FacSciResCon 2019

Faculty Research Congress 2019
Faculty of Science
University of Peradeniya
Peradeniya, Sri Lanka

Volume 1

10th May, 2019

MESSAGE FROM THE DEAN FACULTY OF SCIENCE

I am delighted to convey this message to the book of abstract of the Faculty Research Congress (FacSciResCon 2019). This congress is aimed at improving the academic standards, quality, competency and skills of the Bachelor's Degree students of the Faculty.

The Faculty Research Congress is structured through ten main disciplines, Botany, Chemistry, Environmental Science, Geology, Mathematics, Molecular Biology and Biotechnology, Physics, Statistics, Computer Science and Zoology. Seventy six abstracts are included in the book of abstracts and 24 of them have been selected for oral presentations. Of these, many are of value which could be further developed into innovative products, while others contribute to the development of knowledge in the field of Basic Sciences.

The undergraduate student community is a very important resource of the University. It is our responsibility to train and guide undergraduate students to enhance their creativity and innovativeness by imparting knowledge and inculcating skills so that they can face the challenges of the modern society. In this respect, the undergraduate research component is of crucial importance.

We hope that students will acquire important soft skills such as organization, leadership and communication skills and critical thinking through this exercise, in addition to learning how to carry out a successful research.

The University of Peradeniya is ranked as the number one University of the country, to which the research of the academic staff of the Faculty of Science contributes greatly. I wish all success for the FacSciResCon 2019, which is yet another opportunity for young researchers to present their research outcomes to the academic staff members who are eminent researchers and receive valuable feedback from them.

Prof. S.R. Kodithuwakku

Dean/Faculty of Science

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Phaseolus vulgaris L. (common bean) is a popular legume vegetable among Sri Lankans and is cultivated as a commercial crop. Horticultural Crops Research and Development Institute (HORDI) at Gannoruwa, Sri Lanka has introduced five new accessions of common bean, namely HO-1, HO-2, PB164, PB179 and Capri. The current study was carried out to compare and evaluate the shelf life, some nutritional aspects and susceptibility to postharvest fungal rots of the above five common bean accessions in comparison to a released variety, 'Gannoruwa green'(control). Postharvest keeping quality of bean pods harvested at commercial maturity was compared under tropical ambient conditions (at 27 ^{o}C and 40% RH) based on change in pod colour, reduction in freshness and development of rot using self-prepared scales. Percentage (%) fresh weight loss was assessed during storage. Powdered pod tissues were analyzed for crude protein content, antioxidant activity and crude fiber content. Accessions HO-2 and PB164 showed significantly ($P<0.05$) longer shelf life (7.83 and 7.75 days, respectively) vs. control variety (Gannoruwa green [4.96 days]). Fungal rot development (*Fusarium* sp.) was found to be the shelf life-determining parameter of the bean pods. HO-2 exhibited significantly higher (20.83 %DW) crude protein content, antioxidant activity and crude fiber content. Among the bean accessions tested, HO-2 could be considered to possess a better overall quality compared to the control variety Gannoruwa green and the other four accessions investigated in the current study.

Keywords: Common bean, shelf life, nutritional quality, Fusarium rot

A TAXONOMIC SURVEY OF MOSSES IN SOME SELECTED LOCALITIES IN SRI LANKA AND THEIR BIOGEOGRAPHIC AFFINITIES

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Sri Lanka is a tropical island blessed with a high level of topographic and climate heterogeneity, supporting a luxuriant growth of mosses. Mosses (Phylum Bryophyta) are the most speciose of the three phyla of bryophytes. Sri Lanka harbors about 560 species of enchanting mosses. But, the scarcity of literature sources and locality details hamper further research in the field of bryology. The present study was initiated to explore the biodiversity, taxonomy and biogeographic affinities of moss flora of some important localities, which are underexplored for mosses. Four localities were selected, including Horton Plains National Park, Loolkandura Conservation Forest, Kanneliya Forest Reserve and Badagamuwa Conservation Forest representing montane, sub-montane, tropical wet evergreen and tropical moist semi-evergreen forests respectively. Fresh samples of mosses were collected from the selected localities covering different climatic periods. The specimens were surveyed for morphological and anatomical characters and identified up to generic/specific level using latest taxonomic keys and monographs. Herbarium specimens were prepared according to Schofield (1985) method. Distribution maps were prepared using Arcmap and biogeographic affinities were traced. A total of 23 families, 46 genera and 63 species of mosses were identified during the study. The study identified three new species records to Sri Lanka: *Brachymenium capitulatum* (Mitt.) Kindb., *Ctenidium pinnatum* (Brth. & Paris) Broth. and *Fissidens crassinervis* var. *laxus* (Sull. & Lesq.) A. Eddy. More than 75% of species identified during the survey showed close affinities to India and Malaysia. The results of the present study will contribute to the much needed 'Moss Flora of Sri Lanka', while highlighting the necessity of conserving the microhabitats of the bryophyte flora of Sri Lanka.

Acknowledgement*: Authors wish to acknowledge the Department Wildlife and Forest Department of Sri Lanka for necessary permits.*

Keywords: Bryophytes, mosses, taxonomy, biodiversity, conservation, biogeography

DIFFERENCES IN PLASTICITY AMONG SELECTED INVASIVE AND NON-INVASIVE PLANTS EXPOSED TO WATER AND NUTRIENT STRESS

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Plants are often exposed to many abiotic stresses triggering plants to respond in different ways. Plasticity refers to a plant's ability to respond to a given environmental stimulus. Invasive plants often appear to be more plastic than non-invasive plants. Highly plastic plants adjust themselves to harsh environmental conditions more efficiently than less-plastic plants. A pot experiment was carried out to identify differences in plasticity between selected invasive and non-invasive plants exposed to water and nutrient stresses. Two invasive plants, *Clidemia hirta*, *Clusia rosea* and two non-invasive plants, *Ricinus communis*, *Urena lobata* were exposed to varying levels of water stress. Two sets of seedlings were exposed to water stress (+ stress) conditions for 11 weeks before switching off to non-water-stressed (- stress) conditions and *vice versa*. In the second experiment, the seedlings of *C. hirta* (invasive) and *C. sophera* (non-invasive) were compared by subjecting them to different levels of nutrient stress. The plants were destructively harvested and biomass measurements were taken. Results were analyzed using General Linear Model. The test plants showed mostly species-specific differences to water and nutrient stresses with no consistent patterns between invasive and non-invasive plants. However, C. *hirta* showed higher plasticity in comparison to the other test species, especially when plants were exposed to nutrient stress. Furthermore, *R. communis* showed higher plasticity to water stress conditions compared to other test plants, perhaps due to its inherent ability to tolerate harsh conditions. The results suggest that it is not plausible to generalize that invasive plants are more plastic than non-invasive, as plasticity seems a more genetically determined characteristic than environmentally determined.

Keywords: Abiotic stresses, water stress, nutrient stress, invasive, non-invasive

EFFECT OF UV-C TREATMENT IN CONROLING TOMATO ANTHRACNOSE DISEASE AND IMPROVING POSTHARVEST QUALITY

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Tomato (*Solanum lycopersicum*), is a fruit with numerous health benefits, thus popular worldwide. Among the several postharvest diseases in tomato, Anthracnose caused by *Colletotrichum coccodes* is more significant. At present, fungicides are used to eliminate the disease. However, there are negative impacts of fungicide usage. Therefore an alternative method is needed to suppress postharvest fungal diseases. As a potential method of postharvest treatments, UV-C hormesis was tested in the study. Due to the availability in local and supermarkets, 'Thilina' and 'Roma' varieties were used. Five different UV-C dosages (0, 1, 2, 3, 4, 5 kJ/m^2) were applied to pure cultures of *C. coccodes* at an intensity of 254 nm (at a distance of 15 cm). The selected dosages (3.0 and 4.0 kJ/m^2) were tested for the effect on anthracnose disease on fresh tomato fruits and the postharvest quality (weight loss, firmness, shelf life, antioxidant and total phenolic content). There was a significant difference of *in vitro* growth suppression at 3.0 and 4.0 kJ/m^2 dosages. Anthracnose disease was suppressed at 4.0 kJ/m^2 for 'Thilina' variety and 3.0 and 4.0 kJ/m^2 dosages for 'Roma' variety. The weight loss of treated 'Thilina' variety significantly increased ($P < 0.05$), while that of 'Roma' had no significant difference. The antioxidant activity and the total phenolic content of both varieties increased after treatment. The firmness was significantly increased in treated 'Thilina' variety ($P < 0.05$) however, in 'Roma' there was no significant difference in firmness retention. Further the shelf life was significantly extended in both 'Roma' and 'Thilina' varieties ($P < 0.05$) by approx. 2 folds compared to the control. Improvement of postharvest quality varied between the two varieties and the two dosages used. In conclusion, UV-C treatment could be a potential solution to suppress postharvest diseases along with postharvest quality improvement of tomatoes.

Keywords: Postharvest, Tomato anthracnose, *Colletotrichum coccodes*, UV-C hormesis

MORPHOLOGICAL AND MOLECULAR CHARACTERIZATION OF *COLLETOTRICHUM* CAUSING ANTHRACNOSE IN SRI LANKAN *BEGONIA*

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Anthracnose is a common and most destructive postharvest disease in many fruit species, vegetables, cut-flowers and foliage plants, especially under warm and humid climates. The causal agent of anthracnose disease in many hosts has been known for decades as *Colletotrichum gloeosporioides* or *C. acutatum*. The identification has been based mostly on morphological and cultural characteristics. Taxonomy of the genus *Colletotrichum* has been questioned since many *Colletotrichum* species have now been accepted as complexes of cryptic species using molecular approaches. Re-identification of *Colletotrichum* causing anthracnose disease to species level is carried out worldwide, using molecular data. Among the hosts that have been re-visited, the attention that has been paid to ornamentals is minimal. *Begonia* is an ornamental plant grown worldwide, while anthracnose is a common disease in *Begonia* in Sri Lanka which reduces the plant's horticultural value. Further, the disease in *Begonia* plants has not been studied or recorded in Sri Lanka. Anthracnose symptoms appear as brown color, irregular and often large, 2 – 5 cm diameter necrotic lesions mainly on the leaves, towards the margins. *Colletotrichum* was isolated from anthracnose lesions on infected *Begonia* leaves, collected from the *Begonia* nursery of the Royal Botanical Gardens, Peradeniya, Sri Lanka. Among the thirty isolates made, seven isolates representing two morphological categories were subjected to DNA sequence analysis, using ITS, β-tubulin 2 (TUB2) and GAPDH as primers. For resulting sequences, the species affiliations and identities were determined through similarity-based searches of the NCBI GenBank Database. Considering >98% similarity, *C. siamense* and *C. truncatum* were identified as species associated with *Begonia* anthracnose. This is the first report of the association of *C. siamense* and *C. truncatum* with *Begonia* anthracnose in Sri Lanka and *C. siamense* for the first time in the world. *C. truncatum* was isolated at a lower percentage, (20%), compared to that of *C. siamense*.

Keywords: Anthracnose, *Colletotrichum*, molecular data, morphology, *Begonia*

PROBIOTIC POTENTIAL OF BACTERIAL ENDOPHYTES ISOLATED FROM LEAVES OF *MURRAYA KOENIGII* L.

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Endophytes are bacteria and fungi that live inside plant tissues, while *Murraya koenigii* L. is a common cuisine and herbal ingredient used in the South Asian region. The objective of the current study was to isolate bacterial endophytes from *M. koenigii* leaves and to assess their probiotic characteristics. Young and mature leaves of *M. koenigii* were collected from Hindagala, Gampaha and Jaffna covering both wet and dry zones of the country. Endophytes were isolated from leaves by placing leaf segments, leaf macerations and preparation of pour plates on/of three different media *viz*., Nutrient Agar, Lauria Bertani and deMan, Rogosa and Sharpe (MRS) media. The isolated endophytic bacterial species were identified by Gram staining, endospore staining, motility test and catalase test. Probiotic characterization of the isolates was carried out by assessing resistance to low pH (pH 3), tolerance of bile salts, antimicrobial activity (*Escherichia coli* and *Pseudomonas aeruginosa*), antibiotic resistance (Gentamycine), anti- haemolytic activity and anti- DNase activity. Ten endophytic bacteria (two bacilli [Gram negative], eight cocci [one Gram positive, and seven Gram negative]) were isolated from young and mature leaf samples collected from both wet and dry zones. All the isolates gave positive results for probiotic characterization tests except antimicrobial activity, while with four isolates showing antibiotic susceptibility. The results indicate a possibility of *M. koenigii* leaves possessing bacterial endophytes with a probiotic potential. Since *M. koenigii* has various medicinal properties including anti-cancer, anti-diabetic and anti-cholesterol effects, the presence of potential probiotic endophytes in *M. koenigii* leaves would be an added feature that could be exploited either for the leaves to be consumed raw (paste) or to produce probiotics as a commercial product. Future studies include testing the ability of isolates, against adherence of pathogenic bacteria to the gut epithelial cells, and molecular identification of isolates.

Keywords: Probiotics, Endophytes, *Murraya koenigii* L., Antimicrobial activity, Antibiotic resistance

SEED DYNAMICS IN A TROPICAL FOREST FRAGMENT IN SRI LANKA

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Halgolla Forest Reserve (HFR) is an isolated tropical lowland wet evergreen rainforest patch, located in the central province of Sri Lanka and its biodiversity is threatened due to human impacts. The current study investigated the regeneration potential of the fragment by assessing seed dynamics in the reserve. Comparisons were made for seed rain and seed bank in three habitats in the forest for one year. Thirty plots of 10x 10 m^2 (ten plots each per habitat) were established using stratified random sampling at the forest edge, forest interior and riverine areas. The contents of seed traps in each plot were collected once in two weeks from November 2017 to October 2018. Three replicate soil samples were taken from each of the 30 plots during the dry and wet season to determine the soil seed bank. A total number of 27,731 seeds were recorded under 105 morphospecies in the seed rain. The seed density was higher in forest edges than interior habitats and the highest seed abundance was recorded by *Ficus* sp. Species diversity and evenness were lower in edge habitat than forest interior habitats. A total of 780 and 385 seedlings emerged during the wet and dry soil seed bank samples, respectively. A similar pattern to seed rain was observed for species diversity and evenness in soil seed bank for both seasons. Higher abundance of pioneer species in soil seed bank indicates the ability of forest community to regenerate after a disturbance. The high percentage of germinants of invasive species such as *Clidemia hirta* (L.) D. Don and *Mikania cordata* (Burm.) Robinson may affect the regeneration potential of soil seed bank, indicating that management of invasive species in this forest fragment is vital to stop vanishing of HFR in future.

Acknowledgement*: The authors gratefully acknowledge the financial support provided by University of Peradeniya - University Research Grants (Grant No: URG/2017/49/S).*

Keywords: Forest fragment, Seed rain, Soil seed bank

SEED GERMINATION BEHAVIOR OF EIGHT MEDICINAL PLANT SPECIES FROM SRI LANKA

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With the increase in demand, medicinal plants are overexploited from the wild, while lack of information on seed biology obstructs the propagation and conservation of them. Thus, seed germination behaviour of eight medicinal plants species in the wet zone of Sri Lanka was studied to assist their conservation. Seeds were collected from at least five individuals from each species. Seed and embryo morphology was recorded. Seed moisture content (SMC) was determined by an oven dry method. Hundred seed test was conducted to determine the desiccation sensitivity. Germination and signs of imbibition were studied in seeds at 32 and 25 ^{o}C in light/dark (12 hr/12 hr) or in complete darkness. Effect of GA_3 and manual scarification on seed germination was determined. Four replicates each with at least fifteen seeds were used in all experiments. Arcsine transformed data were analyzed using the one-way ANOVA procedure. Results indicated that seeds of all the species had fully-developed embryos indicating the absence of morphological dormancy. Signs of imbibition were absent in most *Entada pusaetha, Adenanthera pavonina, Cassia fistula, Urena sinuata* and *Sida rhombifolia* seeds, indicating that they were physically dormant. However, none of the manually scarified *E. pusaetha* seeds germinated, indicating the presence of combinational dormancy. GA_3 treatment, manual scarification + GA_3 treatment and warm stratification increased the germination of *Salacia chinensis, Calophyllum inophyllum* and *Madhuca longifolia* seeds, respectively indicating that they have physiological dormancy. SMC suggested that *S. chinensis, E. pusaetha, A. pavonina, C. fistula, U. sinuata* and *S. rhombifolia* seeds have orthodox storage behaviour, while the results of the hundred seed method indicated that seeds of *C. inophyllum* and *M. longifolia* are recalcitrant and orthodox, respectively. Seed germination pattern of *A. pavonina*, and *S. rhombifolia* after storage suggested a possible occurrence of sensitivity cycling phenomenon. Separate low-cost dormancy breaking treatments for each species were identified.

Keywords: Orthodox, physical dormancy, physiological dormancy, recalcitrant, seed propagation, storage behaviour

BIOACTIVITY DETERMINATION OF *HOLARRHENA MITIS* (VAHL) R.BR. EX ROEM. AND SCHULT. PLANT EXTRACTS AND ITS ALKALOIDS

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Holarrhena mitis is an endemic plant belonging to the family Apocynaceae which is known for its richness in alkaloids. During this study, determination of the antioxidant and anti-inflammatory activities of the dichloromethane, ethyl acetate and methanol extracts of leaf and bark of *H. mitis* was carried out. The contribution of the alkaloid fraction of the bark to the plant bioactivity was determined by testing the antioxidant, anti-inflammatory, antibacterial activities and cytotoxicity. Compared to the positive control, ascorbic acid, dicholoromethane extract of leaves and methanol extracts of leaves and bark showed considerable antioxidant activities. Compared to ascorbic acid (IC_{50}: 5.15 ppm), the methanol bark extract and its alkaloids did not show a comparable antioxidant activity (IC_{50}: 210 ppm and 399 ppm). Compared to the positive control indomethacin, the ethyl acetate extracts of leaves and bark and the methanol extract of bark showed significant anti-inflammatory activity. In addition, alkaloids of the methanol bark extract also showed considerable anti-inflammatory activity. Furthermore, alkaloids of the bark showed antibacterial activity against both *Staphylococcus aureus* and *Pseudomonas aeruginosa* but not against *Escherichia coli*. In the brine shrimp lethality assay, the methanol extract of the bark showed a higher LC_{50} value (208.20 ppm) than that of positive control, $K_2Cr_2O_7$ (LC_{50}: 2.26 ppm) indicating medium toxicity. Alkaloids of the bark exhibited a much higher LC_{50} value (1410.11 ppm) indicating its non-toxicity. These results suggested that the alkaloids of the bark have significant antibacterial activity and would be source of potential antibacterial compounds. Furthermore, alkaloids of the bark exhibited significant anti-inflammatory activity due to its membrane stabilizing properties that was tested using the heat induced haemolysis method.

Keywords: *Holarrhena mitis*, endemic plant, alkaloids, antibacterial, anti-inflammatory activities

EFFECT OF CORE-SPACER LENGTH, CORE-COORDINATION AND GENERATION NUMBER ON ENTRAPMENT EFFICENCY OF DENDRIMERS

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Dendrimers are a class of polymeric material which is monodisperse, highly branched and macromolecular. Dendrimers are widely used in biomedical and industrial applications due to their controllable structural features, such as: generation number, core coordination, core spacer length and terminal functionality. Although dendrimers have high utility, it is difficult to study dendrimers at the molecular scale using laboratory techniques. Hence, molecular dynamics computer simulations were used to study the effect of architectural parameters on the physical properties of dendrimers, focusing on their entrapment efficiency. Dendrimers with coarse grained structures of generation (G) 5 and 4, core coordination (C) 2, 3 and 6, and core spacer length (-C_6H_{12}-) and (-$C_{12}H_{24}$) were simulated at 300 K and 1 atm conditions. Radius of gyration (R_g), bead distribution, and entrapment efficiency were obtained through analyzing the simulation trajectories. For the analysis of R_g, the dendrimer was simulated inside phenol, where results show that the R_g has a linear relationship with the number of monomers. For the analysis of entrapment efficiency and bead distribution, a two-phase system (water and phenol) was used. Entrapment analysis shows that capacity has increased with the increase of core-spacer length and decreased with the increase of generation number and core coordination. The highest loading capacity was found with S4 dendrimer. Bead distribution results show that the hydrophobic beads are concentrated towards the core and hydrophilic beads are distributed throughout the dendrimer.

Acknowledgement*: The authors would like to acknowledge technical assistance from P.V.G.M. Rathnayake.*

Keywords: Molecular dynamics, drug loading, molecular entrapment

EVALUATION OF ANTIBACTERIAL COMPOUNDS IN *TRIANTHEMA PORTULACASTRUM* PLANT EXTRACTS FOR PATHOGENS CAUSING URINARY TRACT INFECTION

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Urinary tract infections (UTI) are the second most common type of infectious diseases in the world and treatment of UTI includes herbal remedy and antibiotic therapy. In this study, the evaluation of the antibacterial activity of roots and leaves of *Trianthema portulacastrum* was performed against microorganisms known to cause UTI. A sequential extraction was performed by the bottle shaker method using hexane, DCM and methanol. Screening of antibacterial activity of the extracts was done using disc diffusion and agar dilution methods against gram-negative *Escherichia coli*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae* and gram-positive *Staphylococcus aureus*. In the disc diffusion method, leaf extracts of 10.000 g L^{-1} concentration showed activity for all four microorganisms. The highest inhibition zone was observed against *Klebsiella pneumonia*, (21.50 ± 0.28) mm, and the lowest against *Staphylococcus aureus*, (7.00 ± 0.58) mm. According to the agar dilution method, which was performed for concentrations between 2.000 g L^{-1} and 0.125 g L^{-1}, the leaf hexane extract showed the highest activity against *Escherichia coli* (MIC 0.250 g L^{-1}), *Pseudomonas aeruginosa* (MIC < 0.125 g L^{-1}) and *Staphylococcus aureus* (MIC < 0.125 g L^{-1}). A vacuum liquid chromatography fractionation was performed to separate the components in the leaf hexane extracts where some fractions were found to be more active than the crude extracts against *Escherichia coli* and *Staphylococcus aureus*. The highest inhibition zone was observed against *Escherichia coli*, (26.00 ± 1.14) mm, for the fraction collected using the solvent system, ethyl acetate, methanol and DCM (1:1:8 v/v) and against *Staphylococcus aureus*, (14.75 ± 0.50) mm, for the fraction collected using the solvent system, methanol and DCM (1:9 v/v). Considering these results, it can be confirmed that the hexane extract of *Trianthema portulacstrum* leaves has significant antibacterial activity towards the selected microorganisms and may have the potential in treating UTI.

Keywords: UTI, *Trianthema portulacastrum*, anti-bacterial activity

FINE-TUNING SEMICONDUCTOR PROPERTIES OF MOF199 BY INTRODUCING GUEST MOLECULES

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A metal organic framework (MOF) is a porous material that consists of a three-dimensional (3-D) framework built up using metal ions/clusters and organic linker ligands. Although these structures are highly ordered, porosity, geometry and functionality could be fine-tuned by changing the metal or the organic ligand. MOF-199 is a highly investigated MOF that has a 3-D framework of copper metal centers and benzene-1,3,5-tricarboxylic acid linker ligands. This has been utilized in research areas, such as photocatalysis, photovoltaics and gas storage, owing to its high stability and simple preparation procedure. However, the performance of MOF-199 in photovoltaics is limited due to its poor conductivity (10^{-10} S m^{-1}). To improve the conductivity, the only successful attempt that has been reported is the encapsulation of iodine. Thus, in this project, a variety of guest molecules were introduced within MOF-199, with the aim of fine-tuning physical and electrical properties. First, MOF-199 was synthesized using benzene-1,3,5-tricarboxylic acid and copper(II) nitrate trihydrate, and its structure was confirmed by powder X-ray diffraction, Fourier transform infrared (FTIR) spectroscopy and scanning electron microscopy (SEM). Thereafter, inorganic salts ($FeCl_3$ and $LiClO_4.3H_2O$) and organic compounds (aniline, *m*-aminobenzoic acid, acetyl-*p*-chloroanilide, rhodamine-6G and *p*-benzoquinone) were introduced within the framework by refluxing. Modified MOFs were found to be stable at high temperatures, within a range of pHs and in many different solvents. The structure and properties of the modified MOFs were determined using SEM, energy dispersive X-ray, FT-IR, X-ray photoelectron, solid state UV-visible spectroscopic methods and Mott-Schottkey plots. Optical properties of these MOFs have been changed, as a variety of colours could be obtained by encapsulating different ions/molecules. Carrier concentration varied from 3.78×10^{16} cm^{-3} (bare MOF-199) to 7.14×10^{16} cm^{-3} (doped with aniline). Shift in flat band potentials was observed from −0.29 V (MOF-199) to −0.90 V (with $LiClO_4.3H_2O$). However, a significant variation in the band-gap was not observed, and all remained as semiconductors. Thus, this study introduces a method to fine-tune the properties of a MOF depending on its application.

Keywords: MOF-199, encapsulation, fine-tune

GRAPHENE OXIDE AS A POTENTIAL MATRIX FOR DRUG STABILIZATION

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During the last decade, the use of antibiotics for bacterial infections has increased dramatically. Continuous usage and misuse of antibiotics cause a serious health problem, known as antibiotic resistance. It is the ability of pathogenic bacteria to resist the effect of an antibiotic which is successfully used to treat the infection raised due to the same pathogenic bacteria. The most threatening type of this antibiotic resistance is multi-drug resistance, which arises due to the high genetic variability of bacteria, and it would avoid the action of antibiotics. Among novel antibiotics investigated as a solution for multi-drug resistance (MDR), plant-based antibacterial substances are the best solution due to less side effects and the low-cost. Antimicrobial activity of cinnamaldehyde has been known for centuries. Due to the volatility and instability against environmental conditions, cinnamaldehyde cannot be widely used. In this study, cinnamaldehyde was bonded to graphene oxide (GO), which is a two-dimensional one carbon atom thick structure having oxygenated groups, such as epoxy, hydroxyl and carboxylic in order to investigate the effect on the stability of cinnamaldehyde. A modified Hummer's method was used to prepare GO, which was characterized using Fourier transform infrared (FTIR), attenuated total reflectance (ATR) and X-ray diffraction (XRD) studies. Binding of cinnamaldehyde on to GO was confirmed using XRD, ATR and UV-Visible spectra. Antibacterial activity of the complex prepared was studied using the disk diffusion method, and Gram-negative pathogenic bacteria *Escherichia coli* and Gram-positive bacteria *Staphylococcus aureus* were selected for the investigation. The complex prepared has shown an effective antibacterial activity toward both bacteria.

Keywords: Multi-drug resistance, graphene oxide, cinnamaldehyde, antibacterial activity

INVESTIGATION OF ADSORPTION PROPERTIES OF GRAPHENE OXIDE FOR EFFICIENT REMOVAL OF METAL IONS FROM AQUEOUS SOLUTIONS

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Adsorption properties of graphene oxide (GO) for efficient removal of metal ions in aqueous solutions were investigated. GO was synthesized according to the Hummer's method and characterized by powder X-ray diffraction (XRD) and Fourier transform infrared (FTIR) spectroscopy. The results of adsorption experiments and measurements by flame atomic absorption spectrometry (F-AAS) indicate that the adsorption capacity of GO is highly dependent on pH, and the maximum adsorption was obtained at pH = 4. The adsorption equilibrium was attained after 120 min for the adsorption of Cu^{2+} ions by GO, and the maximum adsorption capacity was calculated to be as high as 91.53 mg g^{-1}. The noticeable reduction in adsorption capacity was observed with increasing the contact time greater than 210 min. Pseudo first order and pseudo second order models were applied to understand the adsorption mechanism. The results obtained correlate with the pseudo second order model, and suggests that adsorption of Cu^{2+} ions onto GO is controlled by chemisorption involving strong surface complexation of Cu^{2+} ions through sharing or exchanging of electrons between the oxygen containing functional groups of GO and metal ions.

Keywords: Graphene oxide, Cu^{2+} ion removal, kinetics

INVESTIGATION OF CORROSION INHIBITION PROPERTIES OF CITRONELLA OIL AND CINNAMON OIL TOWARD ALUMINIUM

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Corrosion has become a worldwide problem, which requires unexpectedly high amount of money and much human resources for its remediation. Most corrosion inhibitors employed at present are chemical in nature, associated with inherent drawbacks, such as the cost and environmentally unfriendly nature. Consequently, it is of utmost necessity to search for environmentally friendly, less expensive, non-toxic and efficient corrosion inhibitors for applications where metals and their compounds are in use. The work reported herein includes a systematic investigation of corrosion inhibition of aluminum, a heavily used industrial metal, in five different acidic solutions having concentrations in the range from 0.10 to 1.00 mol dm^{-3} using commercially available citronella oil and cinnamon oil as inhibitors. Mass loss measurements indicate the corrosion inhibition ability of both citronella oil and cinnamon oil, due to the electron donating ability of the functional groups present, making the aluminium surface electron rich to survive against the corrosion attack. The corrosion inhibition ability of the two natural products was conclusively demonstrated by more accurate electrochemical impedance spectroscopic measurements, resulting in significant increase in the polarization resistance in the presence of the inhibitor in all concentrations attempted, with percentage inhibition in the range of 30 – 50%. These observations were further supported through Tafel extrapolation plots, which resulted in decreased rates of corrosion with the inhibitor. Further, solution analysis performed using atomic absorption spectroscopy at different time intervals indicates high concentrations of Al(III) in the absence of the inhibitor with increasing trend with the increase in the strength of the acid in the medium. This multi-technique approach concludes that both the natural products investigated have corrosion inhibition properties toward aluminum, with stronger inhibition ability of cinnamon oil over citronella oil. Extrapolation of the findings of this study to less aggressive, natural, wet environments is possible through corrosion modeling, which will be a possible future direction.

Keywords: Corrosion inhibition, aluminum, electrochemical impedance spectroscopy, Tafel analysis

INVESTIGATION OF PROPERTIES OF WO_3/TiO_2 SOLID SOLUTIONS WITH HIGHER PERCENTAGES OF WO_3

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Properties of WO_3 have been enhanced via different ways. Combination of WO_3 with transition metal oxides is an effective method to enhance the properties of WO_3. In this investigation, TiO_2 modified with WO_3 (with 30%, 50%, 70% WO_3) was prepared by the sol–gel method, and their photochromic and adsorptive dye removal properties were studied using methylene blue (MB) as the model industrial dye. Ammonium tungstate and 2-butanol were used as the precursors of the synthesis. For comparison, pure TiO_2 was also prepared by the sol–gel method, and pure WO_3 was synthesized by calcining ammonium tungstate at 500 °C for 4 h. The products were characterized by X-ray fluorescence and powder X-ray diffraction (PXRD) analysis. Pure TiO_2 and pure WO_3 exhibited crystalline anatase and monoclinic phases respectively. The PXRD analysis of TiO_2 modified with WO_3 products showed the formation of solid solutions in which TiO_2 was the host and WO_3 was the guest component. However, with the increase in the amount of WO_3, the crystallinity of TiO_2 modified with WO_3 reduced significantly. Results of photochromism showed that 70% WO_3/TiO_2 samples became relatively intense blue upon irradiating with UV light within 5 min, when compared to pure WO_3. The adsorptive dye removal under dark condition showed that 30% and 50% WO_3/TiO_2 samples exhibited excellent adsorptive dye removal ability within 3 h, achieving 92% and 94% efficiency, respectively. These results suggest that preparation of solid solutions via the sol–gel method is convenient with relatively high amount of WO_3, and shows advanced photochromic and adsorptive properties based on their composition.

Keywords: Sol-gel method, solid solution, photochromism, adsorptive properties

MODIFICATION OF ZEOLITE WITH γ-Fe_2O_3 FOR REMOVAL OF FLUORIDE IN WATER

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High amount of fluoride in drinking water causes many health issues worldwide, including Sri Lanka. Drinking water is the main source of fluoride exposure compared to others. Among many methods available for removal of fluoride ions, adsorptive methods are prominent, due to relatively low-cost and operation simplicity. Zeolite is a highly crystalline porous material which was modified with $FeCl_2$ in order to adsorb fluoride. Solid state ion exchange process was used to impregnate Fe species into zeolite. Synthesized Fe-zeolite was characterized before and after fluoride adsorption using Fourier transformation infrared (FTIR) spectroscopy, scanning electron microscopy (SEM), energy dispersive spectrometry (EDX) and X-ray diffraction (XRD) techniques. The Langmuir and Freundlich isotherm models were used to study the fluoride adsorption behavior. Kinetics studies were performed to study the order of the adsorption reaction. According to the characterization results, it was concluded that Fe species undergo an ion exchange process with acidic hydrogen present in the zeolite matrix by compensating negative charge of the framework. Adsorption of fluoride on to Fe-zeolite was observed with respect to contact time, adsorbent dosage and initial fluoride concentration. As the dosage of Fe-zeolite, initial fluoride concentration and contact time increase, the extent of adsorption also increased. Therefore, the optimum values of 20 g L^{-1} dosage and 10 mg L^{-1} of initial fluoride were selected. An efficient fluoride adsorption (about 75% of the initial fluoride) was observed within 60 min by 20 g L^{-1} of Fe-zeolite. Thus, Fe-zeolite was proven to be an effective fluoride adsorbent since pure zeolite does not cause a significant adsorption. The Langmuir adsorption isotherm was the best fit for fluoride adsorption onto Fe-zeolite. Kinetics studies showed that the reaction is more compatible with pseudo second-order model. Findings of this study could be applied in developing low-cost water purification filters using modified zeolites.

Keywords: Zeolite, fluoride, adsorption, isotherm, kinetics

ORGANIC DYE DEGRADATION WITH METAL ORGANIC FRAMEWORKS THROUGH HETEROGENEOUS CATALYSIS UNDER DARK CONDITION

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Industrial revolution developed the world's economic growth, while it largely contributes to the environmental pollution as well. Currently, water pollution is concerned as a global problem affecting human and other living organisms. To date, synthetic dyes are used in a broad range of applications, and hence, production of synthetic dyes is ever increasing. Thus, water pollution by synthetic dyes is also increased. A broad scope of strategies has been achieved for the expulsion of organic dyes from contaminated water to reduce their effect on water pollution. Due to tunable properties of metal organic frameworks (MOFs) which belong to 3-D coordination polymers, they can be used in a variety of applications. In this research, several MOFs were synthesized using hydrothermal method with the succinate linker. Among MOFs characterized, $Co_5(OH)_2(C_4H_4O_4)_4$ (Co-MOF) was used to determine the catalytic activity in degradation of synthetic dyes; aniline blue, crystal violet and methylene blue. Catalytic dye degradation efficiencies were determined under both dark and light conditions in the presence of 0.05 mL of 40% H_2O_2. Under optimized mass (0.005 g) and prevailing pH conditions, the Co-MOF showed excellent Fenton-like heterogeneous catalytic dye degradation ability by degrading 99% of crystal violet within three hours in the dark. Experiments carried out with *t*-butanol as a hydroxyl radical scavenger revealed that dye degradation mechanism undergoes via hydroxyl radical formation. Dye degradation of 99% was observed at the fourth catalytic cycle as well proving the high reusability as a heterogeneous catalyst working under dark condition. Simply by washing with distilled water and oven drying at 100 °C, the regeneration of the used Co-MOF can be achieved.

Acknowledgement: *Financial support provided by the University of Peradeniya (Grant No. URG/ 2017/46/S) is acknowledged.*

Keywords: Coordination polymer, dye degradation, heterogeneous catalysis, dark condition

REMOVAL OF NITRATE IN WATER USING ACTIVATED CARBON DERIVED FROM COCONUT COIR DUST (ACC)

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Nitrate in shallow wells in Sri Lanka, specially, near farming and beach areas, is at high level. The optimum level of nitrate is 50 mg NO_3^- L^{-1} in drinking water according to WHO standards. The excess nitrates are toxic to human body. The nitrate concentration in water bodies is on the increase, mainly due to anthropogenic activities. This research project was focused on removal of nitrate from water using activated carbon derived from coconut coir dust (ACC), which was prepared by treatment of raw coconut coir with 50% (w/w) phosphoric acid, followed by pyrolysis at 450 °C under nitrogen gas atmosphere for one hour. The synthesized ACC was characterized using Fourier transform infrared spectroscopy, X-ray diffractometry, scanning electron microscopy and particle size analysis. Adsorbent dosage, stirring time and pH of the solution were optimized for nitrate removal using standard 100 ppm $NaNO_3$ solutions. The maximum percentage removal of nitrate under optimum conditions (pH = 7, 0.40 g of ACC, 30 min stirring time) is 57%. The adsorption was also studied by varying the initial concentration of the standard nitrate solution. The equilibrium adsorption data were fitted to the Langmuir and Freundlich isotherms. Linear plots were obtained for both cases, the Langmuir plot with R^2 = 0.994 and the Freundlich plot with R^2 = 0.989, due to heterogeneous nature of surface of ACC. Percentage removal of nitrate using commercial activated carbon is higher than the value obtained in this project, and therefore, purification and modification of surface of ACC should be studied in future for higher removal of nitrate.

Keywords: Activated carbon, coconut coir, pyrolysis, nitrate removal

SYNERGISM OF CELL PENETRATING PEPTIDES IN TRANSLOCATING LIPID BILAYERS

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A major difficulty faced in administering active molecules as therapeutic agents is their inability to reach specified targets sites. Discovery of cell penetrating peptides (CPPs) represents a potential breakthrough for the transport of a range of biological cargos. CPPs, which are small peptidic molecules capable of translocating through cell membranes, have received significant attention due to their low cytotoxicity and high transduction efficiency. They are classified as cationic, amphipathic and hydrophobic depending on their physicochemical characteristics. Permeation mechanisms of CPPs are not fully understood. There is evidence for both energy dependent and energy independent pathways. Here, four CPPs (penetratin, C6, transportan, and K-FGF) were studied to investigate the effect of synergism of multiple peptides in translocation through DOPC bilayers. Results of all-atom molecular dynamics (MD) computer simulations show that all CPPs have stable α-helical secondary structures. Moreover, translocation free energy profiles for a single peptide and multi-peptide systems were constructed through coarse grained MD simulations. Free energy profiles indicate that all CPPs spontaneously adsorb on to the surface of the bilayer and the synergism facilitates the spontaneous adsorption. Furthermore, although none of the peptides showed spontaneous translocation for individual peptides, in the case of C6 and K-FGF, synergism may facilitate translocation by reducing the energy barrier.

Keywords: Free energy profiles, molecular dynamics simulations, membrane translocation

SYNTHESIS AND CHARACTERISATION OF Mg-Al LAYERED DOUBLE HYDROXIDE (Mg-Al LDH) AND ITS ABIITY FOR REMOVAL OF FLUORIDE AND NITRATE

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Layered double hydroxides (LDHs) are a class of positively charged brucite-like layered compounds with an interlayer region containing charge compensating anions and/or solvent molecules. The contamination of F^- in surface and ground water could be found either natural geological sources or industrial wastewater. Nitrate (NO_3^-) is widely spread ground water contaminant as a result of poor agricultural practices. Excess amount of F^- and NO_3^- will cause health and environmental issues. This research aimed to synthesise and characterise Mg-Al LDH, and to study its F^- and NO_3^- removal capacity from aqueous solution. The synthetic product of Mg-Al LDHs, obtained using the co-precipitation method, was confirmed by powder X-ray diffraction (JCPDS No-89-0461), which reveals peaks close to 2θ = 11°, 23°, 34°, and 60°, corresponding to the (003), (006), (012), and (110) reflections of Mg-Al LDH. Fourier transform infrared spectroscopic peaks observed at 558 cm^{-1} (Mg-O stretching), 876 cm^{-1} (Al-O stretching), 1411 cm^{-1} (C-O stretching), 3200-3500 cm^{-1} (O-H stretching) further support the synthesis of Mg-Al LDH. Removal of F^- by Mg-Al LDH follows pseudo 2nd order kinetics, which is not affected by initial concentration and amount of adsorbent quantity. The highest efficiency of removal of F-has been found with 4.00×10^3 mg dm^{-3} of Mg-Al LDH and 10.00 mg dm^{-3} initial fluoride concentration. Removal of nitrate follows pseudo 1st order kinetics. Removal capacities of F^- and NO_3^- were recorded as 87.58 % and 85.38 %, respectively.

Keywords: Mg-Al Layered double hydroxides, fluoride, nitrate

SYNTHESIS AND CYTOTOXICITY STUDIES OF DERIVATIVES OF 3*β*-[(*α*-L-ARABINOPYRANOSYL)OXY]OLEAN-12-EN-28-OIC ACID

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Synthesis of natural product derived compound libraries to improve the cytotoxicity and bioavailability is important in the field of modern anticancer drug discovery. The compound, 3*β*-[(*α*-L-arabinopyranosyl)oxy]olean-12-en-28-oic acid (3-O-*α*-L-arabinosyl oleanolic acid) is a natural product possessing cytotoxic activities for several cancer cell lines. This compound can be isolated from the three species of the genus *Schumecheria*, a genus endemic to Sri Lanka belonging to the family Dilleniaceae. In the present study, structural analogues of the target saponin were synthesized by modifying C12-C13 olefin moiety, and brine shrimp lethality bioassay was used as a preliminary study to identify the potential cytotoxicity. Initially, cleaned, air dried, ground stem bark of *S. castaneifolia* was extracted into dichloromethane: methanol (1:1) solution at room temperature using a bottle shaker for 3×24 h. The compound, 3-O-*α*-L-arabinosyloleanolic acid was isolated from the crude extracts using column chromatography, in 0.02% yield and the structure was confirmed by comparing the literature data with observed IR and ^{1}H-NMR spectroscopic data. Modifications were done for the target compound via acetylation of sugar hydroxyls followed by allylic oxidation at C12-13 double bond, esterification of the COOH group at C28, followed by the oxidation of C12-C13 olefin. Characterization of the derivatives synthesized was done using IR and ^{1}H-NMR spectroscopy. Finally, cytotoxicity of the derivatives synthesized was studied using brine shrimp lethality assay. The LC_{50} values calculated for all the synthesized derivatives using probit analysis are higher than that of the original compound indicating that the cytotoxicity has been decreased for all the synthesized derivatives. However, in comparing the cytotoxicity of the derivatives, it was observed that the cytotoxicity is high in acetylated derivative than the other four derivatives. Based on these empirical data, it can be concluded that C12-C13 double bond is important for the cytotoxicity reported.

Keywords: 3-O-*α*-L-arabinosyloleanolic acid, anticancer activities, *Schumecheria*

SYNTHESIS OF γ-Fe_2O_3 COATED SAND FOR ABSORPTIVE REMOVAL OF FLUORIDE IONS FROM DRINKING WATER

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Contamination of water sources due to the presence of fluoride ions creates major health problems for human beings. Among various methods available for the removal of excess fluoride ions from water, absorptive methods are predominant, mainly due to relatively lower cost. In the present study, experiments were carried out to synthesize a low-cost adsorbent by coating the surfaces of sand particles with γ-Fe_2O_3 nanoparticles, prepared using the chemical co-precipitation method. Preliminary tests were performed using two different sizes of silica gel particles. The nanoparticles synthesized were characterized using Fourier transform infrared spectroscopy (FTIR), scanning electron microscopy and surface titration techniques. Absorptive and kinetics studies were used to establish adsorptive behavior of the material with various parameters. The optimum particle size of silica gel/sand particles was found to be 0.50 mm with the observed point of zero charge at the pH of 9.47. Batch adsorption studies indicated that the synthesized material has an adsorption efficiency of up to 85 ± 5 % which is higher than that of silica. A rapid adsorption was detected for the initial 60 min period, and then reached equilibrium. The adsorption behaviour was found be highly sensitive to the pH value of solutions, and the efficiency was found to be higher at lower pH values. The Freundlich isotherm model best fitted with the observed kinetics data. For the initial 30 minutes, adsorption behaviour was consistent with pseudo first order kinetics and for the latter part with pseudo second order kinetics. FTIR data were used to identify a mechanism for the fluoride adsorption. The adsorption of fluoride ions can be explained using dehydroxylation of hydroxyl groups attached to the iron oxide and silica surfaces with incoming fluoride ions. From the isotherm models, it can be concluded that multilayer adsorption takes place during the removal process. This has enabled sand used for water purification to be used for multiple purposes.

Keywords: Adsorption, fluoride ion removal, sand coating, γ-Fe_2O_3 nanoparticles

SYNTHESIS OF Co^{2+} DOPED ZnO QUANTUM DOTS AND ENCAPSULATION OF THE ANTICANCER DRUG CISPLATIN FOR TARGETED DELIVERY AND SLOW RELEASE

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Cisplatin, also known as cis-diamminedichloroplatinum(II), is the first heavy metal coordination compound which exhibits antineoplastic activity. The toxicity of cisplatin to healthy cells can be minimized by encapsulating the anticancer drug into an appropriate host. Nowadays nanoparticles are heavily used as host carriers. An affirmative host carrier is quantum dots. Interestingly, its intense fluorescence can be effective in tracking the path of drug travels, *in-vivo*. The desired fluorescence property can be tuned by doping the quantum dots using eligible transition metals. In this research, Co^{2+} doped ZnO quantum dots (CDZQD) were synthesized using the simple sol-gel method. For this, a mixture of $Zn(CH_3COO)_2.2H_2O$, $Co(CH_3COO)_2.4H_2O$ and distilled water in methanol was allowed to react at 65 °C. The resulting blue coloured CDZQD were characterized by powder X-ray diffraction, scanning electron microscopy, energy dispersive X-ray analysis, laser light scattering based particle size analysis, X-ray fluorescence spectroscopy, Fourier transform infrared spectroscopy, and also were observed under UV light. The encapsulation of anticancer drug cisplatin into CDZQD, and its pH dependence for targeted drug delivery and slow release were investigated using atomic emission spectroscopy. The CDZQD synthesized were stirred in 100 mL of cisplatin for a period of 24 h, and the encapsulation efficiency was evaluated as 52.4% by determining the exceeding cisplatin concentration. During the first 6 h period, the rate of release of cisplatin was very slow, and the percentage release for pH 4 and pH 8 buffers were 2.5% and 3.3%, respectively. The maximum extent of release of cisplatin for both pH 4 and pH 8 buffers was 4.5% after 24 h. Therefore, the final study reveals that cisplatin shows slow release in both acidic and basic medium due to the amphoteric nature of ZnO. Targeted therapies can also be triggered by selectively binding cisplatin encapsulated CDZQD to the acidic tumor cells which may be destroyed with the slow release of a low dosage.

Keywords: Quantum dots, cisplatin, amphoteric nature

EXTRACTION OF POEA-15 FROM COMMERCIAL GLYPHOSATE (ROUNDUP) AND DETERMINATION OF TOXICITY OF POEA-15 USING HAMSTER CELL LINES

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N –(phosphonomethyl)glycine (glyphosate) is a systemic and non-selective herbicide used in the control of annual and perennial weeds. Surfactants are used in glyphosate formulations for efficient absorption of the active ingredient to the plant. The major surfactant present in glyphosate formulation, Roundup, is polyethoxylated tallowamine (POEA) which is POEA-15. According to the literature, glyphosate formulation is more toxic than glyphosate alone due to the presence of POEA-15 surfactant. The objectives of this study were to determine the amount of POEA-15 in Roundup glyphosate; to characterize and compare standard POEA-15 and POEA-15 extracted from commercial glyphosate (Roundup); and to determine the toxicity of POEA-15 and commercial glyphosate using cell viability assay. The best wavelength of 300 nm was obtained for standard POEA-15, using UV–Visible spectroscopy, and thereby, the concentration of POEA-15 in Roundup was determined to be 136 g L^{-1}. Toxic effects of POEA-15 (standard and extracted), glyphosate formulation (Roundup) and glyphosate acid samples were tested using standard Hamster's kidney cell line by taking viable cell counts after 24 h and 48 h of exposure time. The cells were treated with Tryphan Blue dye in order to take the cell count using hemocytometer. The average percentage cell viability calculated for the above samples was plotted against the concentration of the substance mentioned above, and thereby, 50% inhibitory concentrations of cell viability (IC_{50}) were determined for each sample at 24 h and 48 h exposure time. After exposure time of 24 h, IC_{50} values obtained were 3.46, 4.75 and 50.00 for the standard sample, extracted sample and glyphosate formulation, respectively. It is observed that IC_{50} value has decreased with the exposure time. This study shows that POEA-15 is more toxic than glyphosate formulation, and hence, POEA-15 is the toxic component in Roundup.

Keywords: Glyphosate, systemic, POEA, Tryphan Blue, IC_{50}

SYNTHESIS OF ACIDITY TRIGGERED CISPLATIN ENCAPSULATED SLOW RELEASE ZINC OXIDE TARGETED DRUG DELIVERY NANO COMPOSITE FOR CANCER TREATEMENT

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Cisplatin is the first platinum-based anticancer drug, which is frequently used. The cis configuration enables the coordination complex to be covalently bound to one or two DNA strands, and thus, cross-linking the DNA strands causes the cells to die in a programmed manner. Cisplatin is administered as an IV infusion in saline solution for medication of solid malignity. Encapsulation of the drug in a suitable host material minimizes its side effects while improving the efficacy of the drug due to its slow release only at the target. The aim of this research is to develop a simple, but effective mechanism for the preparation of porous zinc oxide nanoparticles (PZnO NPs) using the forced hydrolysis method reaction of zinc acetate dihydrate with deionized water in diethylene glycol medium. This synthesized PZnO NPs were characterized by scanning electron microscopy (SEM), energy dispersive X-ray analysis (EDX), Fourier transform infrared (FTIR) spectroscopy, particle size analysis and X-ray diffraction (XRD). The encapsulation of cisplatin within the porous zinc oxide nanoparticles was confirmed by X-ray fluorescence (XRF), SEM, EDX, and FTIR studies. The results show that the nanoparticles synthesized have the hexagonal Wurtzite structure as confirmed by XRD. The average particle size as determined by light scattering is 52.4 ± 0.1 nm. SEM images show porous spherical morphology with aggregated particles. XRF data of the cisplatin encapsulated product show a Pt:Cl ratio of 1:2 showing encapsulation without any fragmentation or other chemical change. The presence of $-NH_2$ in the encapsulated product is also apparent from FTIR data. The encapsulation of the anti-cancer drug cisplatin to PZnO NPs and its pH dependence on the release of the drug from PZnO NPs were studied by measuring the amount of Pt released using inductively coupled plasma atomic emission spectroscopy at λ_{max} 265.94 nm, as a function of time. The encapsulation efficiency of cisplatin into PZnO NPs was found to be 50.52%. The percentage of cisplatin released from PZnO NPs during the first 7 h was < 6.30% within the pH range from 4.0 to 8.0 with the maximum release of 8.64% at pH = 6.0 after 24 h.

Keywords: Nanoparticles, cisplatin, drug release, encapsulation

USE OF POST-CONSUMER POLY(ETHYLENE TEREPHTHALATE) BOTTLES AS A SOURCE OF METAL ORGANIC FRAMEWORK SYNTHESIS

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Poly(ethylene terephthalate) (PET) has a wide range of applications due to its distinct properties, and consequently, the global PET consumption has increased dramatically over the past years. This has resulted in a significant problem due to the harmful impacts of post-consumer PET on both human and natural environment. Out of many post-consumer PET remediation methods, depolymerization by hydrolysis can be considered as one of the efficient methods. Acid hydrolysis of post-consumer PET bottles into its 1,4-benzenedicarboxylic acid (BDC) monomer, and the use of isolated BDC as a precursor to synthesize two metal organic frameworks (MOFs) is reported in this work. BDC was isolated by acid hydrolysis of four different types of used PET beverage bottles using H_2SO_4 acid. Decolorization was done with charcoal for the coloured samples. Isolated products were characterized by Fourier transform infrared spectroscopy, and 75% yield was obtained for all the samples tested. Two MOFs, Zn(BDC) and Cu(BDC), were synthesized by reacting Zn^{2+}, Cu^{2+} and isolated BDC using simple non-solvothermal method, which was further applied in two distinct routes as direct synthesis and interfacial synthesis methods. The synthesized MOFs were characterized using scanning electron microscopy (SEM) and powder X-ray diffraction analysis. SEM studies reveals that Zn(BDC) has a cubic shaped crystal morphology, while Cu(BDC) has a cluster morphology with irregular shaped flakes. Particle size of each MOF varied depending on the method of synthesis. Particles obtained for each MOF by direct synthesis are smaller in contrast to those obtained by the interfacial method. Porosity of external surface of Cu(BDC) was higher than that of Zn(BDC). This study indicates that the BDC isolated by acid hydrolysis of post consumer PET products can be successfully used as a precursor in the synthesis of Zn(BDC) and Cu(BDC) MOFs.

Keywords: Poly(ethylene terephthalate), depolymerization, hydrolysis, metal organic framework, synthesis.

A COMPARISON BETWEEN RESISTIVITY SOUNDING INTERPRETATIONS AND BOREHOLE LOGS IN EVALUATING HYDROLOGICAL FAVORABILITY OF WATER SUPPLY BOREHOLES

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Being a non-destructive and more efficient field method, electrical resistivity surveying has become a favorite tool in prospecting groundwater, particularly for locating water supply boreholes in hard rock areas. However, comparison of resistivity interpretations with borehole logs and documentation of such work is scarce. The present study focuses on interpreting resistivity sounding data and predicting the hydrological favorability of well sites and comparing them with the logs of water supply boreholes drilled at sites in the Matale and Polonnaruwa districts. In order to achieve this goal, the resistivity sounding results were modeled in to a three-layer earth model which comprised uppermost high resistive arid overburden above water table, water saturated low resistive middle layer followed by high resistive bedrock. Resistivity sounding interpretations of 21 locations were used in the model for assessing hydrological favorability of the sites. At few locations however, this model had to be extended as a four-layer one due to drastic variation of the field curves from the three-layer model. The models for each location were compared with the logs of the relevant water supply borehole at each site to assess their correlation. The depth to static water level determined particularly in the three-layer model was found consistent with the actual data from the water supply borehole logs. The depth of the fresh bed rock below overburden was clearly identified in the resistivity sounding and showed a satisfactory consistency with the actual borehole data. Demarcation of different sub layers within the weathered overburden was not successful in the three-layer model because of increasing number of sub-layers. It could be concluded that the modeling of sub surface conditions based on resistivity sounding can be used as a reliable tool in identifying hydrological favorability of a particular location prior to siting of a water supply borehole.

Keywords Ground water, Resistivity, Overburden

A NEW METHOD TO OPTIMIZE THE INTERVAL DATA BASED TRANSPORTATION PROBLEM

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Transportation problem belongs to a special class of linear programming problems which can be solved by the simplex method. Linear programming deals with the optimization of a function of variables known as the objective function subject to constraints. In conventional transportation problem, it is assumed that the decision maker is sure about the precise value of the transportation cost, supply and demand. But uncertainty is a common phenomenon in real life situations where some parameters of transportation problem are not always deterministic. So some data may be exact, some can be in fuzzy form or in interval form. This interval form transportation problem is called an *interval based transportation problem*, which is a special type of linear transportation problem. In our work, we investigated the interval based fuzzy transportation problem. There are various approaches to solve such a transportation problem. We develop a method to solve this problem by converting to a crisp number. First, the interval data of cost, supply and demand were transferred into a fuzzy quantity using pentagonal fuzzification approach. After that the crisp value of the fuzzy transportation problem was found by using the proposed ranking method and formulated as a transportation problem. The optimal solution was obtained using Vogel's approximation coupled with Modified Distribution (MODI) Method. The potential significance of our new method over the existing one is found using some benchmark values.

Keywords: Interval data based transportation problem, Fuzzy transportation problem, Pentagonal fuzzification approach

AN INTEGER PROGRAMMING MODEL TO SOLVE THE RAILWAY ENGINE DRIVER SCHEDULING PROBLEM

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The service of a railway engine driver is of utmost importance to maintain the quality of service of the national transportation industry. Scheduling turns of drivers and assigning drivers according to the schedules are significant to have a smooth functioning in the transportation system. In general, the railway engine driver-turn assigning problem is fairly difficult to solve because of the irregular working shifts and the dearth of drivers. Also, there are many conflicts between drivers and the management who is responsible in assigning drivers to turns. This research work presents a scientific approach to overcome this difficulty by formulating a mathematical model so that the drivers will be assigned to turns while satisfying the requirements of the Kandy railway station. The procedure described here is an assignment model that finds a basic feasible solution to the zero-one integer programming problem that assigns drivers to a set of fixed trains for a day. The present driver-turn schedule in the Kandy railway station lasts for a week and it is being repeated weekly. The main disadvantage of this scheduling is not assigning regular working hours among engine drivers. To determine the optimal assignment, an objective function is formulated using a weighted method to minimize the overtime hours for each driver during the respective turn, where weights are assigned according to the overtime hours. It is assumed that necessary drivers are available according to the schedule. The formulated model is solved using Branch-and-Bound Algorithm with the help of LINGO optimization software.

Keywords: Scheduling problem, Zero-one integer programming, Branch-and-Bound Algorithm, LINGO optimization software

AN ALTERNATIVE METHOD TO FIND INITIAL FUZZY BASIC FEASIBLE SOLUTION TO A FUZZY TRANSPORTATION PROBLEM

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Since today's market is very powerful, we have to find the best transportation models to transport goods and items around the world. Currently we have many methods and models to solve those transportation problems. But in the current world scenarios, we do not have precise values for the transportation cost, availability and demand values. So, we cannot apply the characteristic methods to solve these types of problems. Thus, the need to find other methods to solve real world transportation problems. Accordingly, fuzzy transportation models play a major role in solving these types of problems. But when we work with the generalized fuzzy numbers, we cannot apply the already existing methods and need to generalize those. In our work we have modified an existing method introduced by Juman and Hoque in 2015. We can apply our modified method to solve generalized fuzzy transportation problems more efficiently and more accurately. First, we selected some randomly generated numerical examples and applied our modified method to solve the above types of problems. Next, we compared the solutions of our modified method with the solutions coming from three existing modified methods; Generalized Fuzzy North-West Corner Method, Generalized Fuzzy Least Cost Method, and Generalized Fuzzy Vogel's approximation method. According to the comparisons, our method shows better performance than the three existing methods.

Keywords: Transportation models, Fuzzy transportation problem, Generalized fuzzy transportation problem

ANALYSIS OF GENETIC DIVERSITY AND ANTAGONISTIC ACTIVITY OF *TRICHODERMA* ISOLATED FROM DIFFERENT AREAS OF SRI LANKA

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The fungus *Trichoderma* is the most applied biocontrol agent in the world. Due to various beneficial abilities, the fungus has gained much concern of researchers. However, few studies have been conducted on *Trichoderma* in Sri Lanka. This study mainly focused on the genetic diversity and the antagonistic activity of *Trichoderma* isolated from seven districts of Sri Lanka. Soil samples were collected, and *Trichoderma* spp. were isolated using a PDA medium. Different *Trichoderma* spp. were identified based on the colony characteristics and microscopic features. DNA was extracted according to the CTAB-fungal DNA extraction protocol and, an internal transcribed spacer region of the genomic DNA was amplified using *ITS1*, *ITS4* and *ITS5* primers. The antagonistic activity of all *Trichoderma* isolates was investigated using dual culture assay, employing a *Colletotrichum* sp. isolated from Brinjal as the test pathogen. The data were subjected to normality testing and the LS means of the radial growth was calculated by applying PROC GLM in the statistical package SAS 9.4. PCR amplified products of *ITS1* and *ITS4* revealed a DNA polymorphism among different *Trichoderma* isolates, while that of *ITS4* and *ITS5* did not exhibit significant variation. According to the results of the dual culture assay, all the *Trichoderma* isolates significantly inhibited the radial growth of *Colletotrichum*, but the radial growth of *Colletotrichum* was not significantly different in the presence of different *Trichoderma* isolates ($p<0.05$). This study can be further modified by examining the antagonistic activity towards different plant pathogenic microorganisms. The fungal DNA can be amplified using different markers and, the amplified DNA can be sequenced to identify the different *Trichoderma* species and their phylogenetic relationships.

Keywords: Fungal DNA, *ITS*, Dual culture assay

ANALYSIS OF LOCATION BASED INTRASPECIFIC DIVERSITIES OF CEYLON GREEN OLIVES (*WERALU*) AND BLUE OLIVES (*NIL WERALU*) IN KANDY AND MATALE DISTRICTS, SRI LANKA

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Weralu (*Elaeocarpus* spp.) is a well-known tropical fruit in the Indo-Malaysian region owing to its extraordinary curative abilities and economically valuable attributes. However, green and blue *weralu* are preferred over the other varieties since they bear bright coloured, edible fruits. Though the interspecific variations are already evaluated for some extent, the inland intraspecific variations of green and blue *weralu* are not properly appraised in Sri Lanka. The present study was conducted to determine the location-based intraspecific morphological, genetic and phytochemical diversities of the green and blue weralu populations in selected locations in Kandy and Matale districts. The morphological diversity was assessed using fruit, leaf and seed parameters and, the genetic diversity was determined using four barcoding markers; *trnH-psbA*, *trnL*, *trnG-trnS* and *ITS 1-4*. The phytochemical and elemental analyses were performed using the ripe fruit pulp. The location-based intraspecific morphological variations ware not observed for all the parameters assessed ($p<0.05$). The DNA barcode sequences were monomorphic within species; however, 1.56 % nucleotide divergence was detected between green and blue species. The phytochemical and elemental profiling of blue and green *weralu* showed intraspecific divergence within the two populations; however, the variations were not location-specific, indicating that the complex genetic and environmental control on the phytochemical profiles. Comprehensive studies on both the species will increase the awareness of the industrial applications and facilitate the conservation activities.

Keywords: Barcoding markers, tropical fruit, curative abilities

ANALYSIS OF MORPHOLOGICAL AND GENETIC DIVERSITY OF (*MADHUCA* SPP.) IN SRI LANKA

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Madhuca which belongs to the family Sapotaceae is a highly valuable tree species with remarkable medicinal and economical value. This tree species can especially be found in many countries of South, East and South-East Asian region including Sri Lanka. Even though *Madhuca* species is of astonishing values, very few studies have been done on its genetic diversity, especially in Sri Lanka. Therefore, this study was conducted to assess morphological and genetic diversities as well as antimicrobial activity of *Madhuca* species which were collected ten from selected districts *i.e. Anuradhapura*, *Kalutara*, *Kandy*, *Kegalle*, *Kurunegala*, *Mathale*, *Matara*, *Polonnaruwa*, *Ratnapura* and *Jaffna* where they are frequently grown. Mature leaves, fruits, and seeds of each tree were collected for screening the diversity, morphological traits were measured using standard measuring tools and photographs were taken for further clarifications. The genetic diversities of *Madhuca* species were studied by conducting DNA extraction of leaf samples using CTAB protocol and fingerprinting using plastid (*atpB-rbcL*, *trnG-trnS*, *trnH-psbA*, *trnL-trnF*) and nuclear (*ITS4-ITS5*) DNA. Antibacterial and antifungal activities of aqueous extracts of leaves from three accessions were examined against *E. coli* and *Colletotrichum* spp. Variations of morphological traits and inhibition zone diameters were analyzed with Minitab and GLM procedure of SAS 9.1. No significant variation was observed in any morphological trait except G variable of RGB value of fruits ($p<0.05$). Banding patterns for the six loci examined showed no significant differences. Antibacterial activity was observed with *E. coli* cultures, but antifungal activity was not observed with *Colletotrichum* spp. However, significant variation was not observed for three accessions tested. This research can be further extended by collecting samples belong to different species of *Madhuca* and observing their morphological and genetic variation. Moreover, different parts of the plant can be used to identify the phytochemicals, thereby to identify the cures for different diseases.

Keywords: Sapotaceae family, *trnH-psbA*, *trnL-trnF*

ASSESSMENT OF MORPHOLOGICAL DIVERSITY AND GENETIC DIVERSITY OF *SYZYGIUM* (*JAMBU*) IN KANDY DISTRICT, SRI LANKA

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Fruiting trees of *Syzygium* spp including *S. aqueum*, *S. malaccense* and *S. samarangense* are popular for their astonishing medicinal properties and the economic value. However studies regarding the morphological diversity and the genetic diversity of this species have not been carried out especially in Sri Lanka. Therefore this study was conducted to assess the morphological diversity and the genetic diversity of the aforementioned three species in Kandy district, Sri Lanka. Morphological variation and the phytochemical characteristics were determined for the selected accessions. The consumer preferences for the *S. aqueum* and *S. samarangense* were determined. DNA barcoding and sequencing were conducted for the species discrimination and identification. Fruit weight, length, average diameter, leaf length, RGB values of the fruits and the leaves were measured and data were subjected to a normality test followed by GLM procedure using SAS 9.1.3. According to the results, only the fruit weight, length, average diameter, leaf length and G value of RGB of leaves shows significant variation (p<0.05) confirming the inability to use morphological descriptors for the species identification. The species were qualitatively characterized for presence of anthocyanin, flavonoids, terpenoids, phlobatanins, tannins and reducing sugars. Selected accessions showed variable amounts for the selected phytochemicals. DNA was extracted from mature leaves and PCR amplification was conducted with primers for four markers, *trnH-psbA*, *trnL-F*, *ITS4-5* and *trnG-trnS*. DNA sequencing followed by phylogenetic tree construction was conducted using UPGMA method. *ITS4-5* was able to discriminate between the three species selected. As future direction, consumer preference and phytochemical tests have to be conducted for the next fruiting season for the aforementioned species.

Keywords: RGB values, GLM procedure, UPGMA

ASSESSMENT OF THE PHOSPHOROUS DEFICIENCY TOLERANCE IN A SELECTED SET OF RICE VARIETIES AND THEIR DNA MARKER HAPLOTYPES OF THE *PUP1* LOCUS

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Phosphorus (P) crisis is a major problem that will be faced by the rice farmers in near feature due to the depletion of non-renewable global P reserves. P is important for optimum crop growth, development and yield increment. Global and local food demand also gets augmented due to the increased population, therefore despite of all the other problems food demand has to be fulfilled. Rice cultivation excessively requires P fertilizer application but cost and the environmental effects associated with these fertilizers are huge problems. In order to compensate the lack of P fertilizers and its side effects, rice varieties that are able to tolerate P deficient conditions are required. In rice major QTL associated with phosphorus deficiency tolerant (PDT) is located on the chromosome 12 and named as phosphorus uptake 1 (*Pup1*). Transferring the *Pup1* into PD sensitive varieties is the basis of molecular breeding in order to develop PDT rice varieties. Sri Lanka has a diverse collection of rice varieties but screening of these varieties for PDT has not been carried out excessively. Present study based on the screening of 27 rice varieties including land races, old improved and newly improved varieties and identifying their DNA marker haplotypes of the *Pup1* locus. Screening was carried out in the no fertilizer field at Rice Research and Developmental Institute (RRDI), Bathalagoda for two cropping seasons in year 2017. Plant height (PlH), number of tillers (NT), flag leaf length and width (FLL and FLW), shoot dry weight (SDW), shoot phosphorus concentration (SPC), shoot phosphorus uptake (SPU), phosphorus utilization efficiency (PUE) and yield parameters were recorded. All data were statistically analyzed using ANOVA, regression and principle component analyses. Regression plot between the principle component analysis of PUE and SDW categorized the varieties into three classes. *Madathawalu*, H-4, H-10, At 311 and Bw 367 were identified as PDT varieties in both seasons. Four varieties identified as sensitive varieties in both seasons and 11 varieties were identified as moderately tolerant varieties in both seasons. Marker haplotypes identification was performed with the 17 *Pup1* related SSR markers and 27 *Pup1* marker haplotypes were identified. They clustered into 12 haplotype groups. With the association analysis of *RM28102* and *K29* it was able to identify important SNPs and INDELs associated with PDT traits. In there, INDEL of (126-161 base positon) RM28102 is much more descriptive and has a higher gain of selection for the associated traits. In marker *K29*, length polymorphism is due to the recombination from the chromosome 2 for four varieties. Finally the varieties that have been identified as PDT in this study can be readily employed in future MAB programs.

Keywords: Rice molecular breeding, Marker assisted breeding of rice, Phosphorus fertilizer crisis, rice QTL, rice SSR markers

GENETIC DIVERSITY AND POPULATION STRUCTURE OF *COLLETOTRICHUM* SPP. FOUND IN EIGHT FRUIT AND VEGETABLE SPECIES IN SRI LANKAN MARKET

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Colletotrichum is a well-known phytopathogenic fungus which acts as the causal agent of anthracnose disease infecting a wide range of plants. As the genus *Colletotrichum* is economically important, it has been studied extensively. The current study was conducted to determine genetic diversity of *Colletotrichum*, which is responsible for anthracnose disease of selected eight fruit and vegetable species found in Sri Lanka. Although several separate studies on different *Colletotrichum* species were executed in Sri Lanka, so far no collective studies are reported, as per the data collected and literature cited. The anthracnose-diseased fruit and vegetable samples were collected randomly from markets, and different *Colletotrichum* species were isolated. Pure cultures were obtained after sub-culturing repeatedly for several weeks and used to extract genomic DNA. The entire *ITS* region of each isolate was PCR-amplified using the universal primers for *ITS1* and *ITS4* and the PCR products were separated in agarose gel electrophoresis to observe length polymorphism. The *ITS* length polymorphism suggested that all the eight isolates could be classified into seven different groups while isolates from brinjal and capsicum can be grouped under similar group, and the two major groups, fruits and vegetables, can be separately classified; however, the results demand the need for comprehensive molecular analyses on *ITS1* and *ITS2* regions separately. The pure cultures were utilized to prepare conidial suspensions and used to inoculate on healthy fruits and vegetables to test the cross-infection ability of five selected *Colletotrichum* isolates. However, it was unable to establish cross-infection potential of the pathogens as the pathogenicity test produced negative results. The current research can lay a foundation for further studies which will eventually lead to developing effective mechanisms to control and prevent anthracnose.

Keywords: Anthracnose, phytopathogenic fungi, taxonomy, polymorphism

IDENTIFICATION OF A LIPOLYTIC FUNGUS FROM A LIPID CONTAMINATED SITE AND CHARACTERIZATION OF THE CRUDE LIPASE

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Lipases are enzymes belonging to α/β hydrolase fold and are generally known as triacylglycerol acyl hydrolases. Among the widely used enzymes with biotechnological applications today, microbial lipases have occupied a significant place. Novel microbial species producing highly efficient extracellular lipases are industrially demanding for numerous industrial applications in pharmaceuticals, cosmetics, organic synthesis, bioremediation, biodiesel production, biosurfactants and detergents, leather and paper processing, and in medical diagnostics etc. Applications of microbial lipases are evolving with the biotechnological advancements as recombinant lipases with extreme properties can be produced. However, the studies on lipolytic fungi are considerably less than studies on lipolytic bacteria, as bacteria are ubiquitous, easy to culture and modify. To exploit the novel or understudied lipolytic fungi, lipid contaminated soil from a few sites was collected and screened for the presence of lipolytic fungi. Out of the several fugal species isolated, one species, morphologically identified as being belonging to the genus *Fusarium*, gave positive results for both Tween-20 plate assays and phenol red plate assay for lypolytic activity. Out of the large number of extant *Fusarium* species, lipases from only a few species have been descriptively studied. Therefore, the lipase produced by the fungus was subjected to further investigation. The crude enzyme was active at basic pHs, and up to a temperature of 50 °C. The activity of the enzyme was enhanced by divalent cations as well as by the anion CH_3COO^-. Further studies are being conducted to determine the identity of the fugal species by rDNA analysis and to purify and further characterize the enzyme to assess its potential industrial application.

Keywords: Fusarium lipase, Alkalophilic lipase, pNPP lipase assay, High temperature tolerance

ISOLATION OF A CELLULOLYTIC FUNGUS AND STUDIES ON PROPERTIES OF ITS CELLULASE

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Cellulase is a heavily used industrial enzyme. Studies have shown that fungi can secrete cellulase and therefore are considered as the best source of the enzymes since secreted form of cellulases can be purified in a feasible manner. So far it is considered that the fungi of the genus *Trichoderma* are the most efficient producers of cellulase. However, it is now known that fungi belonging to several other genera including *Penicillium* produce cellulases. In a search to identify and isolate novel cellulases, we identified a fungus that appeared to secrete cellulase efficiently. Morphological characteristics suggested that the fungus was a *Penicillium* species. The enzyme was produced by growing the fungus in submerged cultures and the properties of the crude enzyme were studied. The enzyme was highly active at acidic pHs and high temperatures. It was considerably stable and retained significant activity even after treatment of the enzyme at 100 °C for 2.5 hrs. Studies are being continued for detailed characterization of the enzyme and to assess its suitability in biotechnological applications.

Keywords: *Penicillium* species, cellulase production, crude cellulase, characterization

ISOLATION OF DIESEL-UTILIZING BACTERIA FROM PETROLEUM CONTAMINATED SITES

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Petroleum degrading microbes are now being used for remediation of petroleum contaminated soil. However, the effectiveness and the efficiency of this cleaning process, known as bioremediation, depend on the species composition of the microbial population employed in the process. Thus, isolation of efficient petroleum degraders has become an important area of research interest. Indigenous microbial populations in petroleum contaminated sites are potential sources of good degraders. The present study mainly focused on identification of efficient petroleum degrading bacteria from petroleum contaminated soils. Diesel degrading bacteria were isolated from petroleum contaminated soil by culturing them on agar plates. Diesel was chosen as the carbon source since it is a complex mixture of linear and aromatic compounds, and therefore, a great substrate to isolate bacteria which have different degrading abilities. Potential isolates were subjected to turbidity measurements and Bushnell Hass broth-plate assay to estimate the growth of individual cultures on diesel. A total of seventeen potential isolates capable of degrading diesel were isolated, of which, based on turbidity measurements and Bushnell Hass broth-plate assay, five isolates were identified as dominant degraders. Further studies need to be conducted to confirm the identity of the species, to formulate efficient consortia consisting of two or more species and to assess the rate of oil removal by efficient consortia.

Keywords: Biodegradation, petroleum degrading bacteria, Bushnell Hass broth-plate assay

PHYSIOLOGICAL CHARACTERIZATION AND GENETIC DIVERSITY ANALYSIS OF THE RHIZOBIAL POPULATIONS INHABITING *GLIRICIDIA SEPIUM* IN SELECTED LOCATIONS OF *POLONNARUWA* DISTRICT, SRI LANKA

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Gliricidia sepium is a widely distributed, multipurpose tree legume that has a great host range of Rhizobia which is known for Biological Nitrogen Fixation. However, the physiological characterization of stress tolerant Rhizobial strains in *G. sepium* and their genetic diversities are poorly studied in Sri Lanka. This study focused on the physiological characterization and genetic identification of stress tolerant Rhizobial strains which were isolated from the root nodules of *G. sepium* in selected seven locations (*Moragaswewa*, *Jayanthipura*, *Bakamuna*, *Aralaganwila*, *Monarathanna*, *Sinhapura*, and *Madirigiriya*) of *Polonnaruwa* district, Sri Lanka. Isolated Rhizobial strains were subjected to different physiological conditions (pH, temperature, salinity, and drought) by considering the natural soil conditions in *Polonnaruwa* district which is located in the dry zone of Sri Lanka. The growth of isolates was adversely affected by acidic pH like 3.0 and 4.0. However, most strains exhibited tolerance to alkaline pH and extreme drought conditions (3.0 % and 4.0 % polyethylene glycol 8000 concentration). Most of the strains except the strains in *Sinhapura* were moderately tolerant to extreme salt concentrations. However, they showed a higher tolerance at 1.5 % and 2.0 % sodium chloride concentrations as the natural soil salinity level are varying from 7.0×10^{-2} to 0.300 ds m^{-1} range. Some strains in *Bakamuna*, *Moragaswewa* and *Aralaganwila* showed better survival ability at each temperature levels. Although selected 15 strains showed high tolerance to more than two individual conditions, 14 strains showed relatively higher survival ability, except for the MW-a strain, in the combination of adverse physiological conditions. The 15 Rhizobial strains showed great genetic diversity in the Enterobacterial Repetitive Intergenic Consensus profile as they belonged to 10 clusters at the 65 % similarity level. Furthermore, this stress tolerant Rhizobial strains can be used for further studies on cross-inoculate crop legumes as a solution for the vast usage of chemical nitrogen fertilizers.

Keywords: Salinity tolerance, biological nitrogen fixation, drought tolerance, cross-inoculation.

STUDY OF THE PRESENCE OF *HELICOBACTER PYLORI* IN THE ORAL CAVITIES OF A GROUP OF SRI LANKAN DENTAL STUDENTS WITH CLINICAL EXPOSURE

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Helicobacter pylori infection is a leading cause of gastric-adenocarcinoma, chronic-gastritis, and gastric-ulcers. Major transmission mode of *H. pylori* among humans is through oral-oral route. *H. pylori* contaminated droplets of body fluids such as saliva facilitates its further dissemination. Dental healthcare workers carry a high risk of *H. pylori* infection due to their frequent exposure to aerosolized dental plaque and saliva of patients. Therefore, present study was carried out to investigate the oral presence of *H. pylori* in a group of Sri Lankan Dental students with clinical exposure and to compare it with a control group of age-gender matched non-clinical Science students. Oral-biofilm samples were collected from 38 dental students and 33 science students upon their informed consent. Total DNA was extracted after lysis of samples with NaOH. DNA concentrations and purity were measured using absorbance values at 260nm and 280nm. Presence of *H. pylori* DNA in lysates was detected by PCR amplification of the *16S rRNA* gene of *H. pylori* using JW22-JW23 primer pair. Results were confirmed using PCR with *H. Pylori-urease* specific HPU1-HPU2 primer pair. Data were statistically analyzed using Minitab14 software. Out of the 71 participants, 11 (28.95%) dental students and 3 (9.09%) non-dental students were positive for *H. pylori*. Accordingly, presence of *H. pylori* in oral-biofilms of dental students was significantly higher than that of science students ($p<0.05$). An Odds ratio of 4.07 indicated that dental students are four times more likely to harbor *H. pylori* in their oral-biofilm compared to non-dental students. Since dental students appear to be more susceptible to get infected by *H. pylori* inhabiting their patients' oral cavities, there may be an occupational risk of *H. pylori* infections among dental healthcare workers. Hence, proper infection control practices are recommended during clinical dental practice.

Keywords: Dental plaque, PCR amplification, oral biofilm, occupational risk, infection control practices

STUDY ON *TGF-β1* GENE EXPRESSION IN URINE OF STAGES 1-3 CKDu PATIENTS

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Chronic Kidney Disease of unknown etiology (CKDu) is creating a big impact on the socioeconomic structure on the farming community in dry zone of Sri Lanka. Many affected people remain undiagnosed due to the lack of any unambiguous symptoms during the early stages. Transforming Growth Factor-β1 (TGF-β1) has been shown to be highly expressed in biopsy samples of CKD patients. Despite the extensive prevalence of CKDu, no biomarker is yet identified to screen patients in early stages of disease. This study was conducted to ascertain the degree of expression of *TGF-β1* mRNA in urine and whether *TGF-β1* could be used as a specific biomarker for CKDu. Urine samples were collected from CKDu patients of stages 1-3 and endemic controls from *Girandurukotte*, and healthy non-endemic controls from *Mawanella*. From the collected urine samples, RNA was extracted and converted to cDNA. Quantitative real-time PCR was performed for *TGF-β1* against the reference gene *GAPDH*. Agarose gel electrophoresis was also carried out for the amplified products to view band patterns. *GAPDH* had moderate levels of amplification in almost all the samples, which were also observed with clear distinct gel banding pattern. *TGF-β1* had low levels of expression with only a few individuals showing expression. *TGF-β1* expression among the three study groups exhibited very low variation. These results suggest that *TGF-β1* is not differentially expressed in the early stages of CKDu; thus, it is not a suitable biomarker. This is the first study that used urinary RNA for gene expression of CKDu patients in Sri Lanka and the expression of GAPDH in the samples show that urinary RNA can be used as a noninvasive sample to identify a biomarker to diagnose CKDu.

Acknowledgement*: National Research Council, Sri Lanka, Grant No:15-057; CKDu Prevention Program, Teaching Hospital, Kandy, Sri Lanka*

Keywords: Gene expression analysis, urinary transcriptomics, renal failure, qPCR

A STUDY OF THE GEIGER MÜLLER COUNTER

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A Geiger Müller (GM) counter is a radiation detecting instrument which is basically a gas filled detector, relies upon avalanche multiplication of ionizing events due to radiation. GM counters are continued to be used in present time in various nuclear related fields due to their simplicity, high stability, portability, low cost and ease of operation. True counts of the ionizing events are lost due to the successive radiation disintegrations which occur in a very small time intervals due to the dead time (DT) of the GM counter. Accurate estimation of the DT is vital in determining the radiation detected by the GM counter. To study the behavior of the DT of a GM counter, two theoretical models were developed based on two extremely idealistic assumptions namely; paralyzable and nonparalyzable models. These models were studied by attenuating radiation through an Al shield. Using the data collected by attenuating the radiation, the variation of count rate with respect to the thickness of the Al sheet was derived. These data were then subjected to the two idealistic models and graphical expressions of the two models were separately obtained for the same set of data. Using the graphical method dead time of the GM counter was estimated.

Keywords: Dead time, Paralyzable, Nonparalyzable, Attenuation of radiation

AN INVESTIGATION OF THERMOELECTRIC PROPERTIES OF SELECTIVE SEMICONDUCTOR MATERIALS AND THEIR COMPOSITES

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Thermoelectricity is a method of generating electricity by maintaining a temperature gradient in a suitable material. This is a possible solution for the wastage of heat energy in various industries. The importance of a material as a thermoelectric material is represented by its figure of merit (ZT) and power factor (P) values. Moderate electrical and thermal conductive semiconductors have a higher ZT and P values compared to those of conductors and insulators. Electrical conductivity (σ) was calculated by using the measured current and voltage across the sample and thermal conductivity (K) was determined using parallel axis theorem for semiconductive pellets. Seebeck coefficients (S) for semiconductive pellets were obtained using similar setup used for σ measurements. In this study, Bi_2S_3 were synthesized and confirmed the crystal structure utilizing X-ray diffraction technique. SnS from a previous study and graphite were used as it is. TiO_2 was ground and reduced to nanosize using a hydrothermal method. All four semiconductor compounds were made into pellet type sample. Bi_2S_3 had the maximum ZT and P values and TiO_2 and SnS had moderate ZT and P values and graphite had the lowest. Graphite, as a material available in Sri Lanka, was incorporated into insulative PEO to form flexible, low cost and effective thermoelectric material. High σ of graphite and low K of PEO helped to generate high ZT and P values in polymer composites. Graphite: PEO was mixed based on the volume ratio and maximum ZT and P were obtained for 22% graphite to polymer ratio samples. Variation in ZT and P values of composite sample had a similar behavior as in semiconductors. Obtained highest ZT value and P for polymer composite were 0.000123 and 2.24676 $\mu W\ m^{-1}\ K^{-1}$, respectively, at 30 K temperature difference.

Keywords: Thermoelectricity, figure of merit, power factor

AN INVESTIGATION ON CORN STARCH AND CaO NANOPARTICLE BASED POLYMER COMPOSITE

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The growing concern over the issues surrounding the disposal of non-degradable plastics has encouraged the production of environmentally friendly materials. Corn starch is an excellent candidate for the purpose, as corn is sustainable and cheap. In this study, films of corn starch (CS) plasticized with glycerol (GLY) in the presence of CaO nanoparticles were investigated. The solution casting technique was used for the preparation of the films. To enhance the workability of corn starch based packaging materials, it can be blended easily with additives such as plasticizers and fillers. Young's modulus, ultimate tensile strength, and water absorption of the samples were measured to investigate the suitability of the end product as a packaging material. According to the results, addition of GLY significantly reduced the Young's modulus along with the ultimate tensile strength. Incorporation of CaO nanoparticles showed an increasing trend in the Young's modulus and ultimate tensile strength at the levels of nanoparticles below 0.25% (w/w) but the trend started to decrease at higher levels. The water absorption was reduced with increasing amount of plasticizer but increased with increasing amounts of CaO nanoparticles. The most desirable results were observed for the films with 15% (w/w) GLY and 0.25% (w/w) of CaO nanoparticles. When compared with the film fabricated without incorporation of the additives, the elongation was increased by 100% (from 0.92 cm to 1.84 cm) and the Young's modulus was decreased by 96% (from 11.7×10^8 N m^{-2} to 0.4×10^8 N m^{-2}) while maintaining ultimate tensile strength around $(2.30 – 2.70) \times 10^7$ N m^{-2}. Water uptake capacity was reduced by 77% upon incorporation of the additives. The end product with 15% (w/w) GLY and 0.25% (w/w) of CaO nanoparticles can serve as an environmentally (biodegradable) and human (non-toxic) friendly alternative to the traditional petroleum derived packaging materials.

Keywords: Corn starch, Glycerol, CaO nanoparticle, Solvent casting technique

DESIGNING A LOW COST HORN-ANTENNA RADIO TELESCOPE TO OBSERVE 21 cm GALACTIC ATOMIC HYDROGEN EMISSIONS

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Radio astronomy is the study of celestial objects at radio frequencies. In contrast to optical, IR or UV astronomy, radio astronomy mostly deals with large scale structures such as nebulae and galaxies. Information loss due to the absorption, scattering etc. characteristic to optical, IR or UV radiation is negligible when it comes to radio frequencies. Radio telescopes are usually large scale structures and have sensitive electronic components that are expensive. Need for low-cost radio telescope designs to promote radio astronomy is therefore essential. Horn-antennas are compact in design compared to dish type antennas. Other advantages of a horn-antenna are the relatively simple design, high gain and low voltage standing wave ratio (VSWR). The goal was to design a horn-antenna radio telescope keeping the cost down while optimizing performance. The horn-antenna was designed and constructed for an optimum gain and a receiver system was designed to observe 21 cm galactic neutral hydrogen emissions. Observations were done along the galactic plane of the Milky Way galaxy at 10° intervals. The rotation curve of the galaxy was obtained for the first quadrant. The rotation curve shows acceptable agreement when compared with the expected results for radius < 7 kpc. A map of neutral hydrogen was made to identify the spiral structure of the galaxy. From the map, the Perseus arm and the Orion arm were identified. The accuracy of the instrument was found to be acceptable for observations in the local neighborhood. In conclusion, it can be suggested that a radio telescope can be constructed using cost effective materials and components to conduct radio astronomy observations.

Keywords: Radio telescopes, Milky Way galaxy, rotation curve, 21 cm neutral hydrogen emission line

DETERMINATION OF DENSITY VARIATION USING A LOW ENERGY ISOTOPE

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To date, there are number of experimental techniques have been discovered to determine the density of a material. These methods are ranging from simple measurements of mass and volume to more advance techniques such as Compton scattering: the phenomenon of scattering of incident photon by a loosely bound electron of an atom. The number of scattered photons (photon counts) is a measure of the density of the target material. Therefore, the Compton scattering technique is used to study the density variation of the target materials. In this study ^{137}Cs is used as the source of gamma rays which are struck on the target material. The number of photons scattered by the target material at corresponding scattering angles are measured by a NaI (TI) scintillator which detects only gamma photons. Five samples including one alloy (Brass) and four metals (Al, Cu, Pb, Ag) have been used as the target materials (metal sheets) with different thicknesses to examine the validation of Compton scattering and hence, to determine their densities. Density of the each sample was calculated for each scattering angle (0˚-90˚). The respective densities of all the samples were nearly constant for the scattering angles of 30˚ to 90˚. In addition to that, a variation in density can also be seen for the corresponding range of angles. This study can be applied to monitor defects, voids and cracks of a wooden structure since Compton scattering technique competes with the non-destructive techniques.

Keywords: Gamma rays, Compton scattering, NaI (TI) scintillator

DETERMINATION OF THERMAL AND EPITHERMAL NEUTRON FLUX OF THE Am-Be NEUTRON SOURCE USING THE FOIL ACTIVATION METHOD

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Neutron detection by foil activation is based on the formation of radioisotopes by neutron capture, and analyzing the radiation spectrum of that radioisotope. For the applicability of instrumental neutron activation analysis using a neutron source, it is essential to know the flux parameters of the source. To obtain the neutron flux in the irradiation site of the Am-Be neutron source installed at the Department of physics, University of Peradeniya, neutron irradiated Cadmium(Cd) and Copper(Cu) samples were used. In order to characterize neutron flux spectra, results were obtained for thermal and epithermal fluxes and thermal to epithermal ratio (*f*) by using the 'Cadmium difference method'. Variations of the flux with the thickness of the shielding material and the target material were also studied. In addition, the neutron absorption efficiencies of Cu and Cd were compared experimentally. For the neutron source, obtained flux measurements were 2.72×10^7 neutrons m^{-2} s^{-1} and 2.80×10^7 neutrons m^{-2} s^{-1} using Cd and Cu respectively. The values obtained for the thermal flux, epithermal flux and *f* parameter using Cu foils were 2.34×10^7 neutrons m^{-2} s^{-1}, 3.19×10^6 neutrons m^{-2} s^{-1}, and 7.34. It could be deduced that Cd is a better neutron shielding material than Cu. The flux reduction by 1 mm thick Cadmium shielding was 74.11% while the flux reduction by Copper shielding was 29.64%. Also 0.5 mm thick Cd shielding was good enough for thermal neutron shielding purposes. Knowledge of these parameters will be fundamental in the planning of sample irradiation for analysis or radioisotope production in a more accurate way.

Keywords: Neutron activation analysis, Absorption cross section, Am-Be neutron source

DEVELOP SELF-CLEANING NANOCOMPOSITE COATING ON CLAY ROOFING TILES

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Modern days, the phenomenon of heterogeneous semiconductor photocatalysis takes place in the degradation process of many organic contaminants on solid surfaces. The semiconductor photocatalysis is based on the excitation of the electron in the valence band of the semiconductor in to the conduction band by irradiation with energy photons and the migration of electron-hole pairs to the surface of the photocatalysts. These electron-hole pair react with H_2O molecules in the air and make hydroxyl radicals and they have ability to decompose organic materials in to CO_2 and H_2O. In the present studies, TiO_2 is used as the semiconductor photocatalysis, due to its stability and photosensitivity. This system is well studied and is of great interest from an ecological and industrial point of view for use in the field of building materials. Due to their long-term exploitation to natural situations, roof tiles become subject to physical, chemical and biological degradation that leads to deterioration. Roof tile is a type of ceramic systems that has a high percentage of total porosity and the present research is focused on obtaining mesoporous coatings using TiO_2 and Polyethylene glycol with molecular weight 4000 (PEG- MW 4000) as the structure directing agent (SDA). Photocatalytic coatings were deposited on clay roofing tiles using spray technique followed by thermal treatment. The concentration of the TiO_2 solution is varied by varying the quantity of PEG mass in the solution. The functionality of coated roofing tiles were evaluated for; photocatalytic activity by decomposition of Methylene Blue (MB) aqueous solutions under UV light exposed time, hydrophilicity and antimicrobial efficiency. The TiO_2 coating with the lowest PEG mass applied onto roof tiles under lab conditions has better photocatalytic activity in MB decomposition (value), hydrophilicity (contact angle), better antimicrobial activity than the TiO_2 coating with higher PEG mass photocatalytic coating.

Keywords: Semiconductor photocatalysis, Titanium dioxide, Polyethylene glycol (PEG), Structure directing agent (SDA), hydrophilicity, Photocatalytic activity.

FABRICATION AND CHARACTERIZATION OF TRANSPARENT ELECTRODES USING SURFACE MODIFIED SILVER NANOWIRES

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Transparent electrodes (TEs) are related to many optoelectronic applications. The most efficient and widely-used transparent conducting coating material is indium tin oxide (ITO). However, the scarcity of indium associated with ITO's lack of flexibility and the relatively high manufacturing costs have prompted search into alternative materials. Silver nanowire coated transparent electrodes have recently received much attention as a replacement for ITO. Silver nanowires (Ag NWs) are attractive components for a number of materials and applications, including silver nanowire and polymer composites, electrically conductive coatings and transparent electrodes. The present research was carried out to analyze the morphological changes in Ag NWs after surface modification using 2-mercaptoethanol and utilization of surface modification to obtain transparent electrode with lower sheet resistance and higher transmittance. Morphological evidences clearly suggested that, modified silver nanowires with 2-mercaptoethanol have more uniform dispersion compared to non-modified silver nanowires and modified silver nanowires lead to higher transmittance (at 550 nm) through the electrode. Modified Ag NWs were blended with PEDOT:PSS { Poly (3, 4-ethylenedioxythiophene) and poly(styrene sulfonate)} and it yielded low sheet resistance for modified Ag NWs and PEDOT:PSS coated electrodes. The best electrode yielded 86% transmittance at 550 nm with sheet resistance, R_s of 9.5 Ω per square. In conclusion, these values are very close to transmittance and sheet resistance of ITO coated electrode (Tr ~90% at 550 nm and R_s ~10 Ω per square) and they can be used as a substitution for ITO coated TEs.

Keywords: Surface modification, Silver Nanowire, Transparent Electrode, Polymer-nanowire composite, Morphology

GAS SENSING PROPERTIES OF FERRIC OXIDE (α–Fe_2O_3) THIN FILMS IN ETHANOL VAPOUR, ACETONE VAPOUR AND CARBON DIOXIDE GAS

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In this work, Polyethylene glycol (PEG) conducting polymer bindered α-hematite (α-Fe_2O_3) nanostructure was prepared by using doctor blade method and spin coating method. Iron acetate powder mixed with PEG was used as the initial solution, and the sample was annealed at 500 ^{0}C in air for 1 hour to crystallize the phase of α-Fe_2O_3. The gas sensing performance was studied in acetone vapour and CO_2 gas for the prepared samples, and the synthesized films were characterized using UV-visible, FTIR, XRD, SEM techniques. According to XRD patterns, single phase of α-Fe_2O_3 could be crystallized after annealing the sample at 500 ^{0}C for one hour in air. The UV-visible spectrum exhibits an absorbance on set around 630 nm and optical band gap energy of 1.98 eV by confirming the formation of α-Fe_2O_3 in thin film form. In addition, FTIR confirms the formation of PEG bindered α-Fe_2O_3 composite by indicating two vibrational mode frequencies at 456 and 549 cm^{-1}. SEM images revealed the presence of α-Fe_2O_3 Nano sized grains (90 nm) with a high porous nanostructure. This porous nanostructure develops a wide electron-depleted surface by adsorbing atmospheric oxygen which will enhance the surface to detect more analytic gas molecules. The gas sensitivities (gas response) of samples were measured in 1000 ppm of ethanol vapour, methanol vapour, acetone vapour and CO_2 gas. The gas sensor exhibited a remarkable acetone and CO_2 sensing properties at room temperature but weak sensing properties in Ethanol and Methanol vapour. The gas sensitivity of acetone and CO_2 was increased and then decreased with the increase of the operating temperature by indicating a maximum value at particular temperature. For CO_2 gas, the maximum gas sensitivity was 78.22% at 170^{0}C operating temperature. The response and recovery times were 686 and 511 s for CO_2 at maximum gas sensitivity, respectively.

Acknowledgement: *Faculty of Nano Technology, Department of Applied Science, Wayamba University of Sri Lanka, Kuliyapitiya, Sri Lanka.*

Keywords: Polyethelene glycol (PEG), α-hematite (α-Fe_2O_3), Gas sensitivity, Porous nanostructure.

HYDROGEN GENERATION BY PHOTOELECTROCHEMICAL SPLITTING OF WATER

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Hydrogen production using phototelectrochemical (PEC) oxidation of water is a promising technology for efficient storage of solar energy. Hematite (α-Fe_2O_3) is one of the most promising materials tested as a photoelectrode in PEC cells for hydrogen production mainly due to its favourable bandgap of about 2.2 eV and many other advantages. The physical properties and the photoelectrochemical characterization of α-Fe_2O_3 photoanodes doped with different metal oxides and synthesized by spray pyrolysis on indium tin oxide (ITO) glass substrates were investigated to identify the best dopant ion. The investigation was further extended for various doping concentrations of the best dopant ion. The preparative parameters were optimized to obtain uniform thin films with good adherence to the substrate. All the synthesized photoanodes, exhibited *n*-type semi-conductivity which was a requirement for anodic photocurrent generation. The deposited α-Fe_2O_3 thin films resulted in single-phase hematite with rhombohedral crystal structure as confirmed by the XRD analysis. The optical analysis enabled to demonstrate the increase in the band-gap energy with doping compared to the undoped photoanodes. The photocurrent density and the resistivity of the photoanodes exhibit a dependence on the doping concentration. The α-Fe_2O_3 photoanodes with 5.0 mol% Zn exhibited a higher photocurrent response achieving a solar to hydrogen conversion efficiency of 0.86% in 13 pH NaOH electrolyte solution under 1.5 AM solar illumination. Also the above photoanode demonstrated improved visible-light absorption efficiency as well as a high incident photon-to-current efficiency. Moreover that photoanode exhibited excellent stability and corrosion resistance in the alkaline medium with a higher rate of hydrogen generation. The flat-band potentials obtained from Mott-Schottky plots indicated that the photoanode with the highest efficiency have the most negative flat band potential. In addition, the constructed photocell provided the facility to generate and collect oxygen.

Keywords: Splitting of water, Photoelectrochemical oxidation, Hematite photoanodes, Hydrogen generation.

MIXING SUITABLE OILS WITH LUBRICANT OILS FOR AUTOMOBILES AS A COST REDUCTION METHOD

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Lubricant oils are used for the engines of automobiles or any other machine to get the best performance and also for the durability and for the protection of the engine. When the engine is running, lubricants help to cool down and to reduce the corrosion of its metal components and reduce the friction between the moving parts. This study investigates the possibility of mixing engine oil with coconut oil or palm oil by studying different properties such as viscosity and its variation with temperature, density, specific heat capacity, acid number and flash point. In addition to this, Interactions between different types of molecules were characterized using *FTIR* spectroscopy. Viscosity measurements was done by using rotational viscometer. To find the acid number of these compositions *ASTM D664* method was used and to determine the flash point the Cleveland open cup apparatus was used. The viscosity, density and sulfur concentration of 10% palm oil composition are similar to those values of SAE 20 commercially available lubricant oil, which can be used in light duty vehicles. For this same composition specific heat capacity, acid number (acidity) and flash point have better values than *SAE 20* lubricant oil. However, considering Soot, Nitration, water, Glycol, Diesel and Gasoline concentrations of 30% (v/v) coconut oil composition has the similar values to the lubricant oil. By using possible additives to reduce these values for 10% (v/v) palm oil composition, there is a possibility that this composition can be used in an engine for lower cost than pure lubricant oil. For low viscosity lubricant oil required engines, 30% (v/v) palm oil can be used. The reduction of the cost for 10% (v/v) palm oil composition and 30% (v/v) palm oil is about 85 LKR and 250 LKR per liter respectively. These alternatives can be used as good and lower cost substitutes to lubricant oils in engines of automobiles.

Acknowledgement*: National Institute of Fundamental Studies, Kandy.*

Keywords: Lubricant oil, oil composition, viscosity

MONITORING CARBON DIOXIDE CONCENTRATION IN CLOSED ENVIRONMENTS

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People in the modern society mostly live in closed environments due to their present lifestyles. Thus, the air inside closed environments plays an important role for a healthy life. The indoor air quality index is classified to the measurement of nitrogen dioxide, carbon monoxide, sulfur dioxide, ozone and particulate matter. However, carbon dioxide (CO_2) is not classified under the indoor air quality index. Measuring the concentration of CO_2 in closed environments is vital as CO_2 can act as an asphyxiant gas. There is no standard limit set for the concentration of CO_2 in Sri Lanka. The American Society of Heating, Refrigerating and Air-Conditioning Engineers, has set a standard CO_2 concentration for indoor environments to 700 ppm. A device was constructed to measure the CO_2 concentration, ambient temperature and the relative humidity with components available in Sri Lanka. Considering the standard limit for CO_2 concentration as 700 ppm, the research was conducted to measure the concentration of CO_2 inside vehicles with air conditioning (A/C) set with recirculation mode, laboratories and hospital rooms. The increase in CO_2 concentration inside the closed environments relate mainly due to human respiration metabolism. Despite the fact that air conditioning machines controls the temperature and the relative humidity, the concentration of CO_2 is not controlled. The measured CO_2 concentration in above closed environments exceeded the 700 ppm limit. Inside some vehicles, the concentration of CO_2 increased up to 5000 ppm creating a very uncomfortable feeling. Consequently, the increase of CO_2 will create an unhealthy indoor air environment leading to conditions such as headaches, poor metal concentration and slight nausea. The CO_2 concentration inside a closed environment is therefore a key factor related to human comfort and health. Thus, more attention should be paid for construction of closed environments for maintaining a CO_2 level not exceeding 700 ppm.

Keywords: Closed environment, Carbon dioxide concentration, Relative humidity, Healthy indoor air.

STUDY OF SCIENCE BEHIND *BISOKOTUWA* IN ANCIENT LAKES IN SRI LANKA

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Artificial lakes were designed in Sri Lanka to store water from rain or detain water from the floods. Method of breaking the lake bund that used to release water from smaller lakes could not be applied for large lakes because large amount of water flow through the broken bund could cause destruction to the bund and cannel banks. A weak point of the lake bund can be broken due to hammer effect when a direct sluice is used to release water. Therefore, ancient engineers introduced a suitable mechanism, called *Bissokotuwa* to large lakes that caused the development of a greater hydraulic civilization in Sri Lanka. This project investigates the kinetic energy (KE) losses inside the *Bissokotuwa* and compare it with water channeling through a direct sluice with the aid of a scale down physical model constructed using perspex and wood, of *Buuwewa Bissokotuwa* in *Polonnaruwa*. Inlet and outlet sluices are horizontal. The study indicates that the outlet flow (OF) velocity is less than that of the inlet flow (IF). The pressure head inside the *Bissokotuwa* is less than that of the reservoir head. Percentage of KE loss does not depend on the reservoir head and it is about 43.5% for scale down physical model. Turbulence are observed only inside the *Bissokotuwa* and IF and OF obey Poiseuille's law and are laminar. The total head of IF reduces due to this occurrence of turbulence inside the *Bissokotuwa*. The study optimizes square shape to be the most suitable shape for the *Bissokotuwa* to acquire maximum KE loss. The study showed that the lake bund is preserved with the invention of *Bissokotuwa* by controlling the destructive KE and pressure by behaving as a surge tank, whereas cannel banks are preserved by decreasing degradation and erosion resulting with low KE of OF.

Acknowledgement: *Faculty of Engineering, University of Peradeniya, Peradeniya.*

Keywords: Ancient irrigation in Sri Lanka, Artificial lakes, *Bissokotuwa*

A HIERARCHICAL BAYESIAN REGIONAL MODEL FOR PRECIPITATION EXTREMES IN SRI LANKA CONDITIONED ON SOUTHERN OSCILLATION

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The occurrence of extreme precipitation events causes substantial damage to agriculture, ecology, and infrastructure which leads to a disturbance of human activities, harms, and loss of lives. This study presents a frequency analysis of precipitation extremes in Sri Lanka conditioned on El-Nino Southern Oscillation. The daily weather data for two-time steps for a day from 1986 to 2016 was taken from the ERA-Interim global atmospheric site. The selected grid scale for the data set was 0.5 degrees with a total of 22 locations covering the study domain in Sri Lanka. To conduct the analysis, a random subset of 12 precipitation (calibration) sites were selected from 22 precipitation sites, and the remaining 10 sites were used for model validation. A peak over threshold (POT) modeling was applied to the number of occurrences of precipitation events that exceeds some threshold value for each calibration sites. Using the theory of extreme values, an appropriate threshold value was estimated using the mean residual life plot, and then a sensitivity analysis was performed. The number of extreme events was modeled using three nested Bayesian hierarchical models with increasing model complexity by adding site specific characteristics which are elevation, latitude and longitude, and the Southern Oscillation Index to the simple hierarchical structure model allowing partial pooling across calibration sites. All three models were implemented in the BUGS coding language for full Bayesian inference. Markov Chain Monte Carlo (MCMC) simulation method was used to sample from posterior distributions. Trace plots and Gelman & Rubin diagnostics were used to assess the convergence of simulations for three models. Finally, a model comparison was performed among three models. Among those three models, the full Bayesian model outperformed other models. However, the fitted models did not show a significant difference among the models and within the model parameters. The results suggested that the fitted models have the ability to predict the distribution of extreme precipitation events for both a location and a year not included in the fitting process.

Keywords: ERA-Interim, El-Nino, La-Nina, Southern Oscillation Index, POT approach, Extreme Value Theory, Hierarchical Bayesian Modeling, BUGS, MCMC Simulation

ANALYSIS ON WAVE ENERGY RESOURCE IN SRI LANKA AND ITS IMPACT ON POTENTIAL ENERGY PRODUCTION

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In the cause of increment in the human population, researchers are actively searching about the environment-friendly resources to fulfil the demand for energy. Besides the other energy resources, most of the countries with abundant wave resources focused on the energy generation using ocean waves, since it is a renewable, sustainable and eco-friendly marine energy source. As a new step of energy generation in Sri Lanka, this study aimed to find the best energy resource areas around Sri Lanka. A 40-year database from European Centre for Medium-range Weather Forecasting (ECMWF) is used for three locations around Sri Lanka, namely, East coast, South coast and West coast, and the results were compared with selected locations in Japan and Portugal. Throughout this study, time series and basic statistical method were used for the analysis. Results revealed that there isn't any significant seasonal pattern in three locations, and the long-term increasing trend variation only belonged to the East coast. Inter-annual variability was much similar in South and West coasts, but yearly average wave powers showed low values and minimum variation compared to Japan and Portugal. Moreover, the ratio of mean to extreme wave heights indicated that the higher energy production can be done in the South Coast and potential return on investment improved in the East Coast. Furthermore, a weather window analysis is carried out to find the best time frames to establish the devices by minimizing the damages that can happen to particular devices and by reducing the maintenance costs due to unexpected wave heights and powers. The overall results of this study give insights to possible establishments of ocean wave energy generation plant in Sri Lanka.

Keywords: Wave energy resources, Inter-annual variability, Extreme wave heights, Weather windows.

BEYOND NEUTRALITY: ADDING HABITAT FILTERING TO NEUTRAL MODELS

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Many communities in nature show strong spatial structure. However, understanding processes that produce such a spatial structure of a community is still infancy. Hubbell's neutral theory emphasizes three parameters; fundamental bio-diversity number (θ), dispersal limitation (m) and speciation (ν) are sufficient to explain two most striking macro-ecological patterns of a community; i.e. species area relationship and species abundance distribution. However, Hubbell's theory has little emphasizes on understanding the driving processes that leave spatial structures of a community. Such spatial structures may arise due to habitat filtering and dispersal limitations. Although Hubbell incorporated dispersal limitation into his theory, he does not incorporate habitat filtering into it. Adding habitat filtering to the neutral model is useful to understand the species coexistence in detail. The newly develop model considers four parameters, θ, m, ν and habitat suitability (h_i). The model works at two spatial scales; habitat filtering at intermediate scale and stochastic processes at large spatial scales. The model used two stage schemas to generate the individuals-species in the meta-community and the local community. The meta-community was simulated by labeling the individuals. Then the local community is generated for θ = 50, and m = 0.1. The number of individuals in the simulated local community (J_m) is 125,000. The local community size was 50-ha (1000 m x 500 m) and it was divided into seven habitats according to 50 ha BCI forest plot in Panama. Finally, empirical spatial structure of the BCI forest plot compared with the simulated spatial structure. Results show simulated spatial structure (species assemblage) is very similar to the species assemblage of the BCI forest plot. Hence, habitat filtering plays an important role together with stochastic processes to structure species compositions in forests.

Keywords: Neutral theory, Habitat filtering, Fundamental bio-diversity number, Immigration parameters, Panama.

BIRD SOUND CLSSIFICATION USING DEEP LEARNING

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Monitoring animal population to understand their behavior, population dynamics and biodiversity is a special area in ecology which many researchers have paid their attention to. Most acoustically active animals such as birds can be classified by their sounds, because they respond quickly to environmental changes. Manual bird classification is difficult and becomes time consuming with the growth of data. Background noise, multiple birds singing at the same time, inter-species variance, difference between mating calls and songs, a large number of different species and variable length of sound recordings are some of the reasons that makes this task challenging. The aim of this study is to introduce an automatic method for detection and recognition of bird sounds with and without noise. In this system, a deep Residual Neural Network (RNN) is trained by datasets which are obtained from the xeno-canto database with and without noise and the output results are compared with the baseline. For the automatic bird recognition, tonal-based feature representation is used. This recognition uses intercept v3 model for 18 bird species using two datasets that consist of 935 sound recordings. The detection method shows a high accuracy of 90.3% and 84.3% with and without noise respectively. Also, this method shows high prediction rate for most of the bird species.

Keywords: Animal population dynamics, Automatic bird recognition, Deep Residual Neural Networks, Tonal-based feature representation

BUTTERFLY SPECIES DIVERSITY ASSOCIEATED WITH ENVIRONMENTAL FACTORS IN SRI LANKA

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It is well known that butterfly species diversity monitoring is one of the efficient ways to identify biodiversity. This study aims to understand the distributions of 64 different butterfly species in 15 districts, the structure of natural butterfly communities with the competition among butterfly species, and environmental factors that affect for the prevalence of butterfly species in Sri Lanka. Species richness and both Shannon and Simpson's diversity indices were calculated to study whether the distributions of species are homogeneous or not in districts of Sri Lanka, and to identify how they vary. Maximum diversity and richness were observed from Rathnapura district and minimum diversity and richness were observed from Puththalam district. Diamond's assembly rule model and Probabilistic model were used to study species co-existence (positively, negatively or randomly). It was noted that Most of the butterflies were randomly distributed, and there was less co-occurrence between species pairs. Further, eight butterfly species were identified as the frequently occurring species set by using association rule mining technique. Five different types of regression models (Binary Logistic, Bayesian Logistic, Ridge, Lasso and Polynomial) were used to study the distributional patterns of butterfly species with respect to environmental factors. Backward elimination method and Akaike Information Criterion (AIC) were used to identify the best Binary, Bayesian and Polynomial models, and ten-fold-cross-validation method was used to identify the best Ridge and Lasso models. The best model that describes the probability of occurrence of each species was selected by comparing Receiver Operating Characteristic (ROC) curves of each of the five different types of models. It was noted that the distribution of butterfly species varies from species to species according to different environmental factors. Most of the butterflies can be model using Binary logistic regression model and polynomial model, and the majority of the butterfly species depend on temperature and total rainfall. The selected model of each species can be used for prediction of species occurrences with respect to environmental factors.

Keywords: Species occurrence, Co-occurrence analysis, Regression models, Environmental factors.

CLASSIFICATION MODEL FOR GROUNDWATER OF SRI LANKA BASED ON TRACE ELEMENTS AND MAJOR ELEMENTS ANALYSIS

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The need for clean water is one of the most essential basic requirements for mankind. Studying the effect of the groundwater chemistry or quality of the groundwater on the health of the human population in Sri Lanka is extremely important due to the fact that the majority of the people use groundwater directly for their drinking and cooking purposes. Over the past two decades, Chronic Kidney Disease of Unknown aetiology (CKDu) has emerged as a significant contributor to the burden of Chronic Kidney Disease (CKD) in Sri Lanka. As Sri Lanka is a developing country, the cost of treatments is unaffordable for ordinary people. So, it is extremely important to determine the risk factors to prevent this disease. In this study, we tried to find relationships between concentrations of Major/Trace elements in groundwater which are used as drinking water and cooking purposes in CKDu affected and CKDu non-affected areas in Sri Lanka. The main objective of this study is to find the most suitable model to predict the sample area. In order to achieve this goal, we used five classification methods; cluster analysis, factor analysis, Naïve Bayes classifier, Decision tree, and Logistic Regression. The study was carried out using well water samples data in Giradurukotte, Nikawewa, Wilgamuwa (CKDu areas) and Jaffna and Mannar (non-CKDu areas). K-means clustering method had an accuracy rate of 92.9% in differentiation CKDu affected and non-affected areas. Naive Bayes classifier had the highest accuracy in differentiating the five locations (88%) and also differentiating CKDu affected areas and CKDu non-affected areas (98%). In this study, most of the cases CART models often had slightly higher predictive accuracy than CTree models. Selenium has been identified as the main element that can be used to classify the sample area. In Factor analysis, we identified s block elements, d block elements, and Chromium Iron Nickel Alloy as the three factors that explain the groundwater quality.

Keywords: Ground water quality, Major and trace elements, K-means clustering, Naïve Bayes Classifier, Decision tree

COMPARATIVE ANALYSIS OF SMOKED WATER AND KARRIKIN TREATMENTS ON SEED GERMINATION

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Many environmental and internal factors effect on seed germination. An experiment was conducted to test the effects of Smoked Water and Karrikin treatments on seed germination using fourteen species, six smoked water concentrations and four Karrikin concentrations. Four variables of the dataset were Germination percentage, Number of days, Concentration and Species. The primary objective of this study was to identify the species which germination stimulated by the smoked water and ensure that the reason for the stimulation of seed germination by Smoked Water is Karrikin substance. In addition, there were five secondary objectives of this study. Correlation analysis was conducted to identify the correlation between germination percentage and number of days. Behaviours of the germination of each species were studied by conducting a distribution study and significant differences between the distributions of the Smoked Water concentrations were identified by significance analysis. According to the results of the distribution study and the significance analysis, species that germination stimulated by the Smoked Water were identified and six out of the fourteen species stimulated by the Smoked Water. The canonical correlation analysis was conducted to identify the correlation between Smoked Water treatments and Karrikin treatments. Five out of the six species which germination stimulated, showed a strong correlation between the Smoked Water treatments and the Karrikin treatments. Also, the number of days that takes to show different effects was identified and finally the most suitable distribution was fitted to the concentration which showed the highest germination of each species. In this study, we could find the germination of some species stimulated by Smoked Water and most of the time the reason for that stimulation of seed germination is the Karrikin substance which included in Smoked Water.

Keywords: Smoked water, Seed germination, Karrikin treatment, Canonical correlation analysis,

COMPETENCY IN COMPLEX TOUCH GESTURES OF PRE-OPERATIONAL STAGE CHILDREN

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The study was conducted in the research area of Child-Computer Interaction (CCI) which is a subdomain in Human-Computer Interaction (HCI). Research on CCI began in the 1980s and is a discipline concerned with the design, evaluation and implementation of interactive computing systems for children's use. With the evolution of technology, CCI has become an important area of study with children being exposed to these new technologies. One such technology is multi-touch devices such as tablet computers and smartphones. With the widespread use of such devices, there is a plethora of mobile and tablet-based application that target children. However, these applications show signs that they lack a rigorous design and development methodology. The content of a majority of applications for children are increasingly seen as not meeting age-appropriate pedagogical standards and lacking age-appropriate CCI standards. Children in the pre-operational stage lack fine motor skills and cognitive skills, hence they are unable to perform some gestures effectively. As a solution this research attempts to develop an application and a training session to support children to gain the necessary skill of performing the complex touch gestures. The hypothesis that by providing training sessions using an application specifically developed to impart the skill of touch complex touch-gestures to pre-operational stage children, they are able to perform better when using mobile or tablet based applications. The study is mainly focus on four complex touch gestures. The considered four gestures are drag and drop, simple drag, pinch and spread. An application was design and developed for training the mentioned gestures using the participatory design techniques in HCI. Employing an empirical methodology of a pre-test and post-test on thirty seven children in the pre-operational stage, the research attempts to very if the hypothesis is acceptable. Through the pre-test and post-test the study statistically verified that the hypothesis that training session for complex touch gestures is a successful method to enhance the children's competency of the touch gestures is plausible. This research suggests that it is important that application developers should include training sessions for complex gestures at the starting point of the application to enable pre-operational stage children to focus and enhance child engagement with the primary aim of application which in many cases is educational.

Keywords: Complex touch gestures, Child-Computer Interaction, Multi-touch devices, Human-Computer Interaction

EVALUATION OF AGREEMENT BETWEEN TWIN-BLOCK APPLIANCE AND MODIFIED ARCH DEVELOPMENT APPLIANCE FOR MANDIBULAR LENGTH

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The Twin-Block(TB) is an exorbitant appliance used for Class II division 1 malocclusion which is one of the most common orthodontic problems in the world. Hence, most of the patients in Sri Lanka refuse to undergo treatment due to financial constraints. Further, the dentists should identify the skeletal pattern of the patient using an X-ray, before starting treatments. The main objectives of this study are to compare the two methods of development of mandibular length using TB and a novel modified arch development(MAD) appliances and to fit classification models to predict the skeletal pattern. This analysis was performed on 60 patients treated with TB and MAD appliances. Intraclass Correlation Coefficient(ICC) and the Concordance Correlation Coefficient(CCC) were used to check the agreement between the two methods. A mixed effects model was fitted to predict mandibular length, and Akaike Information Criterion(AIC), Bayesian Information Criterion(BIC) and log-likelihood were used to select the best model. Multinomial logistic regression, k-NN algorithm and discriminant analysis were used to predict the skeletal pattern of the patients and the accuracy of the models was computed by confusion matrices. ICC and CCC values after treatment are 0.9743 and 0.9172 respectively. Besides both TB and MAD appliances have a better agreement and can be used interchangeably. Therefore, MAD appliance is more suitable as a treatment for Sri Lankan patients as it is less expensive and easy to use. Further, the multinomial logistic regression model can be used to predict the skeletal pattern with Eastman Correction of the patients and the k-NN algorithm for the skeletal pattern without Eastman Correction.

Keywords: Discriminant analysis Interrater agreement, k-NN algorithm, Mixed effects model, Multinomial logistic regression,

FUNCTIONAL DATA ANALYSIS ON WEATHER DATA IN SRI LANKA

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It is known that, in general, the climate variables such as precipitation and temperature data are collected daily as well as weekly, monthly and annually. These observations are collected in the form of discrete data. The motivation of this study is to construct a functional data object from these discrete observations which could be used to represent the continuous temperature, precipitation process at weather stations. The study is looking for how daily means for both temperature and precipitation alternate at each station over time. This study also focuses on the functional variation, velocity and acceleration of the two climate variables, precipitation and temperature, and their functional relationship. The daily temperature and precipitation data for an 8 year period (2010-2017) have been obtained from the National Oceanic and Atmospheric Administration for five weather stations in Sri Lanka. B-spline bases and Fourier series smoothing technique were applied to represent the variations. Akaike Information Criteria (AIC) was used to figure out the best-fitted model for the climate data at each station. It could be examined a summary statistic on typical weather patterns and variability based on the fitted smoothing curve in these temperature and precipitation patterns. Using the concept of Functional Data Analysis (FDA), the results indicated that a functional relationship between precipitation and temperature could be established for each weather station. In future, these functional relationships could be used to quality control and validate the observed data at different weather stations around Sri Lanka.

Keywords: Functional data analysis, Precipitation, Temperature, B-splines, Fourier series

IDENTIFYING EXTREME BEHAVIOUR AND FITTING AN EMPIRICAL MODEL FOR DENGUE CASES IN SRI LANKA

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Prediction of dengue cases mainly focused on the mean events, and the models based on mean events well fitted to the central part of the distribution and can understand and predict mean features of the relevant event. However, identifying extreme dengue cases is also important for which the tail of the distribution should be considered. To study the extreme events, Extreme value theory (EVT) can be applied which gives the best inferences about the tail of the distribution. One of the objectives of this study was to fit the best extreme distribution for the extreme dengue events in Sri Lanka. Two extreme distributions, the Generalized Extreme Value (GEV) distribution and the Generalized Pareto (GP) distribution, were fitted using the block maxima method and peaks over threshold method. Parameters were estimated using maximum likelihood estimation. The model assumptions were tested using Wald – Wolfowitz, Wilcoxon and Mann-Kendall test, and the model adequacy was tested using the Kolmogorov-Smirnov Test, Anderson-Darling Test and Cramer-von Misses test. Best block size for GEV distribution was selected using root mean square error, and the best threshold value for GP distribution was selected using mean excess function. Using fitted extreme distributions, future extreme quantiles were also estimated. To understand the relationship of dengue cases with climatic factors, empirical models were fitted by taking the number of dengue cases as the dependent variable while rainfall, temperature, humidity and monsoon season as the independent variables. These models were fitted separately for Colombo Gampaha, Kandy, Badulla, Kurunegala, Ratnapura, and Anuradhapura districts. Four models were identified from which the first model was developed without time lag and the other three models were developed by considering the time lag phase of 1, 2 and 3 months, respectively. The best-fitted distribution was selected based on the Akaike information criterion (AIC) and Bayesian information criterion (BIC). Models with lag 2 were chosen as the best-fitted model for Anuradhapura, Badulla, Kurunegala and Kandy district, whereas lag 3 for Ratnapura, and lag 0 for Colombo and Gampaha districts. The information based on the fitted GEV and GP can be used for future predictions of extreme dengue cases. Further, the fitted empirical models can be used to predict dengue cases based on climatic factors and monsoon seasons.

Keywords: Generalized extreme value distribution, Generalized Pareto distribution, Dengue cases, Return levels, generalized linear negative binomial model.

METADATA ADOPTED INTEGRATED DATA PLATFORM FOR IoT

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Internet of Things (IoT) is a concept that has been used today mostly ranging from transportation, health to smart cities. This concept increases the interoperability between embedded computing devices via sensors and this represents the future direction of computing and communication technologies. The proposed framework is to interconnect physical devices through sensors to enable application level communication with each other seamlessly. Each component of the framework has its own responsibilities and provides services to the other components. Unlike the available traditional sensor networks, the proposed framework provides a standard template engine with modern technologies. Data are received from different types of sensors such as environmental temperature, light, sound, video and radiation. Therefore, the properties of data vary from sensor to sensor and also the communication protocols are different. The template of metadata is defined before connecting a sensor to the framework which ensures error notification and data persistence formats. A non-blocking high performance data insertion is taken place to manage a higher number of requests in a short period of time. Once data are inserted to the system, data access authorizations are defined to data consumers. In which predefined permission types are available. The notification module enables message sending mechanisms with the owner of the sensor in case of data are not receiving to the system for a defined period in the metadata configuration. The application integration module is an open standard unique platform that provides communications among various types of sensors or sensor integrated devices. There, sensors are not necessary to be in the same platform in order to interact with other sensors. When considering the application level of this proposed work, this is highly important in the case where the system has to integrate a large amount of data from heterogeneous sensors such as natural disasters, in hospitals etc. This system will optimize an infrastructure of a machine-to-machine ecosystem.

Keywords: Metadata, Data integration, Sensor network

MODELING AND VISUALIZING ROAD TRAFFIC ACCIDENTS IN KANDY, KURUNEGALA AND GAMPOLA POLICE DIVISIONS

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Road traffic accidents have become a noticeable problem in Sri Lanka, and that is one of the leading causes of the deaths and injuries around the globe with an ever rising trend. In 2016, 41981 roads accidents occurred, causing an average of eight fatalities every day, in Sri Lanka. This study is based on road traffic accidents in Kandy, Kurunegala and Gampola police divisions over the years 2011-2014, 2010 and 2017, respectively. The main objective of the study was to use Geo-Visualization techniques to represent the data of road traffic accidents. Since identifying the location of the accident is very important in reducing road traffic accidents, the geo coordinates of the locations of accidents were considered as one variable. The highest number of accident occurrence in Kandy, Kurunegala and Gampola police divisions were identified with respect to the location variable. Interactive maps were generated visualizing the location type, main roads and the fatality of the accidents, for road traffic accidents. In order to identify temporal patterns for road traffic accidents, stack bar charts were used. Further, the Logistic regression model is used to analyze fatal and non-fatal accidents by considering the variable "class of accident" (fatality) as a dichotomous response variable, while the environmental conditions, vehicle conditions and the casualty conditions as influencing factors on the class of accidents. According to the results, the highest number of accidents has occurred in clear weather condition in all three police divisions. Also, most of the accidents have occurred in dry road surface condition, and in a normal working day. From the generated maps, it can be clearly identified that the highest percentage of accidents has happened in daylight condition, and in non-control traffic condition in all three police divisions. Further, the factors "Location type" and "Traffic control" are more influential for fatal and non-fatal accidents in Kandy police division, whereas "Light condition", "Alcohol test", "Casualty age" and "Driver/pedestrian gender" were for Kurunegala police division, and the "Nature of the day", "Light condition", "Location type", "Traffic control" and "Weather" are influential factors for Gampola police division. The results indicate that road traffic accidents can be reduced under the traffic control condition in Sri Lanka, and it is necessary to give road safety education, to minimize the accident.

Keywords: Generating Maps, Road traffic accidents, Logistic Regression, Factor analysis

MODELS FOR PREDICTION AND PREVALENCE OF RISK FACTORS FOR NON-COMMUNICABLE DISEASES IN SRILANKA

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Non-communicable diseases (NCDs) are becoming a principal cause of death in Sri Lanka. Copious research studies have been carried out regarding NCDs; however, most of them focus on control and prevention of NCDs. The present study aims to find the determinants of NCDs, to obtain the best classification model for the future prediction of NCDs and analyze the dependencies between various NCDs. The binary logistic regression model was fitted to the data to find the determinants of NCDs. The results of the logistic model revealed that factors such as age, marital status, residential type, a habit of smoking, province, gender, and education had made a significant contribution towards NCDs. For future predictions of NCDs, five classification models, the CART decision tree, the C4.5 decision tree, the ID3 decision tree, the Naïve Bayes model, and the neural network model, were constructed. The best model selection was done by comparing the accuracy, Kappa statistic, specificity, sensitivity, precision and F-measure of the model. Among those five, the Naïve Bayes model and C4.5 model were chosen as the best predictive models. Then dependencies between the six NCDs considered in this study were analyzed using the association rule mining technique. Finally, it was noted that increasing age, being female, being separated or widowed or divorced, residing in the Western province, least educated, living in urban areas and habit of smoking were highly related to the presence of NCDs. There was a high probability to be suffered from BP if suffered from heart diseases and diabetes or asthma (and wheezing) and diabetes.

Keywords: Binary logistic regression, decision tree, naïve Bayes, neural network, association rule mining

STANDARDIZATION OF PEPPER SEED GRADING

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Pepper is one of the key exports product of Sri Lanka. The quality of pepper barriers is usually understood by grades. According to Sri Lanka Standards (SLS) and International Pepper Community (IPC) standards, pepper is graded into 4 classes, which are grade 01, 02, 03 and 04. At present, pepper barriers are graded manually. Local collectors determine the price just by examining pepper samples with bare eyes. Even though this is the general practice, it cannot be considered a standard procedure. To overcome this problem, this research proposes an image based pepper seed grading technique, and further the method employees image processing and machine learning techniques. The research objectives are to find the best image pre-processing technique for pepper seed images, to find features of pepper seed images related to physical attributes which are used in grading based on SLS as well as IPC standards and to find the algorithm to grade pepper while introducing professional island wide common standard method for pepper grading with a sophisticated web interface. This research methodology consists of four (4) principle sub-modules; image acquisition, image preprocessing, feature extraction and classification. Finally, the samples are graded using the proposed algorithm, where the algorithm takes into consideration the content of the sample. i.e first it identifies the percentage presence of different seed types such as pure black barriers, extraneous, pinheads, etc, within the same and grades it according to the grade tolerance of those seed types. In order to verify the algorithm, a dataset is created using features like colour, size, shape of all kind of possible particles. By using that dataset, the artificial neural network model is trained and seeds are classified with precision 87.76% and 86.92% for black pepper and white pepper, respectively. Finally, pepper sample images are taken and are graded using own algorithm and grading accuracy is 87.5% for black pepper and 86.66% for white pepper. Finally, it is concluded that there is a relationship between image features and physical characteristics of pepper seeds which are mentioned in Sri Lankan and international pepper grading standards and that relationship can be used to grade both white and black pepper.

Keywords: Pepper grading, Image processing, Artificial neural network, Feature extraction

STATISTICAL MODELS FOR PREDICTING ERUPTION TIME AND SEQUENCE OF PERMANENT DENTITION IN SRI LANKAN CHILDREN

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The tooth eruption is the process in tooth development in which the teeth enter the mouth and become visible. There are several studies regarding tooth eruption time in the world, however, none of the studies focused on the Sri Lankan population in the last 25 years. Therefore, the main goal of this study is to create a suitable model to predict the tooth eruption pattern of Sri Lankan children. Also, there are a few minor objectives, namely identifying relationship between variables associated with eruption Sequence, identifying common polymorphisms of tooth eruption sequences of children and determine the frequencies of occurrence of emergence polymorphisms for different tooth pairs This analysis was performed on a sample of children collecting data of the extent of tooth eruption of all 28 teeth at 10 different time periods over the development of the child with an annual observation of oral cavity with regards to the eruption of permanent teeth and refereed for necessary preventive and operative dental procedures for needy children. Welch two sample t-test was used to identify the relationship between variables associated with eruption sequence. Further, the frailty models with distributions of baseline hazard, the Gamma, Inverse Gaussian and Positive Stable distribution, and proportional odds model were used to predict the eruption time for Sri Lankan children. A comparison of the fitted models is conducted using AIC and BIC values. Further, the model accuracy is checked using the Root Mean Square values. Besides the Inverse Gaussian frailty model is considered as the best-fitted model for predicting tooth eruption data.

Keywords: Tooth eruption, Primary dentition, Permanent dentition, Frailty model, Proportional odds model

TOPOGRAPHIC SPECIES-HABITATS ASSOCIATIONS IN A MIXED-DIPTEROCARPUS FOREST IN SRI LANKA

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Species show cluster patterns, random patterns or regular patterns. Such spatial patterns manifest from species-topographic habitat association, dispersal syndrome, pathogen and herbivores. Although several studies were investigated topographic habitat-species association for individual species level only a few studies documented how individual species associated with different topographic habitats; for different life stages (i.e. adults, juveniles, saplings and recruits), life forms (canopy, sub-canopy, understory and shrubs), and its consistency over time. This study investigates individual species association at 25-ha large Sinharaja forest plot (species with > 200 individuals) with respect to six topographic variables (i.e. elevation, slope, roughness, flow direction, curvature and aspect) for different life stages, life forms over the time. In this study, Inhomogeneous Gibbs point processes, where tree density of a given infinitesimal region around a known spatial location depends on above six topographic variables, have been used to test the association of individual-species tree density with the all six topographic variables. The above analysis was performed for four different life stages and for four different life forms and two censuses. The study includes 20 dominant species in the Sinharaja 25ha plot. Results show elevation produced the highest number of association among topographic habitats. Recruits and saplings prefer high elevation and adults prefer low elevation. Only adult species show a positive association with aspect and with all the other life stages aspect is negatively associated. All the life stages show a significant positive association with slope and curvature and negative association with roughness. Elevation and convexity are two most important topographic variables associated with the life form. Canopy prefers high elevation habitat and all the other life forms prefer low elevation habitat. Many species, elevation shows consistent association over time. This study suggests elevation is more important on structuring individual species than the other topographic variables such as roughness, slope and aspect.

Keywords: Gibbs point process, Spatial point patterns, Sinharaja forest plot, Topographic-species association.

COMPARISON OF DIVERSITY OF CORTICOLOUS LICHENS AND THEIR SECONDARY METABOLITE PRODUCTION AMONG THREE VEGETATION TYPES IN KANDY DISTRICT, SRI LANKA

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Lichens are symbiotic associations of the mycobiont (a fungus) and one or more photobionts (either green algae or cyanobacteria). Lichen diversity, distribution and secondary metabolites production are affected by a range of environmental factors. The objectives of this study were to compare corticolous lichen diversity and their secondary metabolite production, in three vegetation types; woodland at Hanthana Forest Reserve (HFR), secondary forest at Gannoruwa Forest Reserve (GFR) and plantation forest at Udawattakele Forest Sanctuary (UFS), in the Kandy District, Sri Lanka. A random sampling method was used to sample corticolous lichens from each site. Percentage cover of lichen species on barks at 1.5 m above ground was recorded using a quadrat ladder. Thin Layer Chromatography (TLC) plates were developed from acetone extracts of lichen samples using solvent system toluene/ethyl acetate/formic acid (139:83:8 v/v/v) and visualized under UV light (254 and 365 nm). Colors and R_f values of each chemical spot were recorded by spraying 10% sulfuric acid and baking in 110 °C for 10 minutes. Possible secondary metabolites relevant for each spot were listed with reference to Culberson, 1972. Highest species richness was seen in HFR (18) followed by UFS (15) and GFR (11). Average cover of corticolous lichen genera was highest in GFR (64.73%) closely followed by UFS (40.05%) and HFR (30.22%). Lichens collected from GFR and UFS had relatively higher numbers of secondary metabolites (0 - 7 and 1 - 9 respectively) compared to HFR (0 - 4). The temperature, RH, tree girth, tree species richness and bark pH were significantly different between the study sites which may be the reason for observed differences in diversity, average cover and secondary metabolite production. A long term intensive study is suggested to observe trends in the diversity and average cover of corticolous lichens in selected sites.

Keywords: Corticolous lichen diversity, Secondary metabolites, TLC

LITTER INVERTEBRATE DIVERSITY AND THE RATE OF LITTER DECOMPOSITION IN SELECTED FOREST PATCHES OF WET AND INTERMEDIATE ZONES OF SRI LANKA

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Litter associated invertebrates are often used as indicators of decomposer activities and play a key role in leaf-litter decomposition. Impacts of litter-invertebrates on key ecosystem functioning in many ecosystems in Sri Lanka have not been adequately addressed. Present study was, carried out to determine the litter invertebrate diversity, abundance and the rate of litter decomposition of two forest habitats *i.e.* Halgolla wet lowland evergreen forest (Kandy district) and Randenigama dry mixed evergreen forest (Kurunegala district). Samplings were done monthly, from December 2017 to November 2018 from 10 selected plots at each sampling. Direct observation, hand collection, and Tullgren extraction methods were used to collect litter invertebrates. Environmental variables *i.e* temperature, humidity and pressure were also reported at each sampling. Litter bag method (40 litter bags) was used to determine the litter decomposition rate. Total of 15,415 litter invertebrates belonging to 86 families representing 33 orders were collected. The majority was arthropods belonged to the classes of Insecta, Diplopoda, Chilopoda, Arachnida, Symphyla, Diplura, Malacostraca and Collembola. Moderate number of Gastropods and Oligochaets were also reported from both forest types. The highest litter invertebrate abundance was reported from the Halgolla forest (n=10,395) while the highest species diversity was reported at Randenigama forest (H'= 1.76). A moderately positive relationship between the rainfall and the abundance of the litter fauna were observed. Analysis of similarity test confirmed the difference in litter invertebrate abundance (64.64%) and the diversity (57.68%) between two forest types. Litter decomposition rate at Halgolla forest (K=0.01) was comparatively higher than that of Randenigama forest (K=0.006). A moderate correlation was observed between the species abundance and the rate of litter decomposition at Halgolla forest (r=0.673, p=0.047) while a weak relationship was observed at Randenigama forest (r=0.367, p=0.331). Findings describe the important information about the litter invertebrate composition at study locations.

Acknowledgement*: Financial assistance given by University of Peradeniya Research Grant 2016-51/S is acknowledged.*

Keywords: Litter invertebrates, diversity, decomposition, Halgolla, Randenigama

WATERBIRD DIVERSITY IN SELECTED REGIONS IN THE JAFFNA PENINSULA: POTENTIAL FOR PROMOTING AVITOURISM

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Waterbirds play a key role in promoting avitourism ('bird tourism'). Jaffna is renowned for its waterbird diversity and it is one of the four richest waterbird areas in Sri Lanka. Hence the objectives of the present study were to evaluate the diversity of waterbird species in selected areas in Jaffna District and to estimate the potential for promoting avitourism. This study is timely and important due to the fact that Jaffna was virtually hidden to the tourism sector during the last three dacades as a result of civil war that prevailed in the area. Waterbirds were censused using a spotting scope and binoculars from January to July 2018. Two distinct areas in Jaffna peninsula, namely Island Area (Mandativu, Allaipiddy, Mankumban, Araly Junction) and Peninsular Area (Sarasalai, Anthanathidal, Kappoothu), were selected. Waterbird diversity was estimated using Simpson's Index. The potential for avitourism and the availability of infrastucture facilities were estimated using a questionnaire survey from local and foreign tourists, and from secondary data. Results indicate that there was a higher diversity of waterbirds in the Island Area (Simpson's Index 0.86) compared tothe Peninsular Area (0.78). The presence of rare species such as Greater Flamingo increases the attraction for avitourists. It was found that most of the tourists (> 50%) were unaware of the birding areas located in Jaffna District. The availability of infrastructure such as accommodation, restaurant facilities, telecommunication facilities, safe drinking water and sanitary facilities are at a medium to high level in the area (> 50%). Bird watching facilities and waste management facilities are low in the area (< 50%). The high waterbird diversity and moderate availability of infrastructure will help promote avitourism in Jaffna peninsula, with special reference to the present study sites.

Acknowledgement*: Financial assistance provided by the University of Peradeniya (Research Grant No. URG/2016/57/S) is acknowledged.*

Keywords: Ecotourism, avitourism, waterbirds, infrastucture facilities, Jaffna District

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