

**RISTCON 2017**

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Technology Conference**

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## Foreword

The 4<sup>th</sup> Ruhuna International Science and Technology Conference (RISTCON 2017) was organized by the Faculty of Science, University of Ruhuna, Sri Lanka. The abstracts arisen from research work in diverse disciplines of Science & Technology have been peer-reviewed prior to acceptance. The abstracts have been edited to maintain language accuracy and page limits. An official electronic PDF copy of the book will be available at <http://www.sci.ruh.ac.lk/conference/ristcon2017> of University of Ruhuna website. Responsibilities of the content text of the abstracts included in this publication remain with the respective authors. No part of this serial publication will be reproduced in any form.

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Editors

RISTCON 2017

## **Message from the Vice Chancellor, University of Ruhuna**

International Conferences have now become annual events in almost all faculties of the University of Ruhuna, fostering and nurturing a research culture among the academics. It truly gives me a great pleasure to send this message for the proceedings of the “4<sup>th</sup> Ruhuna International Science and Technology Conference (RISTCON – 2017)” organized by the Faculty of Science, University of Ruhuna. RISTCON over past three years earned a good reputation as a conference where eminent scientists meet and discuss their research outcome. As conferences are considered as a vital part of academic programmes of any good university, RISTCON provides an opportunity for academics to transmit the knowledge generated through their research to the scientific community and the industry.

As the Vice Chancellor of Ruhuna University, I am proud to witness a remarkable improvement in quantity and quality as well as the relevance of research conducted by our staff and I am also glad to learn that many academics and scholars especially from Asian continent are expected to participate in this conference. In this context this conference will provide a good platform for our academics to share their knowledge in the fields of Science and Technology with the rest of the world. Therefore, I believe that the publication of research findings presented at the RISTCON-2017 will be an incentive to our academics for future evaluations in their areas of expertise.

I take this opportunity to offer my heartiest congratulations to Dean of the Faculty of Science and the organizers of RISTCON-2017 for their efforts to make this event a success. I wish all the best for all paper presenters and participants of RISTCON-2017.

**Senior Professor Gamini Senanayake**

The Vice Chancellor  
University of Ruhuna  
Matara 81000  
Sri Lanka

## **Message from the Dean, Faculty of Science, University of Ruhuna**

Providing a message as the Dean of the Faculty of Science of the University of Ruhuna to 4<sup>th</sup> Ruhuna International Science and Technology Conference (RISTCON-2017) is a great pleasure for me. RISTCON-2017 has provided platform for discussing findings of researchers, practitioners and educators from various scientific fields such as biological science, physical science, medical science and technological and engineering fields. The series of gatherings organized by the Faculty of Science initially as Science Faculty Symposium from 2002 opened its doors to both local and foreign contributors with RISTCON-2014. It is happy to hear that RISTCON-2017 has received more than 100 submissions and many of them will be presented as poster or oral presentations. I would like to thank all the authors who submitted their findings to RISTCON-2017 for their efforts in research work and willingness to share their findings among the contributors and the participants of RISTCON-2017.

It is evident that our country requires collaborative efforts and contributions of researchers, policy makers, governing bodies and citizens for enhancing and developing the socio-economic status of the country. Utilizing solar power, rain water management, rehabilitating abundant paddy fields, reducing waste of human work hours on roads due to traffic and public transport systems, stopping waste of resources, properly managing household and commercial waste, enhancing and popularizing methods of reducing waste of fresh fruit, vegetable and fish harvests so that they can be almost utilized and the excess can be exported, providing adequate facilities for people with special needs, improving transport management in towns and cities, introducing efficient ways to stop wasting many years young manpower of school leavers from the time the complete GCE(O/L) and GCE(A/L) and finding ways for providing children from pre-school up to GCE(A/L) more time to enjoy their life that is free from unnecessarily heavy loads of tuition classes so that they can be more creative and innovative than present students are some of the areas randomly came to my mind from among many areas where the country still need 'advanced' and 'specific to the country' approaches with the guidance of researchers and academics.

I am sure, through the conferences like RISTCON-2017 and many more we would engage in the future, that our scientific community could address not only all of above mentioned areas but also some other areas such as, again if I list a few, proper management of public funds, improving work place health and safety standards, advanced management and provision of health services and providing advanced care for children and elderly population.

Organizing a conference is a very difficult and responsible task and therefore I would like to convey the gratitude of the Faculty of Science of the University of Ruhuna to Professor E. P. S. Chandana, the Chairperson of the Organizing Committee of RISTCON-2017, and his team for their creative, effective and untiring efforts for making this conference a reality.

I hope and wish you all would enjoy the humanity and the hospitality of our community at the Faculty of Science of this university.

Professor P. A. Jayantha  
Dean, Faculty of Science, University of Ruhuna  
Professor in Mathematics  
2017.01.26

## **Message from the Chairperson- RISTCON 2017**

It is with great pleasure that I convey this message on behalf of the organizing committee of 4<sup>th</sup> Ruhuna International Science and Technology Conference. RISTCON-2017 is a preeminent venue for presenting, discussing and exchanging contemporary knowledge from national and international research findings on various fields of Science and Technology. Further, this would be a great platform to build collaborations and strengthen the partnerships among the professionals across the globe. Proving the fact, RISTCON-2017 contains many papers and poster presentations from researchers of diverse disciplines including several foreign participants and the conference is enriched by the contribution of two renowned scientists to deliver the keynote speech (Prof. Rajendra Rathore, Pflerschinger-Habermann Chair, Department of Chemistry, Marquette University, Wisconsin, USA) and the guest lecture (Dr. Nishanta Rajakaruna, Biological Sciences Department, California Polytechnic State University, USA). Thus RISTCON-2017 would be a great opportunity for the Faculty of Science, University of Ruhuna to uplift its recognition in the international context.

As the chairperson of the organizing committee, I would like to extend my sincere gratitude to Senior Professor Gamini Senanayaka, the Vice Chancellor of the University of Ruhuna and Professor P. A. Jayantha, Dean, Faculty of Science for their excellent guidance to make RISTCON-2017 a success. I express my sincere gratitude to the keynote speaker and the guest speaker for their precious contribution. Furthermore, the support extended by the Heads of the Departments, academic and non-academic staff members of Faculty of Science, Assistant registrar, two joint secretaries, the advisory board, the editorial board and the rest of organizing committee are also duly acknowledged for all their hard work, sense of responsibility and team work. I especially thank our sponsors, Harischandra PLC. Matara, Bank of Ceylon, People's Bank and UGC for their financial contribution.

Finally, I would like to extend my sincere wishes to all the authors and presenters for their enthusiasm and willingness shown in sharing the contemporary knowledge on their research findings at RISTCON-2017.

Professor E. P. S. Chandana  
Chairperson - RISTCON 2017  
Faculty of Science  
University of Ruhuna

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**Session C:** Fisheries & Aquaculture, Medical & Health Sciences, Veterinary Science, Zoology

**Session D:** Computer Science & ICT, Engineering, Mathematics & Statistics, Nano Technology, Physics & Geophysical Science

## Keynote speech

### Novel Organic Materials for Photovoltaic Devices

Professor Rajendra (Raj) Rathore

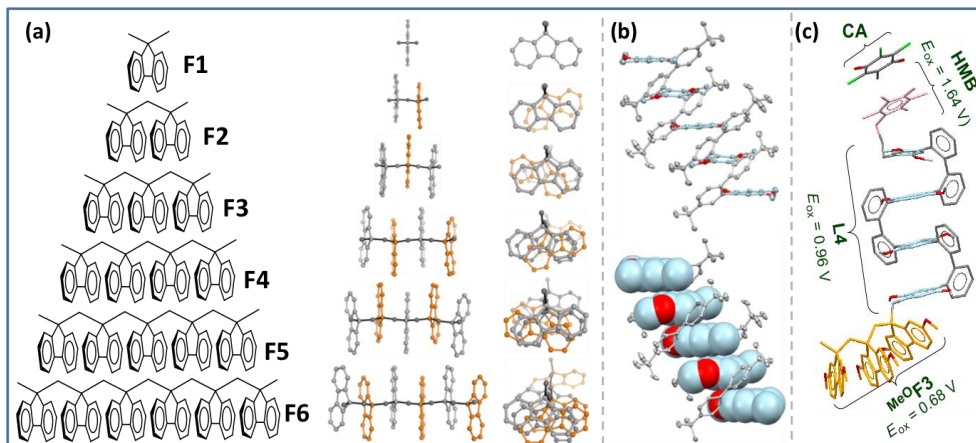
*Department of Chemistry, Marquette University, Milwaukee, Wisconsin, USA*

Current climate changes have caught no one by surprise as today's economic growth from which we all benefitted, albeit to a different extent, came from excessive usage of fossil fuels –a major source of global warming. Despite the deniability by many world leaders, if the CO<sub>2</sub> emission -- the main culprit of global warming -- is not checked, the Earth as we know will cease to exist. The increasing energy needs of today must be met from alternative sources rather than burning of limited fossil fuels. Unlimited and free solar energy has presented itself as the ultimate environmentally-friendly alternative. This talk will address our efforts to generate fundamental knowledge to advance the functioning and efficiency of modern photovoltaic devices for solar energy harvesting and storage.

The general objective of our research efforts is to design and synthesize electroactive molecules for application in organic electronic and photovoltaic devices, which convert light energy into electrical energy. Compared to current inorganic devices, which often rely on expensive and rare inorganic materials, organic-based electronics offer significant advantages in terms of cost and scalability, their full potential is yet to be utilized.

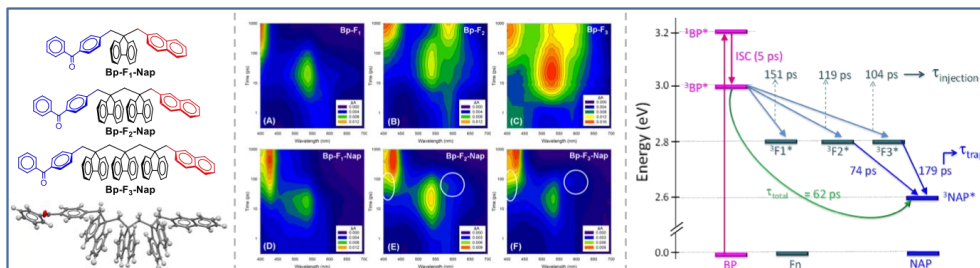
Our approach has used cofacially-arrayed DNA-like electro-active organic molecules (see representative structures below), and much of our current research efforts focus on the structure-function relationship of these materials. In this work, we exploit a variety of techniques such as electrochemistry, X-ray crystallography, and various electronic and emission spectroscopic methods including time-resolved transient laser spectroscopy on the millisecond to femtosecond timescale. The design, synthesis and study of novel polychromophoric molecules that can be readily prepared by versatile synthetic routes provide the foundation for the discovery of new materials for long-range charge transport and hence practical applications in modern photovoltaic devices.



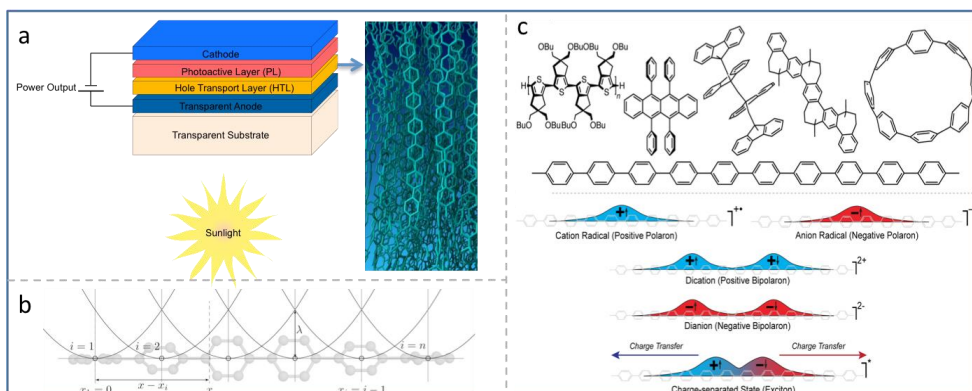


Two representative current research activities will be highlighted in this presentation:

Using a series of [D-molecular wire-A] systems, where D is a energy donor, A is a energy acceptor, and stacked polyfluorenes are molecular wires (see below), we demonstrated sequential energy transport from D to A through DNA-like molecular wires. The ultrafast laser spectroscopic measurements demonstrated that a crossover occurs between single step tunneling and multi-step hopping for energy transfer as the wire length increases. This change in the mechanism of energy transfer was established by direct spectroscopic observation of the spacer-occupied excited state. The details of this work have been described in a Science article (Science 2010, 328, 1547-1550. DOI:10.1126/science.1189354).



Organic electronics and photovoltaics offer the next generation of eco-friendly, flexible, and low-cost electronic devices that can replace and/or complement traditional devices based on inorganic materials. A key research challenge, which needs to be overcome for realizing the vision of organic electronics/photovoltaics as a more innovative, accessible, and sustainable approach to growing our electronic world, is increase of efficiency of organic electronic devices (Figure a, below).



Therefore, a better understanding of the structure-function relationship is required for the design of next-generation advanced materials such as wires, switches, transistors, etc. This undertaking requires developing a detailed understanding of structure-function relationship with the aid of computational chemistry and recently developed theoretical models as tools (Figure b, above). These recently developed tools broadly impact not only the field of photovoltaics but will have direct implications to understanding the chemical reactivity in general (note that mechanisms of many organic reactions involve the formation of cation- or anion-radicals, e.g. Figure c, above) and long-range charge transfers in biological systems.

## **Assessment of Egg Parasitoids in paddy and vegetable Farming Systems in Puliyankulama and Mahailluppallama Area, Anuradhapura District of Sri Lanka**

Samarakoon S. A. M. C.<sup>1</sup>, Priyadarshani T.D.C.<sup>1\*</sup>, Hemachandra K.S.<sup>2</sup> and Sirisena U.G.A.I.<sup>1</sup>

<sup>1</sup>*Faculty of Agriculture, Rajarata University of Sri Lanka*

<sup>2</sup>*Faculty of Agriculture, University of Peradeniya, Sri Lanka*

Biological control of insect pest is becoming popular as an effective pest control strategy. Egg parasitoids are considered as most effective, as they are able to remove the insect herbivores from the agro ecosystem before they emerge as larvae. The present study was conducted with the objective of assessing the egg parasitoid guild in paddy and vegetable farming systems in Anuradhapura district of Sri Lanka. Five Hymenopteran egg parasitoids belong to the super families of Chalcidoidea and Platygastroidea were identified, emerged from the collected host eggs in Puliyankulama. *Telenomus cyrus* (32.14%) was emerged from *paddy black bug eggs collected from* Puliyankulama. Trichogrammatidae egg parasitoids were identified from Green stink bug and *Epilachna* egg masses found from the bean fields in Puliyankulama. Ten egg parasitoid species were emerged from brinjal and legume insect pests egg masses collected in Mahailluppallama. *Trissolcus* sp. (54.54%) was recorded in Mahailluppallama vegetable farming system, and *Trissolcus basalis* was one of the predominantly emerged species from the *Nezara viridula* egg mass. The emerged parasitoid from the *Leucinodesor bonalis* eggs belonged to family Scelionidae (36%), while the others belonged to families Diapriidae, Chalcidoidea, Scelionidae, Ormyridae and Mymaridae. Higher level of parasitism was reported in Mahailluppallama (77.1%) comparable to Puliyankulama (7.1%). Implementation of strategies to conserve existing egg parasitoids is quite beneficial to achieve a high suppression of insect pest populations in ecosystems.

**Keywords:** *Egg parasitoids, Puliyankulama, Mahailluppallama*

\*Corresponding Author: cpchamarika@gmail.com

## **Sensitive indicators of *R. mucronata* Lam. to abiotic stress conditions; early-detection of stressors in mangrove restoration fields**

Kodikara K.A.S.<sup>1\*</sup>, Madarasinghe S.K.<sup>1</sup>, Prasangika K.D.<sup>2</sup>, Jayatissa L.P.<sup>1</sup>

<sup>1</sup>*Department of Botany, University of Ruhuna, Wellamadama, Matara, Sri Lanka.*

<sup>2</sup>*Department of Mathematics, University of Ruhuna, Matara, Sri Lanka.*

Early detection of dysfunctional mangrove seedlings in planting sites offers higher chance to enhance their survival potential. Therefore, this study was aimed at investigating the early detectable stress indicators of *Rhizophora mucronata* seedlings under different salinity levels and soil water stress conditions. The propagules of *R. mucronata* were maintained in a plant house (Three replicates per each treatment level according to completely randomized design) under three salinity conditions i.e., high salinity (>30 psu), moderate salinity (15 psu) (control) and fresh water (~ 0 psu) and three soil water contents as 25% of WHC (water holding capacity), 50% of WHC and 100% of WHC (control). Leaf characters and some selected anatomical features of seedlings in each treatment were studied over a period of 8 months. All plants were dead in 25% of WHC. Leathery texture, very thin waxy layer (>2% of the total thickness of the leaf) and severe necrosis were common under high salinity and water stress conditions. Leaf area, size of the epidermal cells, length of guard cells, chlorophyll content and leaf thickness of plants under the salinity and water stress conditions were reduced significantly by 75%, 72%, 50%, 57% and 52% respectively, compared to their respective controls ( $p<0.05$ ). In contrast, stomata density showed a significant increase in response to these abiotic stresses ( $p<0.05$ ). Among them, leaf area, their appearance and chlorophyll content appeared to be more reliable stress indicators as standards for those parameters can be established easily by selecting 2<sup>nd</sup> fully expanded leaf exposed to full sunlight and keeping age-specific reference for the mangrove seedlings. Early-detection of stress level of seedlings helps restoration practitioners to take early actions to rescue dysfunctional seedlings and eventually to uplift the survival potential of planted mangroves.

**Keywords:** *Stress, leaf characters, high salinity, soil water stress, mangrove restoration*

\*Corresponding Author: sunandaruh@gmail.com

## **Hydraulic architecture and hydraulic conductivity of *Rhizophora mucronata* Lam. in response to water stress**

Dissanayake N.P.\*, Premachandra G.S.D., Kodikara K.A.S., Jayatissa L.P.

*Department of Botany, University of Ruhuna, Matara, Sri Lanka*

Planting mangroves out of their natural habitat (intertidal zone) cause soil water stress in mangrove seedlings. Anatomical variations in the hydraulic architecture were extensively studied. However we argue that hydraulic conductivity should also be considered for proper understanding of mangrove seedling behavior to abiotic stresses. Therefore, this study was aimed to investigate hydraulic architecture and hydraulic conductivity of *Rhizophora mucronata* Lam. seedlings in response to water stress. Twenty seven propagules of *R. mucronata* planted in pots with a prepared soil mixture were maintained in a plant house under three physiological stress levels, i.e. high salinity ( $35\pm 1$ psu), moderate salinity ( $15\pm 1$ psu) and fresh water (0 psu) and under three levels of physical water stress, i.e. ~25%, ~50% and ~100% of Water Holding Capacity (WHC) making three replicates per each treatment. Anatomical features and hydraulic conductivity of the seedlings in each treatment were studied by using safranin stained cross sections of stems and Choatometer (Choat et al., 2007) respectively, over a six month period (on monthly basis). Vessel density and vessel grouping index as well as vessel diameter in seedlings under high salinity and 50%WHC treatments were significantly higher ( $p<0.001$ ) compared to those in fresh water, moderate salinity and 100%WHC treatments. Hydraulic conductivity of seedlings in high salinity was significantly ( $p<0.001$ ) lower compared to moderate and fresh water treatments. In contrast, there was no significant difference of hydraulic conductivity of seedlings kept in 100%WHC and 50%WHC. It indicates that at 50 % WHC, seedlings can adjust their hydraulic architecture in such a way that it will not change the conductivity. Therefore, the adaptability of *R. mucronata* seedlings to abiotic stress conditions is properly described by both hydraulic architecture and hydraulic conductivity.

**Keywords:** *Mangroves, hydraulic architecture, hydraulic conductivity, water stress*

\*Corresponding Author: nandapd@bot.ruh.ac.lk

## **Effect of locus of the crisis on purchase intention of the crisis brand: Sri Lankan young consumers' view**

Samaraweera, G.C

*Department of Agricultural Economics and Extension, Faculty of Agriculture,  
University of Ruhuna, Mapalana, Sri Lanka*

Locus of the product harm crisis influences how a consumer responds to that particular event. The purpose of the study is to examine the effect of the locus of the crisis on consumer purchase intention of the crisis brand. The main objective is to find whether the locus of the product harm crisis shapes consumer purchase intention of the brand in crisis. Fictitious product harm crisis scenarios related to company locus and consumer locus product harm crises were used. A fictitious yogurt brand was considered as a stimulus brand in both cases. Results related to the 250 young consumers revealed that company located product harm crisis affects adversely on purchase intention of the crisis brand whereas consumer locus product harm crisis affects positively on purchase intention of the crisis brand, revealing the negative and positive links between company located and consumer located product harm crisis with purchase intentions of the crisis brand. This study provides new insights for companies to protect their financial status, as they know these positive and negative links attached to the purchase intention of the crisis brand and to ensure the market of the crisis brand during product harm crises.

**Keywords:** *Product harm crisis, Crisis brand, purchase intention, fictitious scenario*

\*Corresponding Author: gangani@agecon.ruh.ac.lk.

## **Taxonomic implications from leaf stomatal anatomy of *Calotropis gigantea* R. Br. (Apocynaceae) found in Matara, Sri Lanka**

Pushpa D. Abeysinghe<sup>1\*</sup>, Tanya Scharaschkin<sup>2</sup>, Rachel Hancock<sup>3</sup>, Sanjleena Singh<sup>3</sup>

<sup>1</sup>*Department of Botany, University of Ruhuna, Matara, Sri Lanka,*

<sup>2</sup>*School of Earth, Environment and Biological Sciences Science and Engineering Faculty, Queensland University of Technology, Brisbane, Australia,*

<sup>3</sup>*Central Analytical Research Facility (CARF) Queensland University of Technology, Brisbane, Australia*

Identification of purple and white flower forms of *Calotropis gigantea* R. Br. (Apocynaceae) found in Sri Lanka is impossible using only morphological characters when there are no flowers in the plant. Flowering is seasonal. In this study, we explored leaf stomatal anatomy of the two forms using scanning electron microscopy (SEM) in order to investigate if stomatal anatomy was informative separating them. Amphistomatic stomatal complexes are elliptical, sunken, irregularly scattered and conspicuous across the epidermis. The lower and upper surfaces of both forms exhibit cuticular striations. Organization and arrangement of the striae around the stomata are different in both forms and each form has its unique organization. In the white form, the individual stomata on both surfaces are separated from one another by 5-6 bundles or clusters of cuticular materials and striations that originated at the tips of the stomata are radiated outwards. Such an organization is not observed in the purple form. In the purple form, clear thread like cuticle striations are remarkable on both abaxial and adxial surfaces. Adjacent stomata are usually interconnected by the heavily cutinized few to several thread like bundles of ornaments which are originated around the stomata and each bundle consist of 5 -8 parallel striae and they are not confined to areas around the stomata but distribution occurs over the other cells; stomatal subsidiary and normal epidermal cells. Accordingly, the results of organization and arrangement of the cuticular striae around the stomata have provided characters to identify the two floral forms which would also be valuable as the correct identification is important to conserve the white form, which is rare and also medicinally important.

**Keywords:** *Calotropis gigantea*, SEM, striations, cuticular anatomy

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\*Corresponding Author: pushpa@bot.ruh.ac.lk



## **Screening of *Trichoderma* isolates as biocontrol agents against banana wilt pathogen and evaluating organic biomass wastes for mass production of conidia**

Chathuranga T. S., Masakorala, K. and Abeysinghe, S.\*

*Department of Botany, University of Ruhuna, Matara, Sri Lanka*

Fusarium wilt disease of banana is a serious threat in the banana growing areas in the world including Sri Lanka and no effective fungicide or resistant cultivars are available to date. Nevertheless, fungicides are extensively being used. Biological control is one of the environmentally sound alternatives in such instances. Therefore, the main objectives of the study were to screen potential *Trichoderma* isolates as bio control candidates and to evaluate cheap, simple and abundant substrates for the mass production of *Trichoderma* for practical application.

*Trichoderma* spp. isolated from rhizosphere of banana (cv. Kolikuttu) from different areas of commercial banana fields in southern province of Sri Lanka were screened under *in vitro* conditions for their antagonistic potential against *Fusarium oxysporum* f. sp. *cubense*, the banana fusarium wilt pathogen. *Trichoderma* isolate T13 was the most effective in inhibiting the mycelial growth of *Fusarium* in Petri plate assay. Out of four different organic biomass wastes, (straw, banana leaf, banana pseudostem, and banana rind) that were tested for mass production of conidia of T13 *in vitro*, straw was found to be the best supportive organic material to enhance conidia production in broth cultures. Strain T13 was colonized in straw within 7 days and exhibited high spore density ( $3.167 \times 10^{13}$  conidia/mm<sup>3</sup>) and absorbance ( $\lambda_{550} = 4.4890$ ) with a strong positive correlation ( $r = 0.986$ ). Those two parameters were significantly different ( $p < 0.001$ ) compared to other treatments. Thus, the results revealed that the applicability of straw could be used as a congenial substrate for mass conidia production of *Trichoderma* isolate T13.

**Keywords:** *Trichoderma*; *Fusarium oxysporum*; mass production; Fusarium wilt

\*Corresponding Author: saman@bot.ruh.ac.lk



## Performance evaluation of a maize growth simulation model

Rajawatta K.M.W.<sup>1,2</sup>, Dongjian He\*<sup>1</sup>, Piyaratne M.K.D.K.<sup>3</sup> and Haidong Lu<sup>4</sup>

<sup>1</sup>*College of Mechanical & Electronic Engineering, Northwest A&F University, Yangling, Shaanxi, PR China.*

<sup>2</sup>*National Engineering Research & Development Centre of Sri Lanka, Ekala, Ja-Ela, Sri Lanka.*

<sup>3</sup>*Faculty of Agriculture, University of Ruhuna, Kamburupitiya, Sri Lanka.*

<sup>4</sup>*College of Plant Protection, Northwest A&F University, Yangling, Shaanxi, PR China.*

Maize is an important cereal and it has a large potential for a high yield production in China. Therefore, improved management practices aimed to increase the production in regional level are in demand. Consequently, the regional level accurate yield estimation of maize has become important and, in fact, a big challenge. Therefore, a region-specific maize model will have a great value in yield simulation in a particular region. Therefore, a maize growth simulation model was developed by analyzing the quantitative growth of maize on daily basis and emphasizing the potential yield prediction with special focus on Northwest region, China. Daily maize growth and development, total dry matter accumulation and final grain yield for one cropping cycle were considered for the simulation of the model. Seven major stages of the crop were considered: sowing date, germination and emergence, three-leaf unfolding, jointing, booting, spinning and harvesting. Model development was based on the Growing Degree Days. Validation was done with five cropping cycles' observation data (2005, 2006, 2007, 2009 and 2011). The common maize variety in the area, 'Zhengdan958' was used and the experimental field was supplied with 40m<sup>3</sup>/ha of water, 300 kg/ha of Nitrogen and 225kg/ha of Phosphorus to avoid water and nutrient stresses in order to ensure a potential maize yield. Simulated and observed data were statistically analyzed and compared. The grain yield was slightly over estimated for three cropping cycles (2006, 2007 and 2011). However, the coefficient of determination ( $R^2=0.94$ ) has shown a positive agreement. The obtained results have shown a fair agreement between simulated and observed values for both development and growth variables. Based on the results, the model can be used as a prediction tool and as an economic management tool in economic planning at regional level for maize cultivation.

**Keywords:** *Maize, maize growth model, growing degree days, cropping cycle*

**Acknowledgements:** *This research was supported by the National High Technology Research and Development Program of China (863 program, Project number: 2013AA102304).*

\*Corresponding Author: [hdj168@nwsuaf.edu.cn](mailto:hdj168@nwsuaf.edu.cn)

## **Effects of used lubricant oil contaminated soil on soil microbial activity and population size**

W.G.S. Sriyanthi and K.Masakorala\*

*Department of Botany, University of Ruhuna, Matara.*

Soil contamination with used lubricating oil (ULO) has become one of the major environmental issues in most of the cities throughout the world. As ULO contains polycyclic aromatic hydrocarbons and heavy metals, ULO contamination of soil may negatively affects the overall soil quality. Microbial properties of soil are vitally important for maintaining the status of the soil. Soil microbes are highly sensitive for any kind of alterations in the ecosystem. Therefore, soil microbial activity in addition to cell culture base technique is important to use as an integrated approach to determine the soil microbial status of ULO contaminated soil. The aim of the study was to investigate the effects of long term contamination of soil by ULO on soil microbial activity and population size. Five Soil samples with different level of contamination were collected from the service station in Mataradistrict, Sri Lanka. Three replicates from each sample were initially analyzed for total petroleum hydrocarbon (TPH) content and pH. Microbial population size of both cultivable heterotrophic bacteria and fungi were obtained as colony forming unit (CFU) by applying dilution plate count technique. Total microbial activity was determined by using Fluoresciendiacetate (FDA) hydrolysis method. TPH content varied from 35,667 mg kg<sup>-1</sup> to 62,667 mg kg<sup>-1</sup> for the analyzed samples. Each of the measured parameters in contaminated soil exhibited significant difference ( $p < 0.001$ ) compared to that in the uncontaminated control. The measured pH showed an increasing trend while cultivable heterotrophic bacterial population size, cultivable heterotrophic fungi population size and total microbial activity showed decreasing trend with the increase of TPH concentration. Overall results indicated the negative impacts of long term ULO contamination on soil microbial activity and population size.

*Keywords: Used lubricating oil, total petroleum hydrocarbon content, soil microbial population size, soil microbial activity*

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\*Corresponding Author: masakorala12@yahoo.com

## **Micro propagation of Jujube (*Ziziphus jujuba* Mill.) through shoot tip and nodal segment culture**

Hansika K.P.<sup>1</sup>, Perera R.N.I.<sup>2</sup>, Ranawake A.L.<sup>1\*</sup> and Senanayake S.G.J.N.<sup>1</sup>

<sup>1</sup>*Department of Agricultural Biology, Faculty of Agriculture, University of Ruhuna, Kamburupitiya, Sri Lanka.*

<sup>2</sup>*Division of Biotechnology, Fruit Research and Development Institute, Horana.*

Jujube is known as *Masan* in Sri Lanka is one of the underutilized fruit crops. It is important due to its high nutritious value and introduced as a potential crop for commercial cultivation. Micro propagation using plant tissue culture is an efficient method for vegetative propagation of commercially important crops. Present study was carried out to determine a proper *in-vitro* protocol for local varieties of Jujube. The most suitable fungicide for surface sterilization procedure was selected by testing Captan (Captan 50%, 1.2 g/l), Topsin (Thiophanate methyl 70%, 2 g/l), and Daconil (Chlorothalonil, 1.8 ml/l). Selection of a suitable concentration of BAP or TDZ for shoot proliferation was assessed in four different concentrations of BAP (1, 1.5, 2, 2.5 mg/l) and of TDZ (0.1, 0.2, 0.3, 0.4 mg/l) and IBA for root induction in two concentrations of IBA (1, 2 mg/l). Dipping shoot tips in Captan solution for 20 minutes gave the highest significant non-contamination percentage (79.9%) and lowest fungal radius (0.15 cm) of contaminated cultures among three treatments. MS medium containing 1.5 mg/l BAP recorded significantly highest percentage of elongated bud (96.66%) and newly produced shoot length (1.08 cm) and lowest significant rate was recorded in TDZ 0.2 mg/l (3.33%). Callus was produced in all the concentrations of TDZ. None of the concentrations of BAP or TDZ produced multiple shoots. Elongated nodal segments in BAP (1, 1.5 mg/l) could be successfully sub-cultured for further multiplication. Rooting was not recorded in both shoot tips and *in-vitro* generated shoots during four weeks of culturing on IBA contained media.

**Keywords:** *Ziziphus jujuba* Mill, *in-vitro* propagation, shoot tips, direct shoot induction

**Abbreviations:** BAP (Benzyle Amino Purine) TDZ (Thidiazuron) IBA (Indole Butric Acid) MS (Murrashige and Skoog)

\*Corresponding Author: lankaranawake@hotmail.com

## **Spatio-temporal changes in mangrove cover of three lagoons in Southern Sri Lanka during the last two decades: A field validated GIS study**

Madarasinghe SK<sup>1</sup>, Yapa KKAS<sup>1\*</sup>, Kodikara KAS<sup>2</sup>, Satyanarayana B<sup>3</sup>,  
Udayakantha PMP<sup>4</sup> and Jayatissa LP<sup>2</sup>

<sup>1</sup>*Department of Physics, University of Ruhuna, Matara, Sri Lanka*

<sup>2</sup>*Department of Botany, University of Ruhuna, Matara, Sri Lanka*

<sup>3</sup>*Institute of Oceanography and Environment (INOS), Higher Institution  
Centre of Excellence (HICoE) in Marine Sciences, Universiti Malaysia  
Terengganu – UMT, 21030 Kuala Terengganu, Malaysia*

<sup>4</sup>*Sri Lanka Survey Department, Colombo, Sri Lanka*

Considerable changes in the mangrove cover of Rekawa (6°02'57"N, 80°50'37"E), Kahandamodara (6°04'02"N, 80°53'12"E), and Kalametiya, (6°05'37"N, 80°56'26"E), three neighboring lagoons of southern Sri Lanka, taken place during the period from 1956 to 1994 were reported by Dahdouh-Guebas F et al., (2005) with implications for further changes in the future. Therefore, this study was aimed at investigating spatio-temporal changes in the mangrove cover of the same three lagoons during the last two decades, from 1994 to 2016. First, eight aerial photographs of 1994 and Landsat-8 image of 2016, covering the three lagoon areas were geo-referenced using respective toposheets of the lagoons (ArcGIS v.10.1). Spatio-temporal changes of mangrove cover and water surface area of each lagoon during the 22 year period were quantified by overlaying the maps. Changes were field validated and possible causes for the changes were studied by on-site observations and through information collected using a questionnaire survey. All three lagoons showed significant increases in mangrove cover from 1994 to 2016. Mangrove covers of Rekawa, Kahadmodara and Kalametiya lagoons have been increased by 17.86% (1.05 ha yr<sup>-1</sup>), 19.04% (1.44 ha yr<sup>-1</sup>) and 144.34% (10.35 ha yr<sup>-1</sup>) respectively, during the last 22 year period. Accordingly, surface water areas of respective lagoons have decreased by 1.20%, 11.90% and 72.43% during the same period. The results indicate that rates of increase of the mangrove cover of the three lagoons for the period from 1994 to 2016 have been accelerated compared to that of the rates from 1956 to 1994. Possible reasons for the changes are discussed.

**Keywords:** *Rekawa, Kahandamodara, Kalametiya, Mangrove cover, Remote sensing*

\*Corresponding author: kanthi@phy.ruh.ac.lk

## **Investigation of extraction conditions to obtain marigold extracts rich in lutein and antioxidants**

M. D. N. N. Jayarathne<sup>1</sup>, B. G. K. Perera<sup>1,\*</sup>

<sup>1</sup>*Department of Chemistry, Faculty of Science, University of Colombo, Sri Lanka*

Lutein which is commercially extracted from marigold flowers, is significantly used in food, pharmaceutical and poultry industries. However, low yields, formation of inactive isomers and high cost of production are the problems associated with current extraction methods. Therefore, optimization of extraction conditions to obtain lutein extracts from marigold flowers with high pigment yield as well as high antioxidant activity (AOA) in an economical manner is important. In this study, crude lutein was extracted from marigold flowers into four different solvents (hexane, ethyl acetate, acetone and methanol) using maceration, sonication and soxhlet extraction. Thin layer chromatograms of the extracts indicated the presence of several carotenoids while lutein being the major. The UV-visible spectra of the extracts enabled to determine the pigment concentration of the extracts using the Beer-Lambert law. The highest pigment concentration was obtained for the sonicated acetone extract ( $7.0 \times 10^{-6}$  mol L<sup>-1</sup>). The highest AOA was obtained for the sonicated methanol extract which displayed the highest results in the Folin-Ciocalteu assay (total antioxidant capacity (AOC) = 564 µg pyrogallol equivalents (PGE)/mg) and the Ferric Reducing Antioxidant Power (FRAP) assay (FRAP = 472 µg of ascorbic acid equivalents (AAE)/mg). However, it was found that maceration of marigold petals in acetone is the best extraction condition to obtain a significantly high lutein concentration ( $5.0 \times 10^{-6}$  mol L<sup>-1</sup>) along with high antioxidant activity (total AOC = 381 µg PGE/mg and FRAP of 448 µg AAE/mg).

**Key words:** *Extraction techniques, Folin-Ciocalteu assay, FRAP assay, Lutein, Marigold.*

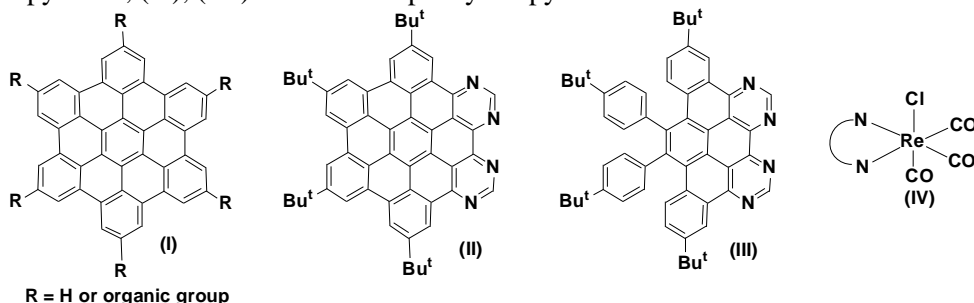
\*Corresponding author – [gayani@sci.cmb.ac.lk](mailto:gayani@sci.cmb.ac.lk)

## Syntheses of $[\text{Re}(\text{CO})_3(\text{NN})\text{Cl}]$ complexes of bulky N,N-donor ligands

Sarath D. Perera\*

*Department of Chemistry, The Open University of Sri Lanka, Nawala, Sri Lanka*

All carbon hexaarylbenzene derivatives are used as simple building blocks for the preparation of hexabenzocoronene or superbenzene derivatives (**I**) which show interesting photo-physical and electrochemical properties. Cyclodehydrogenation of tetraaryldipyrimidyl benzene containing four nitrogen atoms at the periphery lead to the discovery of fully-cyclized tetraazasuperbenzene (**II**) and half-cyclized tetraaza superbenzene (**III**). Ruthenium(II) complexes of the type  $[\text{Ru}(\text{bpy})_2(\text{II})][\text{PF}_6]_2$  and  $[\text{Ru}(\text{bpy})_2(\text{III})][\text{PF}_6]_2$  showed unique optical and electrochemical properties. Re(I) carbonyl complexes are found in applications of supramolecular chemistry such as carbon dioxide reduction and sensors. In here, we report the syntheses of some rhenium(I) complexes of the type (**IV**) containing N,N-donor ligands : tetra-substituted-1,12-diazatriphenylene, tetraphenyl-2,2'-bipyridine, (**II**), (**III**) and 4-bromophenyl-terpyridine.



Seven *fac*-chlorotricarbonylrhenium(I) complexes of the type (**IV**) were prepared in hot benzene or chloroform by reacting  $[\text{ReCl}(\text{CO})_5]$  with an appropriate N,N-donor ligand and the products were isolated in good yields as coloured solids. Mass spectral data indicated the presence of  $\text{M}^+$ ,  $[\text{M}-\text{Cl}]^+$  or  $[\text{M}+\text{Na}]^+$  ion. As expected, IR spectra showed three strong IR bands around 2020, 1900 and 1880  $\text{cm}^{-1}$  for carbonyl ligands. IR,  $^1\text{H}$ -NMR and  $^{13}\text{C}$ -NMR data suggested these complexes to have the *fac*-geometry.

**Keywords:** *Re(I) complexes, N,N-donor ligands, tetraazasuperbenzene, polyphenylenes*

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\*Corresponding Author: ksper@ou.ac.lk

## **Microencapsulation of clove oil to improve its usability as a pesticide**

N.D. Gajasinghe, B. G. K. Perera\* and R.D. Wijesekera

*Department of Chemistry, Faculty of Science, University of Colombo,  
Colombo 03, Sri Lanka*

Clove oil (CO) displays many important bioactivities such as antimicrobial and antioxidant activity. It is also reported to possess significant insect repellent and insecticidal activity against several insect types and acts as a herbicide as well, by disrupting cell membrane integrity and inhibiting seedling growth of weeds. However, direct usage of CO as a pesticide in day-to-day life is restricted due to its strong odor, cytotoxicity and irritability. Microencapsulation can be used to overcome the above undesirable characteristics and obtain prolonged activity of CO. Therefore, CO microcapsules were synthesized using chitosan and gum arabic as wall materials.

The optical and scanning electron microscopic images indicated the formation of irregular shaped microcapsules in the 150-200  $\mu\text{M}$  range. The UV-visible analysis confirmed the successful encapsulation of CO with a 8  $\mu\text{L/g}$  loading. The synthesized microcapsules indicated a significant antibacterial activity against *Bacillus cereus* and *Escherichia coli*. Additionally, the CO microcapsules displayed significant mosquito repellent activity (MRA) against *Aedes aegypti* mosquitoes in an assay carried out using a static air repellent apparatus. The MRA was maintained from  $64\pm4\%$  to  $28\pm4\%$  during a 3 hour time period. CO microcapsules indicated a DPPH radical scavenging activity of  $30\pm1\%$ . The synthesized CO microcapsules did not display any pungent odor as did the unencapsulated oil.

It can be concluded that CO can be successfully encapsulated with its original bioactivities being preserved while allowing the controlled release of CO, minimizing its toxic effects and pungent smell during direct usage.

**Keywords:** *microencapsulation, clove oil, chitosan, gum arabic, mosquito repellent*

\*Corresponding author: gayani@sci.cmb.ac.lk



## **Analysis of nutrient compositions in commercially available selected, processed dry food products and instant dry food mixtures**

Vajira P. Bulugahapitiya\* and L.A. S. Priyangika

*Department of Chemistry, University of Ruhuna, Matara, Sri Lanka*

The food packages of processed dry foods and instant dry foods mixtures which are produced locally, are widely available in the market. The most of such packages do not indicate the nutrients contents of the food inside. Nowadays, non-communicable diseases is the leading causes of death and diseases burden in the society. It has been documented that consumption of unhealthy food is one of the main causes for this. Therefore, knowing the nutrients contents of the processed foods and the instant foods is prime important to the consumers.

In this study, selected varieties of processed dry foods and instant dry foods which are produced locally and available in the market are used for the nutrient analyses. Those food varieties are rice flour, ulundu flour, kurakkan flour, white rice, red rice and kurakkan noodles, white rice and red rice string hopper mixtures, thosai mixtures and hopper mixtures. The crude protein content, carbohydrates content, ash content, fiber content, moisture content and total energy content of each food item were analyzed by following the standard methods. All the values were calculated for 100.00 g of food. It has been found that highest carbohydrate content is in white rice noodles (80.41g), highest protein content is in uludu flour ( $27.85 \pm 0.48$  g), highest fiber content is in kurakkan flour ( $6.68 \pm 0.61$ g), highest ash content ( $24.02 \pm 3.90$  g) and highest fat content ( $2.14 \pm 0.16$  g) is in red rice string hopper, highest moisture content is in white rice noodles ( $8.82 \pm 0.07$  g) and the highest total energy content is in kurakkan noodles (369.95 Kcal) among the items analyzed. The lowest fat content was observed for white rice noodles which was  $0.18 \pm 0.03$  g.

As a conclusion, uludu flour contains highest protein contents out of processed dry food used in this study, white rice noodles contains the lowest fat. The highest energy supplier is kurakkan noodles. This was the first nutrient analysis reported on commercially available locally produced processed dry food and instant dry food items.

**Keywords:** *Nutrient composition, processed dry food, instant dry food,*

**Acknowledgement:** Authors greatly acknowledge Harischandra Mills PLC for providing food items and financial support for the analysis.

\*Corresponding author: vajira@chem.ruh.ac.lk



## **Preparation of cinnamon oil microcapsules to be used as a digestive supplement for humans**

J. P. S. Rasanganie and B. G. K. Perera\*

<sup>1</sup>*Department of Chemistry, University of Colombo, Sri Lanka*

Cinnamon oil is important in treating various disease conditions including digestive problems. However, direct usage of cinnamon oil could cause skin irritations and allergic reactions. Oral administration of cinnamon oil can increase the heart rate, gastric motility and respiration. Therefore, microencapsulation technique was tested as a way to overcome these limitations and to improve the utility of cinnamon oil. Cinnamon oil was encapsulated by the complex coacervation method using chitosan and gum arabic wall materials. These microcapsules appeared to be irregular in the optical and scanning electron microscopic images. UV-visible analysis confirmed the effective encapsulation of cinnamon oil with a loading of 860 µg/g. The prepared microcapsules displayed a  $47 \pm 1$  % and  $32 \pm 1$  % release of the core oil in pH 2 and pH 7 solutions that mimicked the stomach and intestine conditions respectively. This indicated the controlled release of about 79% encapsulated cinnamon oil from the microcapsules under conditions similar to the gastrointestinal tract. The brine shrimp lethality assay indicated that the cytotoxic effects of cinnamon oil are notably masked in the intact microcapsules. Those data also demonstrated the ability of microencapsulated cinnamon oil to be released with time. Furthermore, the encapsulated oil exhibited considerable antioxidant activity and the microcapsules did not possess any strong odor as the unencapsulated oil. These results indicate that microencapsulation can be used to improve the utility of cinnamon oil as a digestive supplement.

**Keywords:** *Microencapsulation, Cinnamon oil, Folin-Ciocalteu assay, Controlled release, Antioxidant activity.*

\*Corresponding author: gayani@sci.cmb.ac.lk

## **Development of a smart textile with medicinal properties using lime oil microcapsules**

P.B. Wijesirigunawardana and B.G.K Perera\*

*Department of Chemistry, University of Colombo, Colombo 03, Sri Lanka.*

A smart textile can be defined as a textile that is developed by changing the functionality of common fibers to result in properties useful to the consumer. The present study was focused on using microencapsulation technique to prepare an antioxidant and antibacterial active smart cotton fabric using lime oil (LO). LO microcapsules were prepared *via* the complex coacervation method using chitosan and gum arabic wall materials. UV-Visible spectrometry and FTIR spectrometry was used to verify the encapsulation of LO in microcapsules. Morphology of the LO microcapsules was observed under the optical and scanning electron microscopes (SEM). It was found that the synthesized LO microcapsules were irregular in shape and differed in size between 40-160  $\mu\text{m}$ . The loading of the microcapsules was found to be  $2943 \pm 128 \mu\text{L/g}$  with a loading efficiency of  $82 \pm 4\%$ . The antioxidant activity was monitored using the DPPH radical scavenging assay which indicated a  $36 \pm 3\%$  radical scavenging activity for the LO microcapsules. The SEM images confirmed the firm attachment of the LO microcapsules to the fibres of the cotton fabric. With respect to the relevant control samples, the LO microcapsules incorporated unwashed cotton fabric displayed significant antibacterial activity against *Escherichia coli*, *Bacillus cereus*, *Salmonella typhimurium* and *Staphylococcus aureus* bacterial species with inhibition zones of  $10 \pm 1$  mm,  $9 \pm 0$  mm,  $9 \pm 1$  mm and  $9 \pm 1$  mm respectively. After a single wash cycle, the LO microcapsules incorporated cotton fabric still displayed significant antibacterial activity with inhibition zones of  $8 \pm 1$  mm,  $7 \pm 0$  mm,  $7 \pm 0$  mm and  $7 \pm 1$  mm against the same bacterial species respectively.

**Keywords:** *Smart textiles, Microencapsulation, Lime oil, Antioxidant, Antibacterial*

\*Corresponding author: gayani@sci.cmb.ac.lk

## Visual Detection of Fluoride ions by a Simple Chromogen, Bromothymol Blue Diacetate

A. S. Dissanayake<sup>1\*</sup>, and W. N. R. Fernando<sup>2</sup>

<sup>1</sup>*Department of Chemistry, University of Ruhuna, Matara, Sri Lanka.*

<sup>2</sup>*Sri Lanka Institute of Nanotechnology, Pitipana, Homagama, Sri Lanka*

This study describes a simple, new, method for the detection and determination of fluoride using a novel chromogen, bromothymol blue diacetate abbreviated as BTBDA. Previously unknown chromogen, BTBDA was designed and synthesized in high yield. The detection of fluoride is based on the removal of acetate groups by fluoride ions in aqueous medium without interference from other common anions. The reaction of BTBDA with fluoride ion was investigated by UV-vis spectroscopy. BTBDA in water (pH ~ 6.0) showed the colour change from pale yellow to intense blue upon addition of fluoride ion due to substantial bathochromic shift of  $\lambda_{\text{max}}$ . (415 to 618 nm). No significant colour change was observed upon addition of a few other anions such as  $\text{Cl}^-$ ,  $\text{Br}^-$ ,  $\text{I}^-$  and  $\text{ClO}_3^-$ . Fluoride ion triggered dramatic change of absorption band and colour show that BTBDA is highly selective towards the fluoride ion over other selected anions. The absorbance at  $\lambda_{\text{max}} = 618 \text{ nm}$  exhibited by the dianion increased linearly with increasing fluoride ion concentration. Therefore, BTBDA derived from readily available simple acid base indicator, allows naked-eye detection of fluoride ions in aqueous medium. Under experimental conditions used, calibration graph was linear with the correlation coefficient of ( $r^2 = 0.994$ ) in water. The most promising feature of this new chromogen is its ability to respond to fluoride ions in aqueous medium compare to the structurally similar chromogen, phenolphthalein diacetate which is reactive towards fluoride ions only in organic media.

**Key words:** *fluoride ions, bromothymol blue, water, spectrophotometry*

*\*Corresponding Author:* arunasd@chem.ruh.ac.lk

## Synthesis and Characterization of Cationic Tri-Oxygen coordinated Ru Complexes

Kalutharage N. K.<sup>1</sup>, and Yi C. S.<sup>2</sup>

<sup>1</sup>*Department of Chemistry, University of Ruhuna, Wellamadama, Matara, Sri Lanka.*

<sup>2</sup>*Chemistry Department, Marquette University, Milwaukee, WI, 53233, USA.*

Using the previously synthesized cationic ruthenium-hydride complex  $[(\eta^6\text{-C}_6\text{H}_6)(\text{PCy}_3)(\text{CO})\text{RuH}]^+\text{BF}_4^-$  (**1**), a method to synthesis O-coordinated cationic ruthenium hydride complexes **2-6** was developed. Synthesis of complex  $[(1\text{-butanol})_3(\text{PCy}_3)(\text{CO})\text{RuH}]^+\text{BF}_4^-$  (**2**) was done in NMR scale from complex **1** using butanol in  $\text{CD}_2\text{Cl}_2$  (1 mL) in a NMR tube.  $^1\text{H}$  NMR at 50 °C shows the appearance of a new ruthenium hydride at  $^1\text{H}$  NMR:  $\delta$  -18.8 ppm (d,  $J = 31.3$  Hz, 1H). The complex  $[(\text{H}_2\text{O})_3(\text{PCy}_3)(\text{CO})\text{RuH}]^+\text{BF}_4^-$  (**3**) was synthesized using a similar method, with water as a reagent  $^1\text{H}$  NMR:  $\delta$  -17.7 ppm (d,  $J_{\text{H-P}} = 30.3$  Hz),  $^{31}\text{P}$  NMR:  $\delta$  73.0 ppm at -10 °C. By using 1,1,1-tris(hydroxymethyl)ethane as the alcohol source the complex  $[(\text{CH}_3\text{C}(\text{CH}_2\text{OH})_3)(\text{PCy}_3)(\text{CO})\text{RuH}]^+\text{BF}_4^-$  (**4**) was synthesized in 80% yield. Under similar experimental conditions the cationic ruthenium hydride complex **1**, dissolved in acetone to generate complex  $[(\text{CH}_3\text{COCH}_3)_3(\text{PCy}_3)(\text{CO})\text{Ru}(\text{H}_2\text{O})]^+\text{BF}_4^-$  (**5**) as a ketone coordinated complex with a  $^1\text{H}$  NMR (400 MHz, acetone- $d_6$ )  $\delta$  4.48 ppm (br.s, 2H), and  $^{31}\text{P}$  NMR (100 MHz,  $\text{CDCl}_3$ )  $\delta$  73.4 ppm. When complex **1** was dissolved in dioxane,  $[(\text{PCy}_3)(\text{CO})\text{Ru}(\text{H}_2\text{O}_4)]^+(\text{BF}_4^-)_2$  (**6**) was formed. Compound **6** has  $^1\text{H}$  NMR peak at  $\delta$  4.48 ppm (br.s, 8H) and  $^{31}\text{P}$  NMR in  $\text{CDCl}_3$   $\delta$  55.09 ppm. Complexes **3-5** have a distorted  $\text{O}_h$  structure with the longest bond for both Ru-CO(1.828 Å) and Ru- $\text{PCy}_3$  (2.3130 Å) according to the results of their single crystal X-ray analysis.

**Keywords:**  $[(1\text{-butanol})_3(\text{PCy}_3)(\text{CO})\text{RuH}]^+\text{BF}_4^-$  cationic ruthenium hydride, O-coordinated cationic ruthenium hydride

\*Corresponding Author: [hdj168@nwsuaf.edu.cn](mailto:hdj168@nwsuaf.edu.cn)

## **Impact of different cooking methods on the Antioxidant content of selected underutilized tubers in Sri Lanka**

HMAJ Herath\*, HDJEWijerathna and A Chandrasekara

*Department of Applied Nutrition, Wayamba University of Sri Lanka,  
Makandura, Gonawila, 60170, Sri Lanka*

Tuber consumption has been limited only to common types where many underutilized varieties remain neglected and underexploited. The knowledge about the cooking methods to obtain the maximum nutritional benefits is also controversial. The present study characterized the antioxidant potential of tubers as affected by different cooking methods.

Twelve different underutilized tubers belonging to five species namely, *Dioscorea alata*, *Dioscorea esculenta*, *Xanthosoma sagittifolium*, *Alocasia indica* and *Amorphophallus campanulatus* were collected from Horticulture Research and Development Centre, Agriculture Department, Gannoruwa. The flesh of the tubers was processed with six different cooking methods; oven drying, roasting, frying, open boiling, pressure cooking and steaming. Processed samples were analysed for their total phenolic content (TPC), 2, 2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity (DRSA), reducing power (RP), and ferrous ion chelating activity. The tests were performed in triplicates and the statistical analysis was carried out using SPSS software.

*Ratala* pressure cooked sample had the highest TPC whereas *Hingurala* flesh possessed the lowest and ranged from 1.8-95.2  $\mu$ mol of gallic acid equivalent/g of dry weight (DW). DPPH radical scavenging activity of the tubers ranged from 1.50 to 245.1  $\mu$ mol of trolox equivalent per/g of DW. The best Fe ion chelating ability was exhibited by *Kahatala* peel while *Guruala* open boiled sample possessed the lowest. Reducing power of the tubers varied between 3.35 and 118.56  $\mu$ mol of ascorbic acid equivalent per /g of DW.

Pressure cooking and steaming revealed its suitability to retain the highest antioxidant potential among tested cooking methods. Further the potential of these underutilised tubers as natural source of antioxidants depends on the species and the cooking method.

**Keywords:** *Antioxidant activities; cooking methods; total phenolic content; underutilized tubers*

\*Corresponding Author: [apekshajayanandi@gmail.com](mailto:apekshajayanandi@gmail.com)

## Adsorption of $\text{Ni}^{2+}$ and $\text{Pb}^{2+}$ by Curry leaves

W.M. Wijetunga and R.H.W. Gunasekera\*

*Department of Chemistry, University of Ruhuna, Matara, Sri Lanka*

Heavy metal pollution causes detrimental health issues for flora and fauna. Numerous methods have been employed to get rid of those metals, but most of them are found to be ineffective and expensive. Biosorption of these metals by microbes or plants has been emerging as an alternative and cost effective method to remove heavy metals in the waste.

In this work curry leaves are used as a new biosorbent for heavy metals. The main objective of this work is fine-tuning the conditions to optimize the biosorption of heavy metals by the curry leaves and employ those conditions to remove heavy metals in food. Back ground experimental results showed that water and fiber content of curry leaves are 68 and 14 % by mass. Methylene blue adsorption experiments revealed that specific surface areas of curry leave powder of particle sizes (250-500) and  $\leq 250 \mu\text{m}$  are  $2.1 \times 10^6$  and  $2.7 \times 10^6 \text{ km}^2 \text{ kg}^{-1}$  respectively. It was also found that curry leaves it self contains 0.03 ppm  $\text{Ni}^{2+}$  and 0.05 ppm  $\text{Pb}^{2+}$  and these values are neglected in biosorption efficiency calculations. Atomic Absorption Spectroscopy was used to study biosorption efficiency of curry leaves against dried/raw nature of leaves, pH, particle size, concentration of biosorbent and contact time. The results revealed that at room temperature, 1 g of curry leave powder of particle size less than  $250 \mu\text{m}$  adsorb 3 mg of Ni at equilibrium. This corresponds to 62 % removal percentage of  $\text{Ni}^{2+}$  present in a 250 mL of 40 ppm solution. The biosorption efficiencies were pH dependent and the optimum pH values for adsorption of  $\text{Ni}^{2+}$  and  $\text{Pb}^{2+}$  were 6 and 8 respectively.

**Keywords:** *Biosorption, curry leaves, heavy metal ions*

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\*Corresponding Author: rangika@chem.ruh.ac.lk

## **Coir Pith Lignin Isolation and Spectroscopic Structure Elucidation**

L.A. Panamgama\* and J.W.W.C. Jayalath

*Department of Chemistry, University of Ruhuna, Matara, Sri Lanka*

Lignin can be considered as one of the most promising renewable resource for the future. Reduction of synthetic adhesive usage in wood composite production by the development of lignocellulosic materials is a challenge. Lignin has been extracted from coir pith and utilized to create an epoxy-lignin hybrid adhesive system. Extraction was done by alkaline [7.5(%wt.) NaOH, 90 min, 90°C and 1:10 ratio] and organosolv [formic: acetic acid 6:11 (v/v), 85(%wt.), 120 min, 90°C and 1:8 ratio] pulping methods in laboratory scale. The yield of lignin in alkaline pulping was high (25 %wt.) compared to organosolv pulping (2 %wt.). Fourier transform infrared spectroscopy (FTIR) studies showed a shift of carbonyl band in the organosolv lignin to longer wavelength at 1702 cm<sup>-1</sup> indicating a partial acetylation due to the acetic acid usage.

Enhancement of reactivity of lignin has been a huge challenge in its applications. Alkaline lignin was chemically modified by two protocols viz, hydroxymethylation and phenolation separately. The obtained FTIR data of modified lignin supported that the contents of hydroxymethyl and phenolic hydroxyl had been increased.<sup>1</sup>H and <sup>13</sup>C CP-MAS NMR results illustrated that the two lignins have different types and extents of hydroxyl functional groups. MALDI-TOF mass spectrometry analysis indicated that oligomeric structures of corresponding functional groups of lignin. UV-vis data revealed a good interpenetration of lignin within epoxy matrix. A lignin-epoxy adhesives system was prepared by polyblending alkaline lignin and epoxy resin varying from 5 to 20 (%wt.). Fracture testing data measured by an Instron machine revealed the decrease of lap shear strength with the gradual increase in the lignin portion of the polyblends. The findings of this research project in lignin isolation by two methods viz., alkali and organosolv and modification can be of high interest in utilizing coir pith as a valuable bio-resource.

**Keywords:** Lignin; UV-Vis, MALDI-TOF-MS; <sup>13</sup>C, <sup>1</sup>H NMR, FTIR

\*Correspondence author: asoka@chem.ruh.ac.lk



## **An evaluation on suitability of fish waste to produce fish oil**

S. P. B. Sajeewani and Hema M.K.K. Pathirana\*

*Department of Chemistry, University of Ruhuna, Matara, Sri Lanka*

Objective of this study was to extract fish oil from fish waste of the marine fish white tip shark (*Triaenodon obesus*) and fresh water catla (*Catla catla*) by solvent free microwave assisted extraction and to investigate the fatty acid profiles and free fatty acid content in the oils, in order to explore the potential of using those fish waste to produce fish oil. The yield of fish oils from viscera of white tip shark and catla were 44.3 % and 35.5 % (w/wet w) respectively. Free fatty acid levels of both oils agree with the recommended level. Fish oil of viscera of white tip shark had 29.7 % saturated fatty acids (SFA), 35.6 % monounsaturated fatty acids (MUFA), 11.6 % n-3 fatty acids, 4.2 % n-6 fatty acids, 7.5 % Docosahexaenoic acid (DHA) and 4.1 % eicosapentaenoic acid (EPA). The SFA content is lower and MUFA, DHA and EPA levels are higher in fish oil from viscera of white tip shark than the reported levels for Cuban shark liver oil. Based on the observations on fatty acid profile of fish oil from viscera of white tip shark, it can be considered as a good source for fish oil. Total n-3 fatty acid level and DHA level in fish oil from viscera of catla was 6.6 % and 4.4 % respectively which indicates that it gives fish oil of low quality when compared with the oil extracted from viscera of white tip shark.

**Keywords:** *fish waste, fish oil, fatty acid profile, Triaenodon obesus, Catla catla*

\*Corresponding Author: [hemap@chem.ruh.ac.lk](mailto:hemap@chem.ruh.ac.lk)



## **Treatment of highly acidic wastewater from a food processing industry**

Hettiarachchi. L. I. and Wanniarachchi. S\*

*Department of Chemistry, University of Ruhuna, Matara, Sri Lanka*

Food processing is one of the most important industries around the world. The food processing industry uses a huge amount of water in the production process and consequently generates wastewater rich in inorganic and organic contaminants. The Wastewater generated needs to be treated before being released into the environment. This research aims to treat wastewater released from a food processing industry. This food processing industry processes spices including *Garcinia* (Goraka), pepper, turmeric, mustard, chili and fenugreek and other food items including noodles, soy products etc. The pH, temperature, TDS, conductivity, COD, and BOD<sub>5</sub> of the wastewater were determined. The wastewater was unusually acidic with pH of 2.35. Its conductivity and TDS were 1240  $\mu$ S and 477 ppm respectively. The average value for COD and BOD<sub>5</sub> were 3667 and 871 ppm. The wastewater was highly acidic due to the presence of (-) hydroxycitric acid released during the processing of *Garcinia*. Thin layer and paper chromatographic studies showed R<sub>f</sub> 0.36 and 0.24 respectively for the solvent system, n- butanol: acetic acid: water = 4:1:5 confirming the presence of (-) hydroxycitric acid in wastewater. Conventional treatment methods using poly aluminium chloride and alum as the coagulants followed by closed aeration were employed to treat the effluents. The Highest COD removal efficiency was observed when coagulation was carried out at pH 5 followed by neutralization to pH 7 using poly aluminium chloride as the coagulant. Under these conditions the COD removal efficiency was 88 % and BOD was reduced by 92 % in the treated wastewater.

**Keywords:** *Food processing wastewater, COD, Coagulation*

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\*Corresponding Author: sarathwan@chem.ruh.ac.lk

## **Removal of Reactive Black 5 Using Activated Carbon Produced From Sawdust and Rice Husks - An Effective Way of Effluent Treatment**

Bandara, T.P.D.S; Wadumethrige, S.H; Wanniarachchi. S.\*

*Department of Chemistry, University of Ruhuna*

The textile industry utilizes various chemicals and large amount of water during the production process. The water is mainly used in the dyeing process and rinsing of the final products. The effluents released during this process contains large amount of dyes and chemicals which affect the ecosystem. Commercial activated carbon has been used for the removal of dyestuffs from dyeing industry effluents. Aim of the current study was to prepare low cost industrial grade activated charcoal using readily available waste materials and study their colour removal efficiencies. The possible utilization of activated rice husk and saw dust carbon as the adsorbents for the removal of Reactive Black 5 dye from aqueous solutions has been investigated. Rice husk and sawdust activated carbon were prepared by  $H_3PO_4$  activation followed by carbonization. The colour removal efficiency of activated saw dust (PASD AC) and rice husks (PARH AC) has been investigated using parameters such as adsorbent dosage, initial dye concentration and reaction time. After 2.5 hour stirring at room temperature, PASD AC decolourized more than 90 % of the dye with 0.2 g/100 mL adsorbent concentration. Percent colour reduction was increased from 53 % to 99 % for the PASD AC and 9 % to 84 % for PARH AC when the activated carbon amount changed from 0.05g to 0.5 g at 6 h stirring time. Adsorption by PASD AC and PARH AC were well fitted to the Langmuir isotherm with the correlation coefficients ( $R^2$ ) of 0.9961 and 0.959 respectively. Iodine number of PASD AC and PARH AC were obtained as 922 mg/g and 280 mg/g respectively. According to the results, both activated carbons may provide promising solution for the removal of Reactive Black 5 dye from textile effluents.

**Keywords:** *Reactive Black 5, Rice husk, sawdust, activated carbon, adsorption*

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\*Corresponding Author: sarathwan@chem.ruh.ac.lk

## **A preliminary study on the evaluation of hypocholesterolemic activity of some *Phyllanthus* species**

P. G. M. Kalpani<sup>1</sup>, S. R. Weerakoon<sup>1\*</sup>, S. Somaratne<sup>1</sup>, N. Nilakarawasam<sup>2</sup>,  
C. Ranasinghe<sup>3</sup>

<sup>1</sup>Department of Botany, <sup>2</sup>Department of Zoology, <sup>3</sup>Department of Chemistry,  
The Open University of Sri Lanka, Nawala

Treating hypercholesterolemia with active principles of herbal origin with minimum side effects is increasing. *Phyllanthus* species are rich in active ingredients and many studies report their hypercholesterolemic activity, and less work is reported on Sri Lankan species. Aim of the present study was to screen the hypocholesterolemic activity of crude methanolic extracts of *P. polyphyllus* (PP-CME), *P. maderaspatensis* (PM-CME) and *P. amarus* (PA-CME) using male Wistar albino rats (*Mus norvegicus albinus*). Induction and maintenance of hypercholesterolemia was achieved by feeding high cholesterol diet throughout experiment. Rats (n=12) were randomly separated to positive control and three treatment groups. PP-CME, PM-CME and PA-CME were administered orally at the dosage of 2000 mg/kg b.w. once a day for fourteen days while distilled water was given to the negative control group. Blood parameters were evaluated at 0<sup>th</sup>, 7<sup>th</sup> and 14<sup>th</sup> days after treatment (DAT). Mean and standard deviation of treatments were calculated. Mean differences between the positive control and treated groups were determined using one-way ANOVA. The acceptable level of significance was  $p \leq 0.05$ .

PM-CME and PA-CME significantly reduced total cholesterol by 7<sup>th</sup> and 14<sup>th</sup> DAT ( $p \leq 0.05$ ) meanwhile effect of PP-CME was insignificant ( $p > 0.05$ ). Three extracts significantly reduced LDL-cholesterol by 7<sup>th</sup> and 14<sup>th</sup> DAT. PA-CME and PP-CME reduced triglyceride levels significantly at 14<sup>th</sup> DAT while PM-CME was significant at 7<sup>th</sup> and 14<sup>th</sup> DAT. Significant increases of HDL cholesterol were observed with PM-CME and PA-CME on 7<sup>th</sup> and 14<sup>th</sup> DAT while effect of PP-CME was significant at 7<sup>th</sup> DAT. Blood glucose level in treated rats was less significantly vary throughout experiment. Except PP-CME, PM-CME and PA-CME exhibited a hypocholesterolemic activity in Wistar albino rats. Further studies are required to confirm the dose-dependent response of positive treatments.

**Keywords:** Cholesterol, Wistar albino rats, *Phyllanthus* species

\*Corresponding author: shyamaweerakoon@gmail.com

## **Identification of gill trematode, *Centrocestus* sp., infected on ornamental fish species in Sri Lanka using morphological characteristics**

Sumuduni B.G.D.<sup>1</sup>, Munasinghe D.H.N.<sup>1</sup>, Arulkanthan A.<sup>2</sup>

<sup>1</sup>Department of Zoology, Faculty of Science, University of Ruhuna, Matara, Sri Lanka

<sup>2</sup>Department of veterinary Pathobiology, Faculty of Veterinary Medicine & Animal Science, University of Peradeniya, Peradeniya, Sri Lanka

Infection of *Centrocestus* sp. makes a considerable impact on the value of fish in fisheries sector of Sri Lanka.

The present study was carried out to identify the parasite up to the species level, using morphological characteristics. The first intermediate host of the parasite, thiarid snails, *Melanoides tuberculata*, were induced for shedding cercaria larvae and 45 days old Koi carps (*Cyprinus carpio*) were exposed to get infected. Infected snails were crushed and examined for developmental stages of parasite. After month of the infection, gills of the fishes were observed for metacercariacysts and 3 chicks (*Gallus gallus*) were fed with infected fishes to complete the life cycle of the parasite. Adult flukes and the eggs were recovered from the feces of chicks after the treatment of Praziquantel. Number of anterior spines of metacercaria and adult stages were recorded and length measurements of all stages were taken. Morphological features of all stages were compared with the available literature for the identification of the parasite. Observed radia larvae were tubular and curved in shape. Cercaria larvae consisted with an oral and a ventral sucker, 2 eye spots, heart shape body and a powerful tail. The encysted metacercaria was oval in shape, spines were possessed with x-shaped excretory bladder. Cysts were composed with 2 walls, the inner one was thin and outer one was thick. Ex-cysted metacercaria was subtly elongated and narrower in the anterior end and possessed 32 spines. The observations of this study helped to confirm the parasite fluke as *Centrocestus formasanus*.

**Keywords:** *Centrocestus formasanus*, koi carp, gill trematode, *Melanoides tuberculata*, Sri Lanka

\*Corresponding Author: donamunasinghe@gmail.com, dhn@zoo.ruh.lk

## **Post-hatch ontogenetic changes and their functional significance in guppy fries (*Poecilia reticulata*) revealed by histology and osteology**

K.I.G. Hewavitharana<sup>1</sup>, S.H.N.P. Gunawickrama<sup>2</sup> and K.B.S. Gunawickrama<sup>1\*</sup>

<sup>1</sup> Department of Zoology, University of Ruhuna, Matara, Sri Lanka

<sup>2</sup> Institute for Combinatorial Advanced Research and Education, General Sir John Kotelawala Defence University, Ratmalana, Sri Lanka

*Poecilia reticulata* (family: Poeciliidae) is an ovoviviparous fish whose fries live independently from birth. Records of ontogenic changes during early days of development in post-hatch guppy are rare. Present study shows developmental changes of post-hatch guppy fries from birth up to 10 days post-hatch (dph) stage in terms of osteology and histology. The functional significance of observed changes are discussed. Fry at birth (24 hour post-hatch), and 5 and 10 dph were studied (n=3-5), 1) for histology by staining with hematoxylin and eosin of both cross and transverse sections, 2) for osteology by staining with alizarin red. Newborn fry had ossified teeth. Jaw bones and axial skeleton were well ossified. Cranial bones were not completely ossified in newborns yet it seemed to occur with age. Gradual fusion of the second and third hypurals of the caudal element took place with changes in thickening of the caudal and pelvic fin rays suggesting an enhanced swimming capability. During early development, the photo-receptor cell layer in the eyes showed a marked increase in its thickness. Liver lipid vacuoles became distorted in shape and showed a decrease in their relative abundance. Cephalic kidney lumen seemed to be broadened and the swim bladder changed its shape with increased volume. In conclusion, the study revealed age-related gradual changes in bones and selected organs of functional significance during early development of guppy fries over 10 dph period. Notably, the newborn fry is already an active swimmer that resembles a miniscule adult.

**Keywords:** guppy fry, ontogeny, osteological changes

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\*corresponding author: suneetha@zoo.ruh.ac.lk

## **Effect of different diets on growth and colour enhancement of red blonde variety of guppy (*Poecilia reticulata*)**

Dharmasiri, T.S.K. and De Silva, M.P.K.S.K.

*Department of Zoology, University of Ruhuna, Matara*

Body colour and the faster growth are important requirements in ornamental fish industry. The experiment was carried out to determine the effect of different diets; Beef liver (Diet A), live feed - *Artemia* (Diet B), commercial feeds: Priema 0 (Diet C) and Priema 0 + Priema 999 (Diet D), and a laboratory formulated diet (Diet E) on fish growth and colour enhancement. Throughout the study period of 90 days (100 days old fish), fish fed with Diet B gained highest weight ( $0.61 \pm 0.024$ ) and length ( $3.53 \pm 0.042$ ) which was significantly different from the fish fed with rest of the diets. No significant difference observed in weight ( $p=0.056$ ) and length ( $p=0.267$ ) of fish fed with other four diets. Diet B recorded 58 times higher expenditure (Rs.450.00) than commercial diets and 4 times higher than the Diet A while Diet E recorded least expenditure (Rs.4.51). Red colour on body and fins and silver colour on belly is the marketable colour for red blond variety. Higher red colour intensity recorded from fish fed with Diet A while least red colouration showed by fish fed with Diet D. Fish fed with diet A also had bright silver colour on the belly side. Sex differentiation was possible in the fourth week in fish fed with Diet B while for other fish, it was at the eighth week of the experiment. Results indicated suitability of *Artemia* as a diet for early fry stage until the sex differentiation. When the growth and the cost is considered, Diet E is suitable for the grow out phase (after 30 days from birth) and this diet however should be improved to gain more red colour in guppy.

**Keywords:** *Guppy, Artificial feeds, Live feeds, Growth, Colour*

\*Corresponding Author: kumududs@zoo.ruh.ac.lk

## **Evaluation of total phenolic content, total flavonoid content, *in vitro* antioxidant activity and *in vitro* antidermatophytic activity of *Rhinacanthus nasutus* (Aniththa) grown in Sri Lanka.**

Hettihewa S.K.<sup>1\*</sup>, De Silva M.N.M<sup>1</sup> and Wijayaratne W.M.D.G.B<sup>2</sup>

<sup>1</sup>Pharmacy programme, Faculty of Medicine, University of Ruhuna

<sup>2</sup>Department of Microbiology, Faculty of Medicine, University of Ruhuna.

*Rhinacanthus nasutus* is highly used in Sri Lankan traditional medicine especially for kitibha (psoriasis). Recent studies have shown that the different parts of this plant exhibit various biological activities. Therefore, it is a great interest in evaluation of the chemical composition and biological activities of *Rhinacanthus nasutus* plant. In this study, two different solvent extracts namely, 80% aqueous acetone and 80% aqueous ethanol were obtained and subjected for phytochemical screening tests. Total phenolic, total flavonoid contents as well as antioxidant activity of the four extracts were assessed spectrometrically by using Folin-Ciocalteu method (FC), Aluminium chloride colorimetric method and, 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay respectively. The *in vitro* anti dermatophytic activity of all extracts was evaluated by using two methods based on minimum inhibitory concentration (MIC) determination by a serial agar dilution technique and inhibitory zone determination by Disc diffusion assay.

The results of the preliminary phytochemical screening tests revealed the presence of phenolic compounds, flavonoids, alkaloids, proteins, tannins and carbohydrates in all plant extracts. Saponins were present in the extracts of 80% aqueous ethanol obtained from fresh leaves and 80% aqueous ethanol obtained from dry leaves. Among the extracts employed, 80% ethanol fresh leaf extract resulted the promising values of total phenolic (2181.36±130 mg gallic acid equivalent (GAE) / 100 g DW), total flavonoid (1248.42±120 mg catechin equivalent (CAE)/ 100 g DW), and antioxidant activity (5.64±0.21 mM Trolox equivalent (TE)/ 100 g DW) respectively. *In vitro* antidermatophytic activity determined using disc diffusion assay of 80% acetone fresh leaf extract showed the highest activity (10.67±1.2 mm for 1000 µg/disc) against *Trichophyton rubrum* while 80% ethanol dry leaf extract showed the highest activity (10±2.1 mm for 1000 µg/disc) against *Trichophyton mentagrophyte*. Further 80% ethanol dry leaf extract revealed the promising activity by using serial agar dilution technique against both *Trichophyton rubrum* and *Trichophyton mentagrophyte* microorganisms.

It is concluded that the extracts of aniththa leaves showed potential antioxidant activity and antidermatophytic activity against *Trichophyton rubrum* and *Trichophyton mentagrophyte*. Further investigations should be carried out to use as natural source of antioxidant and as antifungal agent for treating skin diseases.

**Keywords:** Antidermatophytic activity, Antioxidant activity, Phenolic profile, *Rhinacanthus nasutus*

\*Corresponding Author: krishanthi2001@yahoo.com



## **Micro-climatic gradients across an isolated rainforest remnant bordered by different landuse types in the Knuckles range, Sri Lanka**

Sripal D.D.N.<sup>1\*</sup>, Gunatilleke I.A.U.N.<sup>2</sup>, Gunaratne A.M.T.A.<sup>2</sup> and  
Madawala H.M.S.P.<sup>2</sup>

<sup>1</sup>*Postgraduate Institute of Science, University of Peradeniya, Sri Lanka*

<sup>2</sup>*Department of Botany, Faculty of Science, University of Peradeniya, Sri Lanka*

Forest degradation is a serious problem especially in developing countries. Once continuous tracts of forests are fragmented, the forest interior exposes to external climatic conditions resulting microclimatic gradients across edges those can affect on the ecological processes there. The study investigated the presence of microclimatic gradients in a forest remnant bordered by different landuse types to find the effects of those landuse types on edge habitats. Moraella forest, lowland rainforest remnant in the foothills of the Knuckles Range, is bordered by different landuse types *viz.*, *Pinus*, grasslands, tea and scrublands. Linear quadrats laid parallel to the forest-landuse edge (FLE) at different distances from the FLE (0, 10 and 30 m towards the forest interior and 10, 30 and 50 m towards the bordering landuse) were used in the study. Soil temperature (ST, °C), photosynthetic active radiation (PAR,  $\mu\text{mol s}^{-1} \text{m}^{-2}$ ), air temperature (AT, °C), relative air humidity (RH, %) and soil moisture content (SM, %) were taken using a LI-COR 1400 data logger to represent dry and a wet seasons. The data were analyzed using Generalized Linear Model with pair-wise ranking in Minitab 17. Results showed different microclimatic gradients exist across edges bordered by different landuse types with few exceptions. PAR showed a decreasing gradient towards the forest interior (FI) especially during the dry season, with open grassland having the highest PAR values. In contrast, AT and RH showed increasing trends towards for FI during wet and dry seasons, respectively. All parameters tested showed marked seasonal variations except SM. Results also demonstrated more fluctuations in the bordering landuse types, with less fluctuation within the FI. The findings of the present study collectively paved the way to conclude that the fragmentation and bordering landuse types can create different microclimatic gradients across forest edges with potential influences on the edge effect and other processes.

**Keywords:** *Forest-landuse edge, Moraella forest, microclimate, landuse types*

\*Corresponding Author: dnsripal@gmail.com



## Co-Relational Analysis of Webometric Measurements in Sri Lankan University Library Websites

Ramanayaka, KH<sup>a\*</sup>, Xianqiao Chen<sup>b</sup>, Bing Shi<sup>c</sup>

*<sup>a,b,c</sup>The School of Computer Science & Technology, Wuhan University of Technology,  
Wuhan, China*

Active presence of university libraries on the internet is becoming a hallmark of libraries commitment to facilitate the community to access the knowledge repositories of universities from around the world. Nowadays the university library websites in Sri Lanka play an important role in dissemination of information of the university and library resources. For insightful planning towards a strong internet based information delivery and communication, there is a need for continuous monitoring of library websites status. Built on this need, this paper provides a ranking of university library websites in Sri Lanka based on standard webometric methods. Webometrics methods measure the overall web presence of websites using various indicators.

The results showed that the library website in the Open University of Sri Lanka ranked 1<sup>st</sup> in WISER index while it ranked 6<sup>th</sup> according to visibility rank. University of Colombo library website came in 2<sup>nd</sup> place in WISER index while it ranked in 3<sup>rd</sup> position in scholar rank and richness rank. On the other hand, University of the Visual & Performing Arts library website was the 9<sup>th</sup> place in WISER index while it ranked in 4<sup>th</sup> position in scholar rank. According to the WIF index, library website in University of Moratuwa ranked 1<sup>st</sup> while it ranked 4<sup>th</sup> in WISER index. University of Sri Jayawardenepura library website came 2<sup>nd</sup> in WIF index while it ranked 7<sup>th</sup> according to WISER ranking. The correlation between WISER and WIF (inlinks) is having negative value i.e. -0.01744, which means that the relation between two ranking systems was inversely related. This says that there was no much association or closeness between WISER and WIF (inlinks). Furthermore, there has more significant correlation between WISER and size than between WISER and richness and scholars. Also there has positive relationship between external backlink and WIF (inlinks) which implied that there is much association or closeness between these two variables.

This ranking indicates the extent to which each university library website has successfully represented itself on the internet. The findings of the study will guide to the librarians to evaluate the strength of online presence of their library websites and plan to improve their status on the web. In general, the successful presence of these library websites on the web can be attributed to possessing appropriate number of web pages that influence their visibility through search engines, and thereby the number of received external links. Meanwhile, low richness of most library websites leaves room for them to improve their overall rank by sharing more rich files on the web.

**Keywords:** *Ranking, university library, webometrics, WIF, WISER*

\*Corresponding Author: kramanayaka@gmail.com

## Improving the accuracy of k-means algorithm using genetic algorithm

Fernando W. T. R.<sup>1\*</sup>, Wijeweera K. R.<sup>2</sup>, Dasanayaka D. M. N. K.<sup>2</sup>

<sup>1</sup>*School of Electrical Engineering and Computer Science, Queensland University of Technology, Australia,*

<sup>2</sup>*Department of Computer Science, University of Ruhuna, Matara, Sri Lanka*

Clustering data, by recognizing a subset of representative examples, is used for processing sensory signals and detecting patterns in data. K-means is the simplest clustering algorithm used in data clustering for such purposes. In K-means approach, the number of expected clusters and their initial centroids should be provided as inputs. However the accuracy of convergence of the initial centroids towards the actual centroids depends on the level of approximation of the initial centroids provided as inputs. Inappropriate initial centroids can cause the algorithm to get stuck in a local optimum rather than converging to the global optimum. This work proposes a method to overcome this problem by approximating the initial centroids using genetic algorithm. In the proposed approach a randomly generated set of centroids are arranged as a chain (chromosome). A collection of such chromosomes form the initial population for the genetic algorithm. This population is evolved using a proposed fitness function. The final centroids were observed by changing the percentages of selection, recombination, and mutation amounts. It was observed that the proposed approach yielded optimal results under recombination between 45% - 65%, mutation between 10% - 14%, and number of iterations in between 20-30. The available approaches for improving the accuracy of k-means algorithm using genetic algorithm have limitations such as number of clusters or the dimensions in data sets that can be used with them. The proposed algorithm can be applied to data sets with any number of clusters and can be extended to any dimension.

**Keywords:** *Data Mining, Clustering Algorithms, Genetic Algorithms, K-means Algorithm, Computational Cost*

\*Corresponding Author: [krw19870829@gmail.com](mailto:krw19870829@gmail.com)

## Geometric Brownian Motion Based Hybrid Approach for the Analysis High volatile Financial Time Series

Kapila Tharanga Rathnayaka R.M.<sup>1</sup>, Seneviratna D.M.K.N<sup>2</sup> and Jianguo W.<sup>3</sup>

<sup>1</sup>*Faculty of Applied Sciences, Sabaragamuwa University of Sri Lanka, Belihuloya, Sri Lanka.* <sup>2</sup>*Faculty of Engineering, University of Ruhuna, Galle, Sri Lanka.*

<sup>3</sup>*School of Economics, Wuhan University of Technology, China*

Data forecasting and analysing is a process which can be used for making future predictions. Miscellaneous type of forecasting methodologies can be seen in the literature. Generally, these traditional approaches have been referring to use formal statistical methods for employing time series data under the stationary and normality assumptions. However, most of these traditional approaches have been shown the poor realistic under the high volatility with non-stationary conditions.

The main purpose of this study is to take an attempt to understand the behavioral patterns and seek to develop a new hybrid forecasting approach for forecasting financial data under the high volatile fluctuations. The results are implemented on Colombo stock exchange (CSE), Sri Lanka over the six year period from June 2009 to November 2015.

The methodology of this study is running under the three main phases as follows. In the first phase, stock market validations are identified using the traditional time series approach namely autoregressive integrated moving average (ARIMA). In the second part, volatility patterns are identified using Geometric Brownian Motion (GBM) algorithms. In the last stage, Artificial Neural Network and GBM based proposed ANN-GBM hybrid approach was applied to predict the results.

According to the error analysis results, new proposed ARIMA-GBM is highly accurate (less than 10%) with lowest RMSE error values. Furthermore, the RMSE reveal that ( $RMSE[ARIMA] > RMSE[GBM] > RMSE[ANN\_ARIMA] > RMSE[ANN\_GBM]$ ), new proposed ANN-GBM model is more significant and gives best solution for predicting short term predictions in high volatility fluctuations than traditional forecasting approaches.

**Keywords:** ARIMA, ANN, ARIMA-ANN, CSE and Volatility

\*Corresponding Author: kapilar@appsc.sab.ac.lk

## **Modeling seasonal Leptospirosis cases in Western province of Sri Lanka**

Gnanapragasam S.R.

*Department of Mathematics and Computer Science, The Open University of Sri Lanka*

Leptospirosis is a zoonotic infectious disease in the world. It is growing as a major public health threat in Sri Lanka. The records in Sri Lanka show that, over 2400 cases were reported only in first six months in 2016. Further, it reveals that, nearly 30% of total cases were reported from Western province. Therefore the objective of this study is to model leptospirosis cases in Western province of Sri Lanka using time series analysis.

Standard tests were carried out to develop autoregressive integrated moving average (ARIMA) models. Augmented Dickey- Fuller, Kruskal- Wallis tests were used in addition to autocorrelation and partial autocorrelation functions to test stationary of the data. Anderson- Darling test, Lagrange's Multiplier test, Durbin-Watson statistic and White's general test were employed to verify the diagnostic checking for tentatively fitted models. To select the best model, coefficient of determination, Akaike information criterion and Schwartz's Bayesian criterion were applied. Mean absolute percentage error was used to measure the accuracy of forecasting.

The results show that, Western province (28.92%) is the mostly affected part of the island by leptospirosis. Moreover, Gampaha (11.13%), Kalutara (9.63%) and Colombo (8.16%) districts in Western province are ranked among first 6 districts of Sri Lanka based on number of cases recorded. The accuracy of the fitted seasonal ARIMA(1, 0, 0)(0, 1, 1)<sub>12</sub> model is over 91%. Therefore, it can be used to forecast future leptospirosis cases in Western province. Hence, the expected cases for last six months in 2016 are 707.

**Key words:** *Leptospirosis, Seasonal ARIMA, Western province*

\*Corresponding Author: srgna@ou.ac.lk

## **A Mobile-based Application for Making Timely Decisions using Participatory Sensing: A Case Study from Sri Lankan Agriculture**

R.S.I. Wilson<sup>1\*</sup>, A.I. Walisadeera<sup>2</sup>

*<sup>1\*</sup>Uva Wellassa University, Badulla, Sri Lanka. <sup>2</sup>University of Ruhuna, Matara, Sri Lanka.*

In Sri Lanka, agriculture sector performs as a major economic force that making a significant contribution to the national economy and employment. However, the lack of strong information flow in the agriculture system makes complicated issues that lead to overflow or underflow of agriculture productivity. Current literature shows that a proper information flow can be created using mobile technologies. Last few years, the mobile technology penetration has shown significant improvement in farmer community that has verified through the several studies by holding successful field visits. Most of the mobile-based applications in agriculture make strong information environment for farmers as well as agriculture authorities. In these systems, most of agriculture officers and authorities are the responsible persons to maintain the agricultural information and they are not collecting sensory information regularly related to the farm. The sensory information is important to make correct decisions through the farming life cycle. The smartphone is a magic device that has facilities to capture the sensory information such as time, location, images, voices and that can be used to form a body of knowledge. We already developed a mobile-based application for Sri Lankan farmers to help their farming activities. The information provided by this application is based the ontological knowledge base in agriculture that we already created. This study analyzes how Participatory Sensing Concept can be applied to this mobile application to make further actionable information that will assist for farmers for successful decision making. Participatory Sensing concept was explored to gather the sensory information from the farmers. Emoticon of the mobile-based application is one of the ways to gather information from farmers with their feelings. Texts, images, voices, and videos can be gathered as a meta-information tag related for the moment/event. Those metadata can be shared and used to make further actionable information that will assist for farmers and agriculture authorities for successful decision making. In this paper, the architecture of the mobile system is proposed by analyzing the information flow with the Participatory Sensing concept. Since this is ongoing research, the implementation is only carried out for Disease Management Stage. Emoji icons are defined to identify the different levels of the expressions of the farmers and those are linked with other related information of farmers' queries. The information flow of the system is enhanced by plugging the existing knowledge base. By analyzing the farmers' inputs further actionable information can be predicted and thus can make decisions timely manner. Since farmer is the dominant party, this study identified the farmers' participation is important to make effective information flow in agriculture system and addressing these issues will help to maintain stable productivity and economy in agriculture system in Sri Lanka.

**Keywords:** *Actionable Information, Mobile-based Information System, Participatory Sensing*

\*Corresponding Author: shyama.irangani@gmail.com

## **A method for measuring students' power skills automatically**

JRKC Jayakody\*

*<sup>1</sup>Department of Computing and Information Systems, Wayamba University of Sri Lanka*

The academic performance of the university students is measured with the help of the Grade Point Average (GPA). Further, the marks of a subject of a degree program are accumulated to identify the final academic performance of the degree. Unfortunately, the achievements of special power skills such as knowledge levels, evaluation skills and application development skills are not highlighted in the current GPA. Therefore, this research was mainly designed focusing on measuring students' power skills automatically which reflect specific performances of the students. Cognitive levels of the Blooms taxonomy are identified as the categories of power skills. Knowledge, comprehension, application, analysis, synthesis and evaluation are the main cognitive skill levels of the Blooms taxonomy. Typically, summative and formative assessments are held to cover the Intended Learning Outcome (ILO) of the subject. The questions of the final exam papers of the Computer Science stream of the Wayamba University were used as the dataset. First, a preliminary research was conducted to categorize exam questions automatically. Natural Language Processing (NLP) techniques such as tagging, spell correction, lemmatization, parse tree generation and semantic similarity analysis techniques were used to derive the features for summative assessments classification. Based on the extracted features, rule set was identified to categorize the questions automatically. Once the questions were categorized, the portion of the marks allocated for each Blooms taxonomy performance level was identified. Based on the assigned marks for each category, students' achievements for each category were calculated separately to measure the power skills levels of students. This identification would immensely be helpful to academics and universities to develop the best graduates with high power skills.

**Key words:** *Blooms taxonomy, Natural Language Processing, Power skills*

\*Corresponding Author: kithsirij@wyb.ac.lk

## **Low cost, highly efficient TiO<sub>2</sub> based Electrochromic device for architectural application**

H.N.M.Sarangika<sup>1\*</sup>, G.K.R. Senadeera<sup>2,4</sup>, M.A.K.L.Dissanayake<sup>2,3</sup>,  
W.G.M.D.Karunaratna<sup>1</sup> and M.G.A.N. Perera<sup>1</sup>

<sup>1</sup>*Department of Physical Sciences and Technology, Sabaragamuwa University of Sri Lanka*

<sup>2</sup>*Institute of Fundamental Studies, Hantana Road Kandy, Sri Lanka*

<sup>3</sup>*Postgraduate Institute of Science, University of Peradeniya, Sri Lanka*

<sup>4</sup>*Department of Physics, The Open University of Sri Lanka, Nawala, Nugegoda, Sri Lanka*

Nowadays global warming has become a copiously discussed issue, the need of energy efficient solutions increasingly attracts attention of architectural windows. The reduction of heating and cooling energy consumption in the building construction sector for instance is of an economic and environmental concern. Electrochromic devices are opto-electrochemical systems that change their optical properties, mainly their transmittance, when a voltage is applied to them. This interesting behavior leads to many applications, such as windows, sunroofs, architectural windows, displays and other electro-optical devices. Therefore, in this study we have explored the possibility of replacing expensive WO<sub>3</sub> and CeO<sub>2</sub> using low cost transparent nano-crystalline titanium dioxide (TiO<sub>2</sub>) as the electrochromic material and a FTO glass substrate as the counter electrode in electrochromic devices (ECD). Electrochromic TiO<sub>2</sub>anatase thin films (film thickness ~ 6.49μm) on F-doped tin oxide (FTO) substrates were prepared by doctorblade method using a colloidal solution of titanium dioxide with particles of 15 nm in size. EC devices with the configuration FTO glass/TiO<sub>2</sub>/Poly ethylene oxide-LiCl electrolyte /FTO glass were fabricated and tested their electrochromic properties. A reversible colour change between dark blue and colourless state was observed when an appropriate potential was applied repeatedly to the device. The device changes its transmission between 64% (bleached state) and 0.08% (colored state) at the wavelength of 600 nm. The optical density of the device was 2.89 and the response time of the EC device for coloration process was 30 s for a 1.5 x 2.1 cm<sup>2</sup> sample.

*Key words: Titanium dioxide, Electrochromics, Optical density*

\*Corresponding Author: sarangikah@gmail.com



## **Poly (vinylidene fluoride-hexafluoropropylene) and fumed silica based nano-composite electrolyte for efficient dye sensitized solar cells**

Weerasinghe A.M.J.S.<sup>1,3\*</sup>, Dissanayake M.A.K.L.<sup>1</sup>, Senadeera G.K.R.<sup>1,2</sup>,  
Thotawattage C.A.<sup>1,3</sup>, Kumari J.M.K.W.<sup>1,3</sup>

<sup>1</sup>*National Institute of Fundamental Studies, Hanthana Road, Kandy, Sri Lanka.*

<sup>2</sup>*Department of Physics, The Open University of Sri Lanka, Nawala, Nugegoda, Sri Lanka*

<sup>3</sup>*Postgraduate Institute of Science, University of Peradeniya, Sri Lanka*

Dye sensitized solar cells (DSSC) are considered as most promising molecular photovoltaics and cheaper alternative to the conventional silicon based solar cells due to lower fabrication cost and abundance of materials. However, liquid electrolytes employed in most of the DSSC have several disadvantages such as lack of long term stability due to liquid leakage, electrode corrosion and photo decomposition of the medium. Quasi solid state (gel) electrolytes based on various polymers and gelators, can be used to overcome these drawbacks. In this study, it was used a gel electrolyte consisting of ethylene carbonate (EC), propylene carbonate (PC), poly (vinylidene fluoride-hexafluoropropylene) (PVdF-HFP) nanofiber, fumed silica, potassium iodide (KI), tetra propyl ammonium iodide (Pr<sub>4</sub>NI), PMII ionic liquid, and 4-tert-Butylpyridine (TBP) in DSSCs. Nano fiber and fumed silica provide the structural stability for the gel electrolyte which entraps the liquid electrolyte and provides a higher efficiency in DSSCs compared to the conventional gel electrolyte based DSSCs. A short circuit photocurrent density of 13.8 mA cm<sup>-2</sup>, an open circuit voltage of 699.2 mV, a fill factor of 66.9%, and an overall efficiency of 6.46% were observed under simulated sunlight of 100 mW cm<sup>-2</sup> on a fabricated dye sensitized solar cell in configuration of FTO/TiO<sub>2</sub> electrode/ Ruthenium dye (N719)/ PVdF-HFP and fumed silica nanocomposite electrolyte/ Pt/ FTO.

**Keywords:** *Dye Sensitized Solar cells, Nano composite electrolytes*

\*Corresponding Author: janith@ifs.ac.lk



## **Augmented reality for teaching object oriented programming concepts**

Surendra R.M.D.B.

*E-Library, Faculty of Allied Health Sciences, University of Peradeniya*

Object oriented programming is vital concept in modern computer programming. Teaching, learning and practical implementation of OOP concepts found to be challenge due to its complexity. To demonstrate complexity the definition of Encapsulation i.e. “Encapsulation is a process of wrapping code and data together into a single unit” can be considered. Objective of this study is to suggest to utilize augmented reality concept for teach object oriented programming concepts based on previous work done related to education field and augmented reality such as use of *augmented reality to teach earth sun relationship, augmented reality to teach how to find area of triangle* and other in fields related to education. Based on the study it is found that lack of researches done, lack of awareness, need of specially designed devices and software and financial issues as constraints to use of augmented reality in education field. Accordingly, it is suggested to utilize specially designed mobile devices based on augmented reality to describe OOP concepts while deliver lectures to make teaching and learning process optimal. Hence, this study can be used as starting point to carry-out research to improve such technologies for teaching OOP concepts in more state of art manner.

**Keywords:** *Augmented Reality, Object oriented programming, Encapsulation.*

\*Corresponding Author: [rmdbsurendra@yahoo.com](mailto:rmdbsurendra@yahoo.com)

## **Influence of cation concentration in the electrolyte on photovoltaic performance of dye sensitized solar cells**

J.M.K.W. Kumari<sup>1,2\*</sup>, M.A.K.L. Dissanayake<sup>1,2</sup>, G.K.R. Senadeera<sup>1,2,3</sup>,  
C.A. Thotawatthage<sup>1,2</sup> and A.M.J.S. Weerasinghe

<sup>1</sup>*National Institute of Fundamental Studies, Kandy, Sri Lanka*

<sup>2</sup>*Postgraduate Institute of Science, University of Peradeniya, Peradeniya, Sri Lanka*

<sup>3</sup>*Department of Physics, The Open University of Sri Lanka, Nawala, Nugegoda, Sri Lanka*

The influence of different concentrations of cations on the photovoltaic characteristics of dye sensitized solar cells (DSSCs) have been investigated. Potassium iodide (KI) with a small size cation and tetrapropylammonium iodide (Pr<sub>4</sub>NI) with a bulky cation have been used to prepare liquid electrolytes to be used in DSSCs with  $I^-/I_2$  (iodine/iodide) redox couple. The cation concentration in the liquid electrolyte was varied by preparing a series of electrolytes with different salt concentrations and the efficiency of DSSCs was optimized. The DSSC configuration used was FTO glass/TiO<sub>2</sub>/Ru N719 dye/liquid electrolyte/Pt electrode. The DSSCs fabricated with electrolyte having smaller K<sup>+</sup> cations showed the optimized efficiency of 7.09 % with short circuit current density ( $J_{sc}$ ) and open circuit voltage ( $V_{oc}$ ) as 16.05 mA cm<sup>-2</sup> and 688.2 mV, respectively at a KI salt concentration of 0.57 mol dm<sup>-3</sup>. DSSCs fabricated with electrolyte having larger Pr<sub>4</sub>N<sup>+</sup> cations showed the optimized efficiency of 6.89 % with  $J_{sc}$  as 14.44 mA cm<sup>-2</sup> and  $V_{oc}$ , 743.0 mV, at a Pr<sub>4</sub>NI salt concentration of 0.57 mol dm<sup>-3</sup>. These photovoltaic characteristic results indicate that the selection of the type of cations and their concentration in liquid electrolytes affects the electron injection dynamics and the charge transfer processes. Therefore, the results show that the choice of the size and the concentration of cations play an important role in determining the photovoltaic characteristics, and ultimately the overall performance of the DSSCs.

**Keywords:** *Dye Sensitized Solar cells, electrolyte, cation concentration,*

\*Corresponding Author: kalpiwawana@gmail.com

## **Analysis of the Seasonal Influenza Model in Actuarial Point of View**

Perera S.S.N.\*

*Research & Development Centre for Mathematical Modeling, Faculty of Science,  
University of Colombo, Colombo 03, Sri Lanka*

Investigating the economic burden of the seasonal influenza is highly essential due to the large number of outbreaks in recent years. In this study, we only consider expenditure due to medical care. Classical SIS (susceptible, infected, susceptible) model is used to capture the dynamics of spread of influenza. Considering the potentiality of the movement from susceptible class to infected class and infected class to susceptible class, the dynamics model is constructed. Including insurance based computation and actuarial techniques average economic burden is computed by considering unit future medical care expenditure. Simulation is carried out to demonstrate the variation of the present economic burden with respect to contact rate. Seasonal variation can be captured via contact rate and the proposed model provides theoretical background to investigate the economic burden of seasonal influenza.

**Keywords:** *Mathematical Model, Expected Value, Equivalence Principle, Actuarial Valuation*

\*Corresponding Author: [ssnp@maths.cmb.ac.lk](mailto:ssnp@maths.cmb.ac.lk)

## **An investigation on classical and quantum information entropies and diversity measures**

N. Yapage\*

*Department of Mathematics, University of Ruhuna, Wellamadama, Matara, Sri Lanka.*

We present a possible unification of diversity measures/indices based on information entropies in the classical world and suggest an extension to the quantum world. Motivation came from the new emerging field of quantum biology. Renyi entropy and Tsallis entropy in non-extensive statistical mechanics are two major generalized entropies parameterized by one real parameter. It can be shown that in the limiting case when the parameters approach one we obtain Shannon entropy in classical information theory. The same function is used to measure the diversity in different physical systems and it is known as the Shannon index. Motivated by this, we introduced several entropy-like functions corresponding to different values of the parameters and investigated their properties as diversity indices. Further, following the same path, we investigated the possibility of using Tsallis entropy as a good candidate for measuring diversity. Moreover, we try to find corresponding quantum versions using the Renyi and Tsallis quantum entropies. Finally, we are of the view that measures of diversities in quantum biology also will be applied to many other situations.

**Keywords:** *Information entropies, diversity measures/indices, Shannon index, quantum biology*

\*Corresponding Author: [nihal@maths.ruh.ac.lk](mailto:nihal@maths.ruh.ac.lk)

## **Design and implementation of an altazimuth mount drive for a Newtonian telescope coupled to a DSLR camera**

Amaradasa H.D.S.<sup>1</sup>, Abeywickrama S.S.<sup>1</sup>, Ranatunga E.M.<sup>1</sup>, Mahanama G.D.K.<sup>1\*</sup>, Baduge S.<sup>2</sup>, Priyankara J.G.V.<sup>2</sup>, Gunawardhana S.D.<sup>2</sup>

<sup>1</sup>*Department of Physics, University of Ruhuna, Sri Lanka*

<sup>2</sup>*Department of Mechanical & Manufacturing Engineering, University of Ruhuna, Sri Lanka*

A telescope mount is the mechanical structure which supports the optical elements of the telescope. When obtaining images by attaching a camera to the telescope the performance of the telescope mount becomes critical. Altitude-Azimuth (Altazimuth) telescope mount is a design with two rotational axes. Motorized drive system of an Altitude-Azimuth mount requires a mechanical design compatible with the physical and optical parameters of the telescope. Especially when mount is synchronized with earth's rotation, step size of the motors should be less than the camera field of view (FOV). In this research a motor driven mount was designed to accordant with a Digital Single Lens Reflex (DSLR) camera for a 0.25 m F/10 Newtonian telescope. Parameters of the telescope drive design depend on the weight of the mirror, focal length of the objective mirror and the FOV of the camera attached. Torque of the telescope mount around two axes was calculated considering a slew rate of 90° from 30 seconds. Subsequently, the resolution of the motor steps was derived and the FOV of the camera was compared. Final results indicated that the camera FOV is 0.04874527 arc minutes and motor resolution is 0.00117100 arc minutes. It is evident that the motor resolution is substantially less than the camera FOV and therefore the mechanical drive design of the telescope is suitable for the DSLR camera.

**Keywords:** *Altitude-Azimuth mount, Camera field of view, Resolution of the motor steps, Telescope mount*

**Acknowledgment:** *Faculty of Science, UOR (RU/SC/RP/2014/04), QIG W4 HETC project and National Science Foundation (SF/RG/2015/EQ/10) are acknowledged for the financial assistance.*

\*Corresponding Author- mahanama@phy.ruh.ac.lk

## Study on noise exposure of train passengers in Sri Lanka

S.M.N. Sethunga<sup>1,\*</sup>, J.A.P. Bodhika<sup>1</sup>, W.G.D. Dharmaratne<sup>1</sup>

<sup>1</sup>*Department of Physics, University of Ruhuna, Matara, Sri Lanka.*

According to the statistics published, there are more than 300,000 train passengers per day and 90% of them are daily travelers. All of them are exposing to noise generated by running locomotives. The noise level would depend on the location of the compartment, engine type and the running mode of the train. Preliminary results of a study on the noise exposure by passengers in a sample of Sri Lankan trains are presented here. Noise levels were studied inside 15 trains out of which 7 are Class M trains while 8 are Class S trains, each consisting of 8 passenger compartments powered by a single locomotive at the front.

The noise descriptor, A-weighted equivalent noise level,  $L_{Aeq}$ , was measured using a well calibrated B&K type 2250 hand held analyzer. The average value of  $L_{Aeq}$ , in the first compartment of trains, when they were operated under accelerating, constant speed and decelerating modes, were  $89 \pm 1.3$  dB,  $89 \pm 2.0$  dB and  $84 \pm 2.8$  dB for class M trains and  $88 \pm 1.4$  dB,  $87 \pm 1.1$  dB and  $80 \pm 1.6$  dB for class S trains respectively. The noise level decreased from the front to the back of the train, down to  $74 \pm 1.9$  dB and  $75 \pm 1.5$  dB in type S and type M trains respectively at the last compartment. The results show that passengers in the front of the train were exposed to more than 85 dB noise level. The long term ( $> 8$  hours daily) exposure to  $L_{Aeq} > 85$  dB could cause threshold shifts. As such, it would be advisable for daily train passengers to change the compartments frequently and the train operators to undergo audiometric testing periodically. Noise spectrum shows that the train generates higher noise at lower frequencies ( $< 300$  Hz) including infra-sound, however, at high speeds ( $> 60$  km/h) loud noise spikes of more than 100 dB at higher frequency range ( $> 1$  kHz), have been observed.

**Keywords:** Noise Exposure, Class S & M trains,  $L_{Aeq}$ , Train Passengers

**Acknowledgment:** Authors acknowledge the financial assistance provided by the TURIS Project under Grant No: RU/DVC/Pro 61 and Science Faculty Research grant RU/SF/RP/2016/07.

**\*\*Corresponding Author:** nsethunga@gmail.com

## **A preliminary study on behavioral effects of laboratory rats (Albino Wistar) after the sub-chronic noise stress**

J.R.I.A. Jayakody\* and J.A.P. Bodhika

*Department of Physics, University of Ruhuna, Matara, Sri Lanka.*

Humans and animals can hear a wide range of sound frequencies. If the sense of hearing is impaired, both man and animal cannot fare well in their respective environments. Present study is aimed to investigate the behavioral effects following the sub-chronic noise stress of a rat species, Albino Wistar. The sound source consists of a set of speakers, GWINSTEK AFG-2000 series function generator and an amplifier. Sound levels and frequencies were monitored by B&K type 2250 sound level meter. Six adult Albino Wistars were exposed to sound frequencies of 1- 20 kHz, at intervals of 1 kHz at  $L_{Aeq}$  of 70-80 dB for 5 minute periods and their behavior was recorded. A different behavior in rats was observed in frequency range of 7 – 10 kHz. In the second test four adult rats were randomly divided into control and test groups. The test animals were exposed to noise of 7, 8, 9 & 10 kHz for 4 hours daily while keeping the control group in same room for same period of time without exposing to the sound. Locomotive activity, increase of defecation and decrease of social activities, of rats was assessed by open field test (OFT). Anxiety and depressive behavior were monitored by elevated plus maze test (EPM) and tail suspension test (TST). At the beginning of exposure, all rats were huddled in a group and then some were frozen into motionless stance. A less time spent and less number of entries in open arm was noticed in test sample compared to the controls in the EPM test. A tendency to move to open field compared to controls was identified in OFT. The TST revealed that a significant increase in immobility time, which indicates a depression like behavior of noise stressed rats compared to controls. According to the study the most effective noise frequency range for rats is 7 - 10 kHz and which is agreed with the findings of Fizza, N. et al.

**Keywords:** *Albino Wistar, Noise Stress, Behavioral Effects*

**Acknowledgements:** Authors acknowledge the assistance provided by Prof. E.P.S. Chandana, Department of Zoology, University of Ruhuna and the financial assistance provided by Science Faculty Research grant RU/SF/RP/2016/07.

\*Corresponding Author: [ishani.jayakody@gmail.com](mailto:ishani.jayakody@gmail.com)

## **Quality of service factor categorization for restful web services**

Sewwandi M.A.N.D.<sup>1</sup> and Ilayperuma T.S.<sup>2</sup>

<sup>1</sup>*Department of Information and Communication Technology, Faculty of Technology, University of Ruhuna, Matara, Sri Lanka.*

<sup>2</sup>*Department of Computer Science, Faculty of Science, University of Ruhuna, Matara, Sri Lanka.*

Representational State Transfer (REST) is a lightweight architecture for designing networked hypermedia applications. RESTful web services are web services which are based on REST architecture. Quality of Service (QoS) determines utilitarian value and usability of a web service thus influencing the popularity of the service. On one hand, for web service consumer, having an idea about the quality of service is essential as it will enable him to choose the best-suited web service among many services providing the same service. On the other hand, with the widespread proliferation of web services, QoS will enable service providers to distinguish their services from similar services of their competitors thus giving a competitive advantage. Currently, RESTful web services are primarily focusing on the functionality aspect rather than the quality aspect of services. To address this problem, our objective in this study is to evaluate existing QoS standards and to develop a QoS model for describing quality of RESTful web services. Towards this end, we first analyse different quality factors related to SOAP and WSDL based web services. They are then categorized into two dimensions: perspective (business, system) and behaviour (static, dynamic). The most appropriate quality factors for REST architecture are then selected by considering the lightweight characteristics the REST architecture. The proposed quality categorization can be used by web service developers to develop QoS aware web services. Also service consumers can effectively use this categorization in order to select most suitable web services according to their requirements.

**Keywords:** *REST, web services, Quality of Service, quality factors*

\*Corresponding Author: sewwandi@ictec.ruh.ac.lk



## **Towards a framework for evaluating AOSE methodologies from agent and generic software engineering perspectives**

Hewage U.H.W.A.<sup>1</sup>, Ilayperuma T.S.<sup>2</sup>

<sup>1</sup>*Department of information and Communication Technology, Faculty of Technology, University of Ruhuna, Matara, Sri Lanka.*

<sup>2</sup>*Department of Computer Science, Faculty of Science, University of Ruhuna, Matara, Sri Lanka.*

Agent Oriented Software Engineering (AOSE) is a software paradigm which combines artificial intelligence concepts into software engineering domain. The main concept of AOSE is the *Agent*. In AOSE, the agent has specific characteristics such as autonomy, mental mechanism and adaptability. Characteristics of a multi agent-based software system differ from a generic software system because of this specific behavior of agent. Several evaluation frameworks and criteria have been proposed to evaluate characteristics of multi agent systems. These frameworks propose evaluations of agent-oriented system development methodologies based on different categorizations of characteristics related to multi agent systems as well as different characteristics of generic software engineering processes. The focus of this study is to address the problem of developing a framework, to evaluate multi-agent systems development methodologies, that combines both agent-oriented characteristics and generic software engineering characteristics. To address this problem, our objective in this research is to examine some of the existing frameworks for evaluating characteristics of multi agent systems and to propose a more generic framework to describe the characteristics of a multi agent system by considering agent-oriented as well as generic software engineering paradigms. The framework consists of a two-dimensional matrix with twenty eight characteristics. One dimension of the matrix concerns four generic components (model, process, technique and supportive features) related to software development. The other dimension concerns the characteristics of software agents and the generic software engineering characteristics. The proposed framework is evaluated by applying Prometheus and MaSE methodologies, which are considered as prominent and comprehensive AOSE methodologies.

**Keywords:** *AOSE, Evaluation, Agent Aspect, Generic Software Engineering Perspective*

\*Corresponding Author: waruni@ict.ruh.ac.lk

## Noise pollution in Matara city

S.M.N. Sethunga<sup>1\*</sup>, N.H.R Tharuka<sup>2</sup>, J.A.P. Bodhika<sup>1</sup>, W.G.D. Dharmaratna<sup>1</sup>

<sup>1</sup>*Department of Physics, University of Ruhuna, Matara, Sri Lanka.*

<sup>2</sup>*Department of Physical Sciences, Sabaragamuwa University of Sri Lanka*

Noise pollution is one of the major environmental problems in many urban cities in Asian Countries. In Sri Lanka as well, the number of vehicles registered per year has reached 6.33 million by the end of Feb 2016. Present traffic volume in Matara city is almost double than the particular value in October 2012. The increase of number of vehicles directly contributes to raise the city noise. The main objective of this study is to update the existing noise map in Matara city. The area surrounding the commercial area of the city including the roads A2, A24 and B275 was considered in the study. The noise descriptor, A-weighted equivalent noise level,  $L_{Aeq}$ , was measured using B&K Type-2250 hand held analyzer.

Field measurements were logged in to five minutes period ( $L_{Aeq}$ , 300s) continuously at each location and a total of 95 locations were selected covering the area in Matara city.  $L_{Aeq}$  were measured at both sides of the roads from 7.00 am to 6.00 pm in each day for a period of one week in July, 2016 and noise contours in Matara city were produced. Results show that  $L_{Aeq}$  varies from  $58 \pm 5.4$  dB up to  $89 \pm 5.4$  dB within the commercial area of Matara city, which is exceeding the maximum allowed level of 63 dB.  $82 \pm 1.0$  % of the total area of 6.43 km<sup>2</sup> studied, the noise level was greater than 65 dB. The densely populated area  $40 \pm 1.0$  % in the city lies within the noise contours of 65-70 dB. Along the A2 and B275 roads,  $L_{Aeq}$  is more than 80 dB, especially due to high traffic volume. During the last three years in Matara city, noise level has increased by 10% and the noise contours are extended by 20% deeper. The results suggest that necessary regulations have to be imposed to control the noise pollution and to protect the economic value of the city.

Key Words: Noise zone map,  $L_{Aeq}$ , Traffic noise, Matara-Sri Lanka.

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\*Corresponding Author: nsethunga@gmail.com

## **A study about agro forestry practices in wet zonal home gardens in Akuressa Divisional Secretariat in Sri Lanka**

W.M. Gangani Chandralatha

*Department of Geography, University of Ruhuna, Matara, Sri Lanka*

Agroforestry is an intentional practice that integrated agriculture with forestry to manage the environment, enhancing income diversification, energy security and environmental protection and to solve deforestation related issues. Forest cover that was rich earlier in Sri Lanka has been reduced up to 29% and sustainable solutions are needed to manage and conserve vegetation in the country. According to agro ecology in country, 29 agro economic practices can be seen in Sri Lanka. Wet zone in Sri Lanka is specific for a good vegetation cover, especially home gardens. This study was conducted to identify agro forestry practices in wet zone that done by community in their home gardens. Specific objectives were to appraise the traditional involvement of community to grow flora species in their lands, to identify major flora species found in wet zonal home gardens, and to find out potentials and constraints in extending intentional agro forestry into open lands in the area. Akuressa divisional secretariat division in Matara district was selected as the representative area for the wet zone. Literature survey, questionnaires, interviews, and direct observations were used to collect primary data. With the result and discussion, it could be identified that, highlands and paddy lands ownership of community, land size, distance to lands from their houses, home gardens and its cultivations are directly affect the agro forestry practices. The study concluded that, there were five main agro forestry practices as, crops with wind belts and shelter belts, strip planting, intercropping under coconut, tea and coffee under shade trees and slopping agriculture land technology. Home garden is the main part of those practices. Though there are those practices, the community hasn't knowledge the agro forestry or its importance and they use their traditional knowledge and experiences. Therefore the main suggestion of this study is, wet zonal community should be encouraged to improve their various kinds of agro forestry practices further. Traditional knowledge and forestry techniques of that community should be expanded to other areas those where the vegetation cover is under threat.

**Keywords:** *Agro forestry, community, wet zone, gardens,*

\*Corresponding Author: *gangani365@gmail.com*

## Fatty acid composition of seed oils extracted from six underutilized fruits grown in Sri Lanka

Wedamulla, N<sup>1</sup>, Priyadarshana, Y.A<sup>1</sup>. and Madhujith, T.<sup>2\*</sup>

<sup>1</sup>Postgraduate Institute of Science, University of Peradeniya, Sri Lanka

<sup>2</sup>Department of Food Science and Technology, Faculty of Agriculture, University of Peradeniya, Sri Lanka

Although there has been an influx of literature on nutritional value of underutilized fruit crops, the studies on the properties of seed oils of those fruits is scanty. In this backdrop, the objective of the present study was to determine the fatty acid profile of oils obtained from six underutilized fruits found in Sri Lanka: *Annona muricata* [Annonaceae, Soursop (S)], *Annona squamosa* [Annonaceae, Sugar Apple (SA)], *Annona reticulata* [Annonaceae, Custard Apple (C)], *Flacourtia indica* [Salicaceae, Uguressa (U)], *Pouteria campechiana* [Sapotaceae, Kaha Lulu (L)] and *Durio zibethinus* [Malvaceae, Durian (D)]. Seeds of all the fruits were air-dried and powdered. Oil was extracted into hexane separately and the mixtures were desolventized in vacuo. The fatty acid methyl esters were analyzed using gas liquid chromatography (GLC) and the quantity of each fatty acid was determined. All the seed oils contained palmitic (SA: 12.91%; S: 19.07%; C: 17.30%; U: 19.75%; D: 6.75%; L: 8.80% ), stearic (SA: 31.85%; S: 44.21%; C: 41.21%; U: 8.17%; D: 11.57%; L: 55.36% ) and oleic acids (SA: 23.27%; S: 33.27%; C: 40.30%; U: 30.82%; D: 12.11%; L: 23.24% ) with high concentrations and linoleic acid with comparatively low concentration. Lulu seed oil contained low amount of caprylic, capric, lauric and myristic acid. Uguressa (24.22%) and Durian (7.50%) seed oils contained essential fatty acid -linolenic, thus can be used as a potential nutrient source. The dominant fatty acids, however, are palmitic, oleic and stearic acids. The findings of the present study can be utilized to increase the demand of underutilized fruit crops.

**Keywords:** Fatty acid composition, GC, *Flacourtia indica*, *Durio zibethinus*, *Annona spp*

\*Corresponding Author: madhujith@yahoo.com

## **Labour use pattern and cost of production in Soybean cultivation in Anuradhapura District/ Sri Lanka**

A.V. Dhanapala and T.Kirupananthan\*

*Department of Agricultural Economics, Eastern University of Sri Lanka, Sri Lanka*

There is a space for substitution of hired labour by family or any social farming network in small scale soybean cultivation to ensure the profitability. Therefore, this study analyzed the effect of hired labour with the other costs of ploughing, seed, fertilizer, pesticide and harvesting by multiple regression analysis. The difference in profit between the two situations, used and not used the hired labour, was also tested by paired t-test. Eighty-one respondents selected from 5 divisional secretariat divisions of Thalawa, Thambuththegama, Nochchiyagama, Glenbidunuwewa and Mihinthale in Anuradhapura district of Sri Lanka by simple random sampling was used in this study. Hired labour use by respondents for different practices were as follows: ploughing (42.9%), pesticide application (29.9%), fertilizer application (19.5%), and harvesting (100%). Total cost  $\text{ac}^{-1}$  was found to be Rs. 48430.00. The mean hired labour cost found to be Rs. 19935.06  $\text{ac}^{-1}$  with the minimum and maximum of Rs. 5000 and 28000  $\text{ac}^{-1}$  respectively. Seed and transport were positively ( $p \leq 0.05$ ) affecting the income. Fertilizer and pesticide showed negative effect ( $p \leq 0.05$ ). A significant ( $p < 0.05$ ) difference was observed between the mean values of profit with and without hired labour. The profit with labour cost was Rs. 169440.26 and without labour cost was Rs. 189375.32  $\text{ac}^{-1}$ . Soybean cultivation is a profitable enterprise. In the studied sample, hired labour cost has no significant ( $p \leq 0.05$ ) impact on income while it makes significant difference in profit of soybean cultivation. Hired labour cost could be utilized to purchase processing machineries for soybean based agribusinesses.

**Keywords:** *Cost of production, family labour, hired labour*

\*Corresponding Author: freebirdever04@yahoo.com

## **A preliminary survey of odonates at selected sites in “Kirala Kele” sanctuary, Matara, Sri Lanka**

Kalpani, P.G.M., Dharmasiri, T.S.K., Amarasinghe, N.J.de S. and Chandana, E.P.S\*

*Department of Zoology, University of Ruhuna, Matara, Sri Lanka.*

“Kirala Kele” sanctuary is an important wetland habitat located in Matara Township in southern Sri Lanka. Present study reports diversity of dragonflies and damselflies (Order - Odonata) in “KiralaKele” sanctuary as they are useful indicators of ecosystem health. The study was conducted in weekly basis from September to December 2015 along the belts of selected four sites in “Kirala Kele” area. Each site comprises of one or more shallow water streams in the area. Odonates were collected using standard methods and identified using taxonomic and pictorial keys. Physicochemical parameters of water bodies adjacent to the study sites were also measured. Altogether 15 species of Odonates (seven Anisopterans and eight Zygopterans) were recorded during the study period with higher Odonate species diversity at site three (Shannon’s Diversity Index-1.2660). Pied parasols (*Neurothemis tullia*), Green skimmers (*Orthetrums abinas abina*), Painted wxtails (*Ceriagrion cerino rubellum*), Asian groundlings (*Brachythemis contaminata*) and Blue sprites (*Pseudagrion microcephalum*) were reported in all study sites. Endangered species namely White backed wisp (*Agriocnemis femina femina*), Aggressive river hawk (*Oncychothemis tokinensis*, Sinuate clubtail (*Burmagomphus pyramidalis sinuatus*) were found only at site three. Swarm of Variegated flutterer (*Rhyothemis variegata variegata*) was reported at site two and three only closer to water bodies where *Nelumbo* plants were dominated. Physicochemical parameters were not significantly different in the water bodies associated with study sites except the depth of water bodies (ANOVA:  $F=3.2$ ,  $p<0.05$ ) indicating a little influence on the occurrence of Odonate species at each study site. These findings would be important for further studies on the Odonate ecology and might be beneficial to increase the interest on Odonate ecology and probably to a greater extent, in the conservation and management of “Kirala Kele” ecosystem.

**Keywords:** “KiralaKele” sanctuary, Odonate diversity, Variegated flutterer

\*Corresponding author: epschandana@zoo.ruh.ac.lk

## Floral and Faunal diversity in selected Seagrass beds in the Southern Sri Lanka

P .R. S. A. Abeyrathna<sup>1</sup>, P. B.T. P. Kumara<sup>1</sup>, R. D. A. Gunasekara<sup>2</sup> and T. G Dayananda<sup>2</sup>

<sup>1</sup>*Department of Oceanography, Faculty of Fisheries, Marine Science Technology, University of Ruhuna, Sri Lanka*

<sup>2</sup>*Department of Botany, Faculty of Science, University of Ruhuna, Sri Lanka*

Seagrasses are specialized marine angiosperms, adapted to the near shore habitats. Their physical structure and associations with other flora provide diverse and complex habitats for other associated organisms including fauna and flora. Since there is a dearth of information on macro flora and fauna on seagrass beds, the present study was carried out to investigate the diversity of flora and fauna in selected seagrass beds in four study sites: Dondra, Dickwella, Ahangama and Hikkaduwa in the southern coast of Sri Lanka.

Line intersect method and visual sense methods were used to collect data from the four study sites, and the availability, coverage, density, diversity, evenness and dominance of the species were recorded and the data were analyzed using Minitab 17. Four seagrass species: *Thalassia hemprichii*, *Halodule uninervis*, *Syringodium isoetifolium*, *Cymodocea rotundata* were recorded from the sites. Coverage of *Thalassia hemprichii* in Dondra (P0.000) and *Halodule uninervis* in Dickwella were significantly higher ( $p=0.002$ ), than other three sites. The highest seagrass diversity was recorded in Ahangama where epiphyte coverage also significantly higher (P0.000). Twenty two seaweed species thirty eight invertebrate and twenty four vertebrate species were recorded. Throughout the study the highest seaweed coverage (20.427%) was recorded in Dondra and highest seaweed diversity was recorded in Ahangama (1.7) while the highest invertebrate density and diversity were recorded respectively in Hikkaduwa (1.905 ind/m<sup>2</sup>) and Dondra (2.60). Also the highest vertebrate density and diversity were recorded in Dondra (0.5 ind/m<sup>2</sup>) and Hikkaduwa (1.90).

The highest diversity of flora and fauna were recorded from the seagrass bed in Ahangama. Therefore, application of conservation measures and further research are highly recommended.

**Keywords:** Diversity, Epiphytes, Seagrass, Seaweed

\*Corresponding Author: [achestas@gmail.com](mailto:achestas@gmail.com)



## **Comparison of mosquito repellent activity of citric acid treated and untreated samples of the oil of *Eucalyptus citriodora***

M.C.N.M.Marasinghe<sup>1</sup>, B.G.K. Perera<sup>1,\*</sup> and D.T.U. Abeytunga<sup>1</sup>

<sup>1</sup>*Department of Chemistry, University of Colombo, Colombo 3, Sri Lanka.*

Prevention of insect bites is the first line of defense against Insect borne diseases such as malaria, dengue, and filariasis and use of insect repellents is the most common approach among them. *Eucalyptus citriodora* is an effective plant based insect repellent that is proven to exert minimal risk to environment, wildlife and humans. The oil contains a mixture of monoterpenes out of which citronellal is the major component (84%). Moreover, it has been reported that nerol, limonene and *para*-menthane-3,8-diol in oil of eucalyptus exhibit mosquito repellent activity. Attempts were made to convert citronellal in the oil into components showing repellent activity *via* a simple citric acid catalyzed reaction. The acid treated oil samples were tested for their mosquito repellent ability using a static air repellency apparatus. The reaction was carried out by varying the volume of the acid catalyst (7% acid), temperature and reaction time in order to investigate the optimum reaction conditions. The acid treated oils displayed a significantly high mosquito repellent activity against *Aedes aegypti* mosquitoes compared to the untreated oil. The highest mosquito repellency within a period of 3 hours was observed, when 3.7 g of the oil was reacted with 20 mL of 7% citric acid solution at 50°C for 15 hours. The percentage repellency of 2% of this sample in a neutral lotion was 72% whereas the untreated oil had the repellency of 27% at the 0<sup>th</sup> hour. The results of this study indicated the success of this simple synthetic approach towards enhancing the mosquito repellency of *Eucalyptus citriodora* oil in an economical and efficient manner.

**Keywords:** *Eucalyptus citriodora*, Mosquito repellent, *Aedesaegypti*

\*Corresponding Author: gayani@sci.cmb.ac.lk



## **Ecology and the Level of Habitat Degradation of Upparu Mangrove Forest, Kinniya, Sri Lanka.**

P. A. Kushlani N. Dissanayake<sup>1\*</sup>, D.G.T.C.Balawardhana<sup>1</sup>, P.B. Terney  
Pradeep Kumara<sup>1, 2</sup>, E.P.D.N.Thilakarathna<sup>1</sup>

<sup>1</sup>*Department of Oceanography and Marine Geology, University of Ruhuna, Sri Lanka*

<sup>2</sup>*Marine Environment Protection Authority, Ministry of Mahaweli Development and Environment, Sri Lanka*

Mangroves are productive coastal ecosystems which provide number of ecological and socio economic benefits. The growing demand for the land, resources and the dynamics of climate variability has threatened these environments locally as well as globally. Mangrove pollution by haphazard waste dumping is a serious problem in many countries. Upparu lagoon has been using as a dumping site for several decades and reliable statistics and information are not available on the species composition and resource uses in the area. The study was conducted in 2014 to address this information gap. Transect plots were deployed perpendicular to the shoreline at selected sites to record the mangroves, mangrove associates and their densities. Focus group discussions and semi structured interviews were conducted to understand the prevailing issues in the local community linkages to the mangrove forest. Seventeen true mangroves, seven mangrove associates, nineteen birds, eight molluscs, seven butterflies and five crab species were recorded. According to the socio-economic survey resources were found heavily extracted for timber, construction material and firewood as well as for lagoon fisheries, livestock farming, and the lime industry. Combined effects of resource use and waste dumping had caused detrimental consequences to the community and biota leading to forest degradation mainly in the northern flank of the forest. Several places were found littered with solid cement rubble resulted from house demolition and more than 70% of the trash were plastic and polythene in sampling sites. Currently this valuable ecosystem is degrading due to lacking of proper waste management system. Therefore, attention of relevant authorities is highly needed to adopt site specific management interventions in order to restore and manage this ecosystem sustainably.

**Keywords:** *Mangroves, ecology, pollution, degradation, sustainable*

\*Corresponding author: kushlanidissanayake@gmail.com

## **Heavy metal contamination in the vicinity of a landfill site at Weligama, Sri Lanka**

MGTT Marasinghe<sup>1</sup>, SR Amarasinghe<sup>2</sup>, SD Wanniarachchi<sup>2</sup> and KR Fernando<sup>1\*</sup>

<sup>1</sup>*Department of Chemistry, University of Ruhuna, Sri Lanka*

<sup>2</sup>*Department of Soil Science, Faculty of Agriculture, University of Ruhuna, Sri Lanka*

Environmental pollution due to landfill leachate has given rise to a number of studies in recent years. Heavy metals are a source of environmental pollution affecting the aquatic and terrestrial ecosystems. Main sources of heavy metal pollution are industrial waste, domestic sewage and landfills. Landfill sites are one of the major sources of heavy metal pollution which affect the soil and water around it. Various types of wastes such as waste food cans and scrap metal and the indiscriminate dumping of household hazardous waste and electronic waste such as batteries and electronic apparatus generate heavy metals in a landfill. The release of heavy metal into the adjacent environment is a serious environmental concern and a threat to public health and safety. It is important to identify whether there is any risk of contaminating the environment due to heavy metals by landfill leachate. Therefore, the objective of this research had been to determine the risk of soil pollution by heavy metals in landfill leachate produced by one of the municipal solid waste collecting sites in Weligama, Sri Lanka. Soil samples from the landfill site and water samples from a nearby stream were collected, digested with conc.HNO<sub>3</sub> and analyzed for heavy metals such as Zn, Pb, and Ni by Atomic Absorption Spectrophotometry (AAS). Zn, Pb, and Ni were detected to be (in ppm) 74.5, 52.8, and 94.2 in the cultivated land and 101.8, 54.7, and 80.8 in the landfill site respectively. It is possible to conclude that there are no any harmful impacts from this Weligama landfill site as far as the three heavy metals involved in this study are concerned. However, Ni content in the cultivated land is higher than that in landfill site and also higher in some collection points than the regulatory standards of heavy metals in agricultural soil. A possible Pb contamination was indicated in some water samples as its concentration in some points was detected to be as high as 0.05 ppm.

**Keywords:** *Landfill leachate; heavy metals; soil; water; AAS*

\*Corresponding Author: rodney@chem.ruh.ac.lk

## **Socio-economic Aspects of Fishing Communities: A Case Study in Victoria Reservoir, Sri Lanka**

Wickremasinghe E.S.<sup>1\*</sup>, Dematawewa C.M.B.<sup>2</sup> and Edirisinghe E.M.L.B.<sup>2</sup>

<sup>1</sup>*National Aquaculture Development Authority of Sri Lanka, Kandy*

<sup>2</sup>*Department of Animal Science, Faculty of Agriculture, University of Peradeniya, Peradeniya*

A study was carried out to investigate the socioeconomic characteristics of a fishing community that influences the efficient reservoir fishery management in perennial reservoirs of Sri Lanka. All fishermen (N=66) of Victoria reservoir, a man-made lake (2300 ha at FSL) in Sri Lanka, were surveyed twice in 2014 and 2015. The survey revealed that most fishermen had boats (78.79%) while the others either borrowed or shared boats. Fishermen have used up to 20 nets during the peak fishing time. Majority were full time fishermen (61.4%). Highest, lowest and mean income per day were 8000, 300, and 1653 rupees during peak fishing, and 800, 0 and 219 rupees during low catch periods, respectively. Only 14% were found not having even the basic necessities and the majority have received only primary education (71.2%). Only 19.70% and 34.85% of the fishermen were found as teetotalers and non-smokers, respectively. About 29.6% of fishermen have voluntarily participated in the state-organized raids. However, 25.76% and 37.88% of the fishermen did not have proper operating or boat licenses, respectively. About 77.30% of the fishermen were found to be actively participated in fisheries organization activities while 95.40% have felt that the organization is useful. This study showed the need for improving the livelihood of fishing community in Victoria reservoir. Attitudes of fishermen towards obtaining a valid operation license and participation in fisheries organization activities indicated the potential for managing the above aquatic resource through the fisheries organization.

**Keywords:** *Fishing community, Fishery management, Fisheries Organization, Socioeconomic characteristics, Victoria Reservoir.*

\*Corresponding author: shehanwickrema@yahoo.com

## **Suitability of medicinal plants, *Sesbania grandiflora*, *Aegle marmelos* and *Allium sativum* as feed additives on growth performance of Red tilapia**

Nishshanka K.M.\*, Amarasinghe N.J.De.S. and Guruge W.A.H.P.

*Department of Zoology, University of Ruhuna, Matara, Sri Lanka*

Three months feeding trial was carried out to investigate the effects of diets containing ingredients of three medicinal plants Kathurumurunga (*Sesbania grandiflora*- T<sub>1</sub>), Beli (*Aegle marmelos*- T<sub>2</sub>) and Garlic (*Allium sativum*- T<sub>3</sub>), on growth performance of *Oreochromis* sp. (Red tilapia) and their effect on water quality parameters. Four treatment groups namely T<sub>1</sub>, T<sub>2</sub> and T<sub>3</sub> and untreated control (C) with 40% protein level were subjected for testing. In formulating the test diets, 35% (of weight) of control diet was substituted by medicinal plant ingredient. Each test group was triplicate with twelve identical experimental indoor fiber glass tanks. Red tilapia fries (weight  $0.3052 \pm 0.0086$  g; length  $2.8 \pm 0.02$  cm; n=30) were stocked in each tank and were fed with a ration equivalent to 5% of their body mass twice per day for three months. At the end of the experiment, their final body weights & lengths were recorded to determine their condition factor. Physico-chemical parameters pH, conductivity, temperature, dissolved oxygen (DO), biological oxygen demand (BOD<sub>5</sub>), nitrate and ortho-phosphate concentrations in water were recorded every second week. During the 03 months period, fish with the diet T<sub>3</sub> and the control (C) showed significantly higher growth rates ( $p < 0.05$ ). Condition factors of fish in treatments T<sub>1</sub>, T<sub>3</sub> and C were higher and significantly different ( $p < 0.05$ ) from that of fish in the treatment T<sub>2</sub>. Even though the water quality parameters such as BOD<sub>5</sub>, conductivity, nitrate and ortho-phosphate concentrations in control tanks were higher than those in treatment tanks, they were not significantly different ( $p > 0.05$ ) except pH. This study concludes that diets with garlic can perform as same as the control diets and the inclusion of medicinal plant ingredients into the diet has no impact on the water quality in fish tanks.

**Keywords:** *Medicinal plant ingredients, Kathurumurunga, Beli, Garlic, water quality*

\*Corresponding Author: krishnimanesha@gmail.com

## **An aqueous pod extract of *Capsicum frutescens*– as a potential botanical for controlling *Aphis craccivora***

W.A.K. Thakshila, W.T.S. Dammini Premachandra\* and M.G.V. Wickramasinghe

*Department of Zoology, University of Ruhuna, Sri Lanka*

*Aphis craccivora* Koch, is an insect pest on economically important crops causing damage by sucking the plant sap and transmitting viral diseases leading to heavy yield losses. In this investigation, the effect of aqueous pod extract of *Capsicum frutescens* on survival of nymphs and females and reproduction of females of *A. craccivora* on Yard-long bean plants was determined by directly spraying the extract on the aphids and exposure of the aphid to the pre-sprayed Yard-long bean leaves. The nymphal and female mortalities, and number of nymphs produced by the females were recorded at 24, 48 and 72 h after spraying the extract. The aphids sprayed with distilled water served as controls. Ten replicates were used for the treatment and control, and arranged in complete randomized design. Student t test was used for the comparison of mortalities and nymphal production by female aphids.

When aphids were sprayed directly, percentage cumulative mortality of treated nymphs and females were significantly higher ( $p < 0.0001$ ) compared to non-treated aphids, with the maximum values, 95% and 52%, respectively. Nymphal mortality was greater than the females at all the time periods observed. The mortalities recorded after 24 h was significantly lower compared to 48 and 72 h; however, no significant differences were observed between 48 and 72 h. Treated females produced significantly lower number of nymphs ( $p < 0.0001$ ) compared to non-treated ones. Nymphal production of treated females showed significant increase ( $p < 0.0001$ ) over time. The findings showed that the aqueous pod extract of *C. frutescens* affected the survival of nymphs and females of *A. craccivora* as well as reproduction of females through its direct contact toxicity. Nymphs were more prone to the toxic effect of the extract than the females. Hence, this extract has a potency of controlling *A. crassivora*.

**Keywords:** *Aphis craccivora*, *Capsicum frutescens*, contact toxicity

\*Corresponding author: dammini@zoo.ruh.ac.lk

## An efficient line clipping algorithm against a convex polygon

Wijeweera K. R.<sup>1\*</sup>, Kodituwakku S. R.<sup>2</sup>, Chamikara M. A. P.<sup>2</sup>

<sup>1</sup>*Department of Computer Science, Faculty of Science, University of Ruhuna,  
Wellamadama, Matara, Sri Lanka*

<sup>2</sup>*Department of Statistics and Computer Science, Faculty of Science, University of  
Peradeniya, Peradeniya, Sri Lanka*

This work proposes a new line clipping algorithm against a convex polygon. Cyrus Beck algorithm is the most widely used algorithm for line clipping against a convex polygon. Many algorithms have been proposed by modifying Cyrus Beck algorithm considering special distributions of line segments on the plane. However Cyrus Beck algorithm is the fastest algorithm available in literature when line segments are normally distributed. The proposed algorithm uses a novel approach based on intersection detection. There are three possible situations for a given line segment: (1) Line segment is completely inside. (2) Line segment is completely outside. (3) Line segment is intersecting the boundary of the convex polygon. Note that being end points of a line segment outside does not guarantee that the line segment is completely outside. This makes the clipping algorithms complicated. The Cyrus Beck algorithm computes all the intersection points and selects the actual end points of the clipped line segment. The proposed algorithm is capable of detecting completely inside line segments without doing any intersection calculations. Further the proposed algorithm avoids some of the intersection calculations when the line segment is intersecting the boundary of the convex polygon. Thus proposed algorithm is faster than the Cyrus Beck algorithm theoretically. According to the experimental results, the proposed algorithm is 1.012 times faster than Cyrus Beck algorithm when the convex polygon is a triangle. And the proposed algorithm is 1.147 times faster than the Cyrus Beck algorithm when the convex polygon is an octagon. The performance of the proposed algorithm against Cyrus Beck is significant when the number of edges of the convex polygon is increased since then more intersection calculations can be avoided.

**Keywords:** Computer Graphics, Convex Analysis, Line Clipping, Coordinate Geometry, Polygons

\*Corresponding Author: krw19870829@gmail.com

## **Preparation and characterization of ZnO-Chitosan nanocomposite and evaluation of its antifungal activity against pathogenic *Candida albicans***

Dananjaya S.H.S<sup>1</sup>, Udayantha H.M.V<sup>2</sup>, R.M.C Udayangani<sup>1</sup>, Beom S.S<sup>1</sup>, Jehee L<sup>3</sup>, De Zoysa M<sup>1\*</sup>

<sup>1</sup>College of Veterinary Medicine and Research Institute of Veterinary Medicine, Chungnam National University, Yuseong-gu, Daejeon, 34134, Republic of Korea.

<sup>2</sup>Department of Fisheries & Aquaculture, Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna, Sri Lanka.

<sup>3</sup>Department of Marine Life Sciences, School of Marine Biomedical Sciences,  
Jeju National University, Jeju Self-Governing Province 63243, Republic of Korea.

Nano technology is one of the fastest growing scientific tools with potential to solve many of the burning issues in bio medical sciences today. In this study, a simple, fast, cost-effective, wet chemical route based on cyclohexylamine was used to synthesizing Zinc oxide nanoparticles (ZnO NPs) in aqueous media. Synthesized ZnO NPs and low molecular weight chitosan were used to prepare Zinc oxide-chitosan nano composites (ZnO-C NCs). The synthesized ZnO NPs and ZnO- C NCs were characterized by powder X-ray diffraction, UV-visible diffuse reflectance spectroscopy, and field emission scanning electron microscopy (FESEM), field emission transmission electron microscopy (FETEM). The average particle size of ZnO NPs and ZnO-C NCs were 184 nm and 203 nm and zeta potential determined by zetasizer were +17.4 and +37.3 mV respectively. The anti-fungal properties of ZnO NPs and ZnO-C NCs against *Candida albicans* were determined by Minimum Inhibitory Concentration (MIC) which was determined as 200 µg/mL and 75 µg/mL respectively indicating superior anti-fungal properties of ZnO-C NCs compared to ZnO NPs. The SEM images of treated *C. albicans* cell surface, propidium iodide (PI) uptake and MTT assay results further confirmed the above statement. Concluding the results obtained from current study we strongly suggest that the ZnO-C NCs possess lucid anti candidal activity than ZnO NPs.

**Keywords:** ZnO; Chitosan; Nanocomposites; Antifungal activity; *Candida albicans*

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\*Corresponding Author: mahanama@cnu.ac.kr



## Parametric forms for Pythagorean Triples and Congruent numbers

Padmaprabha H.G.N.L.<sup>1\*</sup>, Shanthidevi K.C.N.<sup>2</sup>,

<sup>1</sup>*Hakmana Road, Nadugala, Matara, Sri Lanka.*

<sup>2</sup>*Department of Mathematics, University of Ruhuna, Matara, Sri Lanka*

In this paper it is obtained someparametric forms for Pythagorean Triples and Congruent numbers. First it is obtained the positive rational solution set

of the Pythagoras equation as  $\left(x, \frac{x^2-k^2}{2k}, \frac{x^2+k^2}{2k}\right)$  where  $x, k(< x)$  are positive rational numbers. Consequently, it can be obtained a parametric form for

positive Pythagorean Triples as  $\left(x, \frac{x^2-l^2}{2l}, \frac{x^2+l^2}{2l}\right)$  where  $x = ll'$  for some

positive integer  $l'$ . Here  $l$  is even when  $x$  is even. A Congruent number is a positive integer that is the area of a right triangle with three rational number sides. Therefore it can be considered a right triangle which is has area

$n \in \mathbb{N}$  with rational number sides  $\left(x, \frac{x^2-k^2}{2k}, \frac{x^2+k^2}{2k}\right)$  where  $x, k(< x)$  are

positive rational numbers. Then  $n = \frac{1}{2}x \left(\frac{x^2-k^2}{2k}\right)$ . Considering  $x = \frac{p}{q}$  where

both  $p, q (q \neq 0)$  are positive integers and  $\gcd(p, q) = 1$  and using a

parametric form for Pythagorean Triples  $\left(x, \frac{x^2-l^2}{2l}, \frac{x^2+l^2}{2l}\right)$  it can be obtain a

parametric form for Congruent numbers as integers of the form  $\frac{p^4-l^2}{4lq^2}$  where  $l$

is a positive factor of  $p$ .

**Keywords:** *Pythagoras equation, Pythagorean Triples, Congruent numbers.*

\*Corresponding Author: mathlasitha@hotmail.com

## **Ranking Environmental Problems in Sri Lanka Using Crowdsourcing and Natural Language Processing**

Lakshika M.V.P.T.<sup>1\*</sup> and Senanayake S.H.D.<sup>1</sup>

*Department of Computer Science & Technology, UvaWellassa University,  
Badulla, Sri Lanka.*

Deforestation, pollution of water bodies, natural disasters are few environmental problems in Sri Lanka. Communities who suffer from environmental problems are not attaining solutions due to lack of awareness and carelessness in agreeable parties. In most influential situations, community uses mass media for gaining responsiveness of authorized parties. Virtual communities in Sri Lanka used social media for emphasizing numerous forms of social problems occurred within last decade. The intention of this research is to assist amenable organizations in making better decisions according to public views.

The application is obtaining the content of environmental problems with crowdsourcing. The virtual community can report environmental problems by using text and images. Users of the application can vote or comment on the problems reported by others. Each problem will receive points according to a pre-defined algorithm based on the number of up or down votes and polarity of user comments they have received. The application highlights genuine high-quality problems while allocating points for each user. Topic based text categorization techniques which used in this prototype is effective for filtering out environmental related information which is not used yet for the most important natural language applications. The polarity of user comments is generated as positive or negative by using sentiment analysis tools.

The application is providing 90% of accuracy in highlighting environmental problems by considering pre-defined user features, user activity measures and community process features. The accuracy of the application can be automatically improved with the growth of corpus provided by the users of the application.

**Keywords:** *Natural language processing, Text classification, Sentiment analysis, Crowdsourcing*

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\*Corresponding Author: lakshikamvpt@gmail.com

## **An automated device to measure a fixed volume of a liquid**

Maduranga U.G.D.<sup>1</sup>, Abeywicrama S.S.<sup>1</sup>, Dharmarathna W.G.D.<sup>1</sup> and  
Ranatunga E.M.<sup>1\*</sup>

*Department of Physics, University of Ruhuna, Wellamadama, Matara, Sri Lanka.*

A simple automated device has been designed and constructed in order to release a fixed volume of a liquid from a container. This preliminary model designed to release a fixed volume of liquid has been tested with water. The results indicate that the device could release 750 ml of water in about 20 seconds with an accuracy of  $\pm 0.05$  ml. The device could be used for other liquids such as kerosene oil and coconut oil, which are sold at small scale shops. However, the rate of release of the liquid would depend on the viscosity of the liquid. With suitable modifications, the device could be used in large scale industries such as bottling of any liquid. The main advantage is that the device could be easily manufactured locally at low cost.

**Keywords:** *Fixed volume, Lower viscosities, Automated device*

\*Corresponding Author: ranatung@phy.ruh.ac.lk

## **A Low Cost Transportation Plan to a Garment Factory**

Dunuwila N.D.K.K.\* and Samarathunga D.M.

*Department of Mathematics, University of Ruhuna, Matara, Sri Lanka.*

Transportation is not only related to goods anymore but also for the passengers in the current society. So many workers in the apparel industry use public transportation services provided by their employer to save their money and time. Therefore, many researchers have studied about the transportation problems in various angles and used many techniques from different disciplines to identify optimal solutions for existing transportation problems in apparel industry. In this research, a case study was conducted using a garment factory where they provide transportation service to their employees. The main objective of this study was to identify a new transportation plan with low cost using some techniques in operational research. As the first step, secondary data was obtained from the selected garment factory and then Floyd's Algorithm was applied to find the shortest path to each destination from the factory. As the second step, a graph was drawn using the shortest paths which was founded and broken that graph into trees. Then Chinese Postman Algorithm was applied to each tree separately. Finally, transportation plan was obtained for each destinations and the results emphasized that the new plan was profitable than the existing plan.

**Keywords:** *Chinese Postman Algorithm, Floyd's Algorithm*

\*Corresponding Author: [kkdunuwila@gmail.com](mailto:kkdunuwila@gmail.com)

## **Analysis of the physico-chemical quality of some consumer preferred plain set yoghurts sold in Matara municipal area of Sri Lanka: A case study.**

Wedage L.T.<sup>1</sup>, Amarathunga S.M.<sup>2</sup>, Hemamali K.K.G.U.<sup>2</sup> and Jayasekara L.A.L.W<sup>1\*</sup>

<sup>1</sup>*Department of Mathematics, University of Ruhuna, Matara, Sri Lanka.*

<sup>2</sup>*Department of Botany, University of Ruhuna, Matara, Sri Lanka.*

Researchers often measure several variables on each subject or experimental unit. If the variables are correlated we have to use multivariate techniques to access the key features of the process. This study is an attempt to fill that gap by providing data on evaluation of the changes of physico-chemical parameters of some brands of plain set yoghurt sold in Matara municipal area of Sri Lanka. Samples from five different brands of plain set yoghurt were collected on the basis of consumer preferences for this study. Fifteen samples from each brand were analyzed of their physico-chemical parameters (syneresis effect, pH, titratable acidity, total protein content and calcium concentration) by using three replicates of each sample at 4, 7, 14, 21 and 28 days intervals from production date and compared against local and international standards by using univariate techniques. In the present study, multivariate techniques were applied to those data and found that total protein content of all plain set yoghurt brands were not within the permissible range for local and international standards. Titratable acidity was only in the permissible range of local standards. Physico-chemical parameters except calcium concentration of collected samples were significantly affected by storage period. This study also revealed that there is a variation in quality parameters of plain set yoghurt among different brands. There is a fallacy of applying the univariate techniques and fidelity of applying multivariate techniques for the correlated data. Hence, we have to use multivariate techniques to analyze these data instead of univariate techniques.

**Keywords:** *plain set yoghurts, physical parameter, chemical parameters, univariate techniques, multivariate techniques*

\*Corresponding Author: leslie@maths.ruh.ac.lk

## **A preliminary model of predictive text for Sinhala using N-gram Statistics**

Chanaka K.M.R.\* , Lorensuhewa S.A.S. and Kalyani M.A.L

*Department of Computer Science, University of Ruhuna, Matara, Sri Lanka.*

Most Sri Lankans use Sinhala text processing in their day to day activities. But, they feel it hard to type documents in Sinhala and also it takes more time and involves typing mistakes and therefore efficiency is low. Integration of word prediction facility helps the user to select words rather than typing the words repeatedly to reduce the number of required keystrokes, minimize mistakes and reduce time. The aim of this research is to explore the use of Natural Language Processing and Machine Learning techniques to assist Sinhala typing tasks by predicting the words.

We predict the next word to type from n-gram probabilistic model which involves bi-gram, tri-gram and a combination of bi-gram and tri-gram. This composite n-gram model includes both bi-gram and tri-gram, giving high priority to the tri-gram suggestions. The n-gram corpus is generated from Sinhala corpus collected from online Sinhala newspapers. A maximum prediction percentage of 41 was achieved for sports documents by using domain specific n-gram corpus of sports documents and obtained an 18.1% average keystroke reduction by using the prediction model. We tested with other news categories such as political, legal and local collected from local newspapers as well. According to our experimental results, composite n-gram model outperformed bi-gram and tri-gram word prediction models and the domain specific composite n-gram model performs better than the composite model created from a mixed corpus.

Our goal is to automatically cluster the document corpus and classify the edited text after entering certain amount of text and get the predictions from a relevant cluster dynamically to improve the accuracy at runtime, giving a more relevant prediction.

**Keywords:** *Word Prediction, Dynamic Text Prediction, N-Gram Model, NLP, Text Mining*

\*Corresponding Author: ruwanpelwatta@gmail.com

## **A novel device for bending PVC pipes for plumbing purposes**

N.A.A.K.Sanjaya<sup>1</sup>, W.G.D. Dharmaratna<sup>1</sup>, S.S. Abeywickrama<sup>1</sup> and E. M. Ranatunga<sup>1\*</sup>

*<sup>1</sup>Department of Physics, University of Ruhuna, Matara, Sri Lanka.*

PVC bends are commonly used by plumbers when laying PVC pipe lines in buildings. Many plumbers make bends by themselves by just heating and bending by hands, which is not the most successful method, especially for less experience plumbers. The quality of some of the bends available in the market is not up to the standard.

In order to address the above practical problem faced by plumbers, a suitable method to produce quality bends was developed under this study. Two sizes of uPVC (Unpasteurized Poly Vinyl Chloride) pipes, diameter  $\frac{1}{2}$  inch and  $\frac{3}{4}$  inch, of gauge 1000, were studied. The optimum values of the two critical parameters, temperature and pressure, were determined to produce quality bends. The best temperature was found to be in the range 85°C - 90°C regardless of the diameter. The optimum values of the pressure for  $\frac{1}{2}$  inch and  $\frac{3}{4}$  inch pipes were in the range 10-13 psi and 14-16 psi relative to ambient pressure, respectively.

Based on the results of the experiment, a device was designed and fabricated to produce quality bends conveniently. Heat resistant rubber tube passing through the pipe was used to apply uniform pressure on the pipe wall by pumping air in to the rubber tube. Pulleys of radii 2.4 cm and 3.4 cm were used in the device to bend  $\frac{1}{2}$  inch and  $\frac{3}{4}$  inch pipes, respectively. Pipes at the optimum pressure was heated to the required temperature uniformly and pressed around the pulley by hand to produce bends. The new device fabricated for bending pipes at 90 degrees could be easily modified to bend at different angles.

**Keywords:** *PVC bends, Fabrication of bends, Optimal parameters and Bending pipes*

\*Corresponding Author: dharma@phy.ruh.ac.lk



## Low-cost impedance spectroscopic system for investigation of solar cell characteristics.

Ajward A.M.<sup>1\*</sup> and Gunawardhana I.D.C.B.K<sup>2</sup>

<sup>1</sup>*Department of Engineering Technology, University of Ruhuna, Matara, Sri Lanka.*

<sup>2</sup>*Department of Physics, University of Ruhuna, Matara, Sri Lanka.*

A low-cost impedance spectrometer capable of measuring impedance spectra of photovoltaic devices such as solar-cells in the frequency domain has been built. In order to consistently find the impedance of the device by applying low voltage signals that are frequently suppressed by noise, reliably finding the phase differences between measured sinusoidal signals are necessary. Thus, for persistently calculating the phase shift  $\Phi_x$  between two measured sinusoidal signals a mathematical function,  $\Phi_x = 2 \left[ \sin^{-1} \left( \frac{\text{Maximum}(V_{CH1n} - V_{CH2n})}{2} \right) \right]$  was derived and used in LabView, where  $V_{CH1n}$  and  $V_{CH2n}$  are the normalized sinusoidal signals recorded by the two channels in the LabView program and where the function  $\text{Maximum}(f)$  was used to find the peak (maximum) value of the function  $f$ . The function was able to provide excellent results for the phase difference  $\Phi_x$  under low voltage and currents, under high noise conditions. The system may be easily altered for different types of experimental necessities and applications due to the flexibility of the design. The measurements could be implemented in frequency range from 10 Hz to 10 kHz and the employed principles of the spectrometer are given in this paper. The spectrometer was tested on commercial solar cells to gain knowledge about them.

**Keywords:** *Low-cost Impedance Spectrometer, Complex Impedance Spectroscopy*

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\*Corresponding Author: [ajwardma@gmail.com](mailto:ajwardma@gmail.com)

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