formation of vertically aligned nanowires. Thus, the number of layer stacks of the spray-coated seed layer was optimised. The obtained SEM images reveal that nanowires grown on top of 10 layers of spray-coated seed were vertically well oriented throughout the surface compared to the nanowires grown on the surface with five and eight layers of spray-coated seed.

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**Keywords:** Chemical bath deposition, Gas sensors, Metal oxide-based gas sensors, Seed layer, Spray coating

**SIMULTANEOUS KINETICS AND RING-DOWN (SKaR) IN A PULSED UNIFORM SUPERSONIC LAVAL FLOW- KINETICS OF THE REACTION  $\text{CN}(v=1) + \text{O}_2$**

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We report the development of a new apparatus that combines cw-cavity ringdown spectroscopy with a pulsed Laval flow (UF-CRDS). This is related to the CRESU (a French acronym for Reaction Kinetics in Uniform Supersonic Flows) technique, developed in France to study reaction kinetics at low temperatures. Cavity ringdown spectroscopy (CRDS) is a highly sensitive absorption technique relying on the decay of light between two high reflectivity mirrors of a cavity. For time-independent absorbing samples, the enhanced rate of power loss compared to the empty cavity leads to faster exponential decays. When the concentration of the absorbing species changes on the empty cavity ringdown time scale, non-exponential decays result, for which the instantaneous decay rate in excess of the empty cavity reference case provides a time-resolved measure of the sample absorbance. The long hydrodynamic time of the flow provides uniform temperature and pressure conditions well-matched to kinetic ringdown measurements in the time regime from 10 – 300  $\mu\text{s}$ . This simultaneous kinetics and ringdown (SKaR) technique are coupled with a uniform flow for the first time. We will be reporting the design and operation of the newly developed UF-CRDS instrument and the rate constants measured for the reaction of  $\text{CN}(v = 1)$  with  $\text{O}_2$  at 70 K and 24 K obtained with this approach.

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**Keywords:** Cavity ringdown, Gas-phase reactions, Laval-flow, Photochemistry, Reaction kinetics

**DEMOGRAPHIC FACTORS AFFECTING THE USE OF ICT IN TEACHING  
LEARNING PROCESS AMONG UNIVERSITY TEACHERS**

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The appropriate use of Information and Communications Technology (ICT) in teaching and learning has been challenging for many higher educational institutes during the COVID-19 pandemic. The study examined the demographic factors that influence the adoption and integration of ICT to enhance the university teaching and learning process. The study adopted a cross-sectional survey design. Data was obtained from academics at the Eastern University of Sri Lanka (EUSL) *via* a paper-based quantitative survey. Respondents were selected based on a convenience sampling method. Structured questionnaires were distributed among academics in different faculties. Out of 180 questionnaires, 155 were valid for data analysis, representing a response rate of 86%. ICT adoption in teaching and learning, the dependent variable, was not normally distributed. Therefore, non-parametric tests were used to conduct the analysis. The results revealed that gender ( $z = -1.046, p = 0.296$ ) and age ( $\chi^2(3) = 5.927, p = 0.296$ ) did not influence university teachers' adoption and integration of ICT. However, educational qualification ( $\chi^2(3) = 8.293, p = 0.040$ ) and teaching stream ( $\chi^2(5) = 14.351, p = 0.014$ ) significantly influenced the university teachers' adoption and integration of ICT. The pairwise comparison revealed a significant difference in ICT use in teaching and learning among those holding a bachelor's degree and a doctorate as their highest educational qualification. Teachers with doctoral degrees adopted ICT better than the other degree holders. There is a significant difference in the adoption of ICT between the Academics who teach Science and Fine Arts. Academics who teach Information Technology (IT) claimed that they use ICT more extensively in teaching and learning than other academics. The survey results show that upgrading educational qualifications would increase the quality of teaching practice of academics, thus incorporating ICT into the teaching and learning process to meet the current needs. Therefore, it is of great importance to improve academics' attitudes towards ICT across all faculties.

**Keywords:** Demographical factors, ICT, Teaching Learning Process

**CO-CREATION EXPERIENCE OF A POSTGRADUATE PROGRAMME: CASE OF MASTERS PROGRAMME ON BUILDING RESILIENCE IN TROPICAL AGROECOSYSTEMS**

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The co-creation approach increasingly becomes the preferred model for designing and delivering solutions with the participation of a knowledgeable community. This study describes a co-creation experience with academia, industry stakeholders and policymakers from agroecosystem setting in designing a Master programme on tropical agroecosystems with the objectives of identifying stakeholder landscape, a co-design a platform and co-create the framework for the planned Master degree programme in tropical agroecosystems. The co-creation process was initiated with a comprehensive literature review followed by several consultations with both European and Sri Lankan partners to develop the framework. Subsequently, an online co-design workshop with the participation of 38 key industry-academia stakeholders was held. Purposive and snowball sampling techniques were used to ensure the inclusion of key participants in the co-creation platform. Co-creation of the Master programme began with the comprehensive literature review of the consortium's academic experts, which facilitated recognising the key thematic areas directly and indirectly in line with tropical agroecosystems. Secondly, two focus group discussions among the consortium members facilitated the laying of the programme structure and identifying program objectives (POs), intended learning outcomes (ILO) and modules, both compulsory and optional. A concept note on programme framework including objectives, intended learning outcomes and modules were developed and shared among the identified stakeholders and was allocated two weeks for review before the co-creation online workshop. Thirdly, an online co-creation workshop on curriculum design was implemented through the Zoom online platform. The stakeholder landscape of the co-creation of the Master programme was developed based on the information derived from the participants. The co-design workshop formed the basis for refining the framework of the Master programme, which comprised objectives, PLOs, ILOs and course modules.

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**Keywords:** Agroecosystem, Co-design, Master programme

**EFFECTIVENESS OF USING DOCUMENTARIES IN TEACHING ENVIRONMENTAL BIOLOGY FOR G.C.E. A/L BIOLOGICAL SCIENCE STUDENTS IN THE BATTICALOA EDUCATION ZONE, SRI LANKA**

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As future decision-makers, the students should be provided with knowledge, skills and attitudes to involve them in environmental protection and sustainable development. This study investigated the effectiveness of using documentaries in teaching Environmental Biology for G.C.E (A/L) Biological Science students in the Batticaloa Education Zone in Sri Lanka. The objectives of the study are to determine the level of environmental knowledge, attitudes and practices and investigate the effectiveness of using documentaries in teaching Environmental Biology. Eighty students of Grade 13 from three schools were selected. Pre- and post-test papers were used to test knowledge, and a structured questionnaire was used to test their attitudes and practices. Documentaries were prepared as teaching aids for two subsections of unit eight for the experimental group. The control group was taught using the traditional lecture method. The data were analysed using descriptive statistics, Mann-Whitney, Wilcoxon signed ranks tests and Pearson correlation in SPSS. Pre-test marks revealed ( $39.1 \pm 1.1$ ) a low level of knowledge in Environmental Biology among the student sample. In the pre-test, the mean percentage score of students' environmental attitudes and environmentally friendly practices were  $57.9 \pm 1.8$  and  $58.3 \pm 1.8$ , respectively. In the post-test, the students of the experimental group scored higher ( $77.6 \pm 1.9$ ) than the control group ( $55.7 \pm 1.4$ ). The knowledge gained by female students was higher than male students. The knowledge on Environmental Biology was not correlated with students' attitudes on the environment ( $r = 0.00$ ) but showed a low positive correlation with environmental practices. However, environmental attitudes and practices showed a high positive correlation ( $r = 0.83$ ). The study concluded that documentaries could be an effective tool in teaching Environmental Biology lessons at G.C.E (A/L) to enhance students' knowledge of the subject.

**Keywords:** Attitudes, Documentaries, Environmental Biology, Knowledge, Practices

**CYBERSECURITY AWARENESS AMONG UNDERGRADUATES: CASE STUDY OF ARTS UNDERGRADUATES AT THE UNIVERSITY OF COLOMBO**

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Over the past months, the Covid-19 pandemic has increased internet usage. Sri Lankan students are compelled to depend on the internet in schools and universities as the teaching-learning scenario is entirely or partially online. These circumstances make an understanding of cybersecurity mandatory for students and teachers to ensure their security. This quantitative study explores cybersecurity awareness and various vulnerabilities faced by new entrants to the Faculty of Arts, the University of Colombo, in 2021. The questionnaire was forwarded to all new entrants through the Learning Management System. The data were analysed using Microsoft Excel and SPSS. A majority of the sample (58%) lacked cybersecurity awareness, and there was no significant difference by gender ( $p = 0.364$ ). Awareness was dependent on factors such as residence (only western province shows more than 50% of awareness), time spent on the internet per day (*correlation coefficient* = 0.788), experience in using the internet (*correlation coefficient* = 0.976), socio-economic standing (*correlation coefficient* = 0.887). The study shows that students become more vulnerable due to unsecure practices adopted during internet use and ignorance of and lack of attention paid to most updated cyberattacks as significant occurrences that concern activities in cyberspace. Even though the reports of international cybersecurity list Sri Lanka to be one of the most vulnerable countries in South Asia, the number of reported incidents to the Sri Lanka Computer Emergency Readiness Team is very low compared to other countries in the South Asian region (481 in 2020 without social media incidents). The present study points to privacy concerns and a lack of awareness of cyberattacks and reporting procedures (71.4%), resulting in underreporting. The findings emphasise the need to improve cybersecurity awareness among university students in Sri Lanka to ensure security in a rapidly changing virtual teaching-learning scenario.

**Keywords:** Cyberattacks, Cybercrime, Cybersecurity awareness



**SATISFACTION OF E-LEARNING DURING THE COVID-19 PANDEMIC: CASE STUDY OF UNIVERSITY COLLEGE OF JAFFNA, SRI LANKA**

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Due to the COVID-19 pandemic, all educational institutes were switched from traditional classroom teaching to e-learning. Switching to e-learning ensures that the students carry out the learning process continuously without disturbances. E-learning facilitates the exchange of knowledge and information between students and teachers. The study aimed to analyse the satisfaction of e-learning in teaching and learning during the COVID-19 pandemic. The study was conducted among National Vocational Qualification (NVQ) Level 6 students and the University College of Jaffna (UCJ) teachers. The volunteer sampling method was used to gather data. Online questionnaires were sent electronically to 135 participants (110 students and 25 teachers). Of them, 91 participants (18 teachers and 73 students) responded to the survey. The online questionnaires consisted of both Likert scale and open-ended questions. The Statistical Package for Social Sciences (SPSS) version 24 was used for data analysis. The correlation analysis was used to examine the association between the independent variables (internet speed, awareness of LMS, LMS access, learning practical skills, submitting assessments, students' interest, accessing e-learning tools, teaching practical skills and conducting assessments) and dependent variables (student's satisfaction, teacher's satisfaction). According to the results, 71.2% of students claimed that teachers used only Moodle as an effective tool in e-learning and teaching, while 24.7% of students claimed that a combination of tools (Moodle, social media, Google Classroom) was used by teachers as an effective tool in e-learning. Further, the study investigated students' and teachers' satisfaction in e-learning. Based on the results, only 15.1% of students and 16.7% of teachers satisfied with the e-learning approach. Approximately 50% of students and teachers were not satisfied with e-learning. Based on the correlation analysis, internet speed at home, awareness of LMS, and LMS access at home have significant associations with student's satisfaction ( $r = -0.359, 0.385$  and  $0.455$ , respectively and  $p < 0.05$ ). Learning practical skills and submitting assessments have no significant association with students' satisfaction ( $r = 0.043$  and  $0.221$ , respectively and  $p > 0.05$ ). Students' interest, accessing e-learning tools at home, and teaching practical skills have significant association with the teachers' satisfaction ( $r = 0.503, 0.517$  and  $-0.573$ , respectively and  $p < 0.05$ ). Conducting assessments had no significant association with teacher satisfaction ( $r = 0.078$  and  $p > 0.05$ ). The study reveals that students' and teachers' satisfaction need to be improved in e-learning. Therefore, it is important to conduct training programs and improve other support to enhance the status of e-learning.

**Keywords:** E-learning, E-learning tools, students' satisfaction, teachers' satisfaction, Teaching-learning

**RELATIONSHIP BETWEEN TALENT IDENTIFICATION METHODS USED BY LEVEL ONE QUALIFIED TRACK AND FIELD COACHES' AND 100 M SPRINTING MALE ATHLETES' PERFORMANCE IN SRI LANKA**

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This study focused on the talent identification (TI) methods that are used by coaches to identify the right talent at the real stage of the athletes. The current study focused on five TI methods which include physiological, anthropometrical, psychological, sociological, and biological and their components. Other countries had investigated the gap between the TI methods which are used by coaches to identify athletes' performance and athlete's performance based on TI methods. However, literature on TI research in the Sri Lankan context is scarce. The main objective of the study was to identify the relationship between talent identification methods which are used by level one qualified track and field coaches' and their 100 m sprinting male athletes' (in the age group 18 – 25) performance in Sri Lanka. Sixty coaches who qualified of level one course for coaches were used as the study population. A questionnaire and interviews were used to gather information from the coaches. The study considered two variables in the analysis that are athletes' best running timing and five TI methods. The findings revealed that, physiological, anthropometrics and psychological methods were strongly but negatively correlated with the athletes' running time while sociological and biological TI methods were correlated moderately negative with the same. The results conclude that physiological, anthropometric, and psychological TI methods are successful in identifying talents of athletes compared to other two methods tested.

**Keywords:** Athlete, Coach, Talent Identification Method, Track and Field

**MISCONCEPTIONS IN MENDELIAN GENETICS AMONG G.C.E. (A/L)  
BIOLOGICAL SCIENCE STUDENTS IN THE BATTICALOA EDUCATION ZONE,  
SRI LANKA: SIMULATION AS AN EFFECTIVE TEACHING AID**

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Genetics is one of the difficult course modules for students in the G.C.E. (A/L) Biology curriculum. This study was designed to identify the misconceptions of G.C.E. (A/L) Biological Science students on basic concepts in Genetics and determine the effectiveness of simulations in teaching the unit Genetics. The study was carried out in Batticaloa Education Zone, Sri Lanka. A mixed-method approach was selected for this study. The data were collected from semi-structured interviews, pre-and post-tests. A two-tier multiple-choice instrument was used to diagnose misconceptions of students in Basic Genetics. The reliability of the instrument was determined with the use of Cronbach's alpha coefficient ( $\alpha = 0.71$ ). The samples consisted of 84 Grade 13 students from three selected schools and five biology teachers. Simulations of Mendel's genetics were used as a teaching aid for experimental groups, and the traditional method was used for control groups. The data were analysed using frequency counts, percentages, means and standard deviations in SPSS. Qualitative data were analysed using Grounded Theory. The results revealed that students possessed misconceptions on ten selected basic concepts in Genetics. Three concepts showed above 25% of misconceptions (gene: 46.4%, chromosomes: 31% and Punnett square: 29.8%) in the pre-test. The mean score of knowledge on Basic Genetics in students was  $24.7 \pm 13.1$  in the pre-test. In the post-test, the mean score of the experimental group (67.0%;  $SD = 14.9$ ) was significantly higher than the control group (51.4%;  $SD = 15.4$ ). In addition, the number of misconceptions was significantly lessened in students in the experimental group than in the control group. Misconceptions in the two selected concepts decreased effectively in the experimental group. The study revealed that simulations could effectively eliminate students' misconceptions in the unit Genetics for G.C.E. (A/L) Biological Science students.

**Keywords:** Mendelian genetics, Misconceptions, Simulations

**ANALYSIS OF G.C.E. (O/L) EXAMINATION RESULTS OF SCHOOLS IN  
MAWANELLA EDUCATION DIVISION**

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The General Certificate of Education (G.C.E) Ordinary Level (O/L) is conducted by the Department of Examinations of the Ministry of Education, Sri Lanka. This examination consists of six main subjects; First language, Religion, Mathematics, Science, English, and History, along with three elective subjects. This examination has become very competitive as it is a qualifying milestone for the G.C.E. Advanced Level (A/L), which determines the University entrance. The objective of the study is to analyse and identify the factors that affect the performance of students who sit the G.C.E. (O/L) examination. Of the 37 secondary schools in the Mawanella Division, Kegalle, 18 are classified as 1AB and the remaining as 1C. The examination results of all the secondary schools of the division from 2015 were used in the study. Among them, 26 schools were Sinhala medium, while 11 were Tamil medium. A student must earn at least six ordinary passes to pass the examination, including three credit passes. Preliminary analysis revealed that more than 40% of students failed the G.C.E. (O/L) examination. A chi-squared test for association indicated that the ability to pass the Language subject did not depend on the medium of delivery ( $\chi^2 = 1.273, p = 0.259$ ). However, there was a significant effect of the medium of delivery to pass other main subjects. Moreover, there was an effect on passing the English language for Sinhala- and Tamil-medium students ( $\chi^2 = 216.4, p < 0.001$ ). Further, there is an association between the type of school and the performance of the six main subjects. The odds ratios (OR) showed that the students of 1AB schools had a higher passing rate than the students in 1C schools ( $OR = 2.365$ ). The students who sat the G.C.E. (O/L) examination in the Tamil medium had a higher passing rate than those in the Sinhala medium ( $OR = 1.999$ ). Similar performances were noted in passing rates of individual subjects of Mathematics, Religion, Science and History. A Path Coefficient Analysis revealed a positive and significant correlation between overall results and the individual passing rates of main subjects. One of the key findings from the study includes a significant positive relationship between the passing of Mathematics and other main subjects. The result of this study is helpful for the decision-makers to identify the issues of the current education system and take remedial actions for the betterment of society.

**Keywords:** G.C.E. (O/L) Examination, Mawanella Division, Odds Ratio, Path Coefficient Analysis

**FACTORS AFFECTING THE SUCCESS OF ONLINE EDUCATION OF PHYSICAL SCIENCE STUDENTS IN THE KANDY EDUCATION ZONE**

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The current global pandemic situation has changed the teaching and learning environment of secondary education worldwide. The traditional classroom delivery method has been transformed into an online platform. The main objective of this study was to identify the online delivery methods that are popular among teachers and students, and the key factors that affect the success of online delivery. The data was collected using a self-administered questionnaire distributed among 219 Physical Science students from seven schools in the Kandy Education Zone where online lessons were conducted. The mode of online delivery, type of equipment used, gender, family income level and ownership of the equipment were the main factors explored in this study, which were identified based on a preliminary survey. A five-point Likert scale was used to measure the overall satisfaction of the online delivery. Of the four teaching methods used by teachers, the most popular method was presentations and live videos. Among the student population tested, 47% participated in more than 50% of online sessions while 33% in all sessions. Despite most male students having their own devices, female student participation in online sessions was significantly higher than the males. The overall satisfaction of the teaching-learning process was 52% (Male: 47%, Female: 56%), and there was a significant association between the level of satisfaction and gender. Overall, findings revealed that most students participated in lessons conducted by their schools *via* live videos and presentations. The level of participation in online classes and the satisfaction of the teaching-learning process are gender-dependent. The outcomes of this study can be used by the relevant authorities to improve the quality of the online teaching-learning process while addressing the difficulties faced by the student community.

**Keywords:** Learning environment, Online delivery methods, Student satisfaction

**CRITICAL EVALUATION ON CONDUCTING PRACTICAL SESSIONS OF  
G.C.E. A/L PHYSICS: CASE STUDY IN SABARAGAMUWA PROVINCE**

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Hands-on experience is beneficial for better understanding the theoretical concepts in Physics. Therefore, a practical component is included in G.C.E. (A/L) Physics syllabus in Sri Lanka. This research aims to evaluate the G.C.E. (A/L) process of conducting Physics practical lessons at schools in the Sabaragamuwa Province, Sri Lanka. Sixty-five schools (Grade - 1 AB) from the Sabaragamuwa Province were selected for the study. Data were collected through two questionnaires, one for teachers who taught Physics in G.C.E. (A/L) classes and another for the Grade 12 students who follow Physics as a subject in Biological or Physical Sciences streams. All schools considered in the study have separate Physics laboratories. Although laboratories are equipped with sufficient instruments and other resources, the support from the Laboratory Assistants was not satisfactory, thus considered a barrier for the teachers to conduct practical sessions in a productive manner. However, teachers were able to complete all the practical sessions in the syllabus within the two years though student participation was poor in the last two terms of Grade 13 classes. In addition, both teachers and students have a good perception of conducting practicals in school laboratories. Despite poor attendance, all students had the experience of performing laboratory experiments during the two years. Teachers motivated students by giving them a chance to perform missed practicals and correct students' practical reports. After conducting practicals in school laboratories, students demonstrated better knowledge, skills, and attitudes towards the subject. Both teachers and students were highly satisfied with the conduct of Physics practicals in schools of Sabaragamuwa Province. There was no relationship between the student gender and the satisfaction level of conducting Physics practicals in school laboratories. The study revealed that the necessary support needs to be improved further with the help of school administration on conducting Physics practicals to meet the stipulated educational goals through meaningful learning.

**Keywords:** G.C.E. (A/L), Laboratory Assistants, Laboratory Experience, Physics, Practical Camps

## **GUIDELINES TO CONSTRUCT AND VALIDATE LESSONS IN AUTHENTIC LEARNING PEDAGOGY**

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Authentic Learning Pedagogy (ALP) is presented as a solution to alleviate the learning gap between theoretical knowledge and its real-world application. In ALP, learners are provided with real-world situations that include constructing, acquiring, and researching knowledge and skills needed to solve complex problems. However, designing lessons in alignment with ALP is a challenging task. The objective of this study was to set guidelines to plan lessons in ALP and a rubric to benchmark the alignment of lessons to ALP. The guideline uses ten steps with underlying principles of ALP. The design guideline helps the lesson designers to construct a complex real-world context in which the student is placed in real-world professional roles where the student performs authentic, real-world tasks that produce unique real-world products. Learning happens intrinsically while performing the tasks and constructing real-world products. The lessons are assessed by the rubric, which uses three criteria: (1) Origin, (2) Complexity, and (3) Higher order thinking skills to check for alignment of lesson elements to the ALP. The design guideline was given to teachers involved in teaching science subjects from grades 6 to 13, and the developed lessons were assessed using the rubric. The benchmarking of lessons revealed that 60% of the lessons had guided recipe-type instructions, which is against ALP principles, while lessons developed with feedback had close alignment with ALP. Feedback from teachers revealed that they found it easy to use the design guideline in the preparation of lessons. However, teachers found difficulty in constructing authentic contexts, task sequences and products, mainly due to confusion regarding definitions of authentic context, authentic tasks, authentic products, and authentic assessments. Therefore, this study shows the need for assistance by lesson designers through feedback on the alignment of elements of lessons, including context, tasks, products, and assessments to the ALP.

**Keywords:** Authentic Learning, Constructivism, Context, Lesson-design, Rubric





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