



*International Conference on*

# MULTIDISCIPLINARY APPROACHES IN SCIENCE

*2021*


## *Conference Proceedings*

*Faculty of Science, University of Colombo, Sri Lanka*

# Proceedings of the International Conference on Multidisciplinary Approaches in Science (ICMAS) - 2021

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**Tips and Tricks on how to Patent your Research Work**

Colombo Cell, Faculty of Science, University of Colombo

**Covid-19: Sri Lankan Perspective**

Centre for Immunology and Molecular Biology (CIMB), Department of Zoology and Environment Sciences, Faculty of Science, University of Colombo:

Prof. Preethi Udagama
Dr. Himali Ratnayake
Dr. Vindhya Fernando
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**R for Data Science- A Crash Course**

Center for Data Science, Department of Statistics, Faculty of Science, University of Colombo:

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Mr. Kasun Amarasinghe
Dr. S. D. Viswakula
Ms. Sandamini Senaratne

**Mini-Symposium on 'Building Resilience together'**

The Sustainability, Resilience and Environmental leadership for Youth (SURE – Youth) under the Environment and Resilience Pitch (ER Pitch), the research group of Prof. Deepthi Wickramasinghe, Department of Zoology and Environment Sciences, Faculty of Science, University of Colombo:

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Ms. Lihini Prematilaka
Ms. Vihanga Amarakoon
Dr. Ayomi Witharana
Ms. Damithri Jayasekara
Mr. Thisaru Perera
Ms. Dilisha Gunawardane

**Mini-Course on Dynamical Systems – Stability, Bifurcation Analysis and Applications**

Research & Development Centre for Mathematical Modelling:

Dr. Kushani de Silva
Ms. K. K. W. H. Erandi
Dr. Yashika Jayathunga

**Mini-Course on Fuzzy Set Theory and Applications**

Research & Development Centre for Mathematical Modelling:

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**International Symposium on Applied Mathematics, Modeling, Analysis and Simulations**

Research & Development Centre for Mathematical Modelling:

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Ms. K. K. W. H. Erandi

**Symposium on Infectious Diseases Modeling**

Research & Development Centre for Mathematical Modelling:

Dr. Kushani de Silva
Dr. Yashika Jayathunga
Ms. K. K. W. H. Erandi

**Mini-Symposium: Special Session on Quantum Computing**

Research & Development Centre for Mathematical Modelling:

Dr. Anuradha Mahasinghe
Ms. Pubudika Gunasekara

**Mini-Symposium on Work Bench to Practice**

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Prof. Deepthi Wickramasinghe
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## MESSAGE FROM THE VICE CHANCELLOR
## UNIVERSITY OF COLOMBO, SRI LANKA

It is with great joy and a sense of fulfilment that I connect with the dean, staff, students and alumni of the Faculty of Science on the occasion of the inaugural International Scientific Conference on Multidisciplinary Approaches in Science (ICMAS - 2021).

This unique convention is a fitting tribute to the pioneering visionaries who would be justly proud of your commitment and achievements. ICMAS–2021 concludes the yearlong commemoration of a wonderful century of scientific discovery and learning, which was formally launched on the 21st of January this year. I am deeply humbled by your apt response to UoC's overarching mission that encourages multidisciplinary research and sustainability. I am confident that your collective effort paves the way for all our faculties, institutes, school, campuses and centres to develop a strong and connected view of research and scholarship for many centuries ahead. You have indeed enhanced the premier seat of higher learning we are privileged to serve in.

The 21st century's ethos 'research and innovation' has become the single factor that defines our ability to remain relevant within the realm of higher education. As such, the importance of conducting a scientific symposium that showcases our scientific research to the world at large, cannot be understated. The formal institutionalization of the research symposium has helped to raise the research profile of our academics and with it, the profile of our university, which is important for the maintenance of academic standards for which our university has a high reputation.

It is my firm belief that the fullest exploration of your chosen theme from an academic perspective is imperative if we are to truly bring about social benefit to every member of our society. Your reaching out to the larger segment of our society through your scientific deliberations, along with the numerous stakeholders to be a part of your networking, has helped showcase your research on a large canvas. You have indeed raised the bar. I am confident that the steps taken today will help the Faculty of Science grow as an academic community as we strive to apply our work to better the lives of our fellow citizens, both at home and across Asia and the globe.

Once again, I thank you for your enthusiasm and wish you a memorable and intellectually stimulating conference.

May the Faculty of Science grow from strength to strength!

**Professor Chandrika Wijeyaratne**
Vice Chancellor
University of Colombo, Sri Lanka

## MESSAGE FROM THE DEAN
## FACULTY OF SCIENCE, UNIVERSITY OF COLOMBO

On behalf of the Faculty of Science, University of Colombo, I extend my warmest welcome to the participants of the International Conference on Multidisciplinary Approaches in Science 2021 held virtually in Colombo Sri Lanka.

This year is a very special year for the Faculty of Science since we celebrate the 100-year legacy of Arts and Sciences in the University of Colombo. The University of Colombo having its roots going back to the establishment of the University College in 1921, played a pioneering role in laying the foundation for the modern-day university education in Sri Lanka. In order to mark this historical event, we have planned to issue a first-day cover stamp depicting the picture of the iconic Royal College Building during the inaugural session of this conference.

For this conference, we have put together a rich scientific programme cutting across boundaries in science. We have invited experts from various parts of the world to exchange ideas and share their knowledge. We have also invited distinguished scholars representing 17 countries as guest speakers. A total of 156 technical papers will be presented during the 3 days of the conference in 6 parallel tracks. Your presence and valuable scientific contribution will no doubt set the standard for future multidisciplinary conferences of this nature.

On behalf of the Faculty of Science, I extend my sincere gratitude to the organizing committee for working under difficult conditions due to the covid-19 pandemic, to make this event a success.

**Professor Upul Sonnadara**
The Dean,
Faculty of Science, University of Colombo

## MESSAGE FROM THE CHAIRPERSON OF ICMAS-2021

On behalf of the organizing committee and the Faculty of Science, University of Colombo, I am honored to welcome you to the International Conference on Multidisciplinary Approaches in Science 2021 (ICMAS-2021). The conference is organized by the Faculty of Science, University of Colombo to celebrate the centenary of excellence in Science. The conference theme, *Basic Sciences: From silos to the cross disciplinary future world*, has been carefully chosen to mark the growth of interdisciplinary research in our society.

ICMAS 2021 consists of forums, workshops, mini symposiums and keynote speeches held on a virtual platform. The main objective of the conference is to update the recent developments of knowledge and practices in basic sciences and to promote multidisciplinary research as a tool to overcome challenges in the coming decade and beyond. More than 160 abstracts were received from all over the globe covering the different tracks of the conference: Modeling and Simulation in Sciences; Research and Innovation towards a Sustainable Future; Advances in Basic Sciences towards Technological Development; Science and Mathematics Education; Biodiversity, Conservation and Natural Resources; and Decision Sciences. The conference also includes symposia on Infectious Diseases Modeling, Quantum Computing, From Workbench to Practice and many workshops covering emerging fields in science. ICMAS 2021 includes more than 40 guest speeches by both local and foreign scholars providing a great opportunity for researchers to share their thoughts, exchange ideas and to explore current and future directions in research.

I would like to express my appreciation to all the reviewers for their professional reviews that helped us maintain the high quality of the conference publications. I would also like to thank all keynote and guests speakers, workshop organizers, track co-chairs, session chairs, co-chairs and authors for their contributions which are the foundation of the remarkable success of this conference.

Organizing a conference of this magnitude is not an easy task. The success of the conference ultimately depends on the people who worked hard in planning and organizing the conference. To this end, I would like to express my sincere gratitude to the organizing committee members who worked extremely hard for the details of the conference program and technical activities.

I wish you a productive and a memorable conference, ICMAS-2021.

**Professor S. S. N. Perera**
Chairperson, ICMAS-2021

## MESSAGE FROM THE CONFERENCE CO-SECRETARIES OF ICMAS-2021

It is with great pleasure that we send this message for the International Conference on Multidisciplinary Approaches in Science (ICMAS - 2021) which is organized by the Faculty of Science, University of Colombo, to celebrate 100 years of Excellence in Science.

The ICMAS 2021 anticipates to establish a platform to update the recent developments of knowledge and practices in basic sciences and to enhance and promote multidisciplinary research as a tool to overcome challenges in the coming decade, and beyond. The inaugural conference is rich and varied with six main tracks, including, Modeling & Simulations in Sciences, Research and Innovation towards a Sustainable future, Advances in Basic Sciences towards Technological Development, Science and Mathematics Education: Challenges and Opportunities, Biodiversity, Conservation and Natural Resources, and Decision Sciences. We believe that the three-day virtual international conference, pre-conference workshops, and Mini-Symposia would provide an ideal platform to share cutting-edge research findings and address emerging issues in Sri Lanka and across the world through the multidisciplinary approaches in science.

The success of this conference is heavily dependent on those who worked with us in planning and organizing the event. We take this opportunity to express our sincere gratitude to our dedicated team for their continuous support and commitment. Also, we wish to extend our appreciation to all keynote speakers, reviewers, editorial team members, session chairs, authors and presenters. Further, we greatly appreciate the continuous guidance provided by the Vice Chancellor, University of Colombo, and the Dean, Faculty of Science throughout the planning process. Finally, we thank all the academic staff members and administrative staff of the Faculty of Science, University of Colombo, without whose support this conference would not have been possible.

Last but not least, we place on record our heartiest congratulations to the Faculty of Science, University of Colombo, for reaching a centenary milestone.

We wish the ICMAS 2021 every success.

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Dr. Sagarika Kannangara, Department of Plant and Molecular Biology, Faculty of Science, University of Kelaniya, Sri Lanka

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Dr. Surani Ediriweera, Department of Plant Sciences, Faculty of Science, University of Colombo, Sri Lanka

Prof. Sampath Seneviratne, Department of Zoology and Environment Sciences, Faculty of Science, University of Colombo, Sri Lanka

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# A Computational Study of Cyclin-dependent Kinases 1 (CDK1) Butyrolactone I Complex and the Role of Mg Ion in the Active Site

**Chinthaka N. Ratnaweera[1*]** and **Chanikya D. Jayawardana[2]**
[1] Department of Chemistry, University of Ruhuna, Matara, Sri Lanka.
[2] College of Chemical Sciences, Institute of Chemistry Ceylon, Rajagiriya, Sri Lanka.
* nadun@chem.ruh.ac.lk

Cyclin-dependent kinases (CDK) 1, 2, 4, and 6 are the protein kinases that play a pivotal role in the cell cycle regulating all eukaryotic organisms by phosphorylating proteins needed during the cell division cycle. Phosphorylation of protein kinase requires the assistance of a divalent metal ion, usually $Mg^{2+}$ ion to facilitate the transfer of a phosphate group onto a particular residue (serine, threonine, or tyrosine) in a substrate. However, only CDK1 is required for the successful completion of the M-phase of the cell cycle. Therefore, inhibition of CDK1 is emerging as a druggable target for diseases caused by unregulated cell proliferation. Butyrolactone I is a natural product with certain bioactivities that have been isolated from the endophytic fungus *Aspergillus terreus*. Experimental studies have revealed that butyrolactone I inhibits the activities of both CDK1 and CDK2. However, its inhibitory mechanism and the role of $Mg^{2+}$ ion remain uninvestigated. In this study, the effect of butyrolactone I on the CDK1-cyclin B complex in the presence and absence of $Mg^{2+}$ ion in the active site is evaluated by applying a computational methodology. The currently available CDK1 crystal structure does not contain any $Mg^{2+}$ ion, therefore, our first step was to position the $Mg^{2+}$ ion in the CDK1 crystal structure (PDB ID:5HQ0) based on the structural information of CDK2 (PDB ID:1HCK). The stability of this modeled structure was investigated by conducting a 200 ns molecular dynamics simulation. Subsequently, butyrolactone I was docked into the active site of CDK1 structures (with and without Mg) using AutoDock Vina, and a post molecular dynamic simulation of 200 ns was conducted for each complex. MM-GBSA binding free energy calculations were conducted to further assess the stability of the complexes. According to the free energy results, binding of butyrolactone I to the CDK1 complex was more favorable in the absence of $Mg^{2+}$ ion than its presence.

***Keywords:*** Cyclin-Dependent Kinase 1 (CDK1), $Mg^{2+}$ ion, Butyrolactone I

# Immuno and Molecular Epidemiology of *Plasmodium falciparum* in Two Previous High Malaria Endemic Foci under the Prevention of Re-establishment (POR) Phase in Sri Lanka

**Dilshan Adhikari[1], Uvindu Aryachandra[1], Sameera Viswakula[2], Renu Wickremasinghe[3], Deepika Fernando[4],** and **Preethi Udagama[1*]**

[1]Department of Zoology and Environment Sciences, Faculty of Science, University of Colombo
[2]Department of Statistics, Faculty of Science, University of Colombo
[3]Department of Parasitology, Faculty of Medical Sciences, University of Sri Jayewardenepura
[4]Department of Parasitology, Faculty of Medicine, University of Colombo
[*]preethi@zoology.cmb.ac.lk

Sri Lanka achieved malaria pre-elimination status in 2008 and was certified "malaria-free" by the WHO in 2016. POR refers to the prevention of indigenous malaria in a malaria-free country. Serology and molecular markers may serve as informative tools to determine current malaria transmission dynamics, vital to assess risk of re-establishment. CSP is essential in *P. falciparum* invasion of hepatocytes while MSP1-19 and AMA-1 are pivotal in invasion of erythrocytes. This study aimed to evaluate the efficacy of using seroprevalence and molecular approaches as potential markers of malaria transmission in a POR setting. Blood was collectedfrom residents of previous malaria endemic districts, Hambantota and Kilinochchi in 2018/2019; Nuwaraeliya served as the non-malarious, control study site. Indirect ELISAs assayed serum anti-CSP, anti-MSP1-19 and anti-AMA-1 antibodies against recombinant *P. falciparum* antigens. Sero-conversion (SCR) and sero-reversion (SRR) rates were predicted by using two simple reversible catalytic models (RCMs). Real-time PCR (RT-PCR) was performed on pooled blood samples (n=10/pool) targeting 18S rRNA region to detect any residual parasites. A total of 3122 individuals (Hambantota-1236, Kilinochchi-1395, Nuwaraeliya-491) were recruited for the study. Anti-PfCSP antibody prevalences were 2.6%, 3.0% and 0% while anti-PfMSP1-19 were 1.5%, 4.9%, 0% and corresponding anti-PfAMA-1 responses were 16.3%, 30.4% and 0% in Hambantota, Kilinochchi and Nuwaraeliya districts, respectively. A solitary striking association was observed between PfMSP1-19, PfAMA-1 seroprevalence and age categories in Kilinochchi ($p<0.01$) with the highest seroprevalence in category 40-90 years. Developed RCM-1 assumed a single force of infection estimated SCRs of 0.0012689, 0.0011569; SRRs of 0.0279742, 0.0340858 for Kilinochchi and Hambanthota respectively, for PfCSP. SCR of 0.0009935, 0.0000444; 0.006253, 0.007013 and SRR of -0.003635, -0.050560; -0.00863, 0.026297 were estimated, respectively for PfMSP1-19 and PfAMA-1. Change point of malaria transmission could not be determined using RCM-2 suggesting that RCM-1 would be ideal ($p=1$). Drastically reduced seroprevalences were observed in comparison to previous data reported in the island during control to elimination phases. Extremely low SCRs, absence ofchange point in transmission, absence of asymptomatic parasite carriers confirmed through RT-PCR, suggested absence of active transmission. Therefore, seroprevalence and molecular approaches appear to be efficient markers of malaria transmission under the POR phase.

***Keywords:*** Malaria epidemiology, Prevention of re-establishment, Serological and Molecular markers

# A Deep Learning Approach to Drought Prediction in Sri Lanka

**Eran Gamage**[1] and **Siyath Gunewardene**[1*]
[1] Department of Physics, Faculty of Science, University of Colombo, Sri Lanka
* siyath.gunewardene@phys.cmb.ac.lk

Weather forecasting has attracted the attention of many researchers of various disciplines due to its impact on the global community. With widespread availability of massive weather observation data, discovering hidden hierarchical patterns for weather forecasting using techniques such as deep learning has become popular. The Standard Precipitation Evaporation Index (SPEI), which uses both precipitation and evapotranspiration parameters in its calculation and also by being a multi-scale index has proven to better represent drought, was chosen for this study. The study focused on predicting the temporal aspect of the drought index (SPEI) using 9 different variables, of which 7 were meteorological variables and the remainder were sea surface temperature indices. Open-source meteorological data obtained from the Climate Research Unit (CRU) of University of East Anglia were used for calculating the SPEI projected for different time scales (1, 3, 6, and 12 months). Predictions were compared using both Recurrent Neural Network (RNN) and Feed Forward Neural Network (FFNN) models. The FFNN model consisted of one hidden layer and the RNN model was developed using a multilayer Long Short-Term Memory (LSTM) architecture. The model was tested on four diverse climatic regions of Sri Lanka, namely, Hambantota, Anuradhapura, Monaragala and Ratnapura. It was found that the FFNN model was able to predict SPEI based drought class; 'severely dry condition' representing the onset of drought with an accuracy of (75.5 ± 0.3) %. The overall SPEI based drought classes were best predicted using the $SPEI_{12}$ index with an overall classification accuracy of (71.1 ± 0.3) % for the region of Hambantota. It is anticipated that the prediction accuracy can be further improved by the utility of deep learning algorithms further optimized for the statistical nature of the variables considered.

# Joint Modelling of Dengue Data Using a Semi Parametric Survival Response and a Parametric Count Response

**H. H. M. Hettiarachchi**[1*] and **M. R. Sooriyarachchi**[1]
[1] Department of Statistics, Faculty of Science, University of Colombo, Sri Lanka
* himashamuvindi.info@gmail.com

In Sri Lanka, dengue has become an increasing health concern in the recent past. The spread of Dengue is influenced by the living surroundings. Therefore the dengue data are related to the climate and also correlated within districts as the weather is similar within a district. The survival time of a patient and the incidences of the disease (count) are frequently encountered phenomenon in medical studies that can be related to each other. Therefore, it is important to give attention to Dengue survival time and Dengue count simultaneously, because these can provide interesting and improved results, rather than modelling survival time and count data separately, while considering the multilevel structure of a district cluster effect. The objective of this study is to perform a joint modeling of survival time and count. A semi-parametric method for modelling the survival data is preferred as it is often difficult to determine the survival distribution, and there is also censoring of the observations. Hence, a frailty piecewise constant proportional hazard semi-parametric model with approximated baseline hazard was preferred to model the survival response. As log of counts are normally distributed, the normal model is preferred as the count sub model. The literature does not contain joint modelling of survival time and the count using the above mentioned sub models, and therefore this is an added novelty of this study. For this study, data recordings on dengue patients all over Sri Lanka from 2006 to 2008 have been used. As explanatory variables, there were the climate variables rainfall, temperature, and humidity with their first and second lag values, as well as Year, Quarter, Outcome, Age, Sex, Classification and Expected Exposed. Districts are considered as clusters. The performance of the proposed joint models is compared with univariate fixed effect models that can be fitted separately for the two responses. According to the model fit statistics which are -2 log likelihood, AIC, AICC and BIC values, the performance of the joint model was superior to the separate univariate models.

***Keywords:*** Survival Semi Parametric Modeling, Dengue, Piecewise Proportional Hazard

# Modeling and Prediction of Energetics and Mechanism of Organic Chemical Reactions: Transference of Knowledge in Deep Learning

**Kavindri D. Ranasinghe**[1] and **Adrian E. Roitberg**[1*]
[1] Department of Chemistry, University of Florida, Gainesville, FL, USA
* roitberg@ufl.edu

Computational descriptions of the physics involved in organic chemistry reactions have become a crucial tool in the toolbox for experimental groups. However, in the field of computational chemistry, a compromise between computational cost and accuracy is required to study the energetics of chemical systems. Machine-learned (ML) potentials, have enabled a remarkable progress during recent years and have proven their ability to predict energies of molecules when trained on a properly developed data set. While these potentials are fast and accurate, the majority of these highly specialized tools limit their usage to only specific molecular systems, lacking an "out-of-the-box" level of transferability.

ANAKIN-ME or ANI, is a methodology for developing a deep-learned atomistic neural network potential (NNP), the first NNP for organic molecules shown to transfer to molecular systems well outside of its training set. Extending the ANI methodology towards modeling and prediction of energetics and mechanisms of chemical reactions, the present work shows a generalized reactive ML potential for accurate organic reaction profiles. This is achieved through building a modified sampling technique, together with an autonomous data selection and learning algorithm based on the concept query-by-committee, that works off the correlation between accuracy and standard deviation of predictions made by an ensemble of ML models for intelligent sampling of the chemical space. The resulting potential represents an example that machine learning can reuse existing knowledge in determining the energetics for similar types of reaction classes it was trained on, extending low error to systems well outside of the training data set. With the enhancement of the chemical space covered, while maintaining universality in the systems it can be applied to, the new ANI potential can be a powerful tool to assist organic chemists and a game changer in the field of drug discovery.

***Keywords**:* Deep learning, Active learning, Reactive molecular potentials

# Rotational Dynamics of Water Molecules in the Vicinity of a Collagen Microfibril Using Molecular Dynamics Simulations

**W. L. Wageesha Widuranga[1]** and **W. A. M. Madhavi[2]***
[1,2]Department of Physics, University of Colombo, Sri Lanka
*monika.madhavi@phys.cmb.ac.lk

Collagen is the major macromolecular constituent of the extracellular matrix of tissues such as cartilage, tendon and ligament. Water plays a major role in the function of these tissues. The water molecules bound to collagen molecules were found to have restricted their motion as a result of binding to specific sites in the collagen triple helix. Based on experimental results, these collagen-bound water molecules which are termed as water bridges are expected to exhibit dynamics and thermodynamics of one-dimensional ice. However, molecular dynamics (MD) simulation-based studies have failed to observe ice-like water bridges. We hypothesized that this difference occurs due to the fact that experimental studies have conducted on whole tissues with large-scale collagen fiber assemblies, while MD simulations have only been conducted on individual tropocollagen fragments.

In the present study, dynamics of water molecules in the vicinity of a collagen microfibril, a larger collagen structure with seven tropocollagen molecules were studied using molecular dynamics simulations. The microfibril structure was constructed by placing six collagen molecules peripheral to a tropocollagen placed in the middle. Each tropocollagen fragment was placed relative to the central molecule at a position where time-averaged potential energy of the system is minimal. The optimal microfibril structure obtained was a distorted hexagonal with a collagen molecule in the middle. This structure found to be compatible with microfibril structures obtained in previous studies.

Constructed collagen microfibril was solvated in a water box and the dynamics of the collagen bound water molecules were studied. Translational motion of long-lived water molecules within a shell of 3 Å from the surface of the microfibril was traced and their binding nature was studied during the time they were translationally restricted. Long-lived water molecules found to be forming two types of water bridges; bridges formed within the triple-helix and the bridges formed between two collagen fragments. Compared to previous studies with a single tropocollagen fragment, an order of magnitude increase in the residence times of water molecules at the bridge sites within the microfibril structure was observed. Further investigations need to be done at all similar bridge sites within the collagen microfibril to verify the existence of long-lived water bridges.

***Keywords:*** Collagen, Molecular dynamics, Water bridges

# Modulatory Role of TMPRSS6 (Transmembrane Serine Protease 6) rs855791T>C Polymorphism on Iron Homeostasis: an *in-silico* Protein-protein Docking Model

**H. L. T. C. Abeywickrama [1], L. Samaranayake [2], T. Thoradeniya [3],** and **G. H. Galhena [1*]**
[1] Department of Zoology and Environment Sciences, Faculty of Science, University of Colombo
[2] Department of Chemistry and Chemical Biology, Northeastern University
[3] Department of Biochemistry and Molecular Biology, Faculty of Medicine, University of Colombo
*gayani@zoology.cmb.ac.lk

The molecular mechanisms of iron deficiency (ID), the most common global nutritional problem, are not yet fully understood. Regulatory messenger molecules like TMPRSS6 (transmembrane serine protease 6) play a vital role in systemic iron homeostasis. When iron levels are low TMPRSS6 cleaves membrane bound hemojuvelin (HJV) causing a negative regulation of BMP-SMAD (Bone morphogenetic proteins-sons of mothers against decapentaplegic) signaling to inhibit hepcidin, the master regulator of iron, and restore iron balance. Our previous study on TMPRSS6 gene among pregnant women, has shown rs855791T>C polymorphism in *TMPRSS6* gene to be associated with ID in the presence of T allele. rs855791T>C is a missense variant in the catalytic domain of TMPRSS6 protein and causes valine (V; by T allele) to alanine (A; by C allele) change at 736 position. Functional studies have demonstrated that, 736A variant inhibits hepcidin more than 736V variant. This may explain the high risk of ID in the presence of latter in our previous study, although the exact mechanism is not yet clarified. We attempted predicting possible molecular mechanisms of rs855791T>C polymorphism and ID using an *in-silico* protein–protein docking model. YASARA workplace was used to build the homology models of HJV and TMPRSS6 proteins. Amino acid changes corresponding to rs855791 SNP were introduced to TMPRSS6 protein using Schrödinger Maestro v 9.0 to obtain the two protein variants. The predicted protein models were validated with Ramachandran plots using RAMPAGE online server. Two protein-protein docking web servers, PatchDock and FireDock were used to predict the protein complexes made by HJV with the two TMPRSS6 protein variants. This was followed by a local docking carried out using Rosetta web server. Interface energy was calculated for these complexes through ROSIE. The complex made of TMPRSS6-736V and HJV generated an interface energy of -4.689 kJ/mol while the complex made of TMPRSS6-736A and HJV generated an interface energy of -7.934 kJ/mol. These results suggest that the TMPRSS6-736A: HJV complex to be thermodynamically more stable than the TMPRSS6-736V: HJV complex. This may explain the observed high risk of ID in the presence of 736V variant, favouring hepcidin action, in pregnant women studied, which warrant further exploration.

***Keywords:*** Iron deficiency, Protein docking, Interface energy

# *In silico* Identification of Natural Product Inhibitors of HMG-CoA Reductase

**Chinthaka N. Ratnaweera[1],** and **Archchana Ganeshalingam[2]**
[1] Department of Chemistry, University of Ruhuna, Matara, Sri Lanka
[2] College of Chemical Sciences, Institute of Chemistry Ceylon, Rajagiriya, Sri Lanka
* nadun@chem.ruh.ac.lk

Coronary heart disease caused by hypercholesterolemia, an elevated cholesterol level in blood is one of the most studied diseases in the world along with cancer and AIDS. Inhibition of 3-hydroxy-3-methylglutaryl-coenzyme A reductase (HMG-CoA reductase) which is the rate determining enzyme in the cholesterol synthesizing mevalonate pathway has been proven to control serum cholesterol levels. Statins that are currently used as medication for hypercholesterolemia have been found to result in certain side effects. Since hypercholesterolemia is a chronic condition needing lifelong therapy, the use of natural product-based drugs can be more beneficial. Therefore, in this study, natural product compounds isolated from various plants that are used as drugs for hypercholesterolemia in ayurvedic medicine have been investigated for their inhibitor activity against the enzyme using molecular docking and molecular dynamics simulations. HMG-CoA reductase is a tightly associated tetramer with a bipartite active site. The crystal structure of HMG-CoA reductase (PDB ID: 3CCZ) was retrieved from the RCSB PDB database. For the initial model, only chains A and B were retained while the remaining chains and all other non-standard residues were removed using Chimera. The stability of the model was investigated through a 100 ns molecular dynamic simulation. Subsequently, selected compounds were docked to the enzyme using the Autodock Vina algorithm in PyRx software. Several commercially available statins along with the original inhibitor ligand in the crystal structure were considered as references. Some complexes with the highest negative binding affinity were studied with a 100 ns molecular dynamic simulation. Drug likeliness of the natural product compounds used as ligands was studied using online servers SwissADME and ProTox-II. Results revealed that several of the natural product compounds studied had comparable binding affinities (> -7.0 kcal/mol) to the references and show drug likeliness with one or no Lipinski violations and acceptable toxicity. The RMSD vs time plots generated for some of the complexes show stability as well. Hence, are being considered for future studies involving GBSA calculations and hydrogen bond analysis to further investigate the stability of the complexes. Among them, coclaurine emerges as a probable candidate for further studies relating to drug development.

***Keywords**:* hypercholesterolemia, HMG-CoA reductase, natural product inhibitors

# Identification and Classification of Covid-19 According to the Severity by Lung CT Scan Images Using Machine Learning and Image Processing Techniques

**W.A.M. Kalpanie[1*], U.P. Liyanage[2],** and **W.M.D.N. Wijeyaratne[3]**
[1] Department of Mathematics, Faculty of Science, University of Colombo, Sri Lanka
[2] Department of Statistics and Computer Science, University of Kelaniya, Sri Lanka
[3] Department of Zoology and Environmental Management, University of Kelaniya, Sri Lanka
* wkalpanie96@gmail.com

The Covid-19 is one of the most fatal pandemics that we have ever experienced in global level. The severity of the Covid-19 effect is highly dependent on not only the immunity but also the other pre-infirmities of the infected person. Currently, the Covid-19 detection is well managed by medical tests such as PCR and Rapid-Antigen test. However, classification of the severity of lung condition of a Covid-19 infected person, is very important to assist the patient, and also to reduce the fatality rates. Addressing this need, the present study proposes a mechanism to detect Covid-19 infection and to classify the Covid-19 caused lung severity levels using CT-scan images. The study focuses on 3 severity levels of lung conditions that are based on spread pneumonia over the lung inner volume. Further, machine learning techniques, namely the Convolution Neural Network (CNN), and image processing techniques are used to analyze the CT-scan images to identify the infection and to classify the severity level. Herein, the analysis used CT-scan images shared by Union Hospital and Liyuan hospital, China. Identification of Covid-19 infection is done by VGG16-CNN model trained and tested approximately 2000 images. Without any image processing techniques, the model accuracy is about 80%, nevertheless, the prediction accuracy was about a maximum of 68%. However, the prediction accuracy has been improved up-to 100% as per the used images, by utilizing the Sequential–CNN model trained and tested by gray-scaled CT-Scan images. Thus, the Sequential–CNN model has well responded in analyzing CT-Scan images of Covid-19 infected patients. Thereby, the Sequential–CNN model, which is trained with gray-scaled CT-scan images, is used to classify the severity levels. Based on the used images, the maximum model accuracy level is about 96% and the prediction accuracy is 100% for “Level-1”, 77% for “Level-2” and 100% for “Level-3”, based on the confusion matrix. According to the results, it can be concluded that the Covid-19 diagnosis can be accurately conducted using CNN models. More importantly, the severity level can be detected with very high accuracy by using CT-scan images and machine learning techniques, leading to the formation of early responding medical expert systems.

***Keywords:*** Convolution Neural Network, Covid 19 severity, Covid 19 diagnosis

# Modelling and Simulating the Transmission Dynamics of COVID-19 Using Agent-Based Modelling

**Ruklan P. Kularatne**[1] and **Upul J. Sonnadara**[1*]
[1] Department of Physics, University of Colombo, Colombo 3
* upul@ phys.cmb.ac.lk

Viral diseases have affected human lives throughout human history. The latest virus to affect human lives throughout the world is the Coronavirus 2019 (COVID-19). Predicting the transmission dynamics of the COVID-19 helps policymakers and health care workers to minimize social and economic impacts due to the virus while keeping the number of deaths and infected cases minimum. Conventional compartment models are widely used to mimic the spread of epidemics. But these models are much inferior compared to agent-based models as compartment models assume homogeneity of compartment populations. Therefore, an agent-based modelling technique was used to predict the transmission dynamics of COVID-19 in this study. Previously developed agent-based models (ABMs) were used to mimic the spread of the virus. The transmission dynamics of COVID-19 was explored considering two parameters, the probability of contracting the virus (chance of infection) and the number of contacts per person (random contacts). Two ABMs were used to predict the number of infected cases. As expected both ABMs suggest that if the parameters 'chance of infection' or 'number of random contacts' increases, the infection curve peak at a shorter time and peak value increases. The spatial ABM takes more time to reach the peak than the non-spatial ABM and the highest number of infections is lower than the non-spatial one. The predictions done by the spatial ABM can be said to be more realistic since it relates to individuals having more contacts with their families and neighbours than outsiders. Since ABMs consider the heterogeneity of individuals, they can be used for scenario modelling such as lockdowns, vaccinations etc.

***Keywords:*** COVID-19, Agent-based Modelling, Infectious Disease Modelling.

# Numerical Investigation of a Mathematical Model for CD4+ and Cytokines Interaction on Tumour Growth

**Sachin Chandrasekara[1*]** and **L.W. Somathilake[1]**
[1] Department of Mathematics, Faculty of Science, University of Ruhuna, Sri Lanka
*sachikavindaa@gmail.com

Immunotherapy is a treatment used at present for treating and healing malignant tumours. It treats the illness by induction, enhancement, or suppression of an immune response. To enhance the immune system, it usually employs cytokines in parallel with the adoptive cellular transition. As our understanding of tumour-immune cell interactions has fully grown, experimental analysis has been supplemented by mathematical modelling to live and predict these interactions. Consistent with recent findings, many tumours are immuno-selected to avoid detection by standard cytotoxic T lymphocytes. This work looks into a mathematical model for the tumour, CD4+ lymph cell, and cytokine interactions to research tumour dynamics and potential interactions of growth and dormancy. Also, based on the results of the considered mathematical model, treatment with either CD4+ T cells or the cytokine IL-4 are being investigated. It is also seen that if the tumour is identified early, the tumour cells can be reduced and regulated with CD4+ treatment. When cytokine treatment is being used, it is possible to thoroughly remove the tumour when the tumour size is at the level of its early stages. If the drug doses are large enough, the treatment will eradicate all tumour cells regardless of tumour conditions. Although the treatment dose is in the middle range, and the tumour's antigenicity $\beta$ is substantial, the tumour can be destroyed depending on its parameter regimes. The numerical simulation performed in our work indicates that cytokine treatments are more successful than transferring CD4+ T cells because cytokine treatments will fully clear the tumour cells.

# Detecting Basal Cell Carcinoma Using Convolutional Neural Networks (CNN) and Image Processing Techniques

**P. G. A. Nayanthara[1*], U. P. Liyanage[2],** and **W. M. D. N. Wijeyaratne[3]**
[1] Department of Mathematics, University of Colombo, Sri Lanka
[2] Department of Statistics & Computer Science, University of Kelaniya, Sri Lanka
[3] Department of Zoology and Environmental Management, University of Kelaniya, Sri Lanka
* anudi.nayanthara@gmail.com

Cancer can be considered as one of the major health problems in the world. Among all cancer types, cases of skin cancer reach 5.9-7.8% every year. Skin cancer is caused by DNA mutation leading to abnormalities of skin tissues. Typically, this DNA mutation is mostly caused the by over-exposure of skin-cells to UV radiation. There are several types of skin cancers such as Basal Cell Carcinoma (BCC), and Melanoma, etc. Among all these skin cancers, BCC can be considered as the most common type. Dermatoscopic images can be used to identify BCC, where doctors can decide the skin condition based on the image characteristics. Early diagnosis and immediate treatments will be much helpful to avoid the cancer spreading and severities. Further, a prompt diagnosis can lead to a very high probability of curing using harm reduction treatments. Machine learning techniques such as CNN and image processing techniques play an important role in medical image diagnosis, and also, it has been tested and utilized in many medical expert systems. The solution proposed in this work presents a computer aided system for dragonizing BCC using CNN and image processing techniques. The inputs to the system is the dermatoscopic images of the susceptive cases. CNN and image processing techniques are combined to analyze and conclude the presence of BCC. The HAM10000 dataset consisting about 10000 dermatoscopic images, is used to analyze and train CNN models, namely InceptionV3 and Sequential, towards BCC diagnosis. Accuracy of the cancer identification is vital as the outcomes will be utilized in initialization of early treatments. Thereby, appropriate measures such as organization of training dataset and also application of preprocessing technique: converting RGB images to grayscale, have been taken to improve the accuracy. Based on the training dataset, the InceptionV3 model gave accuracies for training and validation within the range of 45%-55%. However, the Sequential model with grayscale images resulted in a 90% (Without using grayscale images accuracy is 52%) of accuracy after preprocessing the images. Thus, this study has demonstrated that correct combination of image preprocessing techniques with CNN algorithms can be utilized in skin cancer detection with reasonable accuracy.

***Keywords:*** Cancer detection, Machine learning, Image processing and classifications

# Analyzing the Early Stage of COVID-19 Transmission in Sri Lanka via a Multi–patch Compartmental Model

**Y. Jayathunga[1*], K. K. W. H. Erandi[1], N. C. Ganegoda[2],** and **S. S. N. Perera[1]**
[1] Research & Development Centre for Mathematical Modelling, Department of Mathematics, University of Colombo, Sri Lanka.
[2] Department of Mathematics, University of Sri Jayewardenepura, Nugegoda, Sri Lanka.
* yashika@maths.cmb.ac.lk

The main focus of this work is modelling the spread of COVID-19 within a multi-patch environment. The proposed model incorporates the short-term mobility and a mobility matrix. A SQIHR model including close contact tracing combined with human mobility within patches is discussed. Different scenarios of the imposed mobility restrictions are illustrated with the numerical simulations for the early stage of disease spread in Sri Lanka. The spread of the disease from a hot-spot to the local areas with no initial disease is numerically illustrated. Furthermore, the effectiveness of the close contact tracing of an infected patient is also addressed.

***Keywords:*** COVID-19, multi-patch compartmental model, mobility matrix, contact-tracing with mobility restrictions

# Age Structured Simulation Model for the Spread of COVID-19; a Trial for San Francisco City Data

**Geeshath Panditharatne[1], Hasitha Erandi[1*], Naleen Ganegoda[2],** and **Paduma Eranga[1]**
[1]Department of Mathematics, University of Colombo, Sri Lanka
[2]Department of Mathematics, University of Sri Jayewardenepura, Sri Lanka
* hasitha.erandi@yahoo.com

Epidemiological models have been of immense use in modelling the spread of infectious diseases and these models have been used to understand the dynamics of infectious diseases and to make predictions on how the disease will progress in the future. In this study we develop an age structured extended version of the classical compartmental model to better understand the age specific spread of COVID-19 disease in San Francisco city. We fit actual data into the model to find age specific parameters of the spread of the virus using mathematical methods and the behavior of each infected age group is predicted using the estimated parameters. A sensitivity analysis has been performed to understand the most critical parameters. Furthermore, a parameterized version of the model has been used to determine the change of parameter values due to the effect of the control strategies imposed. It was observed that the age groups 20-40 and 40-60 had a greater impact on the spread of the virus in San Francisco city. The spread of the virus could have been drastically reduced if age specific control measures were implemented on above age groups. The implementation of the mandatory face masks policy resulted in reducing the effective exposure(contact) rate by 50%, whereas the relaxation of the stay-at-home policy almost neutralized the reduction of the parameters.

***Keywords:*** Age-structured, compartmental models, COVID-19

# Developing a Probability Model for Identifying the Dynamics of Viral Marketing

**J.G.S.C. Sampath[1*], S.S.N. Perera[1],** and **S.D. Perera[2]**
[1]Department of Mathematics, Faculty of Science, University of Colombo, Sri Lanka
[2]Department of Decision Sciences, Faculty of Business, University of Moratuwa, Sri Lanka
[*] julgahagamage3545@gmail.com

In the modern world among many strategies of marketing, viral marketing (also known as the word-of-mouth) has become a popular strategy among marketeers all over the world. However, due to lack of accurate mathematical studies to model the dynamics of viral marketing, identifying optimal strategies that trigger a viral campaign has been a difficult task. After studying the process of viral marketing, a similarity between the process of viral marketing and the process of spreading of an infectious disease to a large number of people was identified. In this work, a mathematical model based on the SIR epidemiological model is developed to identify the dynamics of viral marketing. By changing the values $\beta$ (probability of moving from the target audience to consumers who share the message), the dynamics of the SIR model with respect to susceptible, infected and recovered populations were investigated and subsequently converted into the viral marketing context. Further the model was extended by incorporating a function for $\beta$. This model was validated using a data set, which was obtained from the views of some YouTube videos. It can be seen from the results that, as the value of $\beta$ increases, the spreading of a message occurs faster and a successful viral marketing campaign can be accomplished.

# Validation of Mathematically Modeled Serological Data to Compare Malaria Transmission Intensities between Two Previous High Malaria Endemic Districts in Sri Lanka under the Prevention of Re-establishment Phase

**Uvindu Aryachandra[1], Dilshan Adhikari[1], Sameera Viswakula[2], Renu Wickremasinghe[3], Deepika Fernando[4],** and **Preethi Udagama[1*]**

[1]Department of Zoology and Environment Sciences, Faculty of Science, University of Colombo
[2]Department of Statistics, Faculty of Science, University of Colombo
[3]Department of Parasitology, Faculty of Medical Sciences, University of Sri Jayewardenepura
[4]Department of Parasitology, Faculty of Medicine, University of Colombo
[*]preethi@zoology.cmb.ac.lk

Sri Lanka has been co endemic to both *Plasmodium vivax* and *P. falciparum* for eons. Achieving malaria pre elimination status in 2008, in 2016 the country was certified malaria free by WHO. Sri Lanka's vulnerability and receptivity to malaria remain high with the persistence of vector mosquitos of the genus *Anopheles*, and a sporadic influx of imported malaria cases, rendering surveillance a critical requirement. Serology proved to rectify the lost precision of the existing malariometrics over declining numbers of cases, yet requires further validation. This study aimed to validate serology as a marker of malaria transmission intensity and to compare the levels of anti-malarial antibodies in two previously high malaria districts; Hambantota and Kilinochchi. Non-malarious Nuwaraeliya district served as the control site. Indirect ELISA measured seroprevalences against three recombinant marker antigens each from *P. vivax* and *P. falciparum* (CSP, MSP1, and AMA1). The control site showed zero seroprevalence against all markers. Based on respondents' seroprevalence and age, seroconversion rates for test districts were estimated using two reversible catalytic models and the loglikelihood ratio test determined the best data fitting model. Changes in transmission intensity were identified for the two previous malaria districts, concerning anti MSP1, AMA1, and CSP antibodies, in parallel to both *P. vivax* and *P. falciparum*. As per model-1, seroconversion rates of Hambantota and Kilinochchi were 0.0057 and 0.00121, 0.00023 and 0.00049, 0.00064 and 0.00138 and 0.00116 and 0.00127, 0.00004 and 0.00099, 0.00701 and 0.00625 for CSP, MSP1, AMA1 to *P. vivax* and *P. falciparum*, respectively. As per Model-2, Past and present seroconversion rates of Hambantota, Kilinochchi of *P.vivax* were –0.00049 and 0.00038, 1.11604 and 0.00064 for CSP, -0.00005 and 0.00009, 0.02243 and 0.00098 for MSP and 0.20494 and 0.00180, 0.00707 and 0.00050 for AMA1, while those of *P. falciparum* were 3.41184 and 0.00022, 0.34468 and 0.00127 for CSP, 3.41184 and 0.00022, -0.00123 and 0.00069 for MSP1, -0.00324 and 0.00487, -0.00099 and 0.00109 for AMA1.The likelihood ratio test determined thatModel-1 had the best-fit data ($p$=1). In conclusion, more recent infections of Kilinochchi in contrast to Hambantota, traced by seroconversion rates, showed the efficacy of serology in estimating malaria transmission intensities under malaria eliminated settings.

***Keywords:*** Malaria, Prevention of re-establishment, serology

# Linear and Quadratic Fuzzy Valued Regression Model

**Mrutyunjaya Sahoo**[1*] and **S. Chakraverty**[1]
[1] NIT, Rourkela
* mrutyunjay.sahoo716@gmail.com

In this work, we have discussed the concept of a fuzzy variable and the corresponding expectation. Based on this concept, we introduce a fuzzy regression model known as fuzzy valued regression model (FVRM) to approximate the fuzzy coefficients. Firstly, we have designed a linear regression model and this idea has been extended to the quadratic case. Trapezoidal fuzzy numbers have been used to express both input and output fuzzy variables. We have illustrated our approach with some numerical examples.

***Keywords:*** Fuzzy variable, Excepted value, Fuzzy linear and quadratic regression model.

# Term Structure Model for Sri Lankan Bond Market

**Lorraine Dehoedt**[1*] and **J. K. Wijerathna**[1]
[1] Department of Mathematics, University of Colombo, Sri Lanka
* lorrainedehoedt@gmail.com

Modelling the term structure of interest rates is one of the most challenging topic in quantitative finance. This research employed a quantitative research design to determine the most suitable term structure model to estimate the Sri Lankan yield curve. To achieve this, we considered primary and secondary market treasury securities issued by the Central Bank of Sri Lanka from Jan-2014 to Dec-2019 on a weekly basis and Jan-2018 to Dec-2019 on daily basis respectively.

The Nelson-Seigel models were calibrated and compared using the absolute accuracy error method and the statistical t-test method. Both methods confirmed that the Dynamic Nelson-Seigel Svensson (DNSS) model fitted to the Sri Lankan yields curve with a higher precision than Dynamic Nelson-Seigel (DNS) model.

***Keywords:*** Dynamic Nelson-Siegel, Dynamic Nelson-Siegel Svensson, Term structure model

# Fast and Practical Algorithms for Solving Non-square Linear Systems

**Claus Fieker**[1*] and **Jayantha Suranimalee**[2]
[1] University of Kaiserslautern, Germany
[2] University of Colombo, Sri Lanka
* fieker@mathematik.uni-kl.de

In this paper we present a deterministic algorithm for solving a non-square linear system over rationals and number fields. When the solution is not unique, we compute a basis for the kernel to normalize the solution. In this computation we use a modified version of Dixon's algorithm. We rigorously assess its complexity as $O\sim(m^3d^2 + m^2nd + m^2d^5)$ operations over $\mathbb{Z}$, where as the Gaussian method takes $O\sim(m^3n^2d^2)$ operations to solve a linear $m \times n$ system $Ax = b$ over number field *K* of degree *d*.

***Keywords:*** Non-square linear system, Kernel, Dixon's algorithm

# Developing Force Field Parameters for a New Class of Biomolecules – Sulfated Poly-Amido-Saccharides

**A. Bandara**[1,2*], **H. E. Caputo**[1], **J. McNeely**[1], **M. W. Grinstaff** [1], and **J. E. Straub**[1]
[1] Department of Chemistry, Boston University, Boston, MA, USA
[2] Pledge Therapeutics, Canton, MA, USA
* abandara@pledge-tx.com

Poly-amido-saccharides (PASs) are an important class of synthetic biomolecules that share many features such as defined stereochemistry, hydrophilicity, and the backbone pyranose rings with their natural polysaccharide counterparts. Substituted polysaccharides like sulfated-PAS play a wider array of functions in biological systems, including maintaining the structural integrity of tissues and cell signaling. It is expected that the sulfate substitution of the synthetic bimolecular class of PASs would enhance their biological applications by improving their physicochemical properties. [1]

Chin et al. have previously developed parameters for simulating PASs with the CHARMM36 force field [2]. Here, we expand their work to present a set of parameters for sulfated-PASs within the CHARMM36 additive all-atom force field framework. We have narrowed our focus to glucose-derived PAS in this study. To model the sulfate groups substituted at 3-, 6-, and 3,6-positions of the carbohydrate ring, we employ parameter sets of sulfates linked to carbohydrates developed by Mallajosyula and coworkers [3].

Extensive molecular dynamics simulations and *Ab-initio* calculations were performed for 3-sulfated, 6-sulfated, and 3,6-bi-sulfated-PAS systems at the monomer and polymer level. Chin et al. have established the two dihedral angles order parameters φ and ψ that encompass the unique C–N and C–C bonds that repeat along the backbone to probe the potential energy surface of the PASs. In the case of sulfated-PASs, minima and barriers in MM potential energy surfaces show qualitative similarities to the one-dimensional QM scans at the DFT level, establishing the accuracy of the parameter set. The parameterization of CHARMM36 force field was carried out at MP2/6-31+G(d) level [3]. As we have employed pre-exiting parameters for PAS and sulfate substituents in an additive manner, we used more computationally efficient DFT based composite PBEh-3c7 method, which has been shown to give MP2-like performance for small-to-medium-sized organic molecules.

We have performed extensive MD simulations of sulfated and un-sulfated PAS monomers in aqueous environments showing the stability of the simulated systems and characterized transitions across torsional barriers in high-temperature simulations. We then investigate the polymeric behavior of sulfated-PAS and the effect of sulfation at 3- and 6-positions by performing MD simulations of 10-mers of each type in aqueous environments.

We observe that the 6-sulfated-PAS polymers behave similarly to the un-sulfated-PAS, but 3-sulfated-PAS polymers are highly helical and rigid. The CHARMM36 force field parameters, topologies, and initial structures for the un-sulfated, 3-sulfated, 6-sulfated, and 3,6-bi-sulfated PAS monomers are available through the GitHub repository (https://github.com/emasangabandara/sulfated-PAS-modelling/).

***Keywords:*** CHARRMM36 Force Field Parameters, PAS, MD Simulations

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# In-silico Investigation to Predict the Potential of HDAC Inhibitors to Inhibit the HDLP Enzyme: A Molecular Dynamics Study

**R. Dushanan[1], S. Weerasinghe[2], D. P. Dissanayake[2],** and **R. Senthilnithy[1*]**
[1] Department of Chemistry, The Open University of Sri Lanka, Nugegoda, Sri Lanka
[2] Department of Chemistry, University of Colombo, Sri Lanka
* rsent@ou.ac.lk

Histone deacetylase (HDACs) enzyme plays an important role in regulating gene expression, thus could be considered as an effective target for cancer treatment. HDAC inhibitors are the new and promising class of drugs that restrict tumor cells from growing. In this study, the inhibitory efficacy of some HDAC inhibitors such as SAHA, LBH589, ITF2357, and PXD101 was studied using molecular dynamics simulation. The inhibitory efficacy was examined in terms of stability of the enzyme, potential energy of the system, the number of hydrogen bonds, and interaction energies between HDLP enzyme and inhibitor. It is hoped that this research will help to get a better understanding of the atomic-level nature of the inhibitor binding site and how HDAC inhibitors modify the active site of the HDLP enzyme. The RMSD and potential energy have revealed that the stability of HDLP enzyme with SAHA, LBH589, and ITF2357 is higher than the wild-type HDLP (apo form). According to the calculated values for interaction energies, the stability of the HDLP enzyme varies as LBH589 > SAHA > ITF2357 > PXD101, and the distance analysis also shows the same trend. The findings revealed that the LBH589 is a potential lead compound similar to the reference inhibitor SAHA. Therefore, it is possible to suggest this molecule to further clinical researches and clinical tests. Also, the outcomes of this study could be utilized to discover new potent inhibitors for clinical research.

***Keywords:*** HDAC inhibitors, PRODRG online server, SAHA

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# Evolution of COVID-19: Analysis through Growth Models

**M. M. Y. E. Marasinghe[1*], A. M. C. H. Attanayake[2], S. K. P. Eranga[1],** and **S. S. N. Perera[1]**
[1]Research & Development Centre for Mathematical Modelling, Department of Mathematics, Faculty of Science, University of Colombo
[2]Department of Statistics & Computer Science, Faculty of Science, University of Kelaniya
*yahanievmini@gmail.com

Exponential, logistic, Gompertz and Richards models are classical growth models which are widely used to model population growths. In this work, the practical use of the mentioned models was identified by fitting these models to the COVID-19 pandemic data using the nonlinear regression method. The models were fitted to the monthly reported total and active COVID-19 cases of the countries; USA, Italy, France, Russia and Brazil using the data from February 15, 2020, to August 15, 2020. The Coefficient of determination ($R^2$) and Root Mean Squared Error (RMSE) were used to determine the best fitting growth curve for each country in each month. Further, the study discussed how each country's social circumstances affect the growth pattern of the pandemic. Results concluded that at the initial stage of the pandemic, it has shown a logistic growth and then it has shown a Richards growth. Thereafter it has shown logistic growth again, after the arrival of the second wave of the pandemic. However, in the second wave, the logistic growth has existed more time period than the first wave. Findings of this study can be used to compare the growth dynamics of the first wave of the pandemic and the second wave of the pandemic as well as to understand the growth patterns of COVID-19 across countries.

***Keywords:*** COVID-19, Growth models and Nonlinear regression method

# Hamming Distance Labeling on Path-related Graphs

**K. Thirusangu[1*], S. Seethalakshmi[2],** and **E. Esakkiammal[3]**
[1] Department of Mathematics, S.I.V.E.T. College, Gowrivakkam, Chennai,India
[2] Department of Mathematics, R.V.Govt.Arts College, Chengalpattu, Chennai,India
[3] Department of Mathematics, S.I.V.E.T. College, Gowrivakkam, Chennai,India
* kthirusangu@gmail.com

Computers use bit or binary digits to store data. A byte is an eight binary digits long unit used by computers to represent a character, a number or a letter. A binary string is a sequence of bytes. The Hamming distance is a metric used to compare two binary strings of equal length and is defined as the number of bit positions in which the two binary strings differ. The hamming distance between two binary strings of equal length *m* and *n* is denoted by *hd*(*m, n*). Hamming distance between two strings is used for error detection in data transmission and in coding theory. In this paper, a new labeling called hamming distance labeling is introduced and is defined as follows: Let *G* be a graph with vertex set *V* and edge set *E*. The function $f: V \to N \cup \{0\}$ is said to be hamming distance labeling if there exist an induced function $f* : E \to \{1,2, \dots n\}$ such that for every edge $uv \in E$, $f*(uv) = hd([f(u)]_2, [f(v)]_2)$ satisfies the following conditions:

(i) for every vertex $v \in V$, the set of all edges incident with $v$ receive distinct labels.

(ii) for every edge $e = uv \in E$ the adjacent vertices $u$ and $v$ receive distinct labels.

The hamming distance number of a graph *G* is the least positive integer n such that $2^n - 1 \geq k$, where $k = \max\{f(v)/v \in V\}$ and is denoted by $\eta_{hd}(G)$. Here the notation $[x]_2$ denotes the binary conversion of the number *x*. Hamming distance labeling is used for transmitting secret messages in cryptography. Here the existences of hamming distance labeling of path graph, *y*-tree graph, comb graph and ladder graph were studied, and their hamming distance number were obtained

***Keywords:*** Hamming distance, Hamming distance labeling, Path related graphs.

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# Correlating Stability of Substituted Cobaltocenium [bis(cyclopentadienyl)cobalt(III)] with the Computed Molecular Properties

**Shehani T. Wetthasinghe, Tianyu Zhu, Chunyan Li, Chuanbing Tang, Qi Wang, Vitaly Rassolov,** and **Sophya Garashchuk ***

[1] Department of Chemistry and Biochemistry, University of South Carolina, Columbia, SC 29208

[2] Department of Mathematics, University of South Carolina, Columbia, SC 29208

* garashchuk@sc.edu

The "Fuel cells" have received the global attention over past few years due to the depletion of world's fossil fuel sources. The polyelectrolyte-based membrane is the key component of a fuel cell which acts as the ionic conductor between two electrodes. While anion exchange membranes (AEMs) in alkaline fuel cells are highly efficient and economical, traditional quaternary ammonium cations could suffer catastrophic degradation under highly alkaline conditions. To overcome this challenge, it is suggested to use membranes with alkaline stable metal cations over conventional organo-polyelectrolytes. [1] Cobaltocenium ($CoCp_2^+$) derivatives are considered for use in AEMs because of their excellent thermal and alkaline stability under operating conditions of a fuel cell. Since synthesis and characterization of the full range of possible derivatives is very demanding, the computational study of the bond dissociation energy (BDE) between cyclopentadienyl (*Cp*) and $CoCp^+$ in $CoCp_2^+$ cations may provide a useful guidance to experiments. [2, 3]

Here, we present a potentially more efficient approach for estimating the BDEs based-on the electronic structure enhanced by the machine learning (ML) techniques. In this study, we perform density functional theory (DFT) calculations for di and multi substituted derivatives of $CoCp_2$+ in aqueous medium using B3LYP-D3 functional with m6-31g*/6-31g** basis set combination. Within the aqueous environment, the positive charge of the metal cation is neutralized by the hydroxide anion through formation of the $CoCp_2OH$ complexes. The derivatives include a variety of electron-donating and electron-withdrawing groups as substituents to both *Cp*s in the $CoCp_2$+ cation. We have identified that BDEs correlate with a few chemical and machine-learnable descriptors related to the electron withdrawing/ donating character of the substituents, leading towards a predictive ML model of the BDEs as measures of stability of the metal cations in polyelectrolytes.

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# Machine-learning-assisted Classification of Thermodynamic Phases in the Classical Heisenberg Antiferromagnet on a Triangular Lattice

**Chanuka Karavita**[1], **Charuka Senavirathna**[2], and **Dilina Perera**[3*]
[1] Wiley Global Technology (Pvt.) Limited
[2] The Open University of Sri Lanka
[3] Department of Physics, University of Colombo
* dilinanp@phys.cmb.ac.lk

The classical Heisenberg antiferromagnet on a triangular lattice is a geometrically frustrated spin system with a rich thermodynamic behaviour. In the presence of an applied magnetic field, the model exhibits multiple distinct phases separated by phase transitions driven by different mechanisms. In this study, we apply semi-supervised and unsupervised machine learning methods to characterize the thermodynamic phases and locate the transition temperatures of the model. As input samples for the machine learning algorithms, we use thermalized spin configurations at different temperatures generated by parallel tempering Monte Carlo simulations. To locate the transition temperatures, we use a semi-supervised neural-network-based approach known as the confusion scheme, which relies on repetitive altering of the proposed sample labels to improve the performance of the neural network. The results for the zero-field case shows the expected continuous transition from the paramagnetic phase to the coplanar 120° phase as the temperature is lowered. For the field value h = 2, we observe the expected double transitions, with the system first passing from the paramagnetic phase to a collinear one-third magnetization plateau through a three-state Potts-type transition, and then to a canted version of the 120° phase via a Berezinskii-Kosterlitz-Thouless transition with quasi-long-range order. Our results indicate that the confusion scheme is capable of detecting different types of transitions, irrespective of the differences in the underlying mechanisms. For the visual identification of distinct phases, we apply principal component analysis and project the spin configurations onto the plane of the two leading principal components. For h = 2, the results show a clear separation between the paramagnetic phase and the two ordered phases.

***Keywords:*** Machine learning, Monte Carlo, Phase transitions

# Application of Optimal Control Theory to an Insulin-Glucose Model

**R. P. S de Zoysa[1*]** and **W. P. T Hansameenu[1]**
[1] Department of Mathematics, University of Kelaniya, Sri Lanka
* pramudi95z@gmail.com

Keeping blood glucose level within the desired range is a challenging task to the human body when the person suffers from diabetes, which is a severe metabolic disorder that occurs due to the inability of the body to effectively use its own insulin. Starchy or sugary foods normally lead to increased blood glucose levels in diabetes patients. The purpose of our study was minimizing the difference between the desired glucose level and the existing glucose level using optimal control theory. The Insulin-Glucose model is an example for the human biological system and the metabolic control of diabetic subjects is critical. Moreover, it is immensely useful for decision making in diabetic treatments. Therefore, we constructed a simple Insulin-Glucose model for capturing the dynamics of insulin-glucose interactions in the blood glucose regulatory system by considering the known physiological mechanisms. We mainly considered the blood glucose level at different time intervals. At the same time, we assumed that no internal insulin is generated in response to blood glucose levels. From the different insulin glucose models available in literature, we considered the one with an impulsive source term. Then we identified the structure of the control that minimizes the difference. Moreover, we found that when a patient's glucose level is high, it takes a longer time to converge to the desired level than a patient whose initial glucose level is lower. We experimented with numerical simulations using MATLAB to verify our analytically derived research findings.

# Simulation of Oscillating Bubbles in Liquids

**S. R. Dantanarayana[1*],** and **K. A. I. L. Wijewardena Gamalath[1*]**
[1]University of Colombo, Colombo 03. Sri Lanka
[*]senuri.rdan3@gmail.com , imalie@phys.cmb.ac.lk

An equation for natural frequency of a bubble oscillating in liquids is derived using the Keller-Kolodner equation by considering surface tension, viscosity, compressibility and ratios of specific heat. It is shown that the derived equation is identical to the Minnaert solution under certain conditions [1]. The simulations are done for a spherical adiabatic bubble assuming bubble oscillations are in small amplitude and graphs are plotted to check the variation of natural frequency and radius along with different physical factors. Growth and collapse of a bubble under the influence of diffusion are investigated. It includes the study of the effect of variations in different parameters in temperature profiles and boundary motions. It is shown that the temperature decreases at the same distance when increasing the ratio of the velocity of the boundary to the heat flux at the boundary [2].

The bubble dynamics of the growth and collapse of a vapour cavity bubble in the vicinity of a rigid boundary is investigated under cases of a bubble with constant pressure vapour and a bubble with a mixture of a constant pressure vapour and ideal gas. The fluid is assumed to be incompressible, irrotational and surface tension is neglected while considering buoyancy forces. Also, the problem is assumed to be asymmetric and the boundary integral method is used for simulations of bubble dynamics [3]. For the simulations, the bubble is assumed to be located in the liquid domain in the vicinity of a rigid boundary and cylindrical polar coordinates are considered. It is shown that the migration of centroid away from the rigid boundary during the growth phase of the bubble increases with increasing buoyancy forces. It is also demonstrated using simulations that the collapse rate of a bubble further away from the rigid surface is less than the collapse rate of a bubble located closer to a rigid surface and, that bubble volume containing a mixture of constant pressure vapour and ideal gas during growth and collapse phase also gives a similar result as in the bubble which contains only constant pressure vapour.

***Keywords:*** Natural frequency, Bubble dynamics, Diffusion

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# Joint Multilevel Discrete Competing Risk with Continuous Outcome via Bivariate Copula Model – Application to a Dengue Epidemiology Study, Sri Lanka

**G. H. S Karunarathna**[*1] and **M. R. Sooriyarachchi** [1]
[1] Department of Statistics, Faculty of Science, University of Colombo, Colombo 3, Sri Lanka
* hasani@stat.cmb.ac.lk

The Competing risk is a special branch of medical research where multiple events can happen. It can encompass the joint modeling approach for dengue epidemiology to model the relationship in different destinations of the length of stay and platelet count. Also, the district effect is an inherent feature of dengue highly associated with climate change. Therefore, this leads to the joint multilevel approaches for analyzing the length of stay of a dengue patient and platelet count in different destinations. Here, length of stay is in discrete form and platelet count is in continuous form. The joint modeling is done through a copula model with the formation of multilevel utility models for discrete competing risk response (length of stay in different destinations) and a multilevel linear regression model for platelet count. The within and between-study variability models are joined through random effects. The fitted model indicated that the white blood cell (WBC) count, year, and sex are the only associated factors for the platelet count and time indicators, age, classification, temperature, and rainfall have a significant impact on the rate of a discharging patient, and only time indicators and classification were significant for death rate in the joint model. Moreover, the joint model yielded more precise results than the univariate model.

***Keywords:*** Multilevel Competing risk, Utility models, Copula

# Protein-protein Interaction (PPI) Network Module Analysis for Detecting Sub-modules and Hub Proteins Associated in Root Development of *Oryza sativa.*

**W. G. A. S. Sandareka[1*], S. P. C. Fernando[1],** and **T. L. S. Tirimanne[1]**
[1]Department of Plant Sciences, University of Colombo, Colombo, Sri Lanka
*2015s15477@stu.cmb.ac.lk

*Oryza sativa* (rice) is one of the main global staple foods, and improved varieties are required to enhance its yield to supply for the increasing population. It is essential to study the root system for plant improvement because it contributes immensely to plant growth and stress tolerance. When producing improved varieties, revealing the molecular mechanisms behind phenotypes, such as root development, is indispensable and requires the identification of associated genes and their interactions. Phenotypes are governed by multiple proteins forming complex interactions; hence, it is important to analyze these interactions rather than focusing on individual proteins. This is achieved via protein-protein interaction (PPI) network module analysis in bioinformatics. This also allows identifying the sub-modules within a particular module for a phenotype, which correspond to different biological pathways governing the final phenotype. Also, there are proteins with higher importance than others, i.e., hub proteins, which have a higher number of interactions compared to non-hub proteins. These hubs can be identified using network analysis. The efficiency of PPI network analysis has been proven in human disease research, but to our knowledge, this method has never been used on root development in rice. Therefore, to better understand the protein interactions involved with root development, PPI network analysis was used to analyze sub-modules and identify hub proteins. Rice PPI network from the STRING database was retrieved and genes with experimental evidence for their contribution to root development were extracted from the literature. These were used to predict 75 new gene candidates. Then, the PPI network module for the root development was extracted and visualized, and sub-modules and hubs were identified. Enrichment analysis was performed to detect the biological pathways related to sub-modules and those pathways and hubs were analyzed using the literature. Altogether, 6 sub-modules, 20 intramodular hubs, and 2 intermodular hubs (DRO1 and FH1) were identified and analyzed. They were mainly associated with root hair development, auxin regulation, cytokinin regulation, and cell wall organization, which are related to the root development, confirming the applicability of our approach.

***Keywords:*** PPI, Rice, Root

# Molecular Dynamics Study on the Effect of As(III) Ion on Human Uracil DNA Glycosylase Enzyme

**Priyani Paligaspe[1], S. Weerasinghe[2], D. P. Dissanayake[2],** and **R. Senthilnithy[1*]**
[1] Department of Chemistry, The Open University of Sri Lanka, Nawala, Nugegoda, Sri Lanka
[2] Department of Chemistry, Faculty of Science, University of Colombo, Sri Lanka
* rsent@ou.ac.lk

Mutations in DNA occur due to exposure to chemicals, toxins, and radiation. The presence of uracil in DNA is a modification that occurs due to the misincorporation and spontaneous deamination of cytosine. Glycosylases can repair mutated DNA, and human uracil DNA glycosylase (hUNG) is one such DNA repair enzyme that initiates the base excision repair pathway. However, the activity of these enzymes gets affected when exposed to toxic metals. Therefore, it is essential to study the mechanism of action of the toxic metals with these enzymes. Experimental investigations have revealed that Cd(II) ions can inhibit the activity of hUNG. These studies suggest that the inhibition takes place due to the replacement of the catalytic water molecule found in the active site of the enzyme by the Cd(II) ion. Other than Cd(II) ion, As(III) is also considered a toxic metal ion categorized under human carcinogens. Therefore, the work here has focused on the accumulation of As(III) with the hUNG enzyme, and the intension of this work was to study the effect of As(III) ion on hUNG. The study was done using CavityPlus web server and computational analysis based on molecular dynamic (MD) simulations considering two systems of the enzyme; in the presence and absence of the As(III) ion. The CavityPlus web server results showed that the number of cavities of the enzyme changes for the two situations of the enzyme. Further, the ability of a ligand to bind with a cavity of the hUNG was comparatively studied using the ligandability results obtained from the server. The root means square deviation and total energy analysis done using the simulation trajectories showed that the enzyme and the system with As(III) obtain high stability compared to the free enzyme and the system, respectively. The localization of the residues of the enzyme in the Ramachandran plot showed that a high percent of residues of the enzyme with As(III) lie in the favorable region of the plot. Based on the analysis of these results, it is concluded that As(III) ion can reduce the activity of the enzyme by forming a stable enzyme-metal ion system.

***Keywords:*** hUNG, CavityPlus web server, Molecular dynamic simulation

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# Joint Marginalized Multilevel Model for Study Program Completion and Performance of Students: The Case of Sri Lankan Open and Distance Learners in Management Studies

**J. C Hapugoda[1*]** and **M. R. Sooriyarachchi[2]**
[1] Department of Organizational Studies, The Open University of Sri Lanka
[2] Department of Statistics, University of Colombo
* jchap@ou.ac.lk

When data with correlated responses are available, joint models may provide interesting and improved results than modeling the responses separately. Such models between those responses can be developed and their applicability in various fields is noteworthy. Though joint mixed models and joint population averaged models are popular and common in statistical literature, Joint Marginalized Multilevel Models (JMMM) is still a developing area. Thus, the main objective of the study is to model survival and count data jointly, utilizing MMM and applying it to data related to Distance Education in Sri Lanka. The data obtained for this study represents records of students who have registered for undergraduate study program in Management at a leading higher education institute in Sri Lanka through Open and Distance Learning (ODL), which conducts the program in all the regional/ study centers across the country. As the students are clustered in different regional/ study centers, the clustering effect is also present in the dataset. In this study, completion time of study programs by the students is considered as a survival response and the number of first time passes by students, which represents student performance, is considered as the count variable. The findings suggest that the time to completion of the study program and gender have a significant impact on completion of the study program and student performance in the said context.

***Keywords:*** Joint modeling, Marginalized Multilevel Model, Open and Distance Learning

# Shared Frailty Model for Joint Survival Data-A Simulation Study

**J. C. Liyanage**[1*] and **G. H. S. Karunarathna**[1]
[1] Department of Statistics, University of Colombo, Colombo 03, Sri Lanka
* jayliyanage1@gmail.com

Performing a survival analysis, allows investigating factors that contribute to outcome over time. In real life, multivariate survival data are experienced mostly. Though, a considerable amount of literature has been this area, analysis of multiple survival responses (for simplicity, in this study bivariate lifetime data have been considered) has not received sufficient attention. The joint modeling fits well when there are two survival responses for the same study unit and it can provide improved results than fitting two univariate models, since the correlation between the two responses can be captured through a joint model. Therefore, the aim of this study was to propose a joint modeling approach (Shared Frailty Model), in which the linkage between the two survival responses was derived by sharing a common random effect under different random effect distributions through parametric forms of the baseline hazard function. In this study, gamma and normal random effect distributions were used and the parametric distributions considered were exponential and Weibull. The performance of the Shared Frailty model was compared with two Ordinary Proportional Hazard models through a simulation study, by fitting models for thirty-six sets of simulated data, under the mentioned distributions, in three different sample sizes; small (50), moderate (500) and large (1000) with 20% and 40% censoring proportions in different correlation structures. With the use of the shared frailties, only positive associations could be captured in this research study. To compare the performance, the bias, Coverage Probability (CP) and Mean Squared Error (MSE) were used. When sample size increases, only a mild improvement in the results could be observed and with the increase of the censoring proportion, parameter estimates deviated more from the true values irrespective of the distribution used. In all the different combinations considered, the parameter estimates showing relatively low bias, moderate CP and minimal MSE under the joint random effect model, confirming the suitability of the proposed model to capture joint survival data, surpassing the fit of two univariate models. Also, the results indicated, that gamma distributed random effects are more suitable with exponential survival times while normal random effects are more suitable with Weibull survival times.

***Keywords:*** survival, joint model, shared frailty

# Evolution of Protein Sequence Family Classification Using Deep Learning

**Sugandima Vidanagamachchi**[1*] and **Sarasi Munasinghe**[1]
[1] Department of Computer Science, Faculty of Science, University of Ruhuna, Matara, Sri Lanka
* smv@dcs.ruh.ac.lk

While the assurance of molecular biological systems to classify protein sequence families accurately and efficiently remains elusive due to the rapid growth of data generation and the variances in protein sequences, recent advances in deep learning can reach higher levels of performance. Existing computational methods are time-consuming and require high computational power. Hence, there is a need for a more accurate and time-efficient method to classify protein sequence families. In this work, we first identify the gap in protein family classification and understand the major evaluation studies across protein sequences and protein family variations. According to our literature review, the deep learning technique is a powerful method that has not yet fully addressed the evolutionary protein sequence family classification challenge. Addressing the above mentioned challenge which has not yet been solved by the state-of-the-art is highly important for the bioinformatics community. Since the deep learning architectures have shown higher accuracy, we developed a multi-label classification model using convolutional neural networks. Our model contains seven convolutional layers, three max pooling layers and two dense layers. We trained our model with stochastic gradient descent (SGD) optimizer with 0.02 learning rate. The network was trained with 80% of the protein sequences of the SwissProt database, and tested the network performance on the remaining 20%. Our proposed model classifies protein sequences into 698 UniProt families and achieved 97.3 % accuracy. Our model obtained around 91% F1 values. The proposed model outperforms existing methods, showing impressive accuracy when classifying protein sequences into 698 UniProt families with less time complexity.

***Keywords:*** Deep Learning, Protein Sequence Family, CNN

# Agent Based Simulation for Infectious Disease Transmission

**L. A. Wijayasooriya[1*], S. S. N. Perera[1],** and **P. D. D. Gallage[1]**
[1]Department of Mathematics, Faculty of Science, University of Colombo
* lawstc96@gmail.com

The entire world is currently facing the COVID-19 pandemic and the main strategies to control the spread are; quarantine and social distancing, travel restrictions, and vaccination. In a situation where most of the countries try to implement optimal control measures, mathematical models which simulate various scenarios are of high importance in decision making. In this study, an agent based model, which was developed with the multi-agent programmable modeling environment - Netlogo is employed to study the spread and control of an infectious disease. The developed simulation model in this study can be used to understand how certain factors would affect the spread of an infectious disease and to simulate the impact of vaccination and quarantine efforts to identify suitable strategies before implementing them. Analysis is done by running the simulation model which consists of a synthetic population of 171 agents in a hypothetical town created with Netlogo. The impact of infectiousness, quarantine effort and vaccination to the spread of an infectious disease is simulated. As expected, when infectiousness was increased, the maximum infected count increased and time to the peak decreased; when quarantine efforts were increased the peak decreased and length to the peak increased; when vaccination coverage was increased the peak reduced, but the impact on length to the peak was low. At the end it was identified that the equation $y = -x + 0.65$, where $y$ is the quarantine effort and $x$ is the vaccine coverage, provides an optimal vaccination-quarantine effort strategy to keep the maximum active patients per day below 6% of the entire synthetic population, and the linear nature of the equation is resulted because the average of 50 model runs is considered in this experiment. This simulation model can be fine-tuned by changing the parameters to get an approximately matching scenario to a real-life epidemic that spreads directly from an agent to another agent of the same type. As Sri Lanka has started vaccinating against COVID-19, a fine-tuned version of this model can be used to get an approximate idea of the best vaccination-quarantine effort strategy to keep the spread under control and return to normal lifestyles.

**Keywords:** COVID-19, Netlogo, Agent Based Simulation

# Automorphisms of Latin Squares

**M. J. L. Mendis[1*]**
[1] Department of Mathematics, University of Colombo, Sri Lanka
[*]jayama@maths.cmb.ac.lk

A Latin Square $L$ of order $n$ is an $n \times n$ array containing $n$ symbols from $[n] = \{1, 2, \ldots, n\}$ such that each element of $[n]$ appears once in each row and each column of $L$. Rows and columns of $L$ are indexed by elements of $[n]$.

An automorphism $\alpha$ of a Latin square is a permutation such that the triple $(\alpha, \alpha, \alpha)$ maps the Latin square $L$ to itself by permuting its rows, columns and symbols by $\alpha$. Let $Aut(n)$ be the set of all automorphisms of Latin squares of order $n$. Whether a permutation $\alpha$ belongs to $Aut(n)$ depends only on the cycle structure of $\alpha$. Stones *et al.* [1] characterized $\alpha \in Aut(n)$ for which $\alpha$ has at most three non-trivial cycles (that is, cycles other than fixed points). A notable feature of this characterisation is that the length of the longest cycle of $\alpha$ is always divisible by the length of every other cycle of $\alpha$. In this research we prove a related result for automorphisms with four non-trivial cycles.

***Keywords:*** Latin Square, Automorphism, Cycle Structure, Permutation.

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# A New Technique for Course Assessment Using Mathematical Optimization

**A. Gunawardena[1], K. Premadasa[2*], R. Meyer[3], S. Samaranayake[4],** and **V. Deshpande[5]**
[1] University of Wisconsin-Whitewater, Wisconsin, USA
[2] University of Wisconsin-Platteville, Platteville, Wisconsin, USA [3] University of Wisconsin-Madison, Madison, Wisconsin, USA
[4] University of Wisconsin-Whitewater, Wisconsin, USA
[5] University of Wisconsin-System, Madison, Wisconsin, USA
* premadasaa@uwplatt.edu

Course assessments provide a very valuable tool that instructors can utilize to ensure that course content and course delivery are well suited to the expectations and interests of students, thus enhancing student engagement and success in courses. This paper explores a novel mathematical modeling approach for course assessment that utilizes optimization models based on John Holland's theory of personality [1] to generate course assessments based on quantitative data obtained from students enrolled in courses.

Holland introduced the theory that most people are one or more of six personality types: Realistic, Investigative, Artistic, Social, Enterprising and Conventional. The acronym RIASEC is used to represent that collection of traits. Standard psychometric tests are used to assign numerical values to each of these traits for an individual. Holland also assumed that *environments* such as college courses could be assessed in terms of those six RIASEC aspects.

Holland's theory also postulates that an individual's satisfaction with an environment may be estimated by applying a congruence measure that compares the individual's RIASEC profile with the environment's RIASEC. The research presented here includes a discussion of a novel dot product congruence measure (DP) that facilitates the development of the computational optimization tools that we consider.

Students in college courses are often asked to complete evaluation questionnaires, and these questionnaires typically include satisfaction level assessment. Hence we develop here an optimization model that may be applied to an input dataset of student RIASEC personality profiles and corresponding course satisfaction data in order to estimate the RIASEC course profile that would yield the best match for that input data. This approach thus provides an indirect assessment methodology for estimating a RIASEC course profile that may then be used in conjunction with a congruence measure such as DP in order to predict course satisfaction levels for prospective future students. Alternatively, we use our Holland-theory-based framework to develop optimization models that provide insight into how to adjust course delivery and content in order to meet satisfaction thresholds for courses with varied audiences. We observe that this methodology can be extended to setting teamwork environments for team members of diverse backgrounds.

***Keywords:*** Course assessment, mathematical modeling, and optimization

# Time Series Analysis to Forecast the Future Confirmed Cases of COVID-19 in Sri Lanka

**Nathasha K. Boralessa**[1*]
[1] Department of Mathematical Sciences, Wayamba University of Sri Lanka, Kuliyapitiya, Sri Lanka
* nathashakb123@gmail.com

The corona virus (COVID-19) pandemic is an ongoing pandemic that originated in December 2019 in Wuhan city, China. It is a contagious disease that causes illnesses in both humans and animals extending in severity from the common cold to Severe Acute Respiratory Syndrome (SARS). This disease has spread all around the world with considerable morbidity, mortality, and is an enormous burden on worldwide public health. As of May 2021, it has infected more than 100 million lives worldwide with more than three million deaths. The first case of COVID-19 in Sri Lanka was reported in late January 2020. That person was a Chinese national, and the first local case was identified in the second week of March. According to the Ministry of Health, currently there are 115,590 confirmed cases with 709 fatalities and 99,115 patients who have recovered and been discharged from the hospitals in Sri Lanka. The government imposed curfew in risk areas expecting to minimize the burden of the disease. Due to it, massive job losses and loss of livelihood took place. Therefore high transmissibility of this pandemic has caused a significant impact on the economy of Sri Lanka. In such grave circumstances, forecasting the future covid-19 infected cases which is an emerging topic in research, is essential to support prevention of this diseases and preparation of public healthcare services. In the present work, several time series models based on statistical methodology were developed and the best model was selected from them to predict the future COVID-19 infected cases in Sri Lanka using MAPE, MAD and MSD. The predictions helped the government to take precautionary measures to be prepared for upcoming conditions and to have more readiness within healthcare systems.

***Keywords:*** COVID-19, Time series models, ARIMA

# A Deterministic Delay Model in the Theory of Contagious Disease

**S. S. C. Silva**[1*] and **S. K. P. Eranga**[1]
[1]Department of Mathematics, Faculty of Science, University of Colombo
[*] sudeshchanaka96@gmail.com

The first case of coronavirus was reported from China in December 2019. Since then it has become a pandemic. Various methods have been used to predict the behavior of COVID 19 outbreak. However, from time to time, new strains of the virus emerge, therefore a promising method is not found up to date. In this work, the goal is predicting the behavior of COVID 19 outbreak considering eight countries from 1st of June to 8th of September (for 100 days) 2020 collecting data from 13th of March to 31st of May by improving the 'SIRS' delay model based on the historical data. The main focus here was on how COVID-19 outbreak varies with incubation period and immunity loss rate. The infected rate was found using Cook's statistic method, and DDE 23 MATLAB function was used to fit the model based on Runge-Kutta 23 method. The main assumption for this was that the selected countries would not be reopened within the selected 100 days. However, due to the economic downturn during this period and the popular protests over the lockdown, the selected countries were unable to keep the lockdown situation before completing the 100 days. It can be seen that the prevalence of COVID-19 decreased during the lockdown period and increased rapidly again after the reopening of the country. It was finally concluded that COVID-19 outbreak decreases with increasing the incubation period and increases with increasing the immunity loss rate.

# A Genetic Algorithm for University Timetabling

**K. Abeywardena**[1*] and **G. D. Illeperuma**[2]
[1] Department of Mathematics, University of Colombo
[2] Department of Physics, The Open University of Sri Lanka
* kasunpaabeywardena@gmail.com

Timetabling is the process of allocating time for planned activities orderly, to bring an optimum solution, without violating any hard constraints and with minimum soft constraint violations. It portrays a difficult optimization problem. There exist many commercial software with general features for this task. However, those cannot be adopted into The Open University of Sri Lanka (OUSL) due to its unique and complex requirements. This work presents the development of a genetic algorithm (GA) based MATLAB program, which automatically generates a semester-long, optimized timetable and eliminates the current, time consuming, manual process. The algorithm takes into account the number of levels in a degree program, credit hours, days and time slots in a semester, clash avoidance, fixed time slots, holidays, lecturer preferences, and workload distributions. The genetic algorithm consists of four main steps: initialization, validation, fitness calculation, and mutation. The solution space is represented by a four-dimensional matrix. Rows, columns, and planes represented slots per day, days in a semester, and levels (year 01,02 and 03 of degree program). The fourth dimension represents different solutions. To measure the performance of the algorithm, a point system was devised where violation of each constraint was penalized and vice versa. Based on this point system, a theoretical maximum was calculated without considering the feasibility of achieving all constraints simultaneously. In this study, the algorithm reached a maximum fitness value of 100 without violating any hard constraints, whereas the theoretical maximum was 126. Repair strategies were implemented to improve the performance resulting in reduction of execution time from 90 minutes to 14 minutes. The results show it is possible to generate an optimized timetable consistently using this method.

***Keywords:*** Timetabling Problem, Genetic Algorithm, Optimization

# Truxillic Acid Monoesters as Novel Fatty Acid Binding Protein 5 inhibitors for Treatment of Chronic Pain

**Kalani jayanetti** [1*], **Adam Taouil**[1], and **Iwao Ojima**[1,]
[1] Department of Chemistry, Stony Brook University, Stony Brook, NY, U.S.A.
[2] Institute of Chemical Biology and Drug Discovery, Stony Brook University, Stony Brook, NY, U.S.A.
*kalani.jayanetti@stonybrook.edu

Fatty acid binding proteins (FABPs) are small cytoplasmic proteins, essential for intracellular transport of fatty acids, N-acyl ethanolamines (NAEs), and can be exploited as therapeutic targets for treating chronic pain. Anandamide (AEA), and 2-Arachidonoyl glycerol (2- AG) are endocannabinoids of Cannabinoid Receptor1 (CB1) that readily traverse the cell membrane through diffusion. The lipophilic AEA and 2-AG are transported through the cytoplasm by binding to the FABP transporter, to the endoplasmic reticulum localized fatty acid amide hydrolase (FAAH), an integral membrane enzyme, for uptake. By inhibiting FABPs or FAAH, suppress the AEA transportation and breakdown which will eventually result in elevated levels of AEA, for signaling at G-protein-coupled CB1 receptors primarily found in the brain and Central Nervous System (CNS). This results in a pressure release that is correlated to anti-inflammatory effects, anti-nociception, and other therapeutically favorable effects, such as chemotherapeutic benefits [1]. Among all the FABPs, FABP5 (Epidermal tissue FABP) and FBP7 (brain/CNS FABP) are targeting in this study since they are excellent drug targets and FABP3 (heart FABP) is also taken into consideration, due to the possible side effects.

By utilizing Footprint Similarity Score (FPS) analysis, the most energetically similar 48 hit compounds were found by virtual screening over one million target compounds from the ZINC database. Further, in vitro assays and in silico energy comparisons were led to select SB-FI-26 (α Truxillic acid-based inhibitor) as the FABP inhibitor scaffold for further developments [2]. Recent Structure-Activity Relationship studies of our group were led to the identification of two new lead compounds, SB-FI-102 and SB-FI-103 (Truxillic Acid Mono Esters -TAMEs) based on their potency and selectivity [3]. Here we included the continuation of TAMEs designs targeting FABP5. Based on docking analysis from Autodock4.2 and predicted potential pharmacokinetic properties from pkCSM, a series of novel α-/γ-truxillic acid-based FABP5 inhibitors were designed and synthesized. cLogP values and toxicology profiles were also taken into consideration to increase the water solubility and polarity of the inhibitors while reducing off-target effects. Selected inhibitors will be further subjected to in vitro characterization to find out potential FABP5 inhibitors with optimized selectivity, potency, and in vivo efficacy.

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# Genome-wide *in silico* Analysis and Characterization of Simple Sequence Repeat loci in Coconut (*Cocos nucifera* L.)

**W. O. K. Weerakkodi**[1] and **H. D. D. Bandupriya**[1*]
[1]Department of Plant Sciences, Faculty of Science, University of Colombo, Colombo 03, Sri Lanka
* dbandupriya@pts.cmb.ac.lk

Coconut (*Cocos nucifera* L.) is an important oil crop that can play a major role in the food security of the people in most of the Asian countries including Sri Lanka. The genomic knowledge on coconut is extremely important to increase productivity by incorporating superior traits targeting quality end products. Simple Sequence Repeats (SSR) are DNA-based markers which are informative for basic and applied studies such as molecular breeding. Coconut genetic and genomic resources, especially molecular markers, have been scarce until recently, impeding coconut breeding efforts. Comprehensive analysis of SSR has become possible now because several coconut genomes have been sequenced. In this study the draft genome of *C. nucifera* Hainan Tall (HAT) variety (accession number GCA_008124465.1) was surveyed to determine the distribution and frequency of SSRs. The polymorphism of the available SSRs of the HAT variety was investigated using an electronic PCR approach and, manual analysis of each PCR product marker in five genomes: *C. nucifera* Chowghat Green Dwarf variety, *C. nucifera* Catigan Green Dwarf variety, *Phoenix dactylifera* and *Elaeis guineensis* and *C. nucifera* L. ESTs. A total of 522,524 SSRs (repeat units 1-6 bp) from the draft genome of variety HAT with an overall density of 258.675 (SSRs/Mbp) was characterized using the GMATA tool. Dinucleotide was the most common repeat motif with a frequency of 58.87%, followed by 28.01% mononucleotides, 7.15% trinucleotide, 4.31% tetranucleotide, 1.50% pentanucleotide and 0.16% hexanucleotide. The motif AG/CT was the most abundant and AT/TA was the second most abundant among all identified SSR motifs by accounting for 42.01% and 32.79% respectively. A total of 245,048 unique SSR markers were developed from the total SSR loci and a high degree of polymorphism (nearly 51 %) was found between different genotypes. Polymorphic SSR sites of *C. nucifera* were mostly comprised of dinucleotide motifs (82.91%), followed by trinucleotide motifs (10.39%), then tetranucleotide motifs (4.15%). The findings of the present study indicate that whole-genome sequencing is an excellent resource for developing SSR markers, and the newly identified large numbers of SSR markers could make an important contribution to the coconut research community

***Keywords:*** C. *nucifera* L., microsatellites, polymorphism

# Modelling Inflated Time Series Counts: An Integer Valued Autoregressive Process Model Development

**M. L. Premarathna**[1*]-and **S. D. Viswakula**[1]
[1]Department of Statistics, Faculty of Science, University of Colombo
* malithlak@outlook.com

Time series data involving counts is an attractive research area which has gained a massive attention among the researchers due to the wide applicability in practice. When dealing with count data, it is possible that the observed counts typically contain a higher frequency of a particular number or few numbers than others. This phenomenon is called inflation. For example, zero inflation, one inflation, two inflation, zero and one inflation, zero-one-two inflation etc. Since the models with "zero inflation" i.e., observing zeros than the other numbers is extensively discussed in the literature, "positive number inflation" phenomenon, which is rarely addressed in the literature, is focused on this study.

Integer valued Auto-Regressive (INAR) (Alzaid, 1987) models which imitate most of the characteristics of Auto-Regressive (AR) processes were chosen as the spine of the study due to its attractive behavior both in handling integer values and the interpretability. Starting from the first order Integer valued Auto-Regressive model with Zero inflated Poisson innovations (ZINAR(1)) (Aghababaei et al., 2012) & Zero and One inflated Poisson innovations (ZOINAR(1)) (Qi, 2018), a first order Integer valued Auto-Regressive model with Zero, One and Two inflated Poisson innovations (ZOTINAR(1)) model was derived and introduced in this study. This newly proposed model can handle zero, one and two inflations at once. Then, a comprehensive simulation study via Monte Carlo methods was performed to check the performances of the proposed estimators for the parameters of the new model.

The simulation study showed that the estimates are closer to the actual values for the larger sample sizes (sample sizes used in the study ($n$) = 100, 300, 500). Moreover, proposed INAR model (ZOTINAR(1)) with all the competitive sub models were fitted to three real data sets along with two carefully fabricated data sets and likelihood ratio goodness of fit test conducted between them.

Results showed that the newly proposed ZOTINAR(1) model performs better when there are higher portion of zeros, ones, and twos in the data set under consideration.

***Keywords:*** INAR models, Inflated time series counts, Likelihood ratio

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# Ranking Countries According to Transmission Risk of COVID-19 Using Grey Relation Analysis

**M. S. H. Perera**[1*] and **I. T. S. Piyatilake**[1]
[1]Department of Computational Mathematics, University of Moratuwa, Sri Lanka
* hirunisperera94@gmail.com

COVID-19 is a contagious disease caused by a newly discovered coronavirus and it was first identified in December 2019 in Wuhan, China. At present, the disease has spread around the world causing mild to severe illness and even death. Therefore, it is essential to identify the risk level of the countries and rank them according to the transmission risk of COVID-19. This also helps in the decision making process by restricting local and outbound travel to control the transmission of the disease. The objective of the study is ranking different countries according to the transmission risk of COVID-19 with respect to risk factors using the *grey relation analysis* method. First, the countries were ranked according to the transmission risk of COVID-19 by taking into account various risk factors such as population density, age (65 or above 65), gross domestic product per capita, cardiovascular death rate, diabetes mellitus prevalence, and hand washing facilities. Selected countries were United States, Afghanistan, Colombia, Pakistan, Philippines, South Africa, India, Sri Lanka, China, Laos, Thailand, Timor, Mongolia, Vietnam, and Yemen. Grey relation approach was used to rank the countries. According to grey relational grades the transmission risk of each country is calculated. Larger the grey relational grade, higher the transmission risk of COVID-19 of the relevant country. The results revealed that population density and diabetes mellitus are the most prominent risk factors in the context of COVID-19 transmission. According to grey relational grades, India ranked in the first place as the country with the highest risk. This may be due to high population density and high diabetes mellitus prevalence. Among the selected countries the second highest transmission risk was obtained from Afghanistan and this is due to the low gross domestic production per capita, high cardiovascular death rate, high diabetes mellitus prevalence and low hand washing facilities. Mongolia and Colombia were identified as low-risk countries. It was identified that many of the risk factors were within a controllable range in these two countries.

***Keywords:*** COVID-19, Grey Relation, Ranks

# Finite Difference Time Domain Simulations of Earth Electrodes for Different Soil Resistivity Profiles.

**S. S. Kudagama**[1*] and **I. M. K. Fernando**[1*]
[1] Department of Physics, University of Colombo, Colombo, Sri Lanka.
[*]sandunikudagama@gmail.com, fernando@phys.cmb.ac.lk

Soil does not have a homogeneous structure, and the resistivity of soil varies due to a variety of reasons, including the type of soil, seasonal conditions, and content of minerals. Moreover, the soil resistivity cannot be zero. Therefore, the lightning current injected into the ground will create a substantial rise in the earth's potential at the grounding point and gradually decrease with distance. An individual standing along this path of current discharge could experience a voltage difference between the two legs (step potential), which could cause a current through his/her body. Depending on the magnitude of the step potential, the person could be at risk during lightning. In this study, the "Finite Difference Time Domain" method was used to design a two-dimensional model, to observe the variation of step potential due to a lightning current injected through a single vertical earth electrode of 1.5m long in different soil resistivity models. The lightning current was simulated as a double exponential impulse waveform with a 30 kA peak current. MATLAB software was used to implement the simulation code. It concludes that when the lightning current discharge through a homogeneous soil, the higher the soil resistivity, the higher the value of step potential. The maximum step potential observed in 1000 Ω·m soil was almost twice as much as in the 400 Ω·m soil. The conductive bottom layer of soil extracts a large portion of current through the intermediate layers resulting in a significant fall in the voltage near the grounding point. Drop in the maximum step potential observed at 2 m distance from the grounding point in conductive bottom layer soil (400 Ω·m) and resistive bottom layer soil (1000 Ω·m) were 41.81% and 37.68%, respectively. In vertically layered soil, significant peaks were observed in the step potential due to the difference in the soil resistivity and the current reflection at the boundaries of soil layers. More complex analysis was carried out using a soil resistivity profiles in which the soil resistance vary in both horizontal and vertical direction. The results obtained were compared with theoretically expected results and are shown to be satisfactory.

***Keywords:*** Finite Difference Time Domain Simulations, Soil Resistivity, and Step Potential.

# The Effect of Control Strategies on the Spread of COVID-19 Based on a Mathematical Model

**B. A. P. N. Sandaruwini**[1*] and **L. W. Somathilake**[1]
[1] Department of Mathematics, Faculty of Science, University of Ruhuna, Matara
* nadishikasandaruwini2@gmail.com

CoronaVirus-2019 (COVID-19) is an infectious disease that is spreading in most countries all over the world. Control strategies such as social distancing, quarantine protocols and hospitalized isolation are used to suppress the spread of COVID-19 in the community. This research proposes a deterministic compartmental mathematical model for the COVID-19 control process by considering the above-mentioned control strategies. Population subclasses: susceptible (S), exposed (E), immigrant (E1), infectious (I), self-quarantine (Q1), quarantine in centers (Q2), hospital isolated (H), and recovered (R) are considered in constructing the model. This model is formulated by a system of nonlinear ordinary differential equations. There are two equilibrium points of the model; the disease-free equilibrium point and the endemic equilibrium point. We computed the basic reproduction number ($R_0$) of the model by using the *next-generation matrix* (NGM) methods. Also, we solved the system numerically and the numerical solutions are helpful in estimating the number of individuals in each population subclass at a given time. We check the effectiveness of the model parameters on the spread of the disease by analyzing the sensitivity of the basic reproduction number. It is observed that the most effective parameter is the transmission rate from the exposed population to the self-quarantine population and the next effective parameter is the exposed rate. We show that the infectious curve flattens when actions are taken to increase the quarantines and hospitalized isolations and to decrease the incidence and the exposed rate.

**Keywords:** Basic Reproduction Number, Sensitivity Analysis, Control strategies

# Exploring the Molecular Level Effects of ATRP Initiators on a Conjugated Model Protein via Molecular Dynamics Simulations

**B. Lakshitha A. Perera**[1,2,3] and **Coray M. Colina**[1,2,3,4*]
[1] Department of Chemistry, University of Florida, Gainesville, FL, USA
[2] George & Josephine Butler Polymer Research Laboratory, University of Florida, Gainesville, FL, USA
[3] Center for Macromolecular Science & Engineering, University of Florida, Gainesville, FL, USA
[4] Department of Material Science and Engineering, University of Florida, Gainesville, FL, USA
*colina@chem.ufl.edu

The sensitive entanglement between proteins' extraordinary functionalities, and their natively operable environments has limited the ability to exploit their naturally fine-tuned capabilities for a wide range of industrial and bio-medical applications. Decades of extensive research has demonstrated the conjugation of synthetic polymers to natural proteins as a promising strategy to overcome this limitation. Nevertheless, to rationally design a protein-polymer bioconjugate without adversely affecting the conjugated protein's functionality; it is essential to decipher the effects of each constructing component of these chimeric molecules (i.e., the proteins, the linkers/initiators, and the polymers). Of the various techniques used to form protein-polymer bioconjugates, Atom Transfer Radical Polymerization (ATRP) technique utilizes small initiators connected to the protein to facilitate the growth of polymers from the protein surface. Yet a molecular level understanding of the effects exerted by these initiators on the conjugated proteins are left unexploited.

During this work, atomistic molecular dynamics simulations were utilized to explore the effects of a commonly used ATRP initiator; *N*-2-bromo-2-methyl-propionyl-*β*-alanine *N'*-oxysuccinimide ester on the structure-dynamics of a conjugated model protein. To facilitate a wider conformational sampling, multiple replicas with different initial initiator conformations were utilized for each system studied. The end-to-end and angle measurements performed using: 1) the carbonyl carbon connecting the initiator to the protein, 2) the $sp^3$carbon next to the amine nitrogen, and 3) the quaternary carbon connected to the Br atom, suggested that irrespective of being bound to the protein or not, the initiator would adopt two primary conformations: an extended conformation and a slightly preferred bent conformation. Further analysis showed that, while the N-terminal mono-conjugation did not pose a significant effect on the protein's overall structure-dynamics; the dense multi-conjugation of the protein with initiators induced rigidity to its naturally highly dynamic unstructured C-terminal. It was deduced that the strong preferential interactions between the initiators, and the lysine side chains to which they were connected—have huddled the initiators closer to the C-terminal, resulting in its anchoring, and reducing its mobility—without affecting the protein's overall structure-dynamic relationship. These in-silico observations will provide molecular level insights to enhance the ability to produce bioconjugates via ATRP.

***Keywords:*** ATRP, Initiators, Bioconjugates

# Developing a Fuzzy Operator Based Model to Capture Transmission Risk of COVID-19

**S. T. D. M. Silva[1*], I. T. S. Piyatilake[2],** and **S. S. N. Perera[1]**
[1] Research & Development Center for Mathematical Modeling, Department of Mathematics, Faculty of Science, University of Colombo, Sri Lanka
[2] Department of Computational Mathematics, University of Moratuwa, Sri Lanka
* madumalidineshi@gmail.com

COVID-19 is one of the worst epidemics in human history. In 2019 infected individuals were found in Wuhan, China, and subsequently the disease was spread to the other regions in the world too. It is important to identify high risk regions in the world in the context of COVID-19 spread. The dynamics of COVID-19 transmission are complex and uncertain due to various factors such as social, biological, environmental, educational, climate and economic conditions. Fuzzy logic and fuzzy set theory are mathematical tools proven to work effectively in modeling the systems with uncertainty for which the classical approaches do not provide accurate solutions. This explains the applicability of fuzzy concepts for modelling the transmission risk.

We capture the transmission risk of COVID-19 with respect to factors such as healthcare index, poverty rate, population density, number of hospital beds, social distancing, hand washing facilities and percentage of mask wearing. Fourteen countries are used to develop the model. Interactions of these factors are modeled using fuzzy operators such as Hamacher, concentration, dilation, and algebraic product. Considering literature and expert opinions, membership functions are defined for each risk factor. These membership functions are combined using the Hamacher operator to determine the overall risk of countries. Five other countries are selected for model validation. Using the developed model, three risk levels are identified. These three risk levels are compared with the total number of cases in each country to validate the proposed model. Sensitivity analysis of the model is also carried out to investigate how the fuzzy model reacts to small change in the parameters. According to our results, India, Colombia, South Africa, Indonesia, Nepal, Philippines, and Bangladesh are identified as high-risk countries. This is due to the high population density and high poverty rate in these countries.

***Keywords:*** COVID-19, Fuzzy Sets, Hamacher Operator, Risk

# Exploring the Role of Disulfide Bonds in the Conformational Stability of Lysozyme in Organic Solvents

**Jose Rodriguez Sanoja**[1,3], **B. Lakshitha A. Perera**[2,3,5], and **Coray M. Colina**[2,3,4,5]
[1] Chemical Engineering Department, University of Florida, FL, USA
[2] Department of Chemistry, University of Florida, FL, USA
[3] George and Josephine Butler Polymer Research Laboratory, University of Florida, FL, USA
[4] Department of Materials Science and Engineering, University of Florida, FL, USA
[5] Center for Macromolecular Science & Engineering, University of Florida, FL, USA
*colina@chem.ufl.edu

In nature, proteins have unique folds which are crucial to perform their native functions. A protein's structural fold is sensitive to the environmental in which it operates. Therefore, proteins often tend to lose their tertiary structure when exposed to external stressors, such as, high temperatures, acids, salts, and organic solvents. Nevertheless, the preservation of a protein's structure in non-native environments is of great importance to broaden their industrial and medical applications. Disulfide bonds are key contributors to the conformational stability of proteins in native environments, and thus understanding their relevance in maintaining a protein's structure in organic solvents is essential. Lysozyme is an enzyme with natural antibacterial properties, and it has shown to be susceptible to structure-dynamic changes in the presence of ethanol [1]. This work utilizes atomistic molecular dynamics (MD) simulations to study the effect of disulfide bonds in hen egg-white lysozyme, in pure water and pure ethanol. The structural analysis of the preliminary simulation data demonstrated a significant conformational change occurring for lysozyme in pure ethanol in the absence of disulfide bonds, compared to the relatively smaller changes observed in its native aqueous environment. The disulfide bridge between residues 6-127 appears to be particularly important for maintaining protein secondary structure in ethanol. These findings are expected to help understand the relevance of disulfide bonds for maintaining lysozyme's structure and its behavior in non-native organic environments.

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# An Atomistic Molecular Dynamics Investigation of Cysteine Variants of *Bacillus subtilis* Lipase A

**Mohomed Afnan Jaufer**[1,2,3], **B. Lakshitha A. Perera**[1,2,3], **Gail E. Fanucci**[1,2], and **Coray M. Colina**[1,2,3,4*]
[1] Department of Chemistry, University of Florida, Gainesville, FL, USA
[2] George and Josephine Butler Polymer Research Laboratory, University of Florida, Gainesville, FL, USA
[3] Center for Macromolecular Science and Engineering, University of Florida, Gainesville, FL, USA
[4] Department of Material Science and Engineering, University of Florida, Gainesville, FL, USA
*colina@chem.ufl.edu

*Bacillus subtilis* Lipase A (LipA) is an alpha/beta-hydrolase protein that has various industrial and medical applications. The use of spectroscopic techniques such as Fluorescence and Electron Paramagnetic Resonance (EPR) require active labels/probes connected to the protein to acquire information. The most preferable site to attach such labels are cysteines-which in the case of LipA, are absent. Therefore, identifying residue candidates for cysteine point mutations that minimally affect the native functionality of the protein is essential, but could be a time-consuming process to achieve experimentally.

In this study 6 cysteine variants have been selected using a method primarily based on relative solvent accessible surface area. These variants are investigated via atomistic molecular dynamics simulations to understand the impact of selected mutations on the protein's native structure and dynamics; hence successively facilitating the identification of variants with minimal effects.

The simulation results suggest that certain dynamic regions, such as functionally important loop regions (e.g., loop 130-140) show specific sensitivity to the mutations of interest despite being spatially apart. These observations along with hydrogen network analyses suggested the induction of allosteric effects by certain mutations. Additional explorations via principal component analysis showed that while certain mutations (i.e., L108C) yielded wild-type like behavior, others (i.e., S163C) showed to have a noticeable effect on the overall structure and dynamics. This information helps us to effectively choose which mutations would be most desirable when labelling is needed.

***Keywords:*** Molecular Dynamics, Lipase A

# Perspectives of Modeling COVID-19 Transmission via Integral Equations

**R. G. U. I. Meththananda**[1*], **N. C. Ganegoda**[2], and **S. S. N. Perera**[3]
[1] Department of Spatial Sciences, General Sir John Kotelawala Defence University, Sri Lanka
[2] Department of Mathematics, University of Sri Jayewardenepura, Sri Lanka
[3] Department of Mathematics, University of Colombo, Sri Lanka
* umameththananda@kdu.ac.lk

The ongoing COVID-19 pandemic has become a major threat to the entire world. In order to support better understanding and controlling strategies, different modeling approaches can be used. Compartment models such as SIR and SEIR are the center of attention in many models. General concern on integral equation models in disease transmission is considerably low due to the intuitive temptation of modeling in terms of rate of change of response variables. This study expresses the possibilities of modeling COVID-19 transmission in terms of integral equations catering accumulation effect that can be observed in several influencing factors. Both Volterra and Fredholm integral equations can be used to model this, since these influences can accumulate within constant, variable or fixed intervals. Several advantages of integral form over differential form arise via different types of kernels accommodating a variety of behaviors. The accumulation of factors with time deferment effect can be modeled by a difference kernel while causative factors which consist of cross-references in different platforms can be formulated by degenerated kernels. This study motivates to oversee integral equations as a modeling tool in the broader area of mathematical epidemiology.

***Keywords:*** COVID-19, Integral Equations, Kernel, Accumulation and Mathematical Modelling

# Unraveling the Mechanism of the Hydroxide Transport between the Cobaltocenium Groups in Polyelectrolytes

**Sachith Wickramasinghe[1], Tianyu Zhu[1], Yujin Cha[1], Chuanbing Tang[1], Qi Wang[2],** and **Sophya Garashchuk[1]**
[1] Department of Chemistry & Biochemistry, University of South Carolina, Columbia SC
[2] Department of Mathematics, University of South Carolina, Columbia SC
GARASHCH@mailbox.sc.edu

Development of anion-exchange membranes (AEMs) with high ionic conductivity and sufficient chemical stability for the use in fuel cells is an outstanding scientific and technological challenge. A promising type of AEM materials are copolymers containing cationic cobaltocenium, mechanically stabilized by hydrophobic polyethylene backbone, which exhibit rapid hydroxide transport [1]. Fundamental insight into the pathways of ion transport inside polyelectrolyte membranes will help the development of efficient AEMs.

Generally, in aqueous medium the transport of hydroxyl ions proceeds through diffusion and through the Grotthuss mechanism. In this study, we analyze the OH- transport mechanism among the cobaltocenium groups with the aid of computer simulations: the cobaltocenium cations are placed between the graphene sheets which provide the hydrophobic environment and mimic nanoconfinement within the polymeric environment [2]; a single OH- group per cation is included into the molecular model under different hydration levels. The molecular dynamics simulations of 400-500 atoms in a periodic cell are performed using the forces obtained from the density functional tight-binding approach [3] capable of describing reactive processes. The dependence of the ion transport mechanism and conductivity, and the diffusion coefficients on the parameters of the molecular model, will serve as input for the mean-field model describing the phase separation in AEM on the micrometer scale, leading to the formation of the ion-conductive channels. We find that the rate of hydroxyl diffusion depends on the hydration level which correlates with the number of proton-hopping events, as well as the separation between the cobaltocenium cations and the relative orientations. Ultimately, the promising modifications to the polymeric material, such as the optimum separation of the cations within the polymer, backbone and side-chain modifications, suggested by theory and modeling will be used to guide the experimental design of AEMs.

***Keywords:*** hydroxyl, transport, polyelectrolytes

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# Validation of Geant4 Monte Carlo Model of $^{60}$Co High Dose Rate BEBIG Brachytherapy Source

**M. Jayakody[1*], J. Jeyasugiththan[1],** and **Arun Chougule[2]**
[1] Department of Nuclear Science, University of Colombo, Sri Lanka
[2] Department of Radiological Physics SMS Medical College and Hospital, Jaipur, India
* maheshajayakody@nuclear.cmb.ac.lk

The $^{60}$Co sources are widely used for high dose rate (HDR) brachytherapy treatments. The purpose of this study is to validate a Geant4 (version10.7.1) computational model of the BEBIG $^{60}$Co HDR source. The Geant4 Monte Carlo (MC) model has been used in compliance with the standard TG-43 formalism. The air-kerma strength per unit source activity (Sk/A) was estimated by keeping the source at the center of the xyz coordinate system. The air-kerma was scored at 100 cm on the transverse axis in a spherical air volume of 1 cm radius. Histories of $1 \times 10^9$ were used with an uncertainty below 0.4%. A cubic water phantom with dimensions 1 m x 1 m x 1 m was modeled to obtain the dose rate distribution. The radial dose distribution of the source was scored by placing the source at the center of a 40 cm radius water phantom. Histories of 2 x $10^8$ were simulated and the density and temperature were taken as recommended in TG-43. The calculated Sk/A in this work was 2.944 x $10^{-7}$ UBq$^{-1}$. Dose rate constant ($\Lambda$) was measured at 1cm on the transverse axis in water medium using 0.1 mm$^3$ cubic volume and the measured $\Lambda$ was 1.155 c Gyh$^{-1}$ U$^{-1}$. The values Sk/A and $\Lambda$ show good agreement with the previous simulation studies and has the ability to produce dose profiles. The dose rate per unit air kerma strength and the radial dose functions calculated in this study are consistent with the previous study data.

***Keywords:*** High dose rate brachytherapy, Monte Carlo simulation, Coboalt-60

# Sensitivity Analysis of Simulating Rainfall over Sri Lanka Associated with the Cyclone Amphan Using WRF

**T. D. Gamage**[1,2] ***, D. U. J. Sonnadara**[2]**, S. Jayasinghe**[3]**,** and **S. Basnayake**[3]
[1] Department of Electrical and Information Engineering, University of Ruhuna, Sri Lanka
[2] Department of Physics, University of Colombo, Sri Lanka
[3] Climate Resilience Department, Asian Disaster Preparedness Center, Thailand
* tharindu@eie.ruh.ac.lk

The cyclone "Amphan" is reported from 16th to 21st May 2020. It has affected Sri Lanka during its initial stage and moved towards the "Bay of Bengal". This study is to identify the best set of physics options in simulating the daily rain fall under the influence of the cyclone "Amphan" using Weather Research and Forecasting (WRF) model. The considered physics options are microphysics (MP), cumulus parameterization (CU) and planetary boundary layer (PBL). Twelve different combinations of those physics options are experimented. The best combination is identified by calculating the pattern correlation between the simulated and satellite measured rainfall obtained using Global Precipitation Measurement (GPM). GPM Level 3 dataset is used in this research with 0.1˚x 0.1˚resolution.

Pattern correlation is calculated by considering the rainfall of the entire simulation domain for a period of 24 hours. The total length of the simulation was six days and the average pattern correlation is calculated to identify the best physics option combination. The physics option combination which had the highest average pattern correlation was "Thompson Scheme" for MP, "new modified Tiedtke scheme" for CU and "University of Washington scheme" for PBL. In general the intensity of the simulated rainfall is comparatively lower but on the other hand the area and the pattern is accurately simulated by the identified set of physics options. We conclude that the use of such physics option combination with WRF has the potential in forecasting the rainfall in Sri Lanka under the influence of a cyclone.

***Keywords:*** WRF, Rainfall and cyclone Amphan

# Incorporation of Immunity Enhancing Selected Plant Materials to Milk to Develop a Consumer Product

**P. A. L. Jayathilake[1*], M. A. Jayasinghe[1], J. Walpita[2], M. M. Weerasekara[3], W. D. S. A. Wickrama[3]**
[1] Department of Food Science and Technology, Faculty of Applied Sciences, University of Sri Jayewardenepura, Sri Lanka
[2] Instrument Center, Faculty of Applied Sciences, University of Sri Jayewardenepura, Sri Lanka
[3] Department of Microbiology, Faculty of Medical Sciences, University of Sri Jayewardenepura,Sri Lanka
* anujayathilake.ab@gmail.com

The aim of this study was to develop a consumer product by incorporating immunity enhancing selected plant materials to cow's milk with acceptable sensory properties, evaluate proximate composition, physiochemical properties and microbial acceptance. Ginger oleoresin, turmeric oleoresin and pomegranate peel extracts were incorporated into milk to enhance human immunity while providing several health benefits due to pharmacological activities of plant extracts.

According to the sensory evaluation conducted by a semi trained panel (n=30) best formulation for the product was identified as 300ppm for ginger oleoresin, 100ppm for turmeric oleoresin and 300ppm for pomegranate peel extracts. In order to identify immunity enhancing active compounds in selected plant materials ginger, turmeric and pomegranate peel extracts were subjected to GC-MS analysis and several pharmacologically important compounds were identified. In order to identify whether these plant extracts can inhibit the action of human pathogens, antimicrobial activity of plant extracts against selected human pathogenic bacteria and fungi was checked using agar well diffusion method. All three plant extracts showed inhibition activity against selected gram positive and negative bacteria and fungi.

Proximate composition of the final product includes moisture, protein, fat, carbohydrate and ash content and all factors except ash content were not significantly different ($p>0.05$) from normal milk sample. When considering microbial acceptance there was no significant difference ($p>0.05$) between the developed sample and the control sample in relation to yeast and mould count and coliform count. But the total plate count of the developed sample was much lower than the control milk sample. And the shelf life of this product can be concluded as 5 days under refrigeration.

When considering physiochemical properties of the final product there were no significant differences ($p>0.05$) between developed and control milk samples with in relation to pH ($6.77\pm0.01$) and titratable acidity ($0.153\pm0.003$) but antioxidant activity (DPPH scavenging activity) ($40.615\pm0.447$) and gallic acid equivalent total phenolic content ($0.532\pm0.004$) was significantly higher ($p<0.05$) in the newly developed product. When antioxidant and total phenolic content is higher it possesses anticancer, anti-inflammatory and cholesterol lowering like properties thus the pharmacological importance of the product will be high. Thereby it can be concluded this product has medicinal value than normal milk as it was incorporated with immunity enhancing ginger, turmeric and pomegranate.

***Keywords:*** Ginger, Pomegranate, Turmeric

# Spatial and Temporal Variation in Land Use Patterns and Their Influence on Urban Green Spaces in a Metropolitan University: An Assessment Using GIS and Remote Sensing Techniques

**A. A. D. A. S. Vimukthi** [1] and **I. A. J. K. Dissanayake**[1*]
[1]Department of Plant Sciences, Faculty of Science, University of Colombo, Sri Lanka.
*jkdissanayake@pts.cmb.ac.lk

Urbanization has led to many changes in natural landscapes and resulted with conversion of many green spaces into built-up areas. A detailed understanding on urban land use is crucial for sustainable urban planning and coping with environmental changes. This study was conducted to investigate the spatial and temporal variations of land use patterns and their influences on urban green spaces in the University of Colombo with the aim of contributing to the improvement of sustainable urban landscaping. These green spaces are actively contributing to the urban biodiversity and ecosystem services of the city of Colombo. Land use patterns were studied in selected years in which quite rapid infrastructure developments were recorded. The Google Earth mosaic high resolution satellite images and aerial photographs were analyzed to prepare the Land Use Land Cover (LULC) maps by on-screen digitizing of eight land use land cover classes, namely, trees, shrubs and herbaceous green areas, playgrounds, bare soil, pervious roads, impervious lands, buildings and impervious roads using Google Earth Pro (version 7.3.2.5776) and ArcGIS (10.3) software. A correlation and a regression analysis was performed to determine the association between Total Built-up Area and Total Green Area. The per capita green space was calculated for the years from 2000 to 2019 and the functional connectivity of green spaces was determined for a 10m wide range divided by 1m buffer zones in ArcGIS platform. The results revealed that the LULC pertaining to trees (12% to 24%), buildings (14% to 29%), playgrounds (16% to 18%), impervious lands (0% to 4%), impervious roads (0% to 9%) were increased while herbaceous covers (20% to 10%), bare soil (36% to 5%) and pervious roads (3% to 0%) were decreased over the last 37 years. The Total Green Area and Total Built-Up area are negatively correlated ($R^2$= 0.731, p-value= 0.003< 0.005). The least square equation for the fit denotes for each additional 1$m^2$ in Total Built-up Area, the expected Total Green Area decreases by 0.408$m^2$. Per capita green space gradually decreased from 11.35$m^2$ to 4.88$m^2$ from 2000 to 2019 and is currently less than the WHO standard (9$m^2$). Functional connectivity of green spaces has decreased, and the disjunct areas have increased from 1982 to 2019. The nearest neighbour distances of the disjunct green areas are very low and in 1-3m range. Therefore, this study strongly recommends the requirement of a policy decision to control further reduction of the per capita green space during any construction. We recommend establishing an area of 0.408$m^2$ of green space to compromise any new 1$m^2$ of built-up areas. The functional connectivity can be easily improved using green infrastructure such as vertical gardening, green roofing and green pavers.

***Keywords:*** Total Green Area, Per capita green space, Functional connectivity

# A Survey on Organic Home Gardens in Sri Lanka: Investigation on the Familiarity and Attitudes towards Organic Home Gardening as an Alternative for Achieving Sustainability

**A. D. Kadawatha[2], S. U. M. Fernando[1]*, B. T. Weththasinghe[2], V. S. Kulatunga[1],** and **E. A. D. N. D. Edirisinghe[3]**

[1] Department of Zoology and Environment Sciences, University of Colombo, Sri Lanka.

[2] Department of Plant Sciences, University of Colombo, Sri Lanka.

[3] Department of Zoology, The Open University of Sri Lanka, Nawala, Sri Lanka.

* shehanisu1994@gmail.com

Organic home gardening (OHG) has always been a sustainable solution towards many environmental problems that arose during the last century. Even though it could not accomplish the ultimate level of expectations, there were many attempts to encourage people to engage OHG in Sri Lanka. During the Covid-19 pandemic in the years of 2020 and 2021 this topic gained attention more than ever. Therefore, this paper attempts to assess the community perception, challenges and success of home gardening (HG) practices with organic amendments in Sri Lanka. From January to February 2021, 300 questionnaires consisting of multiple choice and open ended questions were administered to people island-wide representing 21 districts. Results show that 90.3% of the population were aware about OHG and it was relatively higher ($p = 0.008$) in females (76.7%) than males. Further, it was dependent on their education levels ($p = 0.019$) as well. The percentage for taking up any gardening activity during the Covid-19 pandemic (90.3%) is higher ($p = 0.000$) than that of the regular gardeners while the extent of the property also has a significant influence ($p = 0.005$) on continuing OHG. According to this survey, government support and well organized programs to raise awareness is obligatory in order to achieve sustainability through OHG.

***Keywords:*** Organic home gardening, Sustainability, Covid-19

# Levels of Selected Constituents of Follicular Fluid as Predictive Markers of *in vitro* Fertilization Success in a Cohort of Sri Lankan Females: A Pilot Study

**Manodya Herath[1], Sumedha Wijeratne[3], Sachini Amarasekara[1], Rasika Jayatillake[2], Milhan Batcha[3], Dananjaya Perera[3]**, and **Preethi Udagama[1*]**

[1] Department of Zoology and Environment Sciences, University of Colombo, Sri Lanka.

[2]Department of Statistics, University of Colombo, Sri Lanka.

[3]Vindana Reproductive Health Center, Colombo 07, Sri Lanka.

* preethi@zoology.cmb.ac.lk

*In vitro* fertilization and embryo transfer (IVF-ET) is the most common assisted reproductive method in current usage. During this procedure, oocytes-cumulus complex with surrounding follicular fluid (FF) are aspirated from follicles during egg retrieval from the ovaries. FF is pivotal in determining the maturity of the oocyte, thereby determining its potential to be successfully fertilized. This study investigated levels of glucose, protein, cytokines (IFNγ, IL-4) and nitrogen oxides (NOx) in FF of a cohort of Sri Lankan females undergoing IVF-ET (N=56), to be used as predictive markers of IVF-ET outcome. Participants were recruited with informed consent; fourteen (14) who exclusively recorded male factor infertility served as the control group. Depending on the fertilization rate (FR), the rest (n=42) were divided into three sub-groups; A) FR=100%, B) 65%≤FR<100% and C) FR<65%. FR of the control group ranged between 9.09% and 100%. Glucose and protein levels were measured using commercially available kits while cytokines and NOx were measured using sandwich ELISAs and the Griess assay, respectively. All 56 samples tested positive for glucose, protein and NOx while 55 recorded IL-4 levels. As a majority of the samples tested negative for IFNγ, this was excluded from the analysis. The significant level was set at p=0.05. A significant difference of the analyte levels among A, B, C and the control groups was absent for all analytes tested. Glucose levels showed a significant negative correlation (p=0.044) with FR of group B, and with the proportion of mature oocytes of the total test population (p=0.022). A significant increase in glucose was observed in ovary related infertility vs endometriosis (p=0.039). A significant increase in IL-4 was observed in women with endometriosis vs idiopathic infertility (p=0.031). NOx concentration was significantly low in idiopathic infertility vs endometriosis (p=0.014), tubal factor (p=0.014), ovarian pathologies (p=0.028) and the control group (p=0.007). Of the five analytes tested, it was evident that only glucose may serve as a potential biomarker to predict IVF-ET outcome. Validation of the results of this pilot study is warranted with large study cohorts to establish possible biomarkers to predict IVF-ET outcome and to diagnose different causes of female infertility.

# Determining the Applicability of *Caesalpinia pulcherrima* Seed Gum in the Edible Film Forming for Food Packaging

**Y. S. M. Senarathna[1]*, S. B. Navaratne[1], I. Wickramasinghe[1],** and **R. Coorey[2]**
[1] Department of Food Science and Technology, Faculty of Applied Sciences, University of Sri Jayewardenepura, Gangodawila, Nugegoda, Sri Lanka.
[2] School of Molecular and Life Sciences, Faculty of Science and Engineering, Curtin University, Perth, Western Australia.
* madus@sci.sjp.ac.lk

Researching novel biopolymer sources of biodegradable and edible films has become a recent trend as a potential alternative for plastic packaging films which highly cause environmental pollution. Among the biopolymers used in edible film making, galactomannan is identified as a good film-forming agent. *Caesalpinia pulcherrima* seed gum is a rich source of galactomannan which can be suggested to use as an edible film making material. The main objectives of this study are to identify the ability of *Caesalpinia pulcherrima* seed gum in making food packaging film and assessing its performance. In this study, *Caesalpinia pulcherrima* seed gum was extracted from seeds using ethanol. The film-forming solution was prepared by dissolving *Caesalpinia pulcherrima* seed gum in distilled water along with glycerol. The appropriate seed gum and the range of plasticizer contents were determined based on the preliminary experiments. This study was carried out to find out the optimum plasticizer concentration of the *Caesalpinia pulcherrima* seed gum in edible film making while measuring its physical and mechanical properties. According to the study, the film which did not incorporate glycerol was brittle, not flexible and had a strong film matrix. With the increase of glycerol content, the film was more flexible, sticky and weak. Further, the physical properties namely thickness, moisture content, swelling index, the water solubility of *Caesalpinia pulcherrima* seed gum-based films were increased from 0.039 ± 0.001 to 0.076 ± 0.001 mm, from 62.92 ± 0.51 to 69.40 ± 0.15%, from 5.39 ± 0.17 to 8.45 ± 0.17, from 55.69±0.51 to 66.66 ± 0.45%, respectively with the increase of glycerol content from 0.0 to 1.5%. Concerning the mechanical properties, the tensile strength and Young's module were decreased from 10.90 ± 0.08 to 2.11 ± 0.05 MPa and from 48.46 ± 0.24 to 3.47 ± 0.09 MPa, respectively and the elongation was increased from 22.50 ± 0.05 to 60.84 ± 0.04% with increasing the glycerol content from 0.0 to 1.5%. The analysis of physical and mechanical properties reveals that *Caesalpinia pulcherrima* seed gum is a potential source for edible packaging films.

***Keywords:*** Food packaging; Edible film, *Caesalpinia pulcherrima*

# An Analysis of Temperature and Precipitation Trends in Colombo and Nuwara Eliya Districts during the Past 31 Years (1989-2019)

**N. A. Nuwanthi**[1] and **E. Lokupitiya**[1*]
[1]Department of Zoology and Environment Sciences, Faculty of Science, University of Colombo, Sri Lanka.
*erandi@sci.cmb.ac.lk

Climate trends in different regions must be studied in order to recognize the effects of climate change. Temperature and precipitation trends in Colombo and Nuwara Eliya districts were investigated from 1989 to 2019. Due to their distinct topography, the two districts have quite varied physical and climatic characteristics. Precipitation trends were examined on annual, monthly, and seasonal scales, while mean, minimum, and maximum temperature trends were examined on annual and monthly scales. Decadal variations of average temperature and precipitation were evaluated using decadal time series plots. The trends in extreme temperature and precipitation events were also analyzed. Additionally, the trends for Diurnal Temperature Range (DTR), cool and warm nights, and heat index (HI) were analyzed. The significance of the trend analysis was assessed by the Mann-Kendall test, while the magnitude of the slope was estimated using Sen's slope estimator. The annual precipitation in both regions indicated statistically non-significant trends; an increasing trend in Colombo and a decreasing trend in Nuwara Eliya. In both districts, there was a decrease in southwest-monsoon rainfall patterns, with Nuwara Eliya showing a significant decreasing trend. Corresponding to the global temperature increase, the mean annual temperature trends in both districts showed statistically significant upward trends. In Colombo, the minimum annual temperature increase was higher than the maximum annual temperature increase, while in Nuwara Eliya, the maximum annual temperature increase was higher than the minimum annual temperature increase. Extreme temperature and precipitation events followed similar patterns as the annual mean temperature and annual precipitation trends. In a decadal analysis of average precipitation, the highest average monthly precipitation in Colombo was shifted from October to November during 2010-2019. The trend for maximum monthly temperatures in April during the last decade has also increased significantly in Colombo. There was a substantial narrowing of the DTR, as well as a significant upward trend in HI values in Colombo district. Moreover, trends for cool and warm nights indicated significant decreasing and increasing patterns, respectively, in Colombo. The findings of this study will help the authorities in developing adaptive responses and implementing climate actions within the respective districts.

***Keywords:*** Temperature, Precipitation, Climate trends

# Stimulated Growth and Morphogenetic Responses in Anther-derived Callus of Local Indica Rice Variety, Hondarawalu by Partial Desiccation Stress

**M. D. O. D. Gunathilaka[1], D. M. R. G. Mayakaduwa[1*], G. D. A. Priyantha[2],** and **T. D. Silva[1]**
[1] Department of Plant Sciences, Faculty of Science, University of Colombo, Colombo 03, Sri Lanka.
[2] Regional Rice Research and Development Centre, Bombuwela, Kalutara, Sri Lanka.
* ruwani.mayakaduwa@pts.cmb.ac.lk

*In vitro* anther culture offers a sustainable approach for developing new plant varieties due to rapid fixation of homozygosity. However, there are difficulties in applying the anther culture system for Indica rice, as many varieties that readily produce callus from cultured anthers fail in the subsequent regeneration step. The Indica rice variety Hondarawalu, a prolific callus inducer which lacks regeneration potential was used in this study to investigate the effectiveness of applying partial desiccation stress on anther-derived calluses on their growth and morphogenesis. Calluses were induced on a modified $N_6$ medium. Half of the calluses were subjected to desiccation by placing them on sterile dry filter paper in a Petri dish for 24 h in dark at 27±2 $^oC$. The remaining half of the calluses served as the control. Both partially desiccated and non-desiccated calluses were transferred to MS regeneration medium formulated with four 6-benzylaminopurine (BAP) concentrations (0.5, 1.0, 1.5, 2.0 $mgL^{-1}$), Kinetin (0.5 $mgL^{-1}$) and Naphthaleneacetic acid (0.5 $mgL^{-1}$) and maintained in continuous illumination at 27±2 $^oC$. Average callus growth, percentage callus with chlorophyllous regions and green shoot bud initiation were recorded after 20, 30, 40 and 50 d. Data were analyzed by Two-way ANOVA using Statistical Analyses System (v 9.0). After 20 d and 30 d, partially desiccated calluses showed significantly higher ($p \leq 0.05$) average growth than non-desiccated calluses in all four regeneration media. At 20 d, significantly higher ($p \leq 0.05$) percentage of partially desiccated calluses formed chlorophyllous regions in all regeneration media compared to non-desiccated calluses. However, at 30 d and 40 d, a significant regeneration medium x stress interaction was observed ($p \leq 0.05$), where significantly higher percentage of partially desiccated calluses showed chlorophyllous regions (33.33% and 37.50% respectively) compared to controls (0.00% and 0.00% respectively) on regeneration medium with 0.5 $mgL^{-1}$ of BAP. Also at 40 d, a significantly higher number of partially desiccated calluses on this medium (0.5 $mgL^{-1}$ of BAP) continued to produce green shoot buds (25.00%) compared to the control (0.00%; $p \leq 0.05$). Partial desiccation stress can be used with appropriate level of BAP to improve growth and morphogenetic competence of anther-derived calluses in Hondarawalu.

***Keywords:*** Indica rice, Anther-derived callus, Morphogenesis

# Metagenomic Analysis of Raw Cattle Milk Microbiota in Sri Lanka Employing Illumina MiSeq Platform

**D. U. Rajawardana[1]*, P. C. Fernando[2], P. J. Biggs[3], C. M. Nanayakkara[2], I. G. N. Hewajulige[1],** and **S. Wickramasinghe[4]**

[1] Food Technology Section, Industrial Technology Institute, Malabe, Sri Lanka.
[2] Department of Plant Sciences, Faculty of Science, University of Colombo, Colombo 007, Sri Lanka.
[3] Infectious Disease Research Centre, School of Veterinary Science, Massey University, Palmerston North 4442, New Zealand.
[4]Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya, Sri Lanka.
*upekarajawardana@yahoo.com

Bacterial contamination of raw milk is a major concern worldwide in public health and economic viewpoint. Raw milk is highly susceptible to changes in temperature and humidity of the environment. The impact of tropical climatic conditions on the bacterial communities in raw milk has not yet been broadly examined. Therefore, this study was conducted to evaluate the bacterial composition of raw cattle milk produced in Sri Lanka, an island country located near the equator with year-round warm weather and considerable moisture. Ninety raw milk samples were collected from 18 dairy farms representing all three climatic zones of the country (wet, dry and intermediate zones) divided based on the rainfall distribution. Bacterial DNA extraction and purification was performed using Milk Bacterial DNA Isolation Kit as per the manufacturer's instructions. PCR amplification was carried out targeting the V3 and V4 regions of the 16S rRNA gene. Metagenomic sequences were obtained using IlluminaMiSeq platform at the Massey Genome Services (New Zealand). The operational taxonomic units (OTUs) clustering and classification at several taxonomic levels were performed using QIIME2 (version 2019.1) and Phyloseq (an R package). The OTUs belonged to 23 bacterial phyla, 110 orders, 381 genera, and 348 known species. Milk microbiota in terms of relative abundance (RA) was reported at the phylum, genus and species levels. The core microbiome was predominated by Firmicutes (48.33%) followed by Proteobacteria (22.66%), Actinobacteria (15.33%), Bacteroidetes (11.22%) and TM7 (0.91%) phyla. At the genus level, *Macrococcus* (10.30%) was the most abundant followed by *Streptococcus* (10.24%), *Elizabethkingia* (6.46%), *Staphylococcus* (3.48%), *Enhydrobacter* (3.14%), *Atopococcus* (3.04%), *Corynebacterium* (2.46%), *Arthrobacter* (2.13%), *Kocuria* (2.08%), *Acinetobacter* (1.66%), *Rothia* (1.32 %), *Micrococcus* (1.14%) and *Bifidobacterium* (1.01%). The six most abundant (RA>1%) bacterial species identified were *Streptococcus agalactiae*, *Staphylococcus saprophyticus*, *Enhydrobacter aerosaccus*, *Atopococcus tabaci*, *Kocuria kristinae* and *Rothia nasimurium*. The members of *S. agalactiae* (5.61%), *S. saprophyticus* (3.48%), *E. aerosaccus* (3.14%) and *R. nasimurium* (1.06%) are known etiological agents in both human and animal diseases. The bacterial taxa diversity identified could be utilized to develop hygiene measures targeting the most problematic species.

***Keywords:*** Metagenomic, Illumina MiSeq platform, Bacterial communities

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# A Case-control Study on the Effects of Long-term Meditation on Telomere Length, Quality of Life and Mindfulness

**N. N. Dasanayaka[1*], N. D. Sirisena[2],** and **N. Samaranayake[3]**
[1] Research Promotion and Facilitation Centre, University of Colombo, Sri Lanka
[2] Human Genetic Unit, Department of Anatomy, University of Colombo, Sri Lanka
[3] Department of Parasitology, Faculty of Medicine, University of Colombo, Sri Lanka
* nirodhi@med.cmb.ac.lk

Meditation involves rigorous spiritual and psychophysical training which can result in a range of benefits including creating a clear, stable, calm mind and increasing focus, self-awareness, relaxation, and tranquility. Increasing evidence suggests that meditation and mindfulness-based practices may have favorable effects on the telomere length, quality of life (QOL) and mindfulness level. This study therefore aimed to measure the relative telomere length, QOL and the state of mindfulness between long-term meditators and controls. Meditators were recruited from meditation centers in Sri Lanka. Age, and gender matched controls (non-meditators) were recruited from the community using purposive sampling. Blood was collected into an Ethylenediaminetetraacetate (EDTA) tube using the venepuncture method. DNA was extracted from the buffy coat using a commercially available kit. Telomere length was measured via quantitative polymerase chain reaction using Absolute Human Telomere Length Quantification qPCR Assay Kit. Socio-demographic data were collected. WHOQOL-BRFE scale including 4 subscales with 26 items scored as '1'to'5' and five facet mindfulness questionnaires (FFMQ) comprising 30 items with five facets rated according to a Likert scale were also administered to all participants. Independent sample t-test was used to compare the mean relative telomere length, QOL and mindfulness level between meditators and controls. 26 of the 36 participants (72.2%) were males and mean age ± standard deviation (SD) of the meditators and controls were 42.78 ± 9.8 and 42.83 ± 9.78 years, respectively. Telomere length (meditators: mean±SD=10.32±1.10; controls: mean±SD=6.82±0.65; p=0.010) and total mindfulness score (meditators: mean±SD=147.56±21.41; controls: mean±SD=127.30±9.74; p=0.009), were significantly higher in meditators than controls. QOL scores (meditators: mean±SD=100.38±9.48; controls: mean±SD=93.30±9.60; p=0.070) was not significantly different between meditators and controls. When considering the subscales, observing (meditators: mean±SD=29.33±7.00; controls: mean±SD=23.90±5.68; p=0.037), describing (meditators: mean±SD=33.22±4.02; controls: mean±SD=28.20±3.88; p=0.004) and non-reacting (meditators: mean±SD=27.72±4.46; controls: mean±SD=23.60±3.88; p=0.022) scales of the FFMQ and the psychological scale (meditators: mean±SD=26.61±2.40; controls: mean±SD=22.80±3.90; p=0.009) of the QOL were significantly higher in meditators compared to non-meditators. The findings of this study suggest that long-term meditation practice may have potentially beneficial effects on the state of mindfulness and telomere length.

***Keywords:*** Telomere length, Quality of life, Meditation

# Salt Content of Commonly Consumed Foods in Sri Lanka with Respective to Traffic Light Labeling System (Colour Coding System)

**W. C. Prasadani[1*], H. P. E. De Zoysa[1],** and **H. P. P. S. Somasiri[1]**
[1]Industrial Technology Institute, Sri Lanka.
* prasa.vith@gmail.com

Health Ministry of Sri Lanka introduced colour coding system for fat, salt and sugar content of solid and semi solid foods to facilitate people with minimum health literacy to select foods as per individual health requirements and thereby protect from non-communicable diseases. Due to the lack of a database for salt content of foods consumed in Sri Lanka and different quantities of salt in foods with similar composition, it is important to analyze sodium content to develop recommendations regarding the salt content based on traffic light system. Hence commonly consumed food samples were randomly collected and categorized to groups: confectionary (CON, n=37), cereals (CER, n=10), fine bakery wares (FBW, n=42), bread and ordinary bakery wares (BOB, n=30), curded dairy based desserts (CDD, n=19), composite foods (CPF, n=27), pasta, noodles and like products (PNO, n=4) and sauces, dips and dressing (DRE, n=3). Sodium content was analyzed using flame photometer (Model 420, Sherwood Scientific) after dry ashing. Based on calculated salt content as NaCl, percentage of food items belong to red, amber and green logos of CON, CER, FBW, BOB, CDD, CPF, PNO, DRE are (0,11,89), (0,30,70), (12,74,14), (17,50,33), (0,16,84), (11,85,4), (0,50,50), (33,0,67) respectively. None of the samples of CON, CER, CDD and PNO belong to red logo whereas 12% of FBW, 17% of BOB, 11% CPF and 33% of DRE belong to red (≥1.25g/100g). Among food groups, 85% of CPF, 74% of FBW, and 50% of BOB and PNO belong to amber logo (0.25-1.25g/100g) whereas 89% of CON, 70% of CER, 14% of FBW, 33% of BOB, 84% of CDD, 4% of CPF, 50% of PNO and 67% of DRE belongs to green logo (≤0.25g/100g). Variation in salt content among products of same group suggests that product reformulation to further reduction of salt content less than 0.25g/100g is feasible. Due to huge variation of salt content in products of same group, it is vital to implement recommendations for marketing foods to children and reformulate food products.

***Keywords:*** Salt content, traffic light labelling system

# Identification of Social and Occupational Risk Factors Associated with CKDu Patients in an Agricultural Community in Kebithigollewa, Sri Lanka

**Chamodika Lowe[1], Nishantha Kumarasinghe[2*],** and **Fahim Aslam[3]**
[1]Department of Biomedical Science, University of Wolverhampton, U. K.
[2]Department of Anatomy, General Sir John Kotelawala Defence University, Sri Lanka
[3]Institute of Ayurveda and Alternative Medicine, Panadura
* nishantha@kdu.ac.lk

CKDu (Chronic Kidney Disease of Uncertain etiology) now known as CINAC (Chronic Interstitial Nephritis of Agricultural Communities) is a form of Chronic Kidney Disease which has become a global health burden. With its growing prevalence in Sri Lanka, this study was carried out to identify the social and occupational risk factors associated with CKDu patients living in an agricultural community in Kebithigollewa, Sri Lanka. This community based cross-sectional study was done for a period of three months involving 30 cases (CKDu patients with serum creatinine >1.2mg/dL for 6 consecutive months) from Kebithigollewa CKDu Western Ayurvedic Integrated Clinic in North Central Province (NCP), Sri Lanka and 30 controls (general public of same region who weren't diagnosed with CKDu and whose serum creatinine <1.2mg/dL for 3 consecutive months). An interview based questionnaire was used to collect socioeconomic and socio-demographic data of the participants. Their heights and weights were measured to calculate the BMIs. Blood samples were withdrawn, which were later analysed using an automated blood analyser to obtain the serum creatinine values. Data collected was computed and analysed using the software Graphpad Prism and SPSS. All the participants of the research were active residents living in NCP since birth. As of the results obtained, 83.34% of cases were in the age range 40-70 yrs and 70% were males. Moreover, 86.66% of the diseased population practiced agriculture as their main source of income with chena and paddy cultivation being the main practice followed. Serum creatinine was high in farmers and laborers. Most importantly, 96.66% of them were from families with low income who earn 0-20,000 LKR per month. Furthermore, 40% of CKDu patients have only gained up to five years of school education, while 63.33% were overweight. The number of working hours per day and serum creatinine exhibited a strong association among them while the number of working hours and BMI showed a statistical significance with $P<0.05$ ($P=0.02$) leading to conclude that occupation impacts on CKDu occurrence and progression. The social impact on CKDu occurrence was indicated by the significant relationship of age with serum creatinine.

***Keywords:*** Agricultural activities, CKD of Uncertain etiology (CKDu), Heavy metals

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# Evaluation of the Antioxidant Activity in Cinnamon, Clovebud and Ginger Essential Oils and Oleoresins

**Maheshika Sethunga [1*], K. K. D. S. Ranaweera[1], K. D. P. P. Gunathilake[2]**, and **Imalka Munaweera [3]**
[1] Department of Food Science and Technology, Faculty of Applied Sciences, University of Sri Jayewardenepura, Gangodawila, Nugegoda, Sri Lanka.
[2] Department of Food Science & Technology, Faculty of Livestock, Fisheries & Nutrition, Wayamba University of Sri Lanka, Makandura, Gonawila, Sri Lanka.
[3]Department of Chemistry, Faculty of Applied Sciences, University of Sri Jayewardenepura, Gangodawila, Nugegoda, Sri Lanka.
[*] maheshichathuranganee@gmail.com

Essential Oils (EOs) and Oleroresins (ORs) which are bio-active compounds of spices have been comprehensively investigated for their antioxidant activity as they lead to green substitute in pharmaceutical and nutritional usage probably by decreasing the impact of age-related chronic diseases and preventing the diseases associated with Reactive Oxygen Species. This study focused on Cinnamon (*Cinnamomum zeylanicum*), Ginger (*Zingiber officinale*) and Clovebud (*Syzygium aromaticum*) as they are widely grown spices in Sri Lanka for commercial value. Although there are prior studies to evaluate the antioxidant activity, a comparison of cinnamon, ginger and clovebud and the synergistic effect of their combination were not reported previously. The dried cinnamon bark, clovebud and slices of ginger rhizome were hydrodistilled for obtaining EOs and they were extracted using ethyl acetate for obtaining ORs. Antioxidant properties of EO and OR (dissolved using 80% methanol) were determined using 2,2-diphenyl 2-picrylhydrazyl (DPPH) Radical Antioxidant Scavenging Activity (RASA) and Total Antioxidant capacity (TAC) assay. The yields of the EO were 0.45±0.01% (cinnamon), 15.75±0.79% (clovebud), 1.42±0.039 (ginger). OR gave 2.66±0.15%, 29.92±1.48%, 6.82±0.04%, yields for cinnamon, clovebud and ginger respectively. The EOs and OR exhibited a range of variation in inhibition percentage of DPPH; EOs of cinnamon (53.68±0.62), clovebud (88.70±0.46), ginger (39.48±0.49) at 1000 mg/L concentration and ORs of cinnamon (10.91±0.58), clovebud (52.36±0.48), ginger (27.36±0.48) at 100 mg/L concentration. The TAC of EOs and ORs was within the range of 0.27-3.94 mg AAE/mg weight in EO or OR. Clovebud OR showed the highest TAC (3.94±0.05 mg) followed by ginger (1.78±0.11 mg) and cinnamon (0.29±0.01 mg) per AAE/mg weight of OR. The TAC of EOs was 0.48±0.02, 0.43±0.00, 0.27±0.00 AAE/mg weight of EO in clovebud, ginger and cinnamon EOs respectively. A significant increase of synergistic antioxidant activity of combined EO and OR resulted higher DPPH RASA and TAC in clovebud EO and cinnamon EO, clovebud EO and ginger EO than single EOs. The study reveals that, ORs are rich in bioactive compounds which contribute to higher antioxidant activity than EOs. Amidst studied spices, clovebud showed the highest RASA, TAC in both EOs and ORs. Synergistic antioxidant activity is higher when clovebud EO is combined with cinnamon EO and ginger EO.

***Keywords:*** Essential oils, Oleoresins, Antioxidants activity

# A Study on Cytotoxicity and Apoptotic Potential of Different Fractions of *Gracillaria edulis* (*Gmelin*) *Silva* against Human Breast Adenocarcinoma (MCF-7) Cells

**M. D. T. L. Gunathilaka[1], K.W. Samarakoon[3], P. Ranasinghe[2],** and **L. D. C. Peiris[1*]**
[1]Department of Zoology (Center for Biotechnology), Faculty of Applied Sciences, University of Sri Jayewardenepura, Nugegoda, Sri Lanka.
[2]Industrial Technology Institute, Halbarawa Gardens, Malabe, Sri Lanka.
[3]Institute for Combinatorial Advanced Research and Education (KDU-CARE), Research and Development Office, General Sir John Kotelawala Defence University, Rathmalana, Sri Lanka.
* dinithi@sci.sjp.ac.lk

Marine seaweeds are a rich source of bioactive metabolites that can be used as an alternative source for the development of the anti-cancer drug. The present study was aimed to evaluate the cytotoxicity and apoptotic activity of different fractions of *G.edulis* against the human breast adenocarcinoma (MCF-7) cell line. De-polysaccharide polyphenol-rich methanol extract of *G.edulis* was sequentially partitioned with hexane, chloroform, and ethyl acetate to determine the cytotoxic and apoptotic effects. The cytotoxic activity was assessed by MTT and neutral red assays while apoptotic activity was examined by cellular morphology, DNA fragmentation, and Caspase 3/7 assays. The results of the cytotoxicity assay showed that the decrease in the percentage of cell viability in a dose-dependent manner as signified by cell death Among them, the hexane (HF) and chloroform fractions (CF) showed potent cytotoxic activity as determined by MTT ($IC_{50Hexane:}$29.84±0.65 µg/ml, $IC_{50Chloroform}$: 78.62±3.86µg/ml) and neutral red assay ($IC_{50Hexane}$:33.19±0.44µg/ml, $IC_{50Chloroform}$: 72.28±3.51 µg/ml) compared to the standard cycloheximide ($IC_{50MTT}$:28.76±0.55µg/ml, $IC_{50NEUTRAL\ RED}$: 27.84±0.33µg/ml). Further, the morphological assessment of apoptosis was confirmed using Hoechst 33342 staining and crystal violet staining. The low activation of Caspase 3/7 was observed in the MCF-7 cells treated with all fractions of *G.edulis* together with the standard staurosporine and cycloheximide. Among them, Caspase 3/7 was activated to a moderate extent in both HF and CF after 3 hours of the treatments. Besides, the typical DNA ladder pattern was observed in both HF and standard cycloheximide-treated MCF-7 cells. It can be concluded that the HF of *G.edulis* has the ability to suppress cellular proliferation and induce apoptosis-mediated cell death in the MCF-7 cell line. Thus, the HF of *G.edulis* can be a potent candidate to isolate the new anti-cancer compounds.

***Keywords:*** *G.edulis*; Anti-cancer; MCF-7

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# "Connected Researches" in "Smart Lab Bubble": An Enabler for Innovative Performance Management in Agriculture

**P. C. Abeysiriwardana[1*], U. K. Jayasinghe-Mudalige[2],** and **S. R. Kodituwakku[3]**
[1, 2] Department of Agribusiness Management, Faculty of Agriculture and Plantation Management, Wayamba. University of Sri Lanka, Makandura, Gonawila (60170), Sri Lanka.
[3] Department of Statistics & Computer Science, Faculty of Science, University of Peradeniya, Peradeniya (20400), Sri Lanka.
*abeysiriwardana@yahoo.com

Research on improving the performance of the agriculture sector is one of the main strategies adopt by a country to overcome the challenge of food security, and in turn, to attain the second sustainable goal of 'zero hunger by 2030'. Analyzing the drawbacks of the present research environment and finding out the solutions through digital intervention can be considered an ideal solution to uplift the research outcome, especially in light of disruptions caused by the COVID-19 pandemic. This paper identifies the problems encountered in carrying out research in agriculture and proposes an alternative approach to the traditional person-to-person involvement. A model presented, which connects research beyond physical presence by digital transformations in research institutes, is supposed to encapsulate the concept of connected lab complex - "Smart Lab Bubble". Digitally endorsed performance measurements and evaluation is envisaged and linked with a proposed set of policy measures such as promoting digital innovations within an organizational design and adopting performance management mechanism supported by digital accountability etc. As the concept of "Smart Lab Bubble" develop into a fully-fledged physical network, it can be applied from different perspectives to engineer the real needs of the sustainability of research in agriculture as well as other areas in life sciences. Validation of this methodology is warranted, and for this purpose, the real experiences of the scientists who share laboratory facilities and implement alternative experiment procedures in remote working conditions should be matched against expected outcomes of the "Smart Lab Bubble" concept.

***Keywords:*** Agriculture Research, Smart Research Institutes, Connected laboratories

# Occupational Noise Induced Hearing Loss among the Dental Professionals Working at Dental Institutes in Sri Lanka

**M. D. K. De Silva,[1]*** and **J. H. D. S. P. Tissera[2]**
[1] Department of Disability Studies, Faculty of Medicine, University of Kelaniya, Sri Lanka.
[2] Department of Statistics, Faculty of Science, University of Colombo, Sri Lanka.
* dumini@kln.ac.lk

Noise at the dental setup has an adverse effect on the hearing ability of the dentists. This study aimed to determine the prevalence of hearing loss among dental practitioners and to identify the demographic and service-related factors associated with hearing loss among dental practitioners working at dental institutions in Sri Lanka.

A descriptive cross-sectional study was designed to include 155 dental professionals working at three dental institutions in Sri Lanka; the National Dental Hospital (teaching)- Colombo, Dental Teaching Hospital-Peradeniya, and Institute of Oral Health- Maharagama. Data were collected through an interviewer-administered questionnaire which obtained information on auditory symptoms, demographic and work-related data and a standard hearing assessment; Pure Tone Audiometry where hearing threshold >15dB is considered as having a loss. Descriptive statistics and regression analysis were used to analyse data.

Participants were in the 25- 60 age range. Majority consisted of females, working 6 days per week and attached to restorative dentistry. Work experience ranged from 1 – 37 years. Only 39.4% of dentists were reported to get exposed to loud sounds apart from dentistry. According to the hearing test, 70% of the dentists in the present study were found to have a hearing loss at least in one ear, where left ears were affected more. However, irrespective of the ears, having a normal hearing or hearing loss at hearing thresholds of 6kHz was noted to be poorer, while relatively better hearing in lower frequencies which is characteristic of hearing loss due to noise exposure. The proportion of dentists who experienced tinnitus and difficulty in speech recognition was 14%, while 21% reported difficulty in the following speech only when there is background noise. Age, work experience, specialization in general dentistry, and perceived speech recognition difficulty were significantly associated with hearing loss. More than 10 years of work experience and perceived speech recognition difficulty in noise were significant indicators of the existence of hearing loss in both ears.

Dentists attached to the three dental institutes are at risk of developing hearing loss. It is recommended to conduct annual hearing check-ups and take necessary measures to reduce exposure to noise in the dental setup.

***Keywords:*** Noise, dentists, hearing loss

# Influence and Risk Assessment of Exposure to Fluoride on CKDu in Sri Lanka

**W. S. M. Botheju[1*], J. A. Liyanage[1],** and **S. D. P. Kannangara[2]**
[1] Department of Chemistry, University of Kelaniya, Sri Lanka.
[2] Department of Plant and Molecular Biology, University of Kelaniya, Sri Lanka.
* 2017_botheju@kln.ac.lk

Fluoride is one of the top ten chemicals of concern for human health. Chronic exposure to fluoride in excessive levels results in diseases such as dental and skeletal fluorosis, tissue calcification, and chronic kidney disease. Manifestation of the Chronic Kidney Disease of unknown etiology (CKDu) is mainly due to the prolonged exposure to environmental nephron toxicants and extenuating conditions. Although numerous causative factors for the onset of CKDu have been postulated, the disease is considered a medical mystery. However, fluoride is considered as one of the critical factors as a causative agent of CKDu. Therefore, this study was conducted to investigate the fluoride concentration in drinking and reservoir water within a CKDu endemic area to perform a health risk assessment. Water samples were randomly collected from dug wells (n=30) in Girandurukotte Grama Niladhari Division (GND) and the Ulhitiya reservoir (n=30) in Badulla District, Sri Lanka. Dambethalawa GND (n=30) and the Namal Oya reservoir (n=30) were selected as the reference sites as there is no evidence of CKDu patients. The collected water samples were analyzed for concentrations of fluoride using Ion Chromatography (Metrohm Eco IC, Switzerland) according to the standard procedures. The fluoride exposure dose was measured in terms of Estimated Daily Intake (EDI), and the Hazard Index (HI) of water resources was assessed using fluoride Reference Dose (RfD). Each analysis was performed in triplicates. According to the results, the mean fluoride concentration of water samples collected from Girandurukotte GND and Ulhitiya reservoir was 1.64±0.40 mg/L and 1.05±0.60 mg/L. The mean values obtained for dug wells and reservoir water samples exceeded the maximum permissible levels recommended by WHO. EDIadult values obtained for water samples collected from wells and reservoirs in CKDu prevalent sites were 0.06 mg/kg/day and 0.04 mg/kg/day. The HI values for dug wells and reservoir water were 1.01 and 0.64, respectively. The HI value in dug wells indicates a high risk of health effects as it was above 1. The mean fluoride contents of the drinking and reservoir water samples collected from the reference site were 0.50±0.05 mg/L and 0.48±0.04 mg/L, and they complied with the WHO standard limits. The HI value in dug wells and reservoir water in the CKDu prevalence site indicates a low risk of health effects as it was below 1 (0.31, 0.29). Therefore, it can be recommended that the better management of water supplies in CKDu endemic areas is important to reduce the health impacts due to the excess levels of fluoride and nephron toxicants.

***Keywords:*** CKDu, Fluoride Exposure, Risk Assessment

# Effect of Dinitroso Pentamethylene Tetramine (DNPT) Loading on Cure Characteristics of Filled and Unfilled Natural Rubber Cellular Compounds

**U. A. Weerasinghe**[1*] and **D. G. Edirisinghe**[1]

[1] Department of Rubber Technology and Development, Rubber Research Institute of Sri Lanka, Telawala Road, Ratmalana, Sri Lanka.

*aloka.weerasinghe@gmail.com

Natural rubber foams have been used in a wide variety of applications due to its special characteristics and these can be produced using latex as well as dry rubber. In this study, cure characteristics of dry natural rubber foam in the presence and absence of calcium carbonate ($CaCO_3$) filler were evaluated, while varying the loading of the blowing agent Dinitroso Pentamethylene Tetramine (DNPT). DNPT provides a closed cellular structure to the matrix. The gases released by thermal decomposition of DNPT generate micro-voids within the rubber matrix. A series of natural rubber cellular compounds was prepared by varying the loading of DNPT from 2 phr to 10 phr at 2 phr intervals. Analysis of cure characteristics was carried out and the results indicated a decrease in cure time and increase in cure rate index in the compounds prepared without $CaCO_3$. This indicates that in the absence of filler, the nitrogen containing blowing agent accelerates the vulcanization of the cellular rubber system. A decrease in initial viscosity due to the increase in the gas phase can be observed from the minimum torque values. However, the maximum torque, which represents the state of cure and in turn the stiffness of the cured compound tends to decrease due to the increase in the gas phase. With the incorporation of $CaCO_3$ filler, drastic changes in cure characteristics occur, where increase in cure time and reduction in cure rate takes place. Additionally, an increase in delta cure value was observed with the increase of DNPT loading. As the loading of DNPT increases, the number of cells tends to increase resulting in an increase in cell density. The $CaCO_3$ filler provides a certain amount of reinforcement to the cellular compound as the number of cell walls tend to increase. Cure time of this series of compounds increases with the increase of DNPT loading resulting in a reduction in cure rate index. Furthermore, addition of filler reduces scorch time, which would result in adverse processability effects.

***Keywords:*** Natural rubber, Cellular rubber, Cure characteristics

# The Antioxidant Potency of Leaves and Stem Extracts of *Croton laccifer* L. (Gas Keppetiya) and *Croton aromaticus* L. (Wel Keppetiya) – Two Plants Used in Ayurvedic Cancer Treatments in Sri Lanka

**D. M. J. D. K. Dunukara[1]*, D. N. A. W. Samarakoon[1], D. I. Uluwaduge[2], P. A. A. I. Kanampella[1],** and **H. M. N. U. S. Herath[1]**

[1] Department of Biomedical Science, Faculty of Health Sciences, KIU, Koswatta, Battaramulla, Sri Lanka.

[2] Department of Basic Sciences, Faculty of Allied Health Sciences, University of Sri Jayewardenepura, Sri Lanka.

*29916dilhanidunukara@gmail.com

Reactive oxygen species (ROS) are highly reactive molecules and can damage the body's fatty tissue, DNA, and proteins and alter their functions. The shift in the balance between oxidants and antioxidants favoring oxidants is termed "oxidative stress." Among the causative agents that lead to cancer, oxidative stress on tissues is an important factor. Antioxidants are the body's defence against the undesirable effects of ROS and are targets used in cancer therapy. As modern synthetic drugs and other medications lead to severe side effects, the focus has been directed towards natural plant-based remedies. Species of Croton are widely used in ethnomedicine to treat several diseases, including cancer. According to the information gathered from traditional medical practitioners of Sri Lanka, *Croton laccifer* (Gas-keppetiya and *Croton aromaticus* L. (Wel-keppetiya)) is a valuable medicinal plant used to remedy cancer patients. This study aimed at the scientific validation of *Croton laccifer* L. and *Croton aromaticus* L. antioxidant activity to support authentic use. The methanolic plant extract of Croton species (leaves and stem) was screened for antioxidant activity using DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging assay. The extracts were further analyzed with preliminary phytochemical tests. The *Croton laccifer* $IC_{50}$ value obtained was 0.0206 g/mL in leaves and 0.0208 g/mL in the stem, and *Croton aromaticus* $IC_{50}$ value obtained was 0.0201 g/mL in leaf 0.0182 g/mL in the stem when compared with the standard ascorbic acid. There was a significant correlation between standard ascorbic acid and stem and leaf (p-value < 0.05) of *C. laccifer* and *C. aromaticus.* Phytochemical analysis revealed that the leaves and stem of *C. laccifer* and *C. aromaticus* contain alkaloids and flavonoids. Alkaloids and flavonoids are potent antioxidants, and thus the antioxidant potency of the plant material might be due to those phytochemicals present. These experimental results revealed that *C. laccifer* and *C. aromaticus* plants (leaves and stem) extract have significant antioxidant activity. Thus, scientifically claims the authentic use in Ayurvedic medicine to treat cancers. Therefore, upon extraction and further investigation, the active molecules may be isolated to develop into drug leads for natural drug therapy.

***Keywords:*** *Croton laccifer, Croton aromaticus,* Antioxidant activity

# Model Diet Approach for Quantitative Analysis of Nephrotoxic Heavy Metals to Elucidate the Dietary Causative Factors for CKDu Prevailing in Sri Lanka

**Nalika Dayananda [1*], Janitha Liyanage [1],** and **Sagarika D. Kannangara[2]**
[1] Department of Chemistry, Faculty of Science, University of Kelaniya, Sri Lanka.
[2] Department of Plant and Molecular biology, Faculty of Science, University of Kelaniya, Sri Lanka.
* roshanid@kln.ac.lk

Chronic low-level exposure to nephrotoxic heavy metal contamination is among the main postulated risk factors associated with the emergence of CKDu in certain parts of Sri Lanka. Dietary habits of those Sri Lankan remote communities are distinctly different from most local and global counterparts. Therefore, the sources and magnitude of dietary exposures have to be understood to assess the risk of occurring nephropathy. The present study formulated a model diet using regular dietary consumption data based on a semi-quantitative food frequency questionnaire in a CKDu hotspot; Girandurukotte GND, Badulla district for accurate determination of these nephrotoxic heavy metals, namely Cadmium, Lead, Arsenic, and Chromium, and Dambethalawa GND, Ampara district was selected as the reference. 157 and 162 samples (locally grown or cooked) were collected from the hotspot and the reference, respectively. The contaminants of interest in the eight identified food categories; rice, fruit/flower vegetables, leafy vegetables, legume vegetables, root/ground vegetables, fruits, fats and oils, and inland fish, were analyzed by inductively coupled plasma-mass spectrometry. Assuming the primary exposure route of intake is food, and based on the quantity and type of food items consumed in Girandrukotte GND, a 60 kg man is exposed to average doses of 120.89 ± 56.76 μg Cadmium, 143.58 ± 70.01 μg Lead, and 24.79 ± 14.40 μg Arsenic and 65.19 ± 36.74 μg Chromium per week and approximately 70% of the samples tested were found to have detectable levels of Cd and Pb. The Kruskal-Wallis test results showed a significant difference in mean Cd ($p = 0.024$), Pb ($p=0.040$), and As ($p=0.026$) concentrations in model diets between the CKDu hotspot and the reference. Rice consumption in Girandurukotte GND (3.30 kg per person per week) also exceeds the National per capita intake, indicating that dietary exposure to nephrotoxic contaminants can easily occur via rice consumption. According to the Mann-Whitney U-test performed among identified food categories, Cd, Pb, and, As contents in rice, fruit/flower vegetables, leafy vegetables, legume vegetables, root/ground vegetables, fruits, fats and oils, and inland fish were significantly higher in the CKDu hotspot than the reference. According to the model diet approach results, chronic low-level exposure of Cd, Pb, and, As from regular diets and malnutrition due to lack of a balanced diet appear to be a public health concern in the studied populations. Healthy dietary patterns and integrated agronomic practices to lower the contaminants identified are the two broad strategies suggested.

***Keywords:*** Model diet, Nephrotoxic heavy metals, CKDu prevalence

# A Preliminary Study to Assess Bone Mineral Density of Sri Lankan Population

**A. L. Abeyweera[1*], D. M. Satharasinghe[2], T. C. Chandrasekara[1*],** and **W. M. N. M. B. Wanninayake[1]**

[1] Nawaloka Hospital, Colombo, Sri Lanka.

[2] Horizon Campus, Malabe, Sri Lanka.

* amila92@gmail.com

The loss of bone mass gradually progresses into osteoporosis and this happens as a consequence of aging. However, this possibility is less common in individuals who had gained the optimum bone mass during their childhood and in adolescence. DEXA is a technique which is widely being used to quantify the bone density in humans in order to identify the compromised bone strength. Currently, the bone mineral density (BMD) and its distribution in the Sri Lankan population is not well documented and this would further complicate the early diagnosis of osteoporosis. The BMD of a cohort was evaluated to identify the variations in BMD of the Sri Lankan population. A sample of 302 subjects referred to the DEXA scanning in a reputed private hospital for a duration of six months were included in the analysis. The correlation of the subject's BMI, weight and height with BMD was also evaluated. When considering the early decades of life, women obtained their peak bone density in the fourth decade. A gradual decline of BMD among the women was initiating from 50 years of age. Nevertheless, the peak bone density for men was seen in the fifth decade of life. However, remarkably the highest BMD was seen in men and women of 70-79 years. This can be attributed to individual scan limitations which leads to overestimation of BMD in the older population. No significant correlations were found between BMD with BMI, height and weight for both genders. The lowest BMD (1.006g/cm$^2$) was observed in females aged between 30-39 years. This might be an early indication for poor bone health of Sri Lankan women and need to be re-evaluated in future studies.

***Keywords:*** Bone mineral density, DEXA, Osteoporosis

# Toxicity of Phenanthrene in the Early Life Stages of Zebrafish [*Danio rerio*]

**K. Vithushi**[1] and **W. S. Thulasitha**[1*]
[1]Department of Zoology, University of Jaffna, Sri Lanka
[*]thulasitha@uni.jfn.ac.lk

Phenanthrene belongs to the polycyclic aromatic hydrocarbon (PAHs) family, and is identified as a ubiquitous contaminant in the aquatic environment. It is also one of the major components in oil and grease. Recent studies have indicated that some parts of the Chunnakam and Vadamaradchi aquifers of the Jaffna peninsula, Sri Lanka are contaminated with oil and grease. Therefore, the present study was carried out to identify the potential toxicological impacts of phenanthrene on the development of a vertebrate model Zebrafish (*Danio rerio).* In the present study, laboratory reared healthy *D. rerio* were selected and fed with *Artemia* nauplii twice a day in the Animal House of the Department of Zoology, University of Jaffna. Induced spawning was performed to obtain same aged embryos for the toxicity assays. Healthy fertilized embryos of 6 hours post fertilization (hpf) were transformed to 12-well cell culture plates (10 embryo/ well) containing egg water (200µL of 1% methylene blue and 0.3g of NaCl in 1000mL distilled water) and treated with six different concentrations (range from 20 – 0.75 mg/ L) of phenanthrene dissolved in 1% Dimethyl sulfoxide (DMSO). Embryos treated in egg water alone and egg water with DMSO were considered as control experiments. Mortality and morphological changes in developing embryos were monitored microscopically at 24, 48, 72 and 96 h following exposure. The $LC_{50}$ value for phenanthrene was determined by using Probit analysis. Results indicated that the 96h $LC_{50}$ for phenanthrene was 2.14 mg/ L. Embryos showed developmental deformities such as pericardial edema, haemorrhage in the cardiac vein, yolk sac edema, yolk sac fluid accumulation, yolk sac turbidity, curvature in spinal cord and tail upon phenanthrene treatment in a concentration dependent manner; whereas control experiments showed normal development. Compared to treated un-hatched embryos, treated larvae showed severe deformities. Sub-lethal concentrations (1.25 mg/ L and 1.0 mg/ L) also caused deformities, but no mortality. There were no deformities noticed in larvae treated with 0.75 mg/ L. The results suggest that the environmentally relevant phenanthrene concentrations may have a significant effect on aquatic life. Histological studies are underway to confirm tissue level impacts.

***Keywords***: Phenanthrene, *Danio rerio*, $LC_{50}$, developmental deformities

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# PCR-based Detection and Characterization of Candidate Disease Resistant Gene Analogous (RGAs) in Commercially Grown Capsicum Varieties in Sri Lanka

**K. A. S. I. Kumari[1], D. M. J. B. Senanayake[1*], C. M. Nanayakkara[2], W. A. R. Dhammika[1], P. J. K. Dasanayake[1],** and **A. Balasuriya[3]**

[1] Field Crops Research and Development Institute, Mahailluppallama, Sri Lanka.

[2] University of Colombo, Colombo, Sri Lanka.

[3] Rajarata University of Sri Lanka, Mihinthale, Sri Lanka.

*dmjbsenanayake@gmail.com

Identification of R gene homologous from chilli (*Capsicum annuum* L.) will provide important information for improving disease resistance in breeding programs. A Nucleotide-Binding Site (NBS) domain in the R gene family accounts for the largest number of disease resistant genes in plants. In this study it was aimed at detecting the presence of putative disease resistant genes in commercially growing chilli varieties; MI Hot, MI 02, MICHHY1, MICH3, KA 02, Arunalu, Hen miris using a specifically designed primer pair in a PCR-based approach. The PCR amplified gene products were sequenced and homologies were explored in BLASTn. A sequence identity matrix was constructed using these nucleotide sequences of the chilli varieties along with 5 similar homologous sequences obtaine in Cluster W programme of Bio-Edit (version 8.0). Phylogenetic analysis was performed in MEGA X. The similarity between the tested nucleotide sequences of 07 chilli varieties showed more than 90% similarity with each other except the accession, MICH3. Sequence analysis indicated that the identified partial Resistance Gene Analogous (RGA) belong to the NBS–LRR type, which they gave more similar matching with the RGAs identified in other plant species reported from previous studies; more than 85% with *C. annuum* (XM 016690560), 70% with *Solanum pennellii*; (XM015201323,) *Solanum lycopersicum* (XM026028184), *Camellia sinensis*; (XM028216350) and *Sesamum indicum*; (XM011072521) available in the GenBank®, suggesting the existence of common ancestors. The study reveals that the candidate R gene nucleotide sequences of tested chilli accessions have a close relation to RGAs found in *Solanum peennellii* and *Solanum lycopersium*. However, gradual alteration found in the generated nucleotide sequences may lead to loss of resistance in target gene action for diseases in chilli. Identified partial RGA nucleotide sequences found in this study are supposed to be located on 11$^{th}$ the chromosome due to the location of similar RGAs. The information generated in this study is useful for making combinations of possible crosses for generating genetic resistance in chilli for biotic stresses and these RGAs could be regarded as candidate sequences of resistant genes for marker development. This is the first investigation report of NBS family RGAs in Sri Lankan *Capsicum* germplasm.

***Keywords:*** *Capsicum annuum*, Disease resistance, Resistance Gene Analogous

# Optimization of a Polymerase Chain Reaction Assay for Genotyping of +1444C>T Polymorphism of C-reactive Protein (CRP) Gene

**T. C. J. Senarathne[1*]** and **S. M. T. Jayasena[2]**
[1] Bandaranaike Memorial Ayurveda Research Institute, Sri Lanka.
[2] Department of Biochemistry & Molecular Biology Faculty of Medicine, University of Colombo, Sri Lanka.
*tcjsenarathne@gmail.com

High sensitivity C - reactive protein (hs-CRP) assays are used to quantitatively analyze the basal level changes in CRP concentration and identified as an independent risk marker for Cardio vascular diseases(CVDs). Polymorphisms of this *CRP gene* are associated with plasma CRP concentrations. It is a single PCR reaction, less costly and once optimized, it's more economical to use. Objective of the study was to optimize a tetra-primer amplification-refractory mutation system (ARMS)PCR-based assay to genotype individuals for the CRP gene +1444 C>T polymorphism. The 5685-6461bp segment of CRP gene was taken as the target DNA template. Two forward primers (F1-5'CCT GGT GGG AGA CAT TGG AAA T3', F2-5' AAGAG CTC GTT AAC TAT GCT GGG AAA T -3') and two reverse primers (R1-5' GAA GAT CAG CGC TTC CTT CTC AGC 3', R2-5'CACCT CAA ATT CTG ATT CTT TTG GAC CG 3') were designed of which one forward (F2) and one reverse primer (R2) were allele-specific with melting points of F1-57.2 °C, F2-58.2°C, R1-59.8 °C, and R2-58.1°C. The expected amplicons of the PCR assays are F1-R1 common amplicon, and F1-R2 for GG homozygote or F2-R1 for CC homozygote, and all three amplicons for the heterozygote. PCR was carried out using human blood DNA. The study was approved by the Ethics Review Committee of the Faculty of Medicine, University of Colombo. The PCR assay conditions varied with two different Taq polymerases used, namely Red Taq (Sigma Aldrich) and Taq polymerase from UC biotech. The optimized annealing temperatures for Red Taq (65ºC) and UC biotech Taq (70ºC) were different. Further, the optimal ratio of primer concentrations (outer primers: inner primers) was different as 1:9 for Sigma Aldrich Red Taq (0.5U) and 1:3 for UC biotech Taq (2U). Moreover, the optimum primer concentration ratio of UC Biotech Taq amplified the common DNA band as well as the two allele specific bands. Though the optimization varies with the Taq polymerases used, it is concluded that optimization of the TETRA-Primer ARMS PCR assay for prior to use is significant.

***Keywords:*** C-reactive protein, PCR assay, Tetra primers

# BRAF(V600E) Gene Mutation in Patients with Different Types of Thyroid Tumours in Sri Lanka: A Pilot Study

**Nadeeshani Ekanayaka[1], Kanthi Perera[2], Shakila Rathnayake[1], Praneeth Ratnayake[1],** and **Preethi Udagama[1]***

[1] Department of Zoology and Environment Sciences, Faculty of Science, University of Colombo, Sri Lanka.

[2] National Institute of Cancer, Sri Lanka.

*preethi@zoology.cmb.ac.lk

Thyroid cancer is the most common endocrine malignancy, with an increasing incidence rate, worldwide. On occasions, conventional diagnostics lead to inconclusive results, causing inadequate treatment of malignancies and overtreatment of benign conditions. Poor clinical outcomes prevail due to cancer recurrence or resistance to existing therapies. Better alternatives such as molecular markers are efficient tools in cancer diagnosis and treatment. This cross-sectional study was undertaken to examine the frequency of occurrence of one such molecular marker, BRAF (V600E), in a cohort of Sri Lankan patients with thyroid tumours. An interviewer-administered questionnaire was used to identify associated risk factors. The study included 105 patients reported to the National Hospital, Kandy, diagnosed with malignant thyroid tumours, or follicular adenoma, a benign tumour. Patients with co-morbidities and indistinct diagnosis were excluded. Only 76 formalin fixed paraffin embedded (FFPE) thyroid tissue samples could be retrieved for the molecular analysis, but were representative of all malignant subtypes (n=50), and the benign type (n=26). DNA was extracted from the tissue samples using phenol-chloroform method. Two separate PCRs were performed on each sample, to amplify the wild-type and mutant alleles of the BRAF gene. The products were visualized on agarose gels to establish the genotype. The presence of a 125 bp PCR product on agarose gels determined the occurrence of each allele. Most were heterozygous (n=68), while one sample of an individual with papillary thyroid cancer only indicated the presence of the mutant allele. The remaining samples (n=7) only indicated the presence of the wild type allele. Positivity for the mutation was not significant in malignant subtypes, when compared with the benign sub type ($p>0.05$). Hence its applicability as a diagnostic marker is contentious. Risk factors assessed in relation to tumour onset were family history, gender, age and body mass index. Although significant correlations were not observed ($p>0.05$), a female preponderance was evident, with most subjects aged between 31–50 years at tumour onset. Obesity was prominent among study participants, underlying a possible association. These preliminary findings indicate the potential for optimizing management of thyroid cancer through molecular interventions. However, further research and clinical studies are strongly warranted.

***Keywords:*** Thyroid cancer, BRAF mutations, biomarker

# Isolation and Characterization of Soil N-fixers and Consortia Formation for Developed Azorhizobial Bio-fertilizer

**W. M. D. A. Heshani[1], Thilini A. Perera[1*],** and **Shamala Tirimanne[1]**
[1] Department of Plant Sciences, Faculty of Science, University of Colombo, Sri Lanka.
* thilini@pts.cmb.ac.lk

Even though an excessive amount of N-fertilizers are being used in rice cultivation with the intention of yield maximization, 70% of it is lost from the soil system leading to a large number of economic, environmental and health problems. Alternatives to N-fertilizers are being researched globally and N-bio-fertilizers are considered as a promising alternative. Developed Azorhizobial bio-fertilizer at the Department of Plant Sciences, University of Colombo, replaced up to 50% of recommended N-input in rice cultivation. This can be further increased by incorporating several free-living N-fixers to form a mixed microbial bio-fertilizer, which will be an enhanced bio-fertilizer. The purpose of this study was to isolate two types of free living N-fixing plant growth promoting bacteria, *Azotobacter* spp. and *Azospirillum* spp., from rice soils with the aim of incorporating them into previously developed Azorhizobial bio fertilizer. Microbial isolation from rice soil was performed using selective media and biochemical characterization was conducted. *Azotobacter* spp. was isolated using liquid Burk's medium and Ashby's mannitol agar medium (selective media used for *Azotobacter*). Five different *Azotobacter* isolates; Azo-A, Azo-B, Azo-C, Azo-F and Azo-G were identified based on colony morphologies (colony shape, colour. etc.). These isolates were characterized using biochemical methods, namely catalase, starch hydrolysis, citrate, indole, auxin production and fluorescent pigment production. Out of the five, four isolates resembled *Azotobacter chroococcum*, considering the pigment production, cyst formation, shape and mobility. *Azospirillum* spp. were isolated using N-free malate bromothymol blue (Nfb) media, N-free malate congo red media and BMS (Batata-Malato-Sacarose) medium. The presence of *Azospirillum brasilense* or *Azospirillum lipoferum* or both were confirmed based on the nature of colonies in BMS. Before incorporation of the isolated N-fixers into developed Azorhizobial bio-fertilizer, compatibility between the isolated N-fixers and *Azorhizobium caulinodans* were determined using cross-streak method. Out of five *Azotobacter* isolates; two *Azotobacter* isolates (Azo-B and Azo-F) and *Azospirillum* isolate were used for compatibility testing. Results of cross-streaking revealed that there were no antagonistic reactions between the three isolates and *Azorhizobium caulinodans*. Hence it was concluded that isolated *Azotobacter* spp. and *Azospirillum* spp. were compatible with *Azorhizobium caulinodans* and can be used to improve the developed Azorhizobial bio-fertilizer.

***Keywords:*** *Azorhizobium caulinodans*, Bio-fertilizers, Nitrogen fixation

# Salinity Levels in Coastal Saline Paddy Areas of Jaffna and Mannar Districts

**A. S. A. Vathani[1] and E. Lokupitiya[1*]**
[1] Faculty of Science, University of Colombo, Sri Lanka.
* erandi@sci.cmb.ac.lk

Rice is the staple food in Sri Lanka. Paddy cultivation mostly occur in Dry and Intermediate zones of the country including some low lying land areas along the coastal belt. Coastal zone is more vulnerable to salinity intrusion due to sea level rise induced by climate change. Every year farmers lose their arable lands due to soil salinization. This study primarily focused on identifying and mapping salt-affected paddy cultivating areas in Jaffna and Mannar districts, since these two districts in Northern Province are highly vulnerable to contamination with saline water. Salinity-affected paddy areas were identified with the help of the regional officials of the Department of Agriculture. The soil samples were collected during the Yala season, using Zig-zag soil sampling method. Forty-nine salt-affected areas were identified in Jaffna district and thirteen areas were identified in Mannar district. Composite samples were collected in all identified areas. Composite field sampling was done by collecting sub samples at 15 cm depth by traveling in a zig-zag pattern. Each composite sample consisted of 16 subsamples spread evenly across the field.

Collected soil samples were analyzed for Electrical Conductivity (EC) by using unsaturated soil suspension technique (i.e. 1:5 soil-water extract) to study the degree of salinity. Based on the obtained EC values, the sampled areas were classified as non-saline (<0.15 dS/m), slightly saline (0.16-0.30), moderately saline (0.31-0.60), very saline (0.61-1.20), and highly saline (>1.20). The thematic maps were prepared according to the GPS location and classified data by using ArcGIS 10.3.

The measured EC ranged from 1.6 – 4 dS/m in Jaffna district and 1.5 - 1.7 dS/m in Mannar district. The results revealed that all the study areas are affected by high salinity in both districts. There may be more salt-affected areas in these districts which need to be assessed. Highly saline areas were identified along the coastal low-lying lands and areas close to lagoons. The findings of the current study will support policy decision making and potential remedial measures (cultivating salt tolerant varieties, seedling transplanting, water management and land preparation techniques) in relation to the salt-affected paddy areas in the country.

***Keywords:*** Salinity, Jaffna, Mannar

# Does the Quality of Life Connect with an Individual's Nature Connectedness and Per Capita Greenhouse Gas Emission? A Preliminary Study

**E. A. S. K. Somarathe[1,2*], M. W. Gunathunga[3],** and **E. Lokupitiya[1]**
[1] Department of Zoology and Environment Sciences, Faculty of Science, University of Colombo, Sri Lanka.
[2] Research Promotion and Facilitation Center, Faculty of Medicine, University of Colombo, Sri Lanka.
[3] Department of Community Medicine, Faculty of Medicine, University of Colombo, Sri Lanka.
* sksomarathne@stu.cmb.ac.lk

Sri Lanka is a country that struggles to deal with the negative consequences of climate change caused by increased levels of greenhouse gas (GHG) emission. There is a need to reduce the gap between man and nature while improving the quality of life (QoL). The current study is aimed at finding possible relationships between nature connectedness, GHG emission, and perceived quality of life at individual level. According to our knowledge, this was the 1st attempt taken by a Sri Lankan research group to investigate possible links between GHG emissions, connectedness to nature and quality of life. A preliminary cross-sectional study was carried out with rigorously screened 30 individuals (mean age = 44 $\pm$ 2 years). Participants in the present study included a group of meditation practitioners from a large scale study on "meditation, mindfulness and health". Data were collected to assess perceived quality of life under 5 domains: a) overall perception of QoL, b) physical QoL, c) psychological QoL, d) social relationships associated with QoL and e) environmental QoL; the latter was assessed through a person's attitude towards the environment or connectedness to nature and GHG emissions under electricity consumption and travelling. Bivariate correlational analyses revealed a significant negative relationship between GHG emission due to travelling and psychological QoL ($r = 0.51$, $p < 0.05$). Except GHG emission due to electricity consumption, other environmental variables were linearly correlated with overall QoL. Even though the findings of the current study have limitations in terms of generalizability due to a non-probability sampling, the methodology of the current research opens doors to investigate QoL in environmental research. Our study findings indicate that ensuring the perceived QoL at the individual level may lead to a reduction in GHG emissions while promoting nature connectedness. Hence, this research highlights the importance of considering the perceived quality of life as a determinant of connectedness to nature and GHG emission at the individual level.

***Keywords:*** quality of life, QoL, CNS, GHG

# Trends of Air Pollutants in Colombo City and its Relationship with Meteorological Variables

**A. Jegathesan[1], E. Lokupitiya[1*],** and **S. Premasiri[2]**
[1] University of Colombo, Sri Lanka
[2] National Building Research Organization
* erandi@sci.cmb.ac.lk

Colombo, which is the commercial capital of Sri Lanka, has to address air pollutants such as Sulphur dioxide ($SO_2$), nitrogen dioxide ($NO_2$), particulate matter ($PM_{2.5}$ and $PM_{10}$). The main objective of the study was to observe the trends of $NO_2$ and $SO_2$ concentrations during the period 2013-2019 and predict the future air quality of Colombo by modeling the monthly time series of those pollutants. The data used in this research was secondary, obtained from the National Building Research Organization (NBRO) and the Department of Meteorology of Sri Lanka and collected across 19 sampling locations and meteorological stations in Colombo. Exponential smoothing models displayed the best fit for both air pollutants. Forecasted values of $NO_2$ and $SO_2$ for the year 2020, were found to be higher than the actual values recorded. This was mainly because of the reduction in air pollution levels owing to the travel restrictions and lockdowns during the pandemic period. This study also calculated the Air Quality Index (AQI) from daily $PM_{2.5}$ and $PM_{10}$ of 2019 and all the AQI values were below the prescribed upper limits allowed to reach as per National Environmental Act No. 47 of 1980. Significant differences were observed in AQI values between Southwest monsoon and inter-monsoon ($p < 0.05$) and between Northeast monsoon and inter- monsoon ($p < 0.05$) periods. Correlation of $SO_2$ levels with relative humidity ($r = -0.268$); $NO_2$ levels with temperature ($r = -0.234$) and relative humidity ($r = -0.360$); AQI values of $PM_{2.5}$ with rainfall ($r = -0.618$), relative humidity ($r = -0.397$) and wind speed ($r = -0.105$); AQI values of $PM_{10}$ with rainfall ($r = -0.206$) and relative humidity ($r = -0.441$) were statistically significant ($p < 0.05$). Thus, increased levels of meteorological variables such as precipitation, humidity, wind speed seem to reduce the atmospheric concentrations of the above pollutants. Warm air also could hold higher concentrations of air pollutants. The effects of current and future developmental activities of Colombo urban area on the ambient air quality, needs to be always monitored and suitable policy measures should be initiated.

***Keywords:*** Air pollutants, Forecasting, Meteorological variables

# Preliminary Investigations for Mining and Production of Garnet Sand in the Southern Coast of Sri Lanka

**H. C. S. Subasinghe[1]*, T.D.U. Wijewardhana[1],** and **A. S. Ratnayake[1]**
[1]Department of Applied Earth Sciences, Faculty of Applied Sciences, Uva Wellassa University, Sri Lanka.
* chandimasubasinghe00@gmail.com

Garnet ($(Ca,Mg,Fe,Mn)_3(Al,Fe,Mn,V,Cr)_2(SiO_4)_3$) is a heavy mineral (i.e., having a specific gravity of 3.9-4.2 g/cm$^3$). It is a weathering/abrasion-resistant, and complex silicate mineral, having an average Mohs hardness of about 8. Garnets can be used for several industrial applications such as the production of abrasives, sandblasting agents, media for water filtration, and water jet cutting. Sri Lanka consists of garnet-rich placer deposits along its southern coastline. Therefore, this study focuses to investigate the spatial and temporal variations of garnet-bearing beach placers from Palatupana to Dikwella on the southern coast of Sri Lanka to identify the feasibility of garnet sand mining. Sediment samples (about 5 kg) were randomly collected from the berm by removing surficial materials from 10 locations (i.e., Palatupana, Maluwadiya, Kirinda, Ambalantota, Hambantota, Welipatanvila, Hathagala, Kalametiya, Godawaya, and Dikwella) to determine the percentage of garnet and other heavy minerals. Visual examination along with mineralogical analysis under microscope suggested almost equal occurrences of garnet (~38%) and ilmenite (~35%) along with minor amounts of other heavy minerals such as rutile (~2%) and zircon (~1%). In addition, almost each sampled location had one or more heavy mineral-bearing sand layers of over one foot of thickness. Consequently, the present study suggested occurrences of mineable amounts of garnet-rich heavy mineral placer deposits along the southern coast of Sri Lanka from Palatupana to Dikwella. The major source of garnet-rich sediments was identified as the Walawe River based on field observations, hydrodynamics and geomorphology of the southern coastline of Sri Lanka. Sedimentation of garnet-rich heavy mineral sands was dominantly identified on either side of the Walawe River mouth at Godawaya area. However, a detailed study is required for reservoir and tonnage estimation (e.g., areal extension, depth, and grade) of each of these prospective deposits. Moreover, the identification of new reserves and resources would strengthen the upstream heavy mineral industry in Sri Lanka. In recommendation, the value addition potential of garnet sands will be evaluated during the next stage of this study.

***Keywords:*** Garnet and heavy minerals, Southern coast of Sri Lanka, Mining, and value addition

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# Synthesis and Characterization of CdS Sensitized $TiO_2$ Nanocomposites for Enhanced Photocatalytic Activity

**I. M. E. Sachinthanie**[1*] and **H. C. S. Perera**[2]
[1] Department of Physics, Faculty of Science, University of Peradeniya, Sri Lanka.
[2] Senior Lecturer, Department of Physics, Faculty of Science, University of Peradeniya, Sri Lanka.
*immusachi@gmail.com

The conventional wastewater subsiding treatment methods have proven to be rather ineffective as most of the time the pollutants are removed from water bodies and collected on another substrate in the process. Therefore, the discovery of photocatalytic degradation capability of $TiO_2$ has revolutionized the scope of water treatment. By acting as a photocatalyst, nano $TiO_2$ particles can split water molecules or degrade pollutants by harvesting the energy in the UV range. However, since most of energy from the sun that reaches the earth is in the form of visible light, the photocatalytic efficiency of nano $TiO_2$ particles can be further increased if the absorption range can be extended up to the visible region. In this study, the nano $TiO_2$ particles were coated using a CdS shell with a low power microwave assisted hydrothermal method to meet this expectation. A series of CdS sensitized $TiO_2$ nanocomposites were synthesized with different Cd:Ti molar ratios and characterized using XRD, SEM and UV-Vis spectroscopy. Photocatalytic degradation capability of the nanocomposites was studied by using Methylene blue (MB) as a model pollutant and exciting nanocomposites with visible light. The best Cd: Ti molar ratio with the highest degradation capability was identified using UV-Vis spectroscopy. Different isotherm models such as Langmuir, Freundlich, Sips and Toth were used to analyze the result, and Sips was found as the best fitting isotherm. To analyze the adsorption kinetics, two models, namely pseudo first order rate kinetic model (PFO) and pseudo second order rate kinetic model (PSO) model, were used and PSO was identified as the best-fitting model. All the CdS-sensitized $TiO_2$ samples showed higher photocatalytic degradation efficiencies as well as higher photocatalytic activities compared to $TiO_2$. The photocatalyst with the Cd:Ti molar ratio of 0.3: 1 was identified as the best system with a photocatalytic degradation efficiency of 89%, and a photocatalytic activity that is 8 times higher than that of $TiO_2$.

***Keywords:*** Photocatalysts, Nanocomposites, Hydrothermal

# Driving Forces behind Organic Food through Topic Modelling on Social Networks

**Wathsala Anupama Mohotti [1]*, Nalaka Kaushalya Mohotti [2]*, David Wong [2],** and **Werner Soontiens [2]**
[1] Department of Computer Science, University of Ruhuna, Sri Lanka.
[2] School of Business, University of Notre Dame, Australia.
* wathsala@dcs.ruh.ac.lk , nalaka.mohotti@my.nd.edu.au

Organic foods are derived from the harvesting of crops and raising of livestock without non-organic inputs. The rapid growth of the organic food industry necessitates an urgent need to better understand the driving forces behind the choice of organic food. This study investigated the natural thoughts of people about organic foods to identify the reasons behind their choice. The vast amount of information exchanged through short text on social media platforms that portray the social norms of a community were used for this study. Data were collected to form a Twitter dataset using the keyword 'organic food' and, analyzed with LDA topic modeling. The topics that emerged from the analysis include (1) health, (2) safety, (3) environmental and (4) sensory attributes such as nutritive value, taste, and freshness being concerns of people towards organic food. Additionally, word cloud visualizations revealed further issues such as price and, growing your own which suggests the lack of quality organic food at a reasonable price. These findings are framed according to the Theory of Planned Behavior and, how the findings help provide richness to explain the attitudinal factors impacting buyer behavior in these models are highlighted.

***Keywords:*** Organic Food, Buyer Behavior, Text Mining

# Flexural Properties of Fiber Reinforced Thermoplastic Composites Based on Post-industrial Polyester Textile Waste

**R. M. N. Sulochani**[1,2], **R. A. Jayasinghe**[1*], **A. H. L. R. Nilmini**[1], and **G. Priyadarshana** [1]
[1] Faculty of Technology, University of Sri Jayewardenepura, Sri Lanka.
[2] Faculty of Graduate Studies, University of Sri Jayewardenepura, Sri Lanka.
* randika@sjp.ac.lk

The textile industry is the largest manufacturing sector in Sri Lanka with a significant contribution to the economic development of the country. However, the existing linear model of the textile sector puts huge pressure on the environment. Management of large volumes of post-industrial textile waste is a critical operational challenge faced by the sector. This issue is further complicated due to the lack of proper waste management systems in the country. It is important to reduce the sector's impact on the environment by finding alternative solutions to manage textile waste. For many years, considerable attention has been given to post-consumer textile waste, however, there is little attention on post-industrial waste. As such, this study focuses only on post-industrial textile waste. Valorization of post-industrial waste can help to reduce the volumes of waste that end up in landfills. This work aims to develop and characterize composites from post-industrial polyester textile waste as fiber reinforcement and waste packaging materials as the thermoplastic matrix as a value-added solution to the generated textile waste. Both textile waste and waste packaging materials were collected from a local textile industry. Seven types of composite panels which contain 0%wt, 2.5%wt, 5%wt, 7.5%wt, 10%wt, 15%wt, and 20%wt textile fiber reinforcement were manufactured using compression moulding. The composites were developed without using any chemical additives. The flexural test was conducted according to the ASTM D 790 standard using three-point bending mode. The flexural strength and flexural modulus of the composite materials were focused for the study. The obtained results show that the flexural strength and the flexural modulus have increased to a certain percentage of fiber reinforcement weight in the composite. Then both of the flexural strength and flexural modulus reduce with the increasing reinforcement fiber loading when passing that percentage. From the developed seven types of composites, 10% wt. fiber-reinforced composite shows the best performance for the flexural properties. The experimental results demonstrate that the flexural properties of the developed composite indicate a positive tendency to use the novel composite as an alternative solution for non-structural building materials. Other experiments are in progress to determine the potential of the composite for use in non-structural applications such as wall claddings.

***Keywords:*** Polyester textile waste; thermoplastic; flexural properties

# Efficiency Enhancement of Dye-Sensitized Solar Cells with Multilayered Photoelectrodes by Incorporating Diatom Frustules

**S. S. Withanage[1*], T. M. W. J. Bandara[1],** and **K. Wijayaratne[1]**
[1] Department of Physics and Postgraduate Institute of Science, University of Peradeniya, Sri Lanka.
*subodhiniws@gmail.com

Given the cost-effectiveness, dye-sensitized solar cells (DSCs) have shown promising prospects in solar energy harvesting. The incorporation of nanostructures with light trapping properties onto the photo-electrode has been studied recently to improve efficiency. As a naturally abundant material, three-dimensional nanostructured silica diatom frustules are under the spotlight [1]. In this research work, diatom frustules were incorporated into multilayer photo-electrodes. Two sets of single and double layer photo-electrodes were developed with $TiO_2$ and with frustules/ $TiO_2$ composite. After that, the efficiency of each DSCs was measured by assembling a photoelectrochemical (PEC) cell. Control device measurements were also taken using PEC prototypes without diatom frustule composite. In the control cells, efficiencies were recorded as 1.29% and 2.26%, respectively, for cells with one and two $TiO_2$ layers. After replacing each of the first and second $TiO_2$ layers by layers with the frustules/ $TiO_2$ composite, an increase in efficiencies up to 1.74% and 4.10% were observed. These are 35% and 81% enhancements in efficiency. According to the results, the prototype with frustules/ $TiO_2$ composite-based layers demonstrated a higher efficiency due to optical scattering properties and light trapping effects of diatom frustules [2, 3]. Diatom frustules help increase the dye absorption and the surface area of the photoelectrode due to the nano-scale pore structure. In two-layer diatom frustules/ $TiO_2$ composite DSC, short circuit current density (*J*sc) was enhanced by 94% with comparing two layers of frustules free DSC device. At the same time, open-circuit voltage (*V*oc) shows 687 mV and 665 mV. With three hours, continuous illumination of two layer frustules/ $TiO_2$ DSC device *J*sc was increased from 5.39 mA $cm^{-2}$to 10.10 mA $cm^{-2}$ while *V*oc dropped from 724 mV to 512 mV. Moreover, the efficiency showed a gradual increase up to a plateau and then a slight decrease without exceeding the initial value. Results depict that diatom frustules/ $TiO_2$ composite coated surfaces showed promising efficiency improvement compared to $TiO_2$ coated surfaces, which could open up a new pathway of converting solar energy.

***Keywords:*** Dye-sensitized solar cells, $TiO_2$, Diatom frustule, Photoelectrode

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# Designing and Construction of a Research Grade Raman Spectrophotometer on a Budget

**Dulanjali Rodrigo[1], Sasani Jayawardhana[2*], Hiran Jayaweera[3], Neranga Abeyasinghe[1*], Vijanaka Fernando[4], Ujitha Abeywickrama[3], Dilanjan Diyabalanage[3], Vimukthi Monerawilla[3], Pradeep Perera[5],** and **Siyath Gunewardene[3*]**

[1] Department of Chemistry, Faculty of Science, University of Colombo, Sri Lanka.

[2] Department of Physics, Faculty of Applied Science, University of Sri Jayewardenepura, Sri Lanka.

[3]Department of Physics, Faculty of Science, University of Colombo, Sri Lanka.

[4] Department of Physics, Faculty of Science, Open University of Sri Lanka, Sri Lanka.

[5] Zymergen Inc., Horton Street, Suite 105, Emeryville, CA, USA

[*] sasanijay@sci.sjp.ac.lk, neranga@chem.cmb.ac.lk, siyath.gunewardene@phys.cmb.ac.lk

Raman scattering based on molecular vibrational states is a reliable optical phenomenon for identifying and distinguishing a wide range of molecules and related processes. Raman spectroscopy finds useful utility in the detection of narcotics, explosives, monitoring of contaminants in food and pharmaceuticals, disease diagnostics and metrology just to name a few. Although many research grade Raman spectrophotometers are now available commercially, due to demanding device performances, price becomes excessively high. Therefore, the scientific community with tight financial constraints, especially in the developing world, is deprived of such a useful research facility. Here we present an alternative design for a research grade Raman spectrophotometer built with off the shelf optomechanical components without compromising the device performance. Commercially Available Instruments (CAI) provide standard features with further add-ons available at an extra cost upon request. An instrument such as Renishaw inVia™ confocal Raman microscope can accommodate several lasers and corresponding optical filters, a feature which is also available in this custom-built design. Currently our designed system consists of; options for illumination at 532 nm and 785 nm with compatible detection filters for stokes shifted optical signals and two microscope objective lenses including a ×50, 0.42 NA, long working distance compatible with NIR region. Compared to a standard detector size of 1024 pixel × 256 pixel, this design has a 1600 × 200 back-illuminated electron multiplication (EM) CCD for low light detection (with 16 μm pixel size), which also contains a 16-bit ADC that can be operated at 3 MHz with low read noise = 39.8*e*. While the maximum signal count is at 65535, the noise margin lies around 300. The spectrograph consists of a Czerny-Turner geometry containing ruled diffraction gratings of (either 600 l/mm or 1200 l/mm), able to resolve spectra down to 0.1 nm. The system at 532 nm illumination has, therefore, the capability of measuring Raman wavenumbers of up to 4300 $cm^{-1}$at a resolution of 3.5 $cm^{-1}$ against the 0.3 $cm^{-1}$, spectral resolution of CAI. The overall cost of construction of the spectrophotometer was approximately USD 86,000 relative to the prohibitively high (>USD 250,000) of a CAI with approximately similar features.

***Keywords:*** Optics, Raman spectroscopy, Lasers

# Quasi-solid-state Dye-sensitized Solar Cells Utilizing $Tio_2$/Graphite Composite Counter Electrode and $Tio_2$/N719 Sensitizer Photoelectrode for Low-cost Power Generation

**H. M. N. Wickramasinghe[1*], T. M. W. J. Bandara[1,2], K. Wijayaratne[1,2], L. Ajith DeSilva[2],** and **A. A. I. Perera[3]**

[1] Department of Physics and Postgraduate Institute of Science, University of Peradeniya, Sri Lanka
[2] Department of Physics, University of West Georgia, Carrollton, GA 3011
[3] Department of Mathematics and Postgraduate Institute of Science, University of Peradeniya, Sri Lanka
* narmadawick@gmail.com

Dye-sensitized solar cells (DSSCs) have evolved through the highest devotion of the research community as a low-cost alternative for conventional energy conversion devices. However, practical applications of DSSCs are restricted by the usage of Platinum counter electrodes since Platinum is commercially expensive.

In this study, a new series of low-cost composite counter electrodes based on commercially available Graphite and $TiO_2$ nanoparticles (21nm) is investigated. The photon absorbing working electrode contained photosensitized (N719) six layers of spin-coated $TiO_2$ nanoparticles (13 and 21 nm). In DSSCs, problems inherent to liquid electrolytes can be overcome by replacing them with gel electrolytes. The gel polymer electrolyte utilized in this study comprised ethylene carbonate (EC), propylene carbonate (PC), 1-butyl-3 methylimidazolium iodide (BMII), 4-tert-butyl pyridine (4TBP), tetrahexylammonium iodide ($Hex_4NI$), lithium iodide (LiI) and polyethylene oxide (PEO).

The sheet resistance of the electrodes initially decreases (with the decreasing of Graphite content), and after reaching the minimum for 70% Graphite composition, it increases back again. The conductivity of the composite having 70 wt.% Graphite and 30 wt.% $TiO_2$ was 1.30 S $cm^{-1}$, and the sheet resistance of the respective electrode was 54.84 Ω $cm^{-2}$. The XRD analysis reveals the drop of crystallinity of Graphite upon increasing the $TiO_2$% due to mechanical exfoliation of Graphite forming expanded Graphite or multilayer Graphene films. However, the utilization of 100% Graphene is not desirable due to inefficient film formation and film adhesivity to fluorine-doped tin oxide (FTO) surface.

Table 1: Counter electrode composition (mass fraction) and DSSC efficiency.

| Graphite (wt.) /% | 100 | 90 | 80 | 70 | 60 | 50 |
|---|---|---|---|---|---|---|
| Efficiency /% | 1.22 | 2.78 | 3.81 | 2.70 | 2.58 | 2.12 |

The counter electrode composition and respective cell efficiencies are given in Table 1. The best DSSC efficiency is observed for the counter-electrode with 80% of Graphite and 20% $TiO_2$. This composition optimizes the output as a result of the trade-off between charge carrier transport and transfer properties and catalytic activity (the amount of Graphite plays a critical role due to its catalytic activity) of the electrode. In 3 hours, open-circuit voltage ($V_{OC}$) decreased by 8.0% while the current density ($J_{SC}$) and efficiency increased by 43.2%, 7.0%, respectively. It can be concluded that Graphite/$TiO_2$ counter-electrodes demonstrated here demonstrated to be an excellent candidate to replace Pt to prepare low-cost quasi solid-state DSSCs.

***Keywords:*** Dye-sensitized Solar Cell, Low-Cost Counter Electrode and Graphite/$TiO_2$ Composite.

# Development of Novel Technic Based on Optoelectronics Devices and Opto-characteristic for Determining Analyte Concentration of a Chemical Solution with Fair Precision

**Y.A.Ajith Kumarayapa[1*], Samitha Dilshan[1]** , and **Murthi S.Kandanitiye [2]**
[1] Department of Electronics, Faculty of Applied Sciences, Wayamba University of Sri Lanka.
[2] Department of Nao Technology, Faculty of Technology, Wayamba University of Sri Lanka.
*ksajith@wyb.ac.lk

The recycling of phosphoric acid recovery process deal with fine Activated Carbon manufacturing industry highly based on the density. The current process of evaluating the density of phosphoric acid is done manually using hydrometers. Thus, in order to avoid human errors, to reduce time consumption as well to avoid high expenditure for expensive bulky industrial sensor importing, this study was carried out. Therefore, here we have tried to develop low-cost acid density sensing technique for the industry with the use of Optoelectronics; i.e. by exploring the parameter relationships and related theories practically and theoretically. It could be concluded that there is a correlation between different densities of phosphoric acid vs corresponding refractive index values. Further parameter characteristic analysis with different techniques will be carried out in order to find low cost Optoelectronic-Chemistry analyzer for small business industries.

The photodiode –optoelectronic source combination should be matched with the aqueous solutions absorb spectrum hence the UV spectroscopic results were analyzed.

# Q-cage Silsesquioxane Networks as Photoresponsive Sponges for Substance Uptake and Release

**Joseph C. Furgal[1*], Nai-hsuan Hu[1],** and **Buddhima Rupasinge[1]**
[1] Chemistry Department Bowling Green State University, Bowling Green, OH USA.
* furgalj@bgsu.edu

We have recently developed a set of photoswitchable Q-silsesquioxane based hybrid 3D polymers with azobenzene actuation units. This material responds to light to imbue macroscopic movement to overcome previously troublesome actuation locking in silsesquioxane based materials. Specifically, a hydride–functionalized Q–type silsesquioxane ($Q_8M_8H$) was reacted by hydrosilylation with 4,4'-di-allyloxyazobenzene in 1:1-1:8 ratios. The properties of the resulting materials are controlled by the starting material ratios with 1:2 optimal, and solvents used for synthesis with DCM optimal to generate gels or films. The photoactuation process was studied by DMA, microscopy and UV/Vis spectroscopy. Reversible actuation of 18.3% in a toluene bath under UV irradiation is achieved, with excellent recovery with visible light back to the native state. These smart materials offer reversible modulus switching from 160 kPa in the swollen state to 500 kPa in the UV activated state. Various substances were tested for uptake and release capabilities with polarity and size having the greatest impact on performance. This photo-triggered behavior gives these materials high potential for reusable environmental remediators and in soft robotics applications. Recent advancements in these methods as well as other areas of green silicon chemistry will also be discussed. This will include the use of new photoresponsive cross-linkers as well as the development of polysiloxane catalytic depolymerization technology for polymer recycling.

***Keywords:*** Photochemistry, Silicon Chemistry, Environmental

# Electrochemical Study of Graphene Oxide Films Supported on Glassy Carbon Electrode

**Buddini Nissanka[1], Paula E. Colavita[2],** and **Dilushan R. Jayasundara[1]***
[1] Department of Physics, University of Colombo, Sri Lanka.
[2] School of Chemistry, CRANN and AMBER Research Centres, Trinity College Dublin, College Green, Dublin 2, Ireland.
* dilushanj@phys.cmb.ac.lk

In recent times, Graphene Oxide (GO) based materials have attracted considerable attention in the development of electrodes for a wide range of electrochemical applications. However, insulating nature of GO has limited the use of this material 'as it is' for above mentioned applications. Further, the randomness of oxygen functionalities and their inhomogeneous spatial distribution have a significant impact on the electronic properties of GO. Thus, the investigation of electrochemistry behind this intriguing material is required to realize its application potential. In this study, thin films of GO which were synthesized under different oxidation conditions using Improved Hummers method were casted on glassy carbon (GC) disk electrodes via drop casting. These GO coated electrodes were then electrochemically characterized in the presence of two redox probes potassium ferricyanide and ruthenium(III) hexammine chloride using cyclic voltammetry (CV) to study the effect of oxygen functionalities on electron transfer properties of GOs. The CV results of these GO electrodes for potassium ferricyanide at different scan rates indicate that the electron transfer process is reversible. Further the electrochemically active surface area of GO electrodes measured was much less compared to that of bare GC. This indicates that insulating area of the GO electrodes is higher than the electrochemically active surface area owing to the surface bound oxygen functionalities of GO. Thus, these GO electrodes shows high resistance to electron transfer compared to the bare GC electrode. However, same GO electrodes in ruthenium(III) hexammine chloride showed distinct electrochemical response characteristics to electrocatalytic process due to the presence of oxygen functionalities. In this case, electron transfer process is followed by a catalytic chemical process where electrogenerated reduced ruthenium(III) hexammine chemically react with oxygen functionalities of GO and regenerates the starting material ruthenium(III) hexammine. Further, significant variation can be observed in the rate constants of the chemical reaction for these GO electrodes. Therefore, these GOs can be used as electrode materials for electrochemical applications where oxygenated electrocatalytic reactions are employed.

***Keywords:*** graphene oxide, electrochemistry, cyclic voltammetry

# Study of Z Boson Decay Channels in pp Collisions at √S = 8 TeV with Open Data from the CMS Experiment at the LHC

**W. M. C. M. Weerakoon[1*], K. Kudahewa[2], M. K. Jayananda[3],** and **D. U. J. Sonnadara[4]**
[1] University of Colombo, Colombo 03, Sri Lanka.
*chamithriweerakoon@gmail.com

In this paper, we describe an analysis of public domain data made available by the CMS collaboration of the Large Hadron Collider, at the European Organization for Nuclear Research (CERN), Geneva, Switzerland. The main focus of this analysis was decay of Z bosons generated from Higgs disintegration into leptons. Study of these decay channels gives an indication of a possible new particle generation, invisible to the detector due to their extremely short lifetime.

The analysis was based on CMS open data from 2011and 2012 incorporating CMSSW version 5.3.32 included in a virtual machine provided by CMS. The datasets used in the analysis were in a simulated AOD format DoubleMu, DoubleElectron and SMHiggsToZZTo4L along with its real datasets, all of which were available in the Open Data Portal.

For the analysis of Higgs to four lepton disintegrations, muons and electrons had to be identified from the information available from the detector. The impact parameter values were used to ensure that all four leptons share the same primary vertex. Different restrictions on transverse momenta and pseudorapidity were used for the two types – muons and electrons. Track segment reconstruction via trajectory information was feasible as traversal of particles from silicon tracking system to Electromagnetic Calorimeter or Muon Chambers provide direct information to distinguish them. Three possible permutations – four muons, four electrons and two electrons with two muons were studied. Results from real data were compared with Monte Carlo events provided with the same datasets.

In addition, a measurement of the decay widths of dimuon and dielectron channels of Z was carried out using the identified Z events. To calculate the invariant masses the energy and momentum data were extracted from AODs and for identification of double muons and electrons, charge and track data were extracted. Then the mass peaks were fitted with a convolution of the Gaussian distribution and Breit Wigner curve for estimating the mass widths.

The decay ratio for $\mu^+\mu^-\mu^+\mu^-$ (number of events with four muons, out of all four lepton events) was found to be 0.6944. The ratios for $e^+e^-e^+e^-$ and $\mu^+\mu^-e^+e^-$ were 0.1389 and 0.1667 respectively. Measured decay width for the $\mu^+\mu^-$channel was 4.218 ± 0.005 GeV and for the $e^+e^-$ channel it was 5.067 ± 0.008 GeV. The ratio of mean lives of $Z \rightarrow \mu^+\mu^-$to $Z \rightarrow e^+e^-$ was derived to be 1.201 ± 0.003 which suggested a longer mean life for the $\mu^+\mu^-$ channel.

***Keywords:*** Higgs, Z boson

# Graphene Incorporated Dye-sensitized Solar Cells

**S. M. S. Gunathilake[2,*], G. G. D. M. G. Gamachchi[2], B. M. K Pemasiri[1],** and **T. M. W. J. Bandara[1]**
[1] Department of Physics, Faculty of Science, University of Peradeniya, Sri Lanka.
[2] Postgraduate Institute of Science, University of Peradeniya, Sri Lanka.
* shiwanthakc@gmail.com

The importance of developing novel, highly efficient electrochemical power sources is evident in light of the ever-increasing need for usable energy. Evidently, electrochemical power sources have the potential to fulfill future needs as low-cost energy conversion and storage devices [1,2]. This project focused on developing cost-effective and highly efficient solar cells co-sensitized by Graphene and N719.

The cells composed of dye-sensitized photoelectrodes, which contained six spin-coated $TiO_2$ layers. The counter electrode is Pt and the gel polymer electrolyte was prepared as already reported [3]. The fabricated DSSC was irradiated with 1000 W $m^{-2}$(AM 1.5) by peccell PEC LO1 solar simulator and *J-V* characteristics were obtained for about three hours under continuous irradiation. The cell performance enhancement was observed with the infusion of Graphene into the $4^{th}$ layer. For this purpose, Graphene was synthesized by exfoliation of vein graphite using electrochemical and ultrasonic vibration. The formation of Graphene was confirmed by XRD and Raman spectra. The solar cell with Graphene for the $4^{th}$ layer exhibited the highest energy conversion efficiency of 6.82% in ambient conditions, while that of without Graphene was 6.43%. The efficiency enhancement recorded with added Graphene was about 6%. The performances of DSSCs prepared with and without Graphene were tested by irradiating the cell continuously for about three hours. The efficiency of the cell without Graphene decreased by 35.5%, while that of the cell with Graphene increased by 5.4% in three hours. The present study concludes that the application of Graphene in photoelectrodes of DSSCs can increase both of their efficiency and performance stability.

***Keywords:*** Graphene, Dye-Sensitized solar cells, Gel Polymer Electrolyte

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# Spectroscopic Analysis of Electrochemically Exfoliated Graphene with Tea as Surfactant

**G. G. D. M. G. Gamachchi[1*], B. M. K. Pemasiri[1], T. M. A. A. B. Thennakoon[1], U. Dahanayake[2],** and **T. M. W. J. Bandara[1]**

[1] Department of Physics, Faculty of Science and Postgraduate Institute of Science, University of Peradeniya, Peradeniya, Sri Lanka.

[2] Department of Physical Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.

* dmggamachchi@gmail.com

Graphene is considered as a two-dimensional material made of $sp^2$ hybridized bonding of carbon atoms. In this work, bi-layer graphene was successfully fabricated by electrochemical exfoliation, followed by a sonication process using four different types of tea (Flowery Broken Orange Pekoe Fanning's (FBOPF), Broken Mix (BM), Orange Pekoe (OP), and Refused tea) as an alternative to the costly and toxic solvent, dimethylformamide (DMF). The fabrication was done using high quality vein graphite from Sri Lanka. The UV-Vis spectroscopy confirmed the successful fabrication of graphene, exhibiting a peak around 270 nm for all four tea types. It was challenging to remove all the polyphenols in tea from the resulted graphene samples. The presence of polyphenols in the exfoliated graphene can be traced from the absorbance peak shown at ~ 200 nm in the UV-Vis spectroscopy[1]. For further analysis, FTIR spectroscopy was performed, and it revealed the existence of non-oxidized graphene in the exfoliated sample. The presence of aromatic $sp^2$ hybridized C=C bonds is inferred from the FTIR peak shown at ~ 565 $cm^{-1}$. Exfoliated graphene samples were further characterized using Raman spectroscopy. In the Raman spectra, three distinctive peaks were observed at 1350 $cm^{-1}$, 1580 $cm^{-1}$, and 2730 $cm^{-1}$, and according to the literature, they were D, G, and 2D peaks, respectively[2]. The G peak attributes to the stretching mode of the $sp^2$ hybridized carbon-carbon bonds (bond in graphitic materials) and the D peak attributes to the ring breathing mode of the $sp^2$ carbon, which is governed by defects in the graphite network, in general, caused by oxygen-based functional groups. The 2D peak is located at about 2730 $cm^{-1}$, which is the signature of graphene[3]. The number of layers of the graphene sample can be deduced by calculating the intensity ratio of G peak to 2D peak ($I_{2D}/I_G$). According to the intensity ratio, the average number of layers was two for all the graphene samples indicating the successful exfoliation.

***Keywords:*** graphene, tea, spectroscopy

# Evaluation of Entrance Surface Dose (ESD) for Chest, Lumbar Spine and Abdomen X-ray Procedures in a Selected Hospital in Sri Lanka

**G. P. N. T. Ehalagasthanna[1], D. M. Satharasinghe[1], U. N. Hishaam[1],** and **Jeyasingam Jeyasugiththan[*1]**

[1] Department of Nuclear Science, University of Colombo, Sri Lanka.

* jeyasugiththan@nuclear.cmb.ac.lk

Ionizing radiation is harmful to living beings because it can break apart biologically important molecules such as DNA. Therefore, it is important to enforce radiation protection where radiation is used in medical diagnosis by following justification, optimization and individual dose limitation. Introduction of quality control (QC) programs and regular dose audits assist to ensure that the dose delivered to the patient is in accordance with the principle of As Low as Reasonably Achievable (ALARA). The radiation risk in general diagnostic X-ray imaging can primarily be quantified by the Entrance Surface Dose (ESD), which is known as the radiation dose measured on the surface (skin) where the X-ray beam enters the patient, including the backscatter radiation. The primary aim of this present work is to evaluate the ESD using the normalized X-ray tube output for common diagnostic X-ray examinations of the chest, lumbar spine and abdomen. Moreover, the obtained ESD values were compared with internationally published Diagnostic Reference Levels (DRLs) to identify the procedures which require optimization. The resultant third quartile value of ESD for chest PA, chest lateral, lumbar-sacral spine AP, lumbar-sacral spine lateral and abdomen AP were 0.59, 2.50, 7.56, 14.11 and 5.95 mGy, respectively. These values were significantly higher than the DRLs set by the international bodies. The major contributor to the high doses reported in this study has been identified as low kVp and high mAs combination. The results suggest that efforts are required to reduce patient doses further while securing the image quality. Therefore, a standard operating protocol should be used among all radiography units in Sri Lanka. Furthermore, a proper quality control program should be conducted in X-ray facilities to ensure the accuracy of diagnostic procedures and minimize the radiation dose. A national survey is required to set diagnostic reference levels for all X-ray examinations across hospitals to compare institutional doses and take remedial actions where necessary.

***Keywords:*** Entrance surface dose, X-ray, X-ray tube output

# Radioactivity of Beach Sand from Trincomalee to Kokkilai, Sri Lanka

**D. S. Ranasinghe[1*], J. D. Y.I. Rangina[1], P. Mahawatte[1],** and **M. R. Lamabadusuriya[1]**
[1] Department of Nuclear Science, University of Colombo, Sri Lanka.
* dinethiranasinghe@gmail.com

One of the main sources of natural background radiation is terrestrial radiation which occurs due to radionuclides that are originated in the earth's crust and present everywhere in the environment [1]. The main primordial radionuclides are the members of the two decay chains of $^{238}U$, $^{232}Th$ and $^{40}K$ [1]. These radionuclides, present in minor concentrations in soil which contribute to both external and internal radiation exposure. Certain areas around the world which are related with the occurrence of mineral sand deposits such as Guarapari in Brazil, Yangiang and Quandong in China, Nile delta in Egypt and Rasmar in Iran [2] have been recognized as high background radiation areas due to high primordial nuclide concentrations. Therefore, many researches have been conducted to identify high background radiation areas by measuring primordial radionuclides concentrations around the world.

This Research was conducted to determine $^{226}Ra$, $^{232}Th$ and $^{40}K$ concentrations and annual effective dose rate in beach sand from Trincomalee to Kokkilai, focusing the largest mineral sand deposit in Sri Lanka which is located in Pulmoddai and Kokkilai [3]. Results of the study provided background radiation levels of the area.

Thirty-six sand samples, collected along the coastal strip from Trincomalee to Kokkilai were detected using High purity Germanium detector and analyzed for $^{226}Ra$, $^{232}Th$ and $^{40}K$ radionuclide concentrations. The highest obtained concentrations of $^{232}Th$, $^{226}Ra$ and $^{40}K$ are 2100 ± 50 Bq $kg^{-1}$, 940 ± 20 Bq $kg^{-1}$and 350 ± 20 Bq $kg^{-1}$ respectively. Minimum detection limits for the activity measurements of the above three radionuclides were obtained as, 1.1 Bq, 0.6 Bq and 4.6 Bq respectively. Annual effective dose rate from Trincomalee to Kokkilai due to $^{226}Ra$, $^{232}Th$ and $^{40}K$ concentration of beach sand ranged from 0.0079 ± 0.0008 mSv $y^{-1}$to 2.10 ± 0.04 mSv $y^{-1}$. Average annual effective dose rate 0.485 ± 0.003 mSv $y^{-1}$ was higher than the average annual dose from external outside terrestrial radiation proposed by UNSCEAR report 2008 (0.07 mSv $y^{-1}$). Out of thirty-six sample locations, twenty-five locations exceed the world's average dose rate of 0.07 mSv $y^{-1}$.

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# Construction of Low Cost, Non-toxic Radiation Shielding Material for Radiation Protection

**E. M. D. K. B. Hathnagoda[1]*, V. Sivakumar[1], D. K. K. Nanayakkara[2],** and **N. M. M. S. Rathnayake[2]**
[1] Department of Physics, Faculty of Science, University of Peradeniya, Sri Lanka.
[2] Nuclear Medicine Unit, Faculty of Medicine, University of Peradeniya, Sri Lanka.
*s15340@sci.pdn.ac.lk

Radioiodine or I-131 is mostly used in nuclear medicine to treat thyroid cancer patients who underwent a total or a subtotal thyroidectomy. Radioiodine decays to Xenon-131 by emitting beta particles and gamma rays with a half-life of about 8 days. Energies of gamma radiations emitted in keV are 284 (6.1%), 364 (81.7%) and 637 (7.2%), while the energy of the beta particles emitted has an energy of 606 keV. Once administered, radioiodine is absorbed mainly by thyroid cells and thyroid cancer cells, and hence the patient become the source of radiation. As the principle gamma ray emitted during the decay has the energy of 364 keV, iodine 131 is classified as the group of high radiotoxicities by International Atomic Energy Agency (IAEA). According to Sri Lanka Atomic Energy Regulatory Council, patients treated with low activity (about 1.1 GBq or 30 mCi) iodine 131 are considered as outpatients and hence allowed to go home after the treatment. In order to prevent the radiation exposure to the general public and family members, initiatives were made to construct a disposable shielding material that can be used by theses iodine treated patients as collars. In this study there were two classes of lead free materials were prepared: silicon rubber based and natural rubber based materials. Many fillers were tried based on their atomic number, non-toxicity, and linear attenuation coefficients for high energy photons with above two matrices. Both class of materials show similar reduction of radiation. Out of all the materials tested, the best shielding material was identified as silicon rubber based composite material with a reduction percentage of 41.4%. However, natural rubber based composite material is cost-effective and shows better flexibility.

***Keywords:*** 131I treatment, Radiation exposure, Shielding materials

# Fabrication of Thermoelectric Generators Using Non-toxic Materials

**Y. M. D. C. Y. Bandara[1*], L. K. Narangammana[1],** and **T. M. W. J. Bandara[1]**
[1] Department of Physics and Postgraduate Institute of Science, University of Peradeniya, Sri Lanka.
*dinuthyapa@icloud.com

Global climate warming and shortage of fossil fuel have driven the need for the efficient energy conversion technologies. Thermoelectricity which converts heat energy directly into electricity, offers a promising technology to recover waste heat. The thermoelectric module is an array of junctions formed by joining two dissimilar thermoelectric materials (TEMs) that generates a voltage as a result of an applied temperature difference across the junction. Due to the hazardous nature of best-known TEMs, such as $Bi_2Te_3$ and $Sb_2Te_3$, an attempt has been made to search for new non-toxic TEMs. The polymer polyaniline (PANI) is an attractive p-type conducting material that has many favorable properties to generate thermoelectricity. Zinc oxide is an n-type semiconductor with high electron mobility and low thermal conductivity. Pressed pellets of PANI powder were investigated as the *p*-type material, and pressed pellets of ZnO and Al-doped ZnO were studied as *n*-type materials. Electrical conductivity, thermal conductivity and Seebeck coefficient were measured, and figure of merit was calculated for PANI, ZnO and Al -doped ZnO. In this study, PANI and Al-doped ZnO were synthesized successfully, as confirmed by Fourier-transform infrared and XRD spectra, respectively. The electrical conductivities of PANI, ZnO and Al-doped ZnO pellets at 373 K were 6.36, 31.3, and 35.6 S $m^{-1}$ respectively and the thermal conductivities at 373 K were 0.738, 2.38, 1.40 W $m^{-1}$ $K^{-1}$ respectively. PANI showed a positive Seebeck coefficient of 34.6 µV $K^{-1}$ at 363 K. ZnO and Al-doped ZnO showed negative Seebeck coefficients of -165 µV $K^{-1}$ and -225 µV $K^{-1}$ respectively at 373 K. The calculated figure of merits of PANI, ZnO and Al-doped ZnO at 373 K were $3.74\times10^{-6}$, $1.34\times10^{-4}$ and $4.80\times10^{-4}$ respectively. The PANI/ZnO junction device, at an average temperature of 359 K, generated a potential difference of 21.92 mV for a temperature difference of 78 K.

***Keywords:*** Semiconductors, Non-toxic thermoelectric materials, Seebeck Effect

# Surface Electron Dynamics in Pure and Mixed-phased Copper Oxides Probed by Ultrafast XUV Spectroscopy

**Savini Bandaranayake[1], Ananya Patnaik[1],** and **Robert Baker[1]***
[1] Ohio State University, USA.
* baker.2364@osu.edu

Copper oxides are earth abundant, inexpensive, high absorbance and small bandgap materials that mainly exist in CuO and $Cu_2O$ phases. These binary oxides are attractive candidates to be used as photoanodes in photoelectrochemical cells, for hydrogen production via water splitting. Photocatalytic studies have been carried out with CuO and $Cu_2O$ as photocathodes which has shown promise. Cuprous oxide ($Cu_2O$) is reported to have a maximum theoretical solar-to-hydrogen conversion efficiency of 18% and several modification methods have been utilized to with varying degrees of success to engineer better photocatalysts from copper oxides. Introducing grain boundaries, preparation of layered heterojunctions, changing nanoparticle shape and size, use of cocatalysts and introducing oxygen vacancy defects are some methods that have been explored. Jiang et al. reported that CuO/$Cu_2O$ nanowires have enhanced photocatalytic performance compared to pure $Cu_2O$. [1] Hence utilizing mixed phases of copper oxides seems to be effective. However, very limited attention has been paid to study the manner in which different ratios of $Cu^{2+}$ and $Cu^{+}$ affect the performance of the catalyst. Due to the complex nature of charge carrier dynamics and challenges associated with probing electron and hole dynamics with surface specificity and chemical state resolution, the fundamental processes governing carrier transport, trapping, separation and recombination. While charge carrier dynamics of copper oxides have been investigated using various techniques, a description of catalytically relevant surface study is yet to be studied. We synthesized pure and mixed phased copper oxide thin films and used recently developed extreme ultraviolet (UV) reflection absorption (RA) Spectroscopy to study photoexcited state dynamics in these systems. This method is element and oxidation state specific, surface sensitive, and has ultrafast (femtosecond) time resolution.[2] The studies clearly show changes in ultrafast charge carriers are different in each system where photoexcited charge carriers in $Cu_2O$ shows ultrafast recombination within 1 ps while CuO has a long-lived photoexcited state. This direct observation of electron and hole dynamics in systematically controlled mixed-phase ratios of CuO/$Cu_2O$ provide a better understanding of the material properties responsible for mediating energy conversion efficiency and provides and opportunity to synthetically control carrier transport.

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# Some Remarks on the Solovay–Kitaev Approximations and C*–Algebras

**Pubudika Gunasekara**[1], **Kaushika De Silva**[2], and **Anuradha Mahasinghe**[1*]
[1] Department of Mathematics, University of Colombo, Sri Lanka.
[2] Department of Mathematics, University of Sri Jayewardenapura, Sri Lanka.
* anuradhamahasinghe@maths.cmb.ac.lk

According to the pioneering circuit–gate framework of quantum computing, a quantum program can be regarded as the application of several unitary matrices on qubits, together with measurements at certain instances. In order to implement those unitary operations, basic quantum gates are available, in analogy with the basic gates in classical computing. In a fault–tolerant setting, the universality and the supremacy of quantum computing thus depends upon the cost to implement an arbitrary unitary operation to a given accuracy. This problem has been answered elegantly, and independently, by Solovay and Kitaev, resulting is what is known today as the *Solovay–Kitaev theorem.*

Several previous works have investigated the possibility of having different algebraic structures that support quantum–like computing [1,2]. It is well–known that the circuit–gate framework is based on the Heisenberg and Born interpretation of quantum mechanics, where unitary matrices are applied on qubits. On the other hand, one should not forget in this regard the C*–algebra formalism of quantum mechanics. Therefore, considering the geometric algebra approach and the C*–algebra formalism, it is a natural question to ask whether quantum–like computations are supported in a C*–algebra setting. If the question whether Solovay–Kitaev type approximations are possible in such a setting is explored, it would be helpful for a better understanding of the scope of quantum–like computations. In this work, we explore some aspects of the question whether a generalized version of this theorem can be established in a C*–algebra setting.

***Keywords***: Quantum computing, Operator algebra, Free groups

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# Reformulating Battleship Solitaire for Quantum Annealers

**Vishmi Fernando**[1] and **Anuradha Mahasinghe**[1*]
[1] Department of Mathematics, University of Colombo, Sri Lanka.
*anuradhamahasinghe@maths.cmb.ac.lk

We investigate the possibility of reformulating the puzzle of Battleship Solitaire as a quadratic unconstrained binary optimization problem, in order for the problem to be acceptable to a quantum annealer. Starting from a linear integer programming formulation, we develop two binary quadratic programs and compare them.

***Keywords:*** Boolean optimization, Quantum annealing, Mathematical programming

# Effective Radiation Doses for Head and Neck Multi-Slice Computed Tomography (MSCT) Protocols

**Sanjaya Karunarathna[1,2], D.M Satharasinghe[1], Urshella Hishaam[1], Aruna Pallewatte[2]**, and **Jeyasingam Jeyasugiththan[1*]**

[1] Department of Nuclear Science, Faculty of Science, University of Colombo, Colombo, Sri Lanka.
[2] Department of Radiology, National Hospital of Sri Lanka, Colombo, Sri Lanka.
* jeyasugiththan@nuclear.cmb.ac.lk

Computed tomography (CT) is known as a standard imaging modality prescribed for the head and neck diagnostic imaging. The introduction of multi-detector row CT (MDCT) has enabled imaging of the entire neck region within 2–4 seconds. However, over-ranging due to helical scanning, 3D-volume imaging, and small detector size lead to increased radiation dose in MDCT scans The International Commission on Radiological Protection (ICRP) recommended that the protection of specific tissues, particularly the lens of the eye, should be a priority The objective of this study was to evaluate the radiation dose in MDCT for different head and neck protocols. The Effective Dose (ED) of ten head and neck CT examinations from 214 adult patients (mean age 49.2 ±15.9 years) were evaluated. The median ED values for sinuses:non contrast (NC)+contrast enhanced (CE), sinuses:NC, Petrous bone (PTB)/Internal auditory meatus (IAM):NC+CE, PTB/IAM:NC, or bit:NC+CE, orbit:NC, brain with orbit:NC, brain CT angiography (CTA) subtraction, neck:NC and brain/neck:NC were 1.616 mSv, 0.821 mSv, 2.434 mSv, 0.932 mSv, 1.696 mSv, 0.825 mSv, 3.546 mSv, 6.249 mSv, 2.193 mSv and 5.285 mSv respectively. These values can be considered as typical values for the given institution. Moreover, overall radiation doses of this present institution is well below the values suggested by similar studies. However, brain CTA needs dose optimization since it is higher than the values suggested by similar literature.

# Study of Temporal Variation of Radiofrequency Electromagnetic Radiation Levels in Two Bedrooms in Urban and Rural Locations in Sri Lanka - A Case Study

**S. A. T. U. W. K. Suraweera[1]*** and **K. P. S. C. Jayaratne[1]**
[1] Department of Physics, University of Colombo, Colombo 03, Sri Lanka.
*thusharasuraweera@yahoo.com

Nowadays, most people panic with sleeping disorders, and different causes are emerging day-to-day. Some scientists believe that living inside environments with high Radiofrequency (RF) intensities and keeping mobile phones in the bed may lead to sleeping disorders and may change the behavior of the nerve system. In this study, Radiofrequency radiation is measured within the frequency range 300 MHz – 3000 MHz in two bedrooms inside the houses located in Colombo (Urban Location) and Kegalle (Rural Location) districts, respectively. The reason for selecting the above frequency range is most of the television broadcasting, cellular communication, Wi-Fi, and other data communication networks use this frequency range. At the selected locations, RF plane wave power densities and the electric field intensities were recorded using the Spectran HF6065 spectrum analyzer on an hourly basis for a duration of 12 hours. Measured values were compared with the international reference levels published by ICNIRP (International Commission on Non-Ionizing Radiation Protection) and FCC (Federal Communications Commission). Maximum plane wave power density and electric field strength measured in the urban location are 38.08$\pm$0.01 $\mu$W $m^{-2}$ (0.0005% of the maximum permissible level) and 119.80$\pm$ 0.01 mV $m^{-1}$ (0.23% of the maximum permissible level), respectively. The maximum RF radiation levels were observed at 4 a.m. at the urban location and at 6 a.m. at the rural location. According to the results, recorded RF radiation values are shifted towards 2 GHz frequency region in the urban location, and at the rural location, those are gathered around 1.1 GHz region. It is found that the urban location is nearly 10 times polluted by RF radiation than the rural location, and still, these values are well below the maximum permissible levels. Further studies are underway to observe high RF polluted locations and their effects.

***Keywords:*** Radiofrequency, Electromagnetic pollution, Sleeping disorders, Nerve system.

# Identification of Bioaerosols Heading Direction Using a Quadrant Photo Detector

**S. S. Abeywickrama**[1,2*] and **Hiran H. E. Jayaweera**[1]
[1] Department of Physics University of Colombo, Sri Lanka.
[2] Department of Physics, University of Ruhuna, Sri Lanka.
[*] sisila@phys.cmb.ac.lk

Insects are so important to the natural eco system as well as to humans that they are involved in pollination, nutrient cycling, disease spreading, medicine, aesthetics, and biological control. Besides, monitoring insects' activities is a crucial part of understanding their behaviour though most of the insect monitoring techniques have their own limitations. For instance, passive LIDAR is one of the emerging techniques that is capable of in situ monitoring of insects. However, the detection of insect heading direction is very challenging with passive LIDAR. A novel methodology in detecting insect flight direction for a passive LIDAR system was developed with the use of a quadrant photodetector (Hamamatsu S4349).

A control experiment was conducted by sending beads in selected directions of the field of view of the LIDAR system where the quadrant detector is at the focus of the telescope. The data is sampled at a 10 kHz rate for all four channels of the quadrant detector and analysis was done in iterations. The flight direction can easily be determined by analyzing the time domain signal through understanding the orientation of the quadrant detector. However, this method did not reveal whether the insects flew in transverse or longitudinal direction. In the first iteration, insect detection was determined by considering all four channels. The next step was selecting the data set of full width at 10% of the peak signal of the event for each channel. The dataset was transferred into the frequency domain and then compressed with the Singular Value Decomposition (SVD). By selecting the most dominant components after data compression, the feature set was classified using Hierarchical Cluster Analysis (HCA). Upon investigation of individual clusters with the use of an expert dataset, it was found that the heading direction can be identified in both longitudinal and transverse components with the sensitivity of 96%, specificity of 95 % and accuracy of 96 %.

***Keywords:*** Insect monitoring, Heading direction, Entomological Lidar.

# Investigation of the Accuracy of Monthly Water Surface Extraction from Landsat 8 Using Synthetic Aperture Radar (SAR) Sentinel-1 Data

**N. Alahacoon**[1,2*] and **C. Mahesh Edirisinghe**[1]
[1]Department of Physics, University of Colombo, Colombo, 00300, Sri Lanka.
[2]International Water Management Institute (IWMI), Colombo, 10120, Sri Lanka.
* n.alahacoon@cgiar.org

Accurate assessment and dynamic monitoring of surface water bodies using long-term satellite data are critical for water resource planning, drought monitoring, flood control, and disaster mitigation applications. Despite the Synthetic Aperture Radar (SAR) Sentinel-1 systems with high accuracy, wide-coverage, and the ability to obtain all-weather conditions, Landsat optical satellite data have been used to obtain long-term water surface area since SAR data is available only from 2014 onwards. However, high-efficiency and high-precision water surface extraction and the use of Landsat data for dynamic water surface monitoring are more challenging than SAR data due to the presence of clouds and their shadows. Therefore, the main focus of this study is to analyze the accuracy of monthly water surface area extracted from Landsat-8 using SAR Sentinel-1 base data for water surface area as it provides the most accurate water surface area. The data extracted for five reservoirs in Sri Lanka namely Iranamadu, Mahavilachchiya, Kantale, Senanayaka Samudraya, and Udawalawe were used to investigate the accuracy of Landsat 8 derived water surface area using SAR Sentinel-1 Data. Furthermore, the study referred to data only from 2015 to 2020, taking into account that the presence of both Landsat 8 and Sentinel-1 data. The study utilized the cloud computing platform and algorithms available in Google Earth Engine (GEE) to make the analysis more efficient and robust as it used a large volume of satellite data to analyze. The Pearson correlation coefficient (r2) was calculated using the water surface areas extracted from both Landsat 8 and Sentinel-1 in the reservoirs used for the analysis. The r2 values for five reservoirs were 0.83 (Iranamdu), 0.91 (Mahavilachchiya), 0.91 (Mahavilachchiya). 0.92 (Senanayake Samudra) and 0.91 (Udawalawe). These results show that the water surface areas extracted from Landsat 8 show high accuracy. Henceforth, it can be confirmed that the Landsat series data (1, 2, 5, 7, 8) which used the same sensing mechanism can be used more efficiently to calculate long-term water surface areas as it is available from 1972. The other important point reflected in this study is that GEE can be used more efficiently for long-term water surface extraction.

***Keywords:*** Landsat, Sentinel-1, Google Earth Engine (GEE)

# Estimation of Effective Radiation Dose in 16 Slice Computed Tomography Neck Examination

**Harshana Gunawardhana[1,2], Asanka Mallikaarachchi[2], Sameera Viswakula[3],** and **Jeyasingam Jeyasugiththan[1]***

[1] Department of Nuclear Science, Faculty of Science, University of Colombo, Sri Lanka.
[2] Department of Radiology, Base hospital, Karawanella, Sri Lanka [3] Department of Statistic, Faculty of Science, University of Colombo, Sri Lanka.
*jeyasugiththan@gmail.com

Computed Tomography (CT) is the most essential imaging technique and widely used in various diagnostic radiological and interventional procedures in Sri Lanka. Because of the increased demand for CT imaging procedures, evaluating patient dose is very important to achieve the maximum benefits over the unnecessary radiation exposure. The main purpose of this work was to estimate the effective dose (ED) for neck CT examination protocols (C-Spine and Neck) performed with a 16 slices CT machine at Base Hospital–Karawanella. 172 patients' data including Volumetric CT Dose In dex (CTDIvol), Dose Length Product (DLP), scan parameters and patient demographic data of each examination were collected for a period of one year. These results were compared descriptively and compared with available data. Correlation between adult neck scanning volume (ANSV) and neck scanning length (ANSL) with DLP for each protocol was calculated by using Pearson's correlation analysis. The achievable doses (AD) and Diagnostic Reference Level (DRL) values of calculated ED were 6.2 mSv and 6.8 mSv respectively for single-phase C-Spine protocol and 12.6 mSv and 13.8 mSv respectively for the dual–phase scan. For the neck protocol, AD and DRL values of calculated ED values were 5.7 mSv & 7.8 mSv and 11.6 mSv & 15.8 mSv for dual-phase and single-phase respectively. The p-values of all comparisons were less than 0.05. A strong positive correlation between ANSV and ANSL with DLP were obtained. The results obtained in this study were considerably higher than the data obtained from literature. This study will lead to meaningful stan dardizing optimization of neck CT examination protocols and will provide a starting point for further institutional analysis of CT radiation doses.

***Keywords:*** Computed Tomography, Effective Dose, DRL

# Discovery Learning of Concepts Related to Mechanical Waves in an Online Classroom: A Case Study

**Gagani Rathnayaka[1,2], Barlo Daya[1], Kanishka Wijayaratna[1], Siyath Gunewardene[1],** and **Ramal Coorey[1*]**

[1]Department of Physics, Faculty of Science, University of Colombo, Sri Lanka.
[2]Rawathawaththa Methodist College, Moratuwa
* ramal@phys.cmb.ac.lk

Due to the Covid pandemic, the new normal has relied heavily on online learning. An active learning platform with online student support was created for delivering basic concepts related to mechanical waves in Physics. The 37 learners from the grade 13 following the local advanced level physical and biological science streams were chosen from selected schools in the Moratuwa divisional area in the western province of Sri Lanka. A virtual classroom management platform based on '*google classrooms*' and '*educational blogs*' were adopted with active learning engagement through Physics simulations (using *PhET, Ophysics, Geogebra, Slinky lab*) and videos (*Youtube*). Guided discovery method-based virtual labs were used in the students' instructions to engage them in active learning. '*Whatsapp*' software was used as a communicating platform for learners and '*google forms*' were used for deploying routine assessments. Concepts related to mechanical waves, in the domains of wave propagation, superposition, reflection, and properties related to standing waves were tested in pre-and post-instruction using a standard concept inventory, the mechanical wave conceptual survey (MWCS). The average normalized gain (i.e. the difference of pre-and post-test scores normalized to the maximum possible change) for the entire class was ($0.59 \pm 0.04$), while the mean pre- ($36.9 \pm 0.4$) % and post-test ($74.3 \pm 0.3$) % scores for the class were tested to be significantly different using the student *t*-test ($p<0.001$). The learning gains under the conceptual domains; wave propagation, superposition, reflection, and properties related standing waves were ($0.6 \pm 0.3$), ($0.66 \pm 0.09$), ($0.5 \pm 0.2$) and ($0.6 \pm 0.2$) respectively. It was found despite the instructional strategy utilized, the students' conceptual difficulty was most for realizing the wave speed is independent of the changes in forced vibration source (hand) movement and working out properties related to reflection of an asymmetric pulse with a free end. Overall, the teaching method is suited for delivering content in an online virtual learning platform enabling teachers and students to overcome the barriers of a face-to-face teaching environment. The utility of information and communication technology literacy is a must for 21st century learners, hence the approach helps to access technology using skills as well as self-learning and promotes distance education.

***Keywords:*** Online teaching, Physics education research, Mechanical wave conceptual survey

# A Multimedia Enhanced Smart-board Assisted Teaching Method for Improving Learning Outcomes of Mechanical Wave Concepts: A Case Study

**Chathuri Karunanayake[1,2], Dilina Perera[1], Kanishka Wijayaratna[1], Siyath Gunewardene[1]**, and **Ramal Coorey[1*]**

[1] Department of Physics, Faculty of Science, University of Colombo, Sri Lanka.

[2] Musaeus College, Colombo 07.

*ramal@phys.cmb.ac.lk

Smart-boards and their usage in classrooms are becoming popular. However, its effectiveness and optimal usage for achieving learning outcomes in Physics is less researched. An instructional strategy for teaching concepts related to mechanical waves utilizing a smart-board with interactive multimedia was tested on a sample of 30 students in Advanced Subsidiary Level following the Advanced Level Edexcel syllabus in the Colombo educational zone. As the pre- and post-test for assessing both students and overall efficacy of instructions, 16 questions out of the mechanical wave conceptual survey (MWCS) were used. The MWCS is a standard concept inventory tested for both validity and reliability. The instructions focused on providing graphical input in the form of animations to explain concepts related to waves; harmonics, propagation & phase, superposition, and properties of standing waves. Individual and group work were assigned with assistance given to summarize learnt concepts at the beginning and end of each lesson. The average normalized gain (i.e. the difference of pre- and post-test scores normalized to the maximum possible change) for the performance in MWCS for the entire class was measured to be 0.48 (95% CI = 0.44 to 0.52). Pre-test (median = 50% and std. dev. = 8%) and post-test (median = 68% and std. dev. = 11%) means were significantly different ($p < 0.001$) using the student-*t* test. It also revealed that students had the most difficulty in concepts related to wave superposition & phase (pre-test average of 12%), while only concepts related to wave harmonics recorded pre- and post- test scores > 80%. The best learning gains were reported for concepts related to wave propagation (0.62) and superposition and phase (0.44) respectively. It can be inferred that the concepts requiring the visualization of the dynamic processes in waves can be better communicated when multimedia aided smart-board lessons along with teacher feedback is given to learners.

***Keywords:*** Smart-boards, Physics education research, Mechanical wave conceptual survey

# The Challenges Faced by Lecturers in Online Teaching: Bridging the Gap of Interaction During Online Teaching for a Small Group of Undergraduates

**K. A. D. D. Kuruppu**[1*]

[1]Department of Aeronautical Engineering, Faculty of Engineering, General Sir John Kotelawala Defense University, Ratmalana, Sri Lanka.

*dulanik@kdu.ac.lk, dkuruppu1985@yahoo.com

The objective of this research work was to discuss the challenges faced during online teaching and learning activities and the strategies used to improve the interaction during online teaching. The study group consisted with 35 undergraduates in the 3rd year at the faculty of engineering where there were 7 female students while the rest of the students were male. It was experienced that the interaction of the students was lacked as it was teaching through screens. Therefore, it was decided to change the teaching and learning activities to improve the interaction during online teaching. KWL table was introduced to the students along with a take-home assignment while the option of "breakout rooms" in Zoom was used for group discussion during online teaching. Furthermore, it was also experienced that the interaction of the students with the teacher and also with the peers were enhanced after the practice of using "breakout rooms", in Zoom. In addition, it was also experienced that pre-preparation for the lecture was improved, upon sharing the presentation with the students prior to the lecture. The feedback related to the newly established teaching and learning strategy was collected at the end of the lecture through a focus group interview. All the students were commented that the interventions made at the online lectures assisted them to learn the subject effectively through self-reflection, self-learning and online discussion sessions in a very interactive manner. In conclusion, it was suggested that the different pedagogies practices could be used to improve the interaction of the students during online lectures.

***Keywords:*** Challenges, Higher education, Teaching and learning

# Higher Education Quality Assurance Policy Realization Framework: Special Reference to Teaching and Learning in State Universities, Sri Lanka

**H. M. C. Pushpakumara[1] *, Prasad M. Jayaweera[2]**, and **M. K. Wanniarachchige [1]**
[1] Faculty of Management and Finance, University of Ruhuna, Matara, Sri Lanka.
[2] Faculty of Applied Science, University of Sri Jayewardenepura, Nugegoda, Sri Lanka.
* chandanap@badm.ruh.ac.lk

Higher education has attracted greater attention on assuring and improving the quality of the institution and its study programmes. Generally, quality assurance desires compliance with prespecified policies and procedures in performing activities. Although universities employ a variety of computerized information systems they do not focus on the quality assurance process in the context. Therefore, most of the internal and external quality assurance activities are performed manually. An information system module can be proposed that facilitates the quality assurance process overcoming the existing drawbacks of the manual process. But the realization of respective quality assurance policies and procedures over the information system is a challenging task. The proposed information system provides an appropriate policy realization framework through three main sub-modules i.e., process monitoring and recording, quality assurance rules management and execution, and quality assurance performance evaluation. The study mainly focuses on policy realization of the quality assurance of the higher education teaching and learning process. Furthermore, three main aspects of ISO 9001:2000, monitor or measure the service, performance evaluation, and improvement action have been addressed by the proposed system. This conceptual design will be helpful for higher education policymakers and information system developers.

***Keywords:*** Higher education, Quality assurance, Policy realization

# Representing the Formal Structure of Mathematical Concepts Incorporating Learning Taxonomies

**B. T. Liyanaarachchi[1] *, J. K. Ratnayake[2], R. Jayewardene[1]**, and **S. Gunawardene[3]**
[1] Department of Mathematics, University of Colombo, Sri Lanka.
[2] Department of Mathematics, University of Sri Jayewardenepura, Sri Lanka.
[3] Department of Physics, University of Colombo, Sri Lanka.
*lbavanthi@gmail.com

The main goal of this research is to model a concept structure as a graph that incorporates Bloom's and SOLO taxonomies.

*Content structure*, the "web of concepts and their interrelations" has been modeled as a directed graph, where directed arrows between concepts indicate the relationship between them [1]. This work does not incorporate learning taxonomies in their model. However, incorporating learning taxonomies can play an important role in the teaching-learning process and instructional design. Moreover, *concept structure*, consisting of all the logical implications and manipulations of a concept definition, captures more details and could be used in place of content structure.

Let *A* be the collection of *atomic concepts* that we intend to consider under a particular topic of interest with a chosen level of detail. Some of these concepts and processes together may contribute to new more general concepts (as in SOLO taxonomy). Thus, we can understand the concept structure as a directed graph on the set of all vertices *V*, where each vertex in *V* consists of some collection of atomic concepts in *A*; i.e., we may understand *V* to be a subset of the power set of *A*. Relationships between these concepts in the formal structure is represented by arrows. Each vertex that is a subset of another vertex is depicted as a vertex inside the vertex that is the superset. Such a superset can be understood as a higher level of understanding and interpreted using SOLO taxonomy, as the structure of the graph closely resembles the "graphical interpretation" of the SOLO levels. Moreover, we argue that each arrow can be interpreted using Bloom's taxonomy.

Incorporation of learning taxonomies gives a direct way to use these models in assessment and the teaching learning process. For example, an ongoing research work focuses on assessing a student's concept image and comparing it with the concept structure to diagnose deficiencies in learning. One of the challenges of this work is to model the concept structure accurately.

***Keywords:*** Concept Structure, Directed Graph, Taxonomy

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# Factors Related to Feasibility of Activity Based Learning of Advanced Level Students to Promote Sustainable Development Goals

**H. D. A. Seneviratne[1*],** and **D. V. K. P. Seneviratne[2]**
[1] Faculty of Education, University of Colombo, Sri Lanka.
[2] Department of Science and Technology Education, University of Colombo, Sri Lanka.
* hseneviratne2014@gmail.com

Sustainable Development Goals (SDGs) are compartmentalization of sectors that provide a holistic and multidimensional view on development to transform our world to ensure well-being, economic prosperity, and environmental protection. Literature emphasizes that sustained society would be achieved through education by developing knowledge and attitudes of the young generations towards SDGs which in turn lead to favourable behaviours. Use of activity based learning in this regard would be of utmost important. However, many Sri Lankan and foreign researchers have emphasized that the level of awareness, knowledge, and attitude towards the SDGs is not satisfactory not only among school children but also in the society. Furthermore, availability of the classroom environment for activity based learning is also questionable. Hence, this study as an ongoing research to promote selected SDGs via Activity Based Learning aims to examine the factors which affect the implementation of Activity Based Learning in learning-teaching process of advanced level students to promote SDGs. Descriptive approach was adopted as the method of the study and the main principal with 3 deputy principals and 4 assistant principals, 3 teachers of combined mathematics, 5 teachers of chemistry, 4 teachers of physics, 4 in- service advisors (ISAs) relevant to the physical science stream, 2 directors in Education for All Branch of Ministry of Education were selected using purposive sampling method. Observation schedule and the semi structured interview schedules were used for data collection. Qualitative data and quantitative data were respectively analyzed using thematic content analysis and percentages. Fact findings revealed that 50% of principals, 44% of teachers and 75% of ISAs' are aware of the basic knowledge related to the concept of SD while 62% of principals, 69% of teachers and 100% of ISAs' are aware of the basic knowledge regarding Education for Sustainable Development. Examination oriented mentality of secondary school students and their parents, lack of funds, lack of physical space in schools and non-supportive curriculum to carry out SD related programmes found as the challenging factors in implementing the Activity Based Learning towards Sustainable Development Goals.

***Keywords:*** Sustainable Development Goals, Activity - based learning

# Effectiveness of Using Virtual Education Tools as a Teaching Aid to Reinforce Newtonian Concepts of Gravity. A Case Study: G.C.E. Advanced Level Students in Colombo District

**Vishwaprabha Silva[1], Barlo Daya[2], Siyath Gunewardene[2]**, and **Ramal Coorey[2*]**
[1] Devi Balika Vidyalaya, Colombo 08.
[2] Department of Physics, Faculty of Science, University of Colombo, Sri Lanka.
* ramal@phys.cmb.ac.lk

Physics Education Research has shown that often students hold onto their preconceptions and are reluctant to give them up to learn correct concepts through conventional teaching methods. In the present work, a sample of 337 Sinhala medium students in the G.C.E. Advanced Level grade 13 Physics class from six schools in Colombo district were first taught the lesson on "Gravitational fields" in a classroom setting in their respective schools. Newtonian of Gravity Concept Inventory (NGCI), a 26-item multiple choice instrument was first translated into Sinhala and administered as the pre-test. Virtual education tools (PhET simulators developed by University of Colorado and animated video clips) based on concepts of gravity were then provided as teaching aids to students and NGCI was administered again as the post-test. The time interval between the pre- and post-test was two weeks. Average post-test (mean 68.19, SD 10.11) compared to average pre-test (mean 51.75, SD 9.33), showed that the difference in means is significantly different ($p < 0.0001$) using student paired t-test at 95% confidence interval. Recognizing gravity as an inertial force was the most difficult concept for students to grasp (average pre-test score of 19%). Average post-test score had increased to 43% through virtual learning. Students' conceptual understanding of force law, directionality, independence of gravity in relation to other forces/factors and threshold domains showed average post-test scores > 65% with *N-Gain*s > 0.3 with significant difference in means in student paired t-test at 95% confidence interval ($p < 0.0001$) for each domain. It can be inferred that blended learning mode with a continuous feedback mechanism (repeatedly re-explaining concepts which students find hard to absorb) will be required to change existing students' preconceptions.

***Keywords:*** Physics Education Research, Virtual education tools, Newton's Law of Gravity Concept Inventor

# Eliminating the Misconceptions in Applying Gauss' Law Using PhET–Based Tutorials

**Amila Aponsu[1], W. A. M. Madhavi[2], Dilina Perera[2], Siyath Gunawardene[2],** and **Ramal Coorey[2*]**
[1] St. Sebastian's College, Moratuwa, Sri Lanka.
[2] Department of Physics, University of Colombo, Sri Lanka.
* ramal@phys.cmb.ac.lk

Conceptual misunderstanding on topics related to electromagnetism is common among young learners in Physics which makes them perform poorly in exams. The concept of electric flux and applications of Gauss' Law in electrostatics requires learners to imagine the nature of the abstract concept of electric field lines and the symmetry of the problem in 3-dimensional space. The traditional teaching method which involves a white/black board is incapable of giving a 3- dimensional perspective of objects and therefore, Physics teachers often find it difficult to facilitate student learning using the traditional method when it comes to teaching Gauss' Law.

In this study, we used an instructional setting based on simulations (using PhET) to convey the concepts related to electric flux and Gauss' Law to a group of 50 students in grade 13 in Moratuwa, Sri Lanka. Effectiveness of the teaching intervention was tested through a multiple choice question paper consisting of 25 questions. The questions were taken from the standard concept inventory to ensure the validity and reliability of the test. The pre-test was conducted after teaching the concepts using the traditional method. Then the students were made to follow tutorials based on computer-based interactive simulations developed by the Physics Education Technology (PhET) project at the University of Colorado at Boulder. These simulations provided an interactive platform for the students to visualize the electrostatics concepts in 3-dimensional space. After the students completed the tutorials, the same question paper was given to the same group of students and the marks obtained were recorded.

Results show a significant increase in conceptual understanding on the topics related to electric flux and Gauss' Law with an average normalized gain (i.e., the difference between pre- and post-test scores normalized to the maximum possible change) of $(0.3 \pm 0.2)$ for the entire group. This value was significantly different at the 5% significance level from the student-t test. As a result of the teaching intervention, the average test score obtained by the group increased from 38% to 61% indicating that the method is effective in enhancing students' conceptual understanding on the topics related to electric fields.

***Keywords:*** PhET simulations, Electrostatics, Gauss' Law

# Immunomodulatory and Erythropoietic Effects of the Pulp Extract of a Sri Lankan Traditional Medicinal Fruit (family Moraceae) in Wistar Rat Models

**Tarindhi Ratnayake**[1], **Thilan Wickramarachchi**[2], **Sachini Amarasekara**[1], **Praneeth Ratnayake**[1] **Vindya Udalamaththa**[1], and **Preethi Udagama**[1*]

[1] Department of Zoology and Environment Sciences, University of Colombo

[2] Microtech Biologicals (Pvt) Ltd., No. 211/1 C, Palanwatta Road, Pannipitiya

* preethi@zoology.cmb.ac.lk

Traditional therapeutics in local folklore describes numerous medicinal plants with possible immunomodulatory and erythropoietic properties, yet scientific validation of such claims remain obscure. Hence, the present study evaluates the potential of the pulp extract of a tender fruit (PETF) that belongs to the family Moraceae with traditional claims of immunomodulation and erythropoiesis, using *in vivo* animal models and *in vitro* assays. The thrombocytopenic Wistar rat model established by administering hydroxyurea (1.5 mg/kg), were gavaged once daily for 3 consecutive days with three doses of the PETF (low:0.18, mid:0.36, and high:0.72 ml/ 100 g of body weight) as recommended by a traditional practitioner, while the normal group was treated with the low dose, and the controls (normal and thrombocytopenic) received distilled water (N=6/group). At the end of three days the standard protocols were used to record the selected immunological parameters (platelet, total and differential WBC counts, bone marrow cell count, splenocyte counts, phagocytic capacity), and erythropoietic parameters [RBC count, haemaglobin concentration, packed cell volume (PCV)], alongside sub-acute and genotoxic effects of PETF. Significant increase of immunological parameters in thrombocytopenic rats was most notable in the groups treated with mid and high doses of PETF, while the parameters of the normal group remained comparable to its control. Accordingly, the respective percentage increase of rat platelets (mid dose-139.22%, high dose-150.04%), WBCs (127.13%, 209.50%), bone marrow (433.44%, 2307.52%), and depletion of splenocytes (-28.23%, -37.36%) were evident compared to relevant controls ($p<0.05$). Among WBCs, a significant percentage increment was observed of neutrophils (mid-35%, high-167%), monocytes (200%, 325%), and lymphocytes (25%, 39%), respectively ($p<0.05$). Likewise, the erythropoietic parameters including RBC count (low:345.37%; mid:296.05%; high:370.97%), PCV (low:96.26%; mid:82.70%; high:147.69%), and haemoglobin concentration (mid:60.72%; high:59.92%) of thrombocytopenic rat groups displayed significant augmentation ($p<0.05$). Phagocytic activity of peritoneal macrophages increased with PETF low (26.77%) and mid (76.34%) doses ($p<0.05$). *In vivo* evaluation of sub-acute toxicity of PETF demonstrated that this extract was devoid of general toxicity, hepatotoxicity and renotoxicity. Lack of *in vitro* genotoxicity was evident. The current study displayed significant immunomodulatory and erythropoietic properties of PETF, sans toxicity, which supported the traditional Sri Lankan folklore claims.

***Keywords:*** natural medicine, immunomodulation, erythropoiesis

# Assessing Probiotic Potential of Lactic Acid Bacteria Isolated from Traditional Sri Lankan Buffalo Curd

**C. J. Gunathunga[1], L. J. S. Undugoda[1*], M. M. Pathmalal [3,4], A. H. L. Nilmini[2], N. N. R. N. Nugara[1],** and **D. Udayanga[1]**

[1]Department of Biosystems Technology, Faculty of Technology, University of Sri Jayewardenepura, Sri Lanka.

[2] Faculty of Technology, University of Sri Jayewardenepura, Sri Lanka.

[3] Faculty of Graduate studies, University of Sri Jayewardenepura, Sri Lanka.

[4] Centre for water quality and algae research, Department of Zoology, Faculty of Applied Sciences, University of Sri Jayewardenepura, Sri Lanka.

*lankaundugoda@sjp.ac.lk

Buffalo curd is a potential source of indigenous probiotic lactic acid bacteria (LAB) which are able to provide favourable health benefits to humans. Therefore, current project aims at evaluating probiotic attributes of lactic acid bacteria isolated from traditional buffalo curd produced in Sri Lanka. Lactic acid bacterial species were isolated using modified MRS and M17 media using buffalo curd samples collected from different areas of Sri Lanka and further tested for the ability of lactose fermentation. Out of the isolated thirty-five (35) lactose fermenters, nine (9) were identified as the best lactic acid fermenters based on their biochemical characteristics. The selected nine bacterial species were further evaluated for their probiotic qualities such as tolerance to low pH, resistivity to bile salts, antibiotic resistance to ampicillin, streptomycin, erythromycin, and gentamicin and the antimicrobial activity against *Escherichia coli*, *Pseudomonas aeruginosa* and *Staphylococcus aureus*. All nine LAB species were able to tolerate low pH levels and survived a bile salt concentration of 0.3%. Only three isolates were resistant to all the tested antibiotics while the other isolates were sensitive. In general, a higher sensitivity was shown against ampicillin and erythromycin than other antibiotics. The antimicrobial metabolites produced by all isolates were found active against the tested pathogenic organisms. The study revealed that LAB possesses desirable probiotic properties that can be isolated from traditional buffalo curd of Sri Lanka. Hence the identified strains can be further evaluated as probiotic starter cultures in the production of high quality fermented dairy products.

***Keywords**:* Buffalo curd, Lactic acid bacteria, Probiotics.

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# Assessment of Microbial Water Quality of Upper Catchment of Mahaweli River

**Pinidi Jayawardana[1*], Deepthi Wickramasinghe[1],** and **Ayomi Witharana[1]**
[1] Department of Zoology and Environment Science, University of Colombo.
* pinidijayawardana@gmail.com

Access to clean and safe water is a fundamental human right. Hence, much research focuses only on drinking water quality. As Sri Lanka is a tropical country with plenty of water resources, where communities often use waterways for bathing and recreational activities. The aim of this research is to assess Total Coliform (TC) and Fecal Coliform (FC) counts at four water intake points along the Mahaweli River. TC and FC counts in 2018 and 2019 at Greater Kandy and Polgolla in the upper catchment (UC) and Allai-Kantale and Gallella in the lower catchment (LC) of the river were obtained from the Water Supply and Drainage Board of Sri Lanka. Analysis indicates FC in both Greater Kandy (1052 MPN/100ml ±269.7) and Polgolla (1320 MPN/100ml ±432.83) exceeded National Standards for recreational water quality (1000 MPN/100ml). The highest values were apparent in the rainy season (Greater Kandy -2000 MPN/100ml; Polgolla - 2560 MPN/100ml in October 2018) as monthly rainfall was positively correlated with the FC values in both intake points (Greater Kandy - $r_s=0.126$, $p>0.05$; Polgolla - $r_s=0.042$, $p>0.05$). In contrast, Allai-Kantale did not demonstrate any microbial contamination while Gallella presented water with acceptable microbial quality with ranges of TC 310-1940 MPN/100ml and FC 60-800 MPN/100ml. We conclude that water at Greater Kandy and Polgolla areas present a risk of fecal contamination to those who bathe and swim in the river. The results also highlight the fact that urbanization with inadequate sanitation facilities would have likely contributed to pollution of water with fecal matter. Moreover, consumption of untreated water from the river, if any, remains a pervasive threat to health. Our research suggests that adequate measures to manage water quality in the UC of Mahaweli River is crucial to reduce recreational health risks.

***Keywords:*** Coliform, Recreational water quality, Mahaweli

# Variation in Avifaunal Diversity and Composition along a Paddy Growth Gradient in Kandy, Sri Lanka

**Asmath Haseena Hilmy[1*], Saminda Fernando[2], Vindhya Kulasena Fernando[2],** and **Deepthi Wickramasinghe[2]**

[1] Department of Zoology and Environment Science, University of Colombo, Sri Lanka

[2] Department of Zoology, The Open University of Sri Lanka, Sri Lanka

* ahdheer1@gmail.com

Birds occupy different habitats to fulfill their life requirements. Studies are investigating characteristics of bird assemblages in the same habitat under different resource availability are rare in literature. The present study attempts to understand the variation of avifaunal composition in a paddy field in Kandy, Sri Lanka during different growth stages (Seeding, Transplantation, Flowering and Post harvesting) from December 2020 to April 2021. A variable circular plot method was used to count the birds along a 100m line transect across the paddy field at the three sampling stations, spending 20 minutes at each station. Species were identified, and the abundances was recorded. Sampling in each stage was carried out over 3 days. Species diversity, dominance, evenness and community similarity were determined for each stage using Shannon Wiener Diversity Index, Dominance Index, Evenness Index and Sorenson's coefficient respectively. Fourteen species belonging to 11 families were recorded. Significant differences were noted among the stages for species richness, bird abundance and the 3 indices. Flowering stage showed the highest (14) and Seeding stage the lowest (4) species abundance. Sorenson's quotient indicated that the above two stages had the least community similarity (44%). The most abundant species in all stages was the common mynah. Abundance increased up to the Flowering stage along the growth gradient and dropped at the harvesting stage. Post harvesting stage had a less domination of birds (0.23) but was evenly distributed (0.94) compared to other stages. Diversity was lowest in the Flowering stage (1.26) in contrast to the Transplantation stage (1.55) while species richness was the highest. It may be due to the domination of few species during the Flowering stage (0.53). The flowering stage was more important as a bird habitat. Varied occupancy of birds in different Paddy growth stages provides hints on the different patterns of resource availability such as food, water level, vegetation architecture and presence of open spaces. As paddy is heavily dependent on agrochemicals, birds might be affected by exposure to harmful pollutants. Thus, the results of the present study call for more research on interactions of birds with paddy fields for conservation of avifauna.

***Keywords:*** Bird diversity, Paddy Field, Species richness

**Acknowledgement**: Authors are grateful to the support provided by the Department of Zoology and Environmental Sciences, University of Colombo.

# Species-specific Allometric Relationships and Carbon Content of Succulent Salt Marsh Vegetation of Vidataltivu Nature Reserve

**Nipuni Perera[1*], Susantha Udagedara[2], Devanmini Halwathura[1],** and **Erandathie Lokupitiya[1]**
[1]Department of Zoology and Environment Sciences, University of Colombo, Sri Lanka.
[2] Blue Resources Trust, 86, Barnes Place, Colombo 7.
* nipz.perera95@gmail.com

Coastal vegetated ecosystems, such as mangroves, seagrasses, and salt marshes are known to have a greater potential in atmospheric carbon capture and storage via vegetative biomass and sediment deposits. The growing interest in coastal organic carbon, known as blue carbon, has broadened the scope of blue carbon quantification worldwide. The destructive sampling methods utilized in the assessment of vegetative carbon stock fail to capture the variability due to species composition and growth forms in the estimation. The current study focuses on the salt marsh vegetation in Vidataltivu, and it is aimed to construct species-specific allometric relationships for the accurate quantification of the vegetative carbon. The allometric equations enable the estimation of plant biomass using its linkage to a distinct physical attribute such as stem height, crown volume, etc. The succulent plant communities in Vidataltivu salt marshes were sampled and dominant plant species were identified as *Suaeda maritima*, *Salicornia brachiata*, *Halosarcia indica* and *Suaeda vermiculata*. Species-specific allometric relationships were developed for the four dominant vegetation types by linearly regressing the height and dry biomass of the samples. The relationship between plant height and biomass indicated a positive, statistically significant ($p$ value <0.0001) correlation for all the sampled plant species. In the allometric model between biomass and plant height, highest fit ($R^2$) was observed in *Halosarcia indica*. To determine valid and reliable carbon conversion factors for the vegetative carbon stock estimation, carbon and nitrogen contents in the dry biomass samples were also analyzed. The carbon and nitrogen content ranged between 23.3 – 30.8 % and 0.64 – 3.22% respectively. The *Suaeda vermiculata* species displayed the highest carbon and nitrogen composition. The findings of the study contribute to the regional and global dataset of salt marshes and enable rapid quantification of aboveground carbon stocks in the future blue carbon assessment. Application of species-specific allometric equations and carbon composition data enhance the accuracy of the estimates while encouraging the practice of non-destructive sampling methods which exert minimal disturbance on the habitats.

***Keywords:*** Blue carbon, Coastal wetlands, Allometric relationship

# Degradation of Polyaromatic Hydrocarbons (PAHs) by *Aspergillus* sp. Isolated from Phyllosphere of Urban Areas in Sri Lanka

**R. B. N. Dharmasiri[1], A. H. L. Nilmini[1], L. J. S. Undugoda[1*], N. N. R. N. Nugara[1],** and **D. Udayanga[1], M. M. Pathmalal[2,3]**

[1] Department of Bio-systems Technology, University of Sri Jayewardenepura, Sri Lanka

[2] Faculty of Graduate studies, University of Sri Jayewardenepura, Sri Lanka

[3] Centre for water quality and algae research, Department of Zoology, Faculty of Applied Sciences, University of Sri Jayewardenepura, Sri Lanka

*lankaundugoda@sjp.ac.lk

Polyaromatic hydrocarbons (PAHs) are tenacious pollutants which are toxic to all living beings. Biodegradation of PAHs is an efficient way to remediate polluted environments. The discharged air pollutants settled over the phyllosphere through dry and wet deposition. Phyllosphere is a great habitat for many fungal species and some of them are capable of degrading PAHs. Out of them, *Aspergillus* spp. demonstrated to be a promising microbial agent that can metabolize PAHs. Therefore, this research attempt was to determine the PAH (phenanthrene anthracene naphthalene and pyrene) degradation capability of phyllosphere inhabited *Aspergillus* species. Fungi were isolated from the leaf samples collected from Panchikawatta, Orugodawatta, Pettah, Maradana, Colombo Fort and Sapugaskanda oil refinery sites in Sri Lanka. Out of many isolations, *Aspergillus* spp. were identified up to genus level through colony morphology and microscopic observation. PAH degradation ability of isolated *Aspergillus* spp. was screened using plate assay and confirmed through UV-Vis spectrophotometer. Furthermore, phyto-toxicity assays were performed. Results of UV-Vis spectrophotometric analysis revealed that *Aspergillus* sp. $P_{17}T$ - 43 showed the most efficient degradation on Anthracene (80%), *Aspergillus* sp. $P_{11}B$ – 34 was the most efficient degrader for phenanthrene (79%), *Aspergillus* sp. $P_{11}B$ – 34 showed the most efficient degradation on Naphthalene (82%) and *Aspergillus* sp. $P_{22}T$ – 82 was the most efficient degrader for pyrene (84%). Toxicity assays confirmed that the metabolites of PAHs degradation is not toxic for the growth of *Aspergillus* species. Isolated *Aspergillus* spp. could be a potential biological agent in an effective bioremediation process on polluted environments contaminated with phenanthrene, anthracene, naphthalene and pyrene like polyaromatic hydrocarbons.

***Keywords:*** Bioremediation, UV-Vis spectrophotometer, phytotoxicity, *Aspergillus* spp.

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# Risk Zone Modelling of Lake Ecosystem Using Multi-criteria Assessment to Determine the Ecosystem Degradation Levels of Selected Urban Lakes, Sri Lanka

**M. D. K. L. Gunathilaka**[1,2*], **Devanmini Halwatura**[2], and **Lasantha Manawadu**[3]
[1]Department of Department of Geography, University of Ruhuna, Sri Lanka
[2] Department of Zoology and Environmental Science, University of Colombo, Sri Lanka
[3] Department of Geography, University of Colombo, Sri Lanka
* kalpani.lakmali92@gmail.com

Despite the great advances that have been made in freshwater ecosystem protection, anthropogenic effects on inland waters remain one of the most obvious and prevalent threats. Inland waters and surrounded wetlands in Colombo city play a major role in conserving urban biodiversity. Adverse effects of development activities and pollution on biodiversity of the ecosystem is a known fact. Identifying these external factors and demarcating the risk zones are critical to conserve and manage the wetland ecosystems. Thus, the objective of this study is to apply a multi-criteria assessment technique to model the risk zones in selected lake ecosystems and surrounding wetlands. Three lakes (Thalangama Lake, Boralesgamuwa Lake, and Kesbewa Lake) along with the surrounding wetlands were considered for the study. Remote sensed data extracted from Landsat satellite images and secondary data along with field observations were used. Urban vegetation, building density, population density, temperature, plant water content, lake area changes, the spread of invasive species and water quality were selected as the criterion to assess. GIS, remote sensing techniques (NDBI, NDVI, RVI, NDMI, NDWI, MNDWI, LST, elevation and population parameters as the criterion), and C map tools were used for the analysis. The multi-criteria assessment using the overlay and interpolation methods were used to model the risk zones. The risk zones were identified from the developed maps and the risk areas were categorized. The very high-risk severity indicates the low dense vegetation, high LST, plant water stress, building density, and land use and land cover changes. The very high-risk level was positioned around the lake ecosystems. The largest critical zone is found around Thalangama lake (10.80km$^2$). As per the findings, all three urban lake ecosystems were degraded and are located at environmentally risk zones. Among them, being an Environmental Protection Area, the Thalangama lake is at a critical phase. Urban expansion, the transformation of vegetation to the synthetic environment and population expansion are lucid in these areas. The study recommends the application of modified DPSIR (drivers, pressures, state, impact, and response model of intervention) to further identify conservation measures to avoid or minimize the degradation process or root causes.

***Keywords:*** Urban freshwater Lake degradation, Modified DPSIR, Multi-criteria assessment-risk zoning

# Resource Partitioning among Kingfishers in the Beddagana Wetland

**H. D. A. Seneviratne** [1*] and **M. R. Wijesinghe** [1]
[1] Department of Zoology and Environment Sciences, University of Colombo, Sri Lanka
* hseneviratne2014@gmail.com

Resource partitioning is the division of limited resources by species to help avoid competition in an ecological niche by facilitating coexistence. This study investigates resource partitioning among three kingfisher species inhabiting the Beddagana wetland in Colombo. The wetland complex in Colombo has been collectively ascribed a Ramsar City in 2018, making this study of particular conservation importance. The kingfishers were enumerated along six transects bi-weekly, twice a day (0600 – 0900 h and 1530 – 1830 h) over six months from February to July 2020 (n= 16 days). Foraging microhabitats, perch height and prey type were recorded through focal animal observations. The three kingfishers recorded were – Common kingfisher [CK] (*Alcedo atthis*), White throated kingfisher [WTK] (*Halcyon smyrnensis*) and Stork billed kingfisher [SBK] (*Pelargopis capensis*). A total of 116 observations of kingfishers were recorded which included *A.atthis* (n=60), *H. smyrnensis* (n=31) and *P. capensis* (n=25). The pied kingfisher (*Ceryle rudis*) was not observed during the study. Observations were greater in the morning (2.19 $\pm$ 0.83) than in the evening (1.56 $\pm$0.73). There were significant differences between the use of foraging microhabitats with greater usage of channels by *H. smyrnensis* (44 %), open water bodies by *A. atthis* (25%) and pools by *P. capensis* (38%). Perching heights also differed significantly with *P. capensis* using the highest perches (4.80 m $\pm$ 0.97) and *H. smyrnensis* using the lowest (0.63$\pm$0.54). All three species fed on a diversity of prey taxa, although predominantly on small fish. Overall, there was a significant difference in the frequency of the prey types consumed by each species ($\chi^2_{16} = 27.97$, $p<0.05$). The study showed that, although there is some overlap, food resource partitioning in terms of prey type, foraging microhabitat and perch height, are evident between the three kingfisher species – the squared distance between each pair being CK-WTK (14.57) < SBK-WTK (42.46) < CK-SBK (91.99). The patterns of differentiation in foraging niches most likely reflect the disparity in the bill and body sizes of the three kingfisher species. Resource partitioning thus appears to serve as a mechanism of co-existence among the three considered kingfisher species within this urban wetland.

***Keywords:*** Resource partitioning, foraging microhabitats

# Conserving Mangroves for their Blue Carbon: An Ecological Study in Mannar, Sri Lanka

**Ahalya Arulnayagam[1,2*], Jinsoon Park[1],** and **Jong Seong Khim[3]**

[1] Department of Convergence Study on the Ocean Science and Technology, Korea Maritime and Ocean University.

[2] Department of Coastal and Marine Resources Management, Ocean University of Sri Lanka.

[3] School of Earth and Environmental Sciences and Research Institute of Oceanography, Seoul National University.

* ahalyaa@ocu.ac.lk

Mangrove ecosystems have gained attention in recent years due to their capacity to store carbon and mitigate greenhouse gas emissions. The present study intended to quantify the total ecosystem carbon (TEC) pools of a mangrove forest in the banks of Aruvi Aru, Mannar, Sri Lanka and to understand the phyto-ecological aspects of carbon sequestration. The study was conducted in December 2019 and employed floral mapping and carbon analysis. The forest survey was carried out with a 10m wide belt transect across the water-land gradient. Mangrove species along the transect were identified, enumerated, and Diameter at Breast Height (DBH) for trees with DBH > 5cm was measured. Subsurface (n=18) water samples were taken to measure the edaphic variables. Sediment cores were taken along the same transect at 45cm depths and subsampled to three partitions of 15cm intervals. Forest survey revealed four true –mangrove species. The overstory was dominated with *Rhizophora mucronata* (niche width = 4.90, Important Value Index = 64.51%) and *Avicennia marina* (niche width = 4.81, IVI = 50.59%). Relatively low diversity (Shannon index = 1.24, Simpson index=0.33) and poor distribution (Pielou's evenness=0.89) was observed.

Aboveground, belowground and sediment organic carbon (SOC) of the present site were (mean ±SD) 23.57 ± 0.24 MgC $ha^{-1}$, 9.19 ± 0.94 MgC $ha^{-1}$, and 283.63 ± 8.90 MgC $ha^{-1}$, respectively. TEC pool of the site was 316.39 MgC $ha^{-1}$. On average, SOC accounted for 88% of the TEC pool. If disturbed, they would emit 193.5 ± 81.8 $MgCO_2e$ $ha^{-1}$ of carbon dioxide. There was a gradual increment towards the depth profile with higher carbon stocks in the bottom layer (30-45cm). Principal Component Analysis (PCA) showed that floral distribution and carbon potential were influenced by salinity and dissolved oxygen (DO). Correlation analysis specified that abundance ($R=0.822$; $p<0.05$), and IVI ($R=0.859$; $p<0.05$) strongly influenced floral carbon whilst, SOC was correlated with rainfall ($R=0.794$; $p<0.05$), DO ($R=0.677$; $p<0.05$) and salinity ($R=0.701$; $p<0.05$). The results suggest that despite the lower diversity, the mangrove in the present site should be conserved for their carbon potential and their ecology should be considered during restoration efforts for them to be successful.

***Keywords:*** Mangrove conservation, Blue carbon, Ecology

# A Study on Lichen Diversity in Two Different Agro-ecological Zones of Sri Lanka

**W. M. V. C. Weerasinghe[1], R. G. U. Jayalal[2],** and **C. M. Nanayakkara[1*]**
[1] Department of Plant Sciences, Faculty of Science, University of Colombo, Sri Lanka
[2] Department of Natural Resources, Sabaragamuwa University of Sri Lanka, Belihuloya, Sri Lanka
* chandi@pts.cmb.ac.lk

Sri Lanka is renowned for its unique biodiversity and high endemicity. Among a variety of natural resources the country holds, lichens are hardly studied. However, lichens have been in use as therapeutics by several communities worldwide. Further, they have been identified as bio-indicators which can be used to monitor the quality of an environment. Studies on lichen identification can provide data on the diversity, abundance and distribution which are essential in lichen conservation and their sustainable use as natural sources for practical applications. Climate change is a global crisis leading to loss of biodiversity which emphasizes the study of lichens before extinction.

In the present study, a contrast in lichen diversity was observed between the two sampling sites: Nonpareil Estate (NE) and Samanalawewa Wilderness (SW) which represent two climatologically different areas of the country. A total of 36 lichen specimens were collected from the two locations. Lichen characterization based on morphology and chemistry could identify 22 lichen specimens from NE and 11 from SW, up to genus level. Six lichen specimens were identified up to species level: *Parmotrema tinctorum*, *Cladonia macilenta*, *Heterodermia leucomela*, *Teloschistes flavicans* and *Dirinaria picta*, out of which *P. tinctorum* was common to both sites.

***Keywords:*** Lichen, Nonpareil Estate, Samanalawewa Wilderness

# Reproductive Impacts of Tributyltin (TBT) on Marine Molluscs in Sri Lanka

**K. R. V. Bandara** [1,2] and **P. M. Manage** [1,2*]
[1] Centre for Water Quality and Algae Research, Department of Zoology, University of Sri Jayewardenepura, Sri Lanka
[2] Faculty of Graduate Studies, University of Sri Jayewardenepura, Sri Lanka
*pathmalal@sjp.ac.lk

Tributyltin (TBT) has been widely used in a variety of consumer and industrial products including pesticides, antifouling paints for ship hulls, aquaculture and other structures exposed to marine waters. TBT adversely affects and interrupts steroid metabolism through the conversion of testosterone to estradiol 17β causing development of reproductive impairments like imposex in female biota mainly in invertebrates. The present study assessed the current state of reproductive impairments and tributyltin concentrations in five species of molluscs; *Crassostrea madrasensis*, *Crassostrea cucullata*, *Perna viridis*, *Perna perna* and *Thais clavigera* collected from seven different harbors along the coastal belt of Sri Lanka. The results of the study showed that the highest TBT contamination was in *Perna viridis* (234±3 ngkg-1) collected from Dikkovita harbor. The TBT concentrations in *T. clavigera, C. madrasensis, C. cucullata and P. perna* recorded a range as 32±2 -134±2, 74±3 – 181±4, 12±8 - 116±6 and 35±2 - 126± 6 ngkg$^{-1}$ from the different harbors. *Thais clavigera* was selected as a most suitable bioindicator to assess reproductive impairment incidence in selected harbors in Sri Lanka. The Relative Penis Length Index (RPLI) of imposex affected females ranged from 15.53% to 24.77%. A positive correlation between frequency of imposex incidence and TBT concentrations was recorded ($p$<0.05) suggesting that the number of imposex-affected females in the population of *T. clavigera* expands with increasing TBT concentrations in the marine environment. The highest RPLI and imposex incidence (I%) were recorded in the Dikkovita harbor which is one of the busiest fishery harbors in Sri Lanka and situated adjacent to the Colombo port. This study provides baseline data that could assist long-term monitoring of TBT pollution in Sri Lankan coastal waters, since legislation to reduce the use of TBT-based antifouling paints has not been implemented in Sri Lanka.

***Keywords:*** Imposex; Colombo port; Bioindicator

# Effects of Goat manure, Compost Tea and Gliricidia Leaf Extract on Growth and Yield Performance of Sessile Joyweed (*Alternanthera sessilis*)

**V. H. P. Sewwandi [1], R. Viharnaa [1*], K. Jeyavanan[2],** and **S. Sritharan [3]**
[1] Department of Biosystem Technology, Faculty of Technology, University of Jaffna, Sri Lanka
[2] Department of Agronomy, Faculty of Agriculture, University of Jaffna, Sri Lanka
[3] Faculty of Agriculture, University of Jaffna, Sri Lanka
*vraveenthira@gmail.com

*Alternanthera sessilis* is a popular leafy vegetable in South East Asia cultivated for food, herbal medicines and poultry feed and is commonly called as Joyweed/ Ponnangaani/Mugunuwenna. A field experiment was carried out to analyze the effects of goat manure (GM), compost tea (CT) and gliricidia leaf extract (GLE) on the growth and yield performance of the sessile joyweed at the Crop farm, Faculty of Agriculture, University of Jaffna. The treatments were arranged in a randomized complete block design and replicated in three times. The treatments were defined as follows: T1- Goat manure; T2- Compost tea; T3- Gliricidia leaf extract and T4- Control. Data was analyzed using SAS 9.4 software where ANOVA and Duncan mean separation was carried out to find the significant of variables. The highest number of leaves/plant was recorded from treatment GM (65) and the least from control (40) while, treatments CT and GLE recorded 49 and 44 respectively ($p<0.002$). In case of leaf length, goat manure treated plants exhibited the highest length with 4.4 cm while the lowest was from treatment GLE (2.6 cm). The highest leaf width was obtained with GM as 2.7 cm and the least from the control ($p<0.04$). The highest plant height was also obtained from GM application as 27.9 cm and the least from GLE as 25.2 cm ($p< 0.03$). The highest chlorophyll mean value in the first harvest was indicated by GM and it was 39.57. Among all harvests GM has expressed a higher chlorophyll content compared to other treatments ($p<0.01$). Fresh and dry yield were significantly higher ($p<0.001$) in GM treated plants as 26.47 tons/ha and 7.14 tons/ha and the least was observed from GLE applied plants as 12.31 tons/ha and 3.54 tons/ha respectively. Overall, it was clear that significantly higher number of leaves, leaf length, leaf width, plant height, chlorophyll content, fresh and dry weight were obtained in the treatment with goat manure compared to control, making it the best organic fertilizer to be used. Therefore, based on the growth and yield performance of *A. sessilis* it can be concluded that goat manure had best performance and it was followed by compost tea and gliricidia leaf extract.

***Keywords:*** Organic fertilizer, Yield and Joyweed

# Antioxidant and Anti-inflammatory Properties of Edible Flowers Subjected to Simulated Gastro-intestinal Digestion

**G. Janarny[1*], K. D. P. P. Gunathilake[2],** and **K. K. D. S. Ranaweera[1]**
[1] Department of Food Science and Technology, Faculty of Applied Sciences, University of Sri Jayewardenepura, Gangodawila, Nugegoda, Sri Lanka.
[2] Department of Food Science & Technology, Faculty of Livestock, Fisheries & Nutrition, Wayamba University of Sri Lanka, Makandura, Gonawila, Sri Lanka.
* gjanarny3@gmail.com

Epidemiological studies have revealed that oxidative stress is a major cause for the onset and progression of chronic diseases. Phytochemicals from edible flowers have proven to combat oxidative stress. Though edible flowers have been used for a long time in Sri Lanka, there is not much published literature regarding the health potential of these flowers. The present study documents the impact of simulated gastro-intestinal digestion on the bioactive content, antioxidant and anti-inflammatory activities of four species of edible flowers (*Cassia fistula* (CF), *Bauhinia racemosa* (BR), *Tamarindus indica* (TI) and *Crotalaria juncea* (CJ)). Digested fractions and methanolic extracts were analyzed for total phenolic (TPC), total flavonoid (TFC) and total anthocyanin content (TAC). Antioxidant activity was measured using hydrogen peroxide scavenging activity and nitric oxide scavenging activity. Anti-inflammatory properties were measured using inhibition of protein denaturation and heat induced hemolysis of red blood cells. Statistical analysis was done using one way ANOVA. Mean separation was carried out by Tukey multiple variance test and the $p < 0.05$ was considered as significantly different. The TPC of the raw extracts were within the range of 18.92-34.82 mg gallic acid equivalents per gram of dry weight (mg GAE/g DW) with the highest activity noted in CF (34.82 mg GAE/g DW). In the gastric phase the TPC of all the flowers have decreased. TFC of the methanolic extracts were in the range of 1.75 to 4.85 mg rutin equivalents per gram of dry weight. At the intestinal phase, TFC of BR and TI have increased by 127.96% and 156.65%. Highest TAC among the methanolic extracts was noted in CF (220.43 nmol cyanidin- 3-glucoside/g DW). Hydrogen peroxide scavenging activity of raw extracts were within the range of 53.30% to 67.35%. Considering the anti-inflammatory assays, among the raw flower extracts, BR expressed the highest inhibition activity in both the assays. The edible flowers investigated in the current study are good sources of polyphenols with antioxidant and anti-inflammatory properties. Based on the bioactivities noted in the dialysis phase, it can be concluded that though phenolic content was reduced after digestion, they were sufficiently available to express considerable antioxidant and anti-inflammatory activity after dialysis.

***Keywords:*** Antioxidant, anti-inflammatory, edible flowers

# The Anti-microbial Potential of *Lasiodiplodia theobromae* Inhabiting the Lichen *Heterodermia* sp. Available in Sri Lanka

**M. J. Mathushika[1*], C. M. Nanayakkara[1*], R. G. U. Jayalal[2],** and **S. Thanthirige [3]**
[1] Department of Plant Sciences, Faculty of Science, University of Colombo, Sri Lanka.
[2] Department of Natural Resources, Sabaragamuwa University of Sri Lanka.
[3] Department of Chemistry, Faculty of Science, University of Colombo, Sri Lanka.
* mathushikaj@gmail.com

Sri Lanka is well-known for its lichen biodiversity. Lichen is a symbiotic association between a fungal partner and a photosynthetic partner. Lichen inhabiting fungi may reside in lichens without involving in symbiosis. Unique secondary metabolites, especially lichen inhabiting fungi are reputed for antimicrobial, anti-inflammatory, anti-proliferative and antioxidant activity. The lichen *Heterodermia* sp. was collected from the Paraviyangala mountain of Kalupahana mountain range in Belihuloya of Sabaragamuwa province in Sri Lanka. Lichen inhabiting fungi were isolated by plating surface sterilized thallus pieces onto potato dextrose agar medium. Emerging fungal tips from the plated pieces were transferred onto fresh medium to obtain pure cultures. Among the fungi isolated, *Lasiodiplodia theobromae* was identified using colony characteristics, micromorphology and DNA barcoding. The internal transcribed spacer (ITS) region was amplified using *ITS_1* and *ITS_4* primers to identify the fungus. Crude extracts were obtained from the fungal isolate via solvent extraction using three different solvents: Ethyl acetate, Hexane and Dichloromethane. Then they were screened in triplicate for antimicrobial activity by agar disk diffusion assay using bacteria: *Escherichia coli* (ATCC® 25922), *Pseudomonas aeruginosa* (ATCC® 27853) and *Staphylococcus aureus* (ATCC® 25923) and a clinical isolate of the fungus *Candida albicans*. Ethyl acetate and dichloromethane crude extracts showed antimicrobial activity against gram positives and negatives as well as *Candida*. The Ethyl acetate fraction gave the best results. Therefore, *Lasiodiplodia theobromae* has the potential to be used as a source of novel antibacterial and antifungal compounds.

***Keywords:*** Lichen, DNA barcoding, Antimicrobial activity

# Phytochemical Screening, Quantitative Analyses and *in vitro* Cytotoxic Potential of *Averrhoa bilimbi* L. Leaves Extracts

**A. B. W. R. Silva[1,2], N. N. R. N. Nugara[1*], P. M. Manage[2,3], L. J. S. Undugoda[1], D. Udayanga[1],** and **A. H. L. R. Nilmini[4]**

[1]Department of Biosystems Technology, Faculty of Technology, University of Sri Jayewardenepura, Sri Lanka

[2] Faculty of Graduate Studies, University of Sri Jayewardenepura, Sri Lanka

[3] Department of Zoology, Faculty of Applied Science, University of Sri Jayewardenepura, Sri Lanka

[4] Department of Material and Mechanical Technology, Faculty of Technology, University of Sri Jayewardenepura, Sri Lanka

* nilushinug@sjp.ac.lk

*Averrhoa bilimbi* L., commonly known as bilimbi, is a tropical medicinal plant from family Oxalidaceae which is widely used in Ayurvedic medicine in Sri Lanka to treat cough, cold, syphilis, itching, high blood pressure etc. Previous studies have found beneficial effects of different solvent extracts of *A. bilimbi*. Current study is aimed at investigating the ability of a water- extract (WE) of *A. bilimbi* leaves to resulting more phytochemicals compared to two other extracting solvents, namely ethanol and *n*-hexane (EE and HE). It is also aimed at elucidating the cytotoxic properties of WE of *A. bilimbi* leaves. Leaves of *A. bilimbi* were collected from Embilipitiya, Sri Lanka. Extracts were prepared using 1 g of powdered fresh leaves in 25 mL of ethanol (99.9%), *n*-hexane and distilled water. The mixture was shaken overnight followed by centrifuge at 250 rpm and filtration. Preliminary phytochemical screening of the three extracts was performed according to the Harborne method and Total Phenolic Content (TPC) and Total Flavonoid Content (TFC) were determined using the Folin-Ciocalteu assay and aluminum chloride colorimetric assay, respectively. The cytotoxicity of *A. bilimbi* WE was tested with 125, 250 and 500 µg/mL in 3T3-L1 preadipocytes by MTS assay to determine the suitability of the WE at a higher and frequent dose. Phytochemical screening of the three extracts confirmed the presence of flavonoids, tannin, terpenoids, steroids, anthocyanins, alkaloids and coumarins, whereas the distilled water showed to extract the maximum number of phytoconstituents types. The TPC in WE was 98.9% and 78.9% higher than the HE and EE, respectively, whereas the TFC in WE was 91.9% and 28.1% higher than the HE and EE, respectively. The WE maintained more than 80% cell viability at a concentration up to 500 µg/mL against 3T3-L1 preadipocytes. The presence of high content of different phytoconstituents in WE of *A. bilimbi* indicates its potential in gaining the health benefits. These results provide referential information to reiterate the medicinal value of the plant and to be utilized in screening novel target compounds to treat various diseases.

***Keywords:*** *Averrhoa bilimbi* L., TFC, TPC

# Assessment of Touristic Ecological Footprint of the Udawalawe National Park based on visitor activities

**G. K. Hettiarachchi [1*], M. S. L. R. P. Marasinghe [2], S. Pilapitiya [3],** and **M. R. Wijesinghe [1]**
[1] Department of Zoology and Environment Sciences, University of Colombo, Sri Lanka
[2] Department of Wildlife Conservation
[3] 51, Mahadeiyra, Yodakandiya, Tissamaharama
*gihanikah@gmail.com

The Udawalawe National Park (UWNP) is ranked as the third most visited national park in Sri Lanka. This study assessed the Touristic Ecological Footprint (TEF) of the UWNP based on transportation, waste generation and energy consumption by visitors. TEF is defined as the demand on forest land required to absorb the $CO_2$ emitted by tourist activities within a year. The total $CO_2$ emissions released due to the considered visitor activities (C) were calculated using visitor data for 2018. $CO_2$ emissions due to transportation was calculated using ($\sum$ d *e) * N, where d – is the average distance travelled by a safari vehicle, e – the vehicle specific emission factor and N – the number of vehicles. The weight of degradable waste generated per stay-in visitor per day was calculated through a survey conducted at a selected bungalow which was then converted to $CO_2$ emissions. Energy consumption was estimated based on the use of electricity and liquid petroleum gas (LPG) by visitors which was also translated into $CO_2$ emissions. The TEF = $\sum$ (C $*$ A $*$ ef), where A- Area needed for absorbing 1kg of $CO_2$ per year and ef – equivalence factor (a productivity-based scaling factor for forests taken to be 1.1), were calculated. Additionally, the Ecological Carrying Capacity (ECC) defined as the capacity of forest land required to support tourist consumption for the park was also generated. The ECC = (A * ef ), where A - extent of vegetation available for the absorption of the emitted $CO_2$ and ef – the equivalence factor. Thus, TEF for the UWNP was 1.60 gha and ECC was 25,665.43 gha. Comparison of TEF and ECC values of the park revealed that, at present, the vegetation cover in the park is adequate to absorb the amount of $CO_2$ emissions released by visitor activities. With increasing visitor flow expected in the future, these values are likely to change. The information generated through this study could be made use of to set guidelines for sustainable management of recreational activities within this national park, and other protected areas in Sri Lanka.

***Keywords:*** Touristic Ecological Footprint, protected area, visitor impacts

# Environmental Impact of Cassava Crocket Processing in Sri Lanka

**M. A. D. Somendrika [1*], I. Wickramasinghe [1], M. A. J. Wansapala [1],** and **S. Pieris[2]**
[1] Department of Food Science and Technology, Faculty of Applied Sciences,
University of Sri Jayewardenepura, Sri Lanka.
[2] Business and Industry Development Services (Pvt) Ltd, 631, 10th Floor, Janajaya Complex, Rajagiriya.
[*] dsomendrika@sci.sjp.ac.lk

Cassava crocket also called cassava croquette is one of the convenient processed product, which uses cassava root as the main raw material. It is available in fast food outlets as deep fried, ready to serve and unpacked form. Thus the study was focused on assessing the environmental impact of cassava crocket processing through the life cycle of cassava crocket production. Life cycle analysis was conducted according to the method described by ISO 14040:2006 standards. Three separate but interrelated components: inventory analysis, impact assessment and interpretations were performed for the cassava crocket life cycle using software package SimaPro 8.4.0.0 faculty version. Inventory data were collected through the use of structured questionnaires and personal communication. Data were collected on cassava farming and crocket processing. The impact assessment methodology chosen was the ReCiPe2016 endpoint (H) method in SimaPro software. The results revealed that the Life cycle environmental impact of a cassava crocket was dominated by using refined palm oil for the frying process. High chemical and water usage and high amount of effluent generation while refined palm oil production had contributed mostly for the potential of global warming (73.7%), fine particulate matter formation (82.3%), Stratospheric ozone depletion (55.4%), Ionizing radiation(59.3%), Terrestrial acidification (60.8%), freshwater eutrophication (46.6%), terrestrial ecotoxicity (38.6%), freshwater ecotoxicity (56.6%), marine ecotoxicity (75.7%), human carcinogenic toxicity (89.4%), mineral resource scarcity (72.2%), and water consumption (96.3%). The high amount of NPK fertilizer usage and high land use in cassava farming and coconut cultivation caused for negative environmental impact on Human Non-carcinogenic toxicity. Transportation of raw materials to the production sites and salt addition has not caused a significant effect on all the cassava crockets' environmental impact categories.

***Keywords:*** Cassava crocket Life Cycle Analysis, Environment impact, Simapro software

# Are Raptors Successful in Adopting to Urban Landscapes? A Case Study from Bolgoda North Lake, Sri Lanka

**M. A. Y. N. Weerasinghe[1*], Deepthi Wickramasinghe[1],** and **T. S. P. Fernando[2]**
[1] Department of Zoology and Environment Sciences, Faculty of Science, University of Colombo, Sri Lanka
[2] Department of Zoology, Open University of Sri Lanka
*yuganinayanathara@gmail.com

Growth of human population and developmental pressure alter natural habitats. Birds are sensitive to environmental changes and respond to habitat alterations. Raptors usually occupy top levels of a food web and serve as important bioindicators. Yet, this important group of birds has not gained adequate attention in Sri Lanka. This study focuses on the abundance, species richness and the distribution of raptors in Bolgoda North Lake (BNL), the largest freshwater wetland in Sri Lanka which is situated in the highly populated Western Province. Bird survey was carried out in six study sites within the BNL representing three sites with human-alterations and the rest relatively undisturbed, focusing on three habitats in each site i.e., vegetated sites, edge habitats marking the interface between human-altered and natural habitats, and open water habitat. The study was carried out using the line-transect method from January to May 2021, two hours each in the morning and evenings using direct observations and bird calls. The frequency of occurrence, abundance, species richness, and Shannon diversity index were calculated. Raptor community in the study area comprised of 10 species belonging to two families. The *Haliastur indus indus* (brahmini kite) was the most abundant species while *Ictinaetus malayensis perniger* (black eagle) and *Pernis ptilorhynchus* (oriental honey buzzard) were rarely observed in all sites. One endangered (Falco tinnunculus – common kestrel) and two Near- threatened (*Ictinaetus malayensis* and *Pernis ptilorhynchus*) species were recorded. Twenty-two percent of spices recorded were rare, 55% were common and 33% were very common. The highest raptor abundance (irrespective of species) and the species richness were recorded in the edge habitats in human-altered study sites with a significantly high species diversity compared to undisturbed study sites (One-way ANOVA; $P<0.001$). Raptors tend to use human-altered areas both as random sites and permanent sites for feeding, breeding, and nesting. Novel habitats created in human-altered sites because of human activities act as a positive factor for attraction of raptors. Our results indicate that raptors prefer edge habitats with human interventions which could be related to the availability of preferred feeding and perching habitats. While enhanced protection for avifauna of BNL is a current need, more investigations are essential on the biology and ecology of raptors.

***Keywords:*** Raptors, Urban wetlands, Human-alterations

# Molecular Characterization of Selected Wild Rice (*O.rufipogon* and *O.nivara*) Populations in Sri Lanka

**Disna Ratnasekera**[1*], **Asanka Tennakoon**[1], **Salinda Sandamal**[2], and **Parakkrama Wijerathna**[1]
[1] Department of Agricultural Biology, Faculty of Agriculture, University of Ruhuna, Sri Lanka.
[2] State Key Laboratory of Systematic and Evolutionary Botany, Institute of Botany, Chinese Academy of Sciences, Beijing 100093, China.
* disnaratnasekera@gmail.com

Common wild rice, *Oryza rufipogon* and *Oryza nivara* are widely distributed in the tropics and subtropics of monsoon Asia including Sri Lanka. As the progenitor of the Asian cultivated rice (*Oryza sativa*), both species have been proven to be a valuable gene pool for rice genetic improvement and thus play a significant role in rice breeding in the future. Genetic diversity and population genetic structure of wild rice *O. rufipogon* and *O. nivara* were studied using 33 microsatellite markers. A total of 315 individuals of 11 natural populations collected from wet, intermediate and dry zones of Sri Lanka were used in the study. A moderate to high level of genetic diversity was observed at population levels with the polymorphic loci (P) ranging from 60.6% to 100% (average 81.8%) and the expected heterozygosity (HE) varying from 0.294 to 0.481 with the mean of 0.369. AMOVA indicated that a large proportion of total genetic diversity existed within (47.7%) and among populations (40%), with the genetic differentiation between species relatively low (12.3%) but significant. For specific species, 43.7% and 48.5% of the total variation were partitioned among populations for *O. rufipogon* and *O. nivara*, respectively. The high genetic differentiation was reflected by the high FST values. The UPGMA tree illustrated that all 11 populations were genetically structured into two well-separated major groups (species) and further divided into populations. Based on the allelic richness and expected heterozygosity, *O. rufipogon* populations maintain a higher level of genetic diversity than those of *O. nivara* populations. The results of the multiple relative importance tests indicated that annual mean temperature is the most important variable for determining the distribution of both species. Conclusively, these studies provide important insights into the population genetics, evolution and distribution patterns of these wild species in Sri Lanka, which is of great significance in conservation as genetic resources and for utilization in rice genetic improvement.

***Keywords:*** Conservation, genetic diversity, *O. nivara, O. rufipogon*, Sri Lanka

# Development of Fermented Bitter Gourd Pickle and Evaluation of its Nutritional and Sensory Parameters

**A. A. M. Subodinee [1*], D. M. N. Dilrukshi [1], S. M. S. J. M. Singherathna [1], M. M. G. Dharshani[1],** and **M. G. T. Lakmali [1]**

[1] Department of Food Science and Technology, Faculty of Agriculture, University of Ruhuna, Mapalana, Kamburupitiya, Sri Lanka.

* Subodinee@fst.ruh.ac.lk

Bitter gourd (*Momordica charantia*) possesses numerous health benefits, and consumer preference for bitter gourd is considerably low due to its inherent bitter taste. The present study aimed to develop a fermented pickle with bitter gourd as a healthy and value-added food product. The pickle's essential ingredients were bitter gourd, carrot, radish, dates, ginger, garlic, pepper, and green chilli. De-bittering of the bitter gourd was done before formulating with other ingredients. Two different bitter gourd pickle samples were mainly formulated with lime (LP) and vinegar (VP) added as 25%, 50%, and 75% (v/v) (six different treatments). Prepared pickles in sterile glass bottles were kept at ambient temperature for fermentation. Sensory evaluations were conducted with 30 semi-trained panelists on a five-point hedonic rating scale. Sensory data collected after the preparation (one day) revealed that the pickles developed with 25% (v/v) of lime juice (LP1) and 25% (v/v) of vinegar (VP1) had scored the highest acceptability among lime added and vinegar added pickles, respectively. Moreover, the panelists preferred the bitter gourd pickle with 75% (v/v) of lime juice (LP3), whereas 75% (v/v) of vinegar (VP3) had obtained the least preference. We found that the pickles made with lime showed titratable acidity in the range of 0.4 to 0.7%, whereas the pickles made with vinegar showed it in 0.9 to 1.8%. Based on titratable acidity and sensory properties, four different formulations, pickles with 50% (v/v) of lime juice (LP2), 75% (v/v) of lime juice (LP3), 25% (v/v) of vinegar (VP1), and 50% (v/v) of vinegar (VP2), were selected to continue their fermentation. Interestingly, here we found that afterone week of fermentation, the pickle made in 50% (v/v) of lime juice (LP2) was mostly preferred by the sensory panelists. However, both bitter gourd pickles prepared with 50% (v/v) of lime juice (LP2) and 50% (v/v) of vinegar (VP2) showed a considerable amount of total minerals, crude proteins, and crude fiber in the range of 5.7 to 5.8%, 0.35 to 2.2%, and 7.1 to 8.1%, respectively. In conclusion, a fermented bitter gourd pickle formulated with lime or vinegar up to 50% (v/v) was successful. The study on the developed pickles' shelf life and functional biochemical compounds (total antioxidants, antioxidant activity, flavonoids, and total polyphenols) are being investigated.

***Keywords:*** Pickle, fermentation, sensory evaluation

# Relative Abundance of Genus Chloroflexus in the Maha Oya Hot Spring in Sri Lanka

**H. D. D. Sadeepa[1,2], Kosala Sirisena[3],** and **Pathmalal M. Manage[1,2*]**

[1] Centre for Water Quality and Algae Research, Department of Zoology, University of Sri Jayewardenepura, Gangodawila, Nugegoda, 10250, Sri Lanka.

[2] Faculty of Graduate Studies, University of Sri Jayewardenepura, Gangodawila, Nugegoda, Sri Lanka.

[3] Department of Environmental Technology, Faculty of Technology, University of Colombo, Sri Lanka.

*pathmalal@sjp.ac.lk

Hot springs have been identified as a rich source for exploring bacteria that can tolerate high temperatures and thermo-stable enzymes. Characterization and identification of microbial community in hot springs provide an initial platform for identification of extremophilic microorganisms for industrial applications. In the present study, the relative abundance of the genera *Chloroflexus* in the Maha Oya hot spring in Sri Lanka was studied. Water samples were collected from surface (10.0 cm) and bottom (114.0 cm) of the hot spring and kept at - 4 $^0$C and water quality parameters such as: temperature, Electric Conductivity (EC), pH, and Dissolved Oxygen (DO) of samples were measured at the site. Approximately 1000ml of surface and bottom water sampleswere filtered through 0.22 µm nucleopore filters. DNA extraction was performed using MoBioPowerSoil® DNA extraction kit. The prokaryotic 16s rRNA gene was sequenced on IlluminaMiSeq platform using 115F and 806R universal primer pair at Omega Bioservices Company (USA). Resulted sequencing data were analyzed using Mothur v1.42 program according to the Standard Operating Procedure (SOP). The temperature, EC, pH and DO of surface and bottom water of the hot spring was recorded range from 51.7-52.4 $^0$C; 1487-1507 µS/cm, 8.05-8.07 and 2.0-2.1 mg/L, respectively. The majority of the microbial community was bacteria (>99%) and archaea were rarely present (<1%) in the hot spring. The number of bacteria phyla detected in the surface and bottom was 16 and 14 respectively. Proteobacteria and Chloroflexi were the dominant bacteria phyla. Among the 211 and 204 bacteria genera identified respectively from surface and the bottom; *Chloroflexus, Rubellimicrobium, Acinetobacter* and unclassified genera of *Rhodospirillaceae* family were the major bacteria genera. It was recorded that 19% and 17% of bacterial community of surface and bottom layer water was dominated by the *Chloroflexus* bacteria genera. These bacteria produce thermostable enzymes such as proteinase and amylase which can be used in industrial processes operating under moderate temperatures. These results implied that the Maha Oya hot spring could be a useful source of bacteria genera *Chloroflexus* which can be used in industrial processes. Further studies are in progress along with a metagenomic analysis.

***Keywords:*** Genera Chloroflexi, Enzymes, Industrial

# Investigating the Potential of a Native *Glomus* sp. as a Biofertilizer

**W. A. G. A. B. Chandrasena[1*], C. M. Nanayakkara[1],** and **H. A. Sumanasen[2]**,
[1] Department of Plant Sciences, University of Colombo, Sri Lanka.
[2] School of Agriculture and Environment, Massey University, New Zealand.
* aruni.chandrasena1@gmail.com

Many plant species benefit by forming symbiotic associations with arbuscular mycorrhizal fungi (AM). They are known to enhance plant growth, photosynthetic activity & phosphorus content, act antagonistically towards soil borne plant pathogens, and modify the concentration of plant metabolites. Consequently, the uptake of N, P, and K are also enhanced significantly by AM inoculation. Therefore, mycorrhizae have been developed as biofertilizers in many countries. Hence, it is a timely action to evaluate the potential of local mycorrhizae as plant growth enhancers. A mass propagation method was developed to evaluate the native *Glomus* sp. as a biofertilizer for pepper cultivation. Finger millet, maize and sorghum have been employed as host crops and root colonization was detected by (i) observing the presence of the fungus within root tissue (ii) counting the AM spores in root associated soil, after twelve weeks post inoculation. Both sorghum and finger millet were identified as suitable host crops. Effective spore density for successful colonization of pepper rooted cuttings was determined in a pot experiment. The spore density levels tested were: T1 (400), T2 (800), T3 (1200) and T4 (1600) spores per 800 g of standard potting mixture. The pepper variety Panniyur was used with 5 replicates for the study. After 12, 20 and 28 weeks of post inoculation, root pieces were microscopically examined for the fungal colonization. The cuttings inoculated with 800 spores per 800 g potting mixture was found to be the most effective spore density for pepper inoculation.

***Keywords:*** Arbuscular Mycorrhiza, *Glomus*, Pepper

# Isolation of Heavy-metal Tolerant Fungi from the Ussangoda Serpentine Site in Sri Lanka

**H. M. D. S. Thathsarani**[1] and **P. S. Saputhanthri**[1*]
[1]Department of Plant Sciences, Faculty of Science, University of Colombo, Colombo 03, Sri Lanka.
[*]pradee@pts.cmb.ac.lk

Accumulation of heavy metals in the environment greatly influences the life forms on Earth as it has toxic effects on biological systems. Bioremediation is an approach that utilizes living organisms to remove toxic contaminants from soil or water. Plants and microbiota inhabiting natural ecosystems loaded with heavy metals may have the potential to be developed into efficient bioremediation agents. Serpentines are unique ecosystems where metal-tolerant plants and microbes are found naturally. In Sri Lanka, there are few serpentine outcrops, including the Ussangoda National Park. Although there have been some investigations on serpentine flora in Sri Lanka, reports on serpentine associated microbes, particularly on heavy metal tolerant fungi or bacteria are scarce. This study aimed to isolate and identify heavy metal tolerant soil fungal strains from the Ussangoda serpentine, and to preliminary investigate their metal tolerance capacities. Heavy metal tolerance potential of the fungal isolates was assessed based on the mycelial growth rates in growth media containing varying $Ni^{2+}$, $Cr^{3+}$ and $Cu^{2+}$ concentrations. The results were statistically analyzed by one-way ANOVA at 5% level of significance using SPSS version 20.0. Isolates that showed a significant tolerance to at least one metal under the experimental conditions were selected for molecular identification. DNA extracts of those isolates were used to PCR-amplify the Internal Transcribed Spacer (ITS) region using the universal fungal specific primers ITS_1F and ITS_4. The PCR products were sequenced, and the sequences were compared with those in the GenBank using the NCBI BLAST tool to find similar sequences. Three isolates were identified using molecular techniques to be a *Trichoderma* sp., *Fusarium equiseti* and a *Talaromyces* sp. All three isolates showed significant tolerance to $Cr^{3+}$, $Cu^{2+}$and $Ni^{2+}$ at varying capacities compared to the control, as determined through their growth rates in metal incorporated growth media.

***Keywords:*** Serpentine, Fungi, Metal-tolerance

# Do Wetlands Contribute to "Cooling Effects"? A Case Study from Anawilundawa Ramsar Site, Sri Lanka

**Harsha Dias Dahanayake[1*], Deepthi Wickramasinghe[1],** and **D. D. G. L. Dahanayaka[2]**
[1] Department of Zoology and Environment Sciences, University of Colombo, Sri Lanka.
[2] Department of Zoology, Open University of Sri Lanka.
*harsha.dahanayake@gmail.com

Wetlands are characterized by a unique combination of water, soil and vegetation. They are among the most productive and important ecosystems on earth which render significant ecosystem services to the community. Water and vegetation in and around wetlands help in regulating the microclimate, specially lowering the temperature in the local environment.

The present study attempted to investigate the cooling effects provided by Anawilundawa, a Ramsar site in Puttalam District where diverse land uses exist surrounding the wetland. Land Surface Temperature (LST) variation above different land use classes was investigated during the dry months of January, February, June and July of 2016 and 2020 in natural (water bodies, marsh, thick vegetation, grassland) and anthropogenic areas (built-up areas, coconut cultivation and bare lands). The LST values were obtained at 500m points along seven transect lines starting from the center of the water body and extending up to 7km over different land use areas and reaching towards the anthropogenic area.

The mean LST over the wetland (24.10℃) was significantly lower than that of anthropogenic areas (25.01℃) ($P<0.05$). The temperature range, mean ± standard deviation for different land use areas were as follows: water body (23.21℃-24.67℃; 23.89℃±0.58), marsh (23.49℃-25.94℃; 24.57℃±1.02), thick vegetation (22.99℃-25.03℃; 24.04℃±0.56) grassland (23.18℃-25.93℃; 24.36℃±0.77), built up area (24.00℃-28.32℃; 25.40℃±1.40), coconut cultivations (23.19℃-24.23℃; 23.93℃ ±0.38) and bare land (24.54℃-26.39℃; 25.29℃ ±0.60). The lowest increase of LST was over the water body (+1.13℃) and the highest was over the built-up area (+4.32℃). Findings of this study presents important implications for policy makers to conserve wetlands for community well-being especially during the dry season and for climate change adaptations.

***Keywords:*** Wetland, Ecosystem Services, Cooling effect

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# Online Learning and Students' Perceived Satisfaction: A Case Study

**P. H. D. Buddhima [1*]**, and **J. H. D. S. P. Tissera [1]**
[1] Department of Statistics, University of Colombo, Sri Lanka.
* dilubuddhima24@gmail.com

Due to the COVID - 19 pandemic, a surge of interest for online teaching in the education field in Sri Lanka has emerged. Therefore, it is important to understand how students accept the challenge of virtual learning while they were used to the traditional learning methods. Identifying the factors that are significantly associated with the students' satisfaction with online learning is noteworthy to provide a better online learning environment in the future, which ultimately affects students' learning outcomes positively. Hence, this study is intended to identify the factors associated with students' perceived satisfaction with online learning in the context of online courses offered by the Faculty of Science, University of Colombo. Students' satisfaction was assessed based on several aspects, including students' background information, students' self-regulation and motivation, lecturer and his/her feedback, course design, student support, student-student interaction, student-lecturer interaction, student-IT staff interaction, and students' internet self-efficacy. The target population of this study was the undergraduates of the Faculty of Science during October-2020. Population size in the Faculty of Science, University of Colombo in the year 2020 was 1800. The sampling approach was stratified random sampling with proportional allocation and each batch in the faculty was considered as a stratum. For the study, 317 responses were collected using a questionnaire sent through email. The built-in feature selection method of random forest algorithm was used to identify the potentially important predictor variables for student satisfaction with online learning. The algorithm revealed that students' capability to execute internet-related actions, students' self-generated energy towards a particular goal and their ability to manage the learning process, faculty support to the students, and student-lecturer interaction were the most important factors associated with students' satisfaction with online learning, in the Faculty of Science, University of Colombo. Additionally, students' study year, the course followed at the university, and having prior online experiences seemed to have an effect on student satisfaction with online learning. These findings were also corroborated by the ordinal logistics regression which was utilized to model fitting and interpretation.

***Keywords:*** online learning, student satisfaction, internet self-efficacy

# Factor Identification and Multiple Correspondence Analysis of Road Traffic Accidents in Sri Lanka: With Special Reference to Road A003

**A. A. K. T. Amarasinghe [1*]** and **H. A. S. G. Dharmarathne [1]**
[1] Department of Statistics, University of Colombo, Sri Lanka.
* kasun9628@gmail.com

Road accidents are one of the major causes of death and misery in Sri Lanka and across the globe. Recent trends have not shown any decrease in road accidents or the severity of their impact. In order to enforce prevention methods, a better understanding of road accidents and the factors associated with them are extremely important. Previous studies conducted in Sri Lanka focused mainly on descriptive analysis and identifying significant factors associated with road accidents but have not given the attention needed for the relationships and interactions that exist among these factors. This study was conducted to fill the above identified research gap.

Peliyagoda-Puttalam road (A003) was selected for the study. The factors associated with severity of road accidents were identified using Chi square tests and the categories which differ from independence were also statistically evaluated using post-hoc tests with Bonferroni correction. The results revealed that the number of casualties, vehicle type and urbanism of the area as the most associated factors at 0.05 significance level. The next most significant factors were age of the vehicle, age of the driver and the speed limit. Interestingly it was found that the severity of road accidents is does not depend on whether the accident was the driver's fault or not. Chi square post-hoc tests with Bonferroni correction revealed that when the number of casualties increase, more road accidents of grave nature occur than expected. Road accidents with higher severity levels were observed more in rural areas and less severe road accidents were present in urban areas. Accidents involving pedestrians and cyclists tend to be more severe as well.

Multiple correspondence analysis was performed to identify the relationships between the categories of the significant factors. A hierarchical clustering was incorporated into the Multiple correspondence analysis to objectively identify clusters of categories and analyze. Several clear clusters were identified, and the ones of interest were analyzed. It was found that the road accidents involving pedestrians as second collisions tend to be the most severe, motorbike accidents in rural areas are likely to be severe accidents, cyclist and pedestrian casualties tend to be more females and of younger age, and busses are involved in most of the daytime accidents colliding with another vehicle.

This study covered the identified gap in the field of study. The research findings will be useful for relevant stakeholders and have a positive impact on road safety.

***Keywords:*** Multiple Correspondence Analysis, Factor Identification, Road Traffic Accidents.

# Development of Predictive Models for the Assessment of the Risk of Diagnosing Endometriosis in the Presence of Polycystic Ovary Syndrome (PCOS): A Case Study

**V. E. Jayathunga** [1*] and **C. H. Magalla** [1]
[1] Department of Statistics, University of Colombo, Sri Lanka.
* vinuej777@gmail.com

Coexistence of Polycystic ovary syndrome (PCOS) with endometriosis is not an infrequent finding in women investigated for subfertility. The necessity for laparoscopy, delays the diagnosis of endometriosis in PCOS patients whereas early diagnosis will improve the fertility outcome of patients. Therefore, the aim of this study is to identify the statistically significant clinical features of women having coexistent endometriosis among patients already diagnosed with PCOS. Hence being able to compare the clinical features of women diagnosed only with PCOS with those having coexistent endometriosis. Thus, identifying the associated risk factors for developing endometriosis among PCOS patients by building a predictive model. It also aims to compare these risk factors to the ones obtained in the previously conducted medical research. This study was conducted in the Gynaecology units of Colombo South Teaching Hospital. Data were collected from a total of 90 patients diagnosed with PCOS who have undergone either laparoscopy and dye test or ovarian drilling, via an interviewer administered questionnaire.

Univariate tests and graphical analyses were carried out to identify the significant variables that should be further investigated. Firth's logistic model specifically developed for small datasets like this study was used for the advanced analysis.

18.89% of the women in the study presented with coexistent endometriosis. Women with coexistent endometriosis faced an increased risk of developing or presenting with dysmenorrhoea, dyspareunia, chronic abdominal and back pain and dysuria. Increasing age, high BMI, exposure to pelvic surgeries, gravidity and parity showed statistically significant associations with the response variable of presence of endometriosis.

The extent of how successful this study depends on the attention that is paid to recording and maintaining a meticulous history of the patient, which will be instrumental in early suspicion of endometriosis and expediting its diagnosis.

***Keywords:*** Coexistence, Polycystic ovary syndrome with Endometriosis, Predictive model, Firth's logistic regression

# ARIMA and ARIMAX Modelling of Dengue Cases in Jakarta

**A. M. C. H. Attanayake[1*], S. S. N. Perera[2],** and **U. P. Liyanage[1]**
[1] Department of Statistics & Computer Science, University of Kelaniya, Sri Lanka.
[2] Research & Development Centre for Mathematical Modelling, Department of Mathematics, University of Colombo, Sri Lanka.
*succ@kln.ac.lk

Dengue disease has grown drastically around the world. Prediction of dengue cases is particularly important to address the epidemic nature of the disease and to implement control strategies. The aim of this study is to model and predict the dengue incidence. The present study investigates the appropriateness of ARIMA and ARIMAX methods in this regard. The monthly reported dengue cases in Jakarta, Indonesia from January 2010 to December 2015 were considered to illustrate the applications of the methods. Average monthly rainfall and average monthly humidity data were selected as independent variables that influence the dengue distribution in Jakarta. Results revealed that the most appropriate ARIMAX model as seasonal ARIMAX (1,1,1) $(1,0,0)_{12}$ and the most appropriate ARIMA model as seasonal ARIMA (1,0,0) $(1,0,0)_{12}$. But seasonal ARIMAX model showed a lower mean absolute percentage error than seasonal ARIMA model. Therefore, the seasonal ARIMAX model was able to capture some of the influences of climatic variables on dengue cases than seasonal ARIMA model. All of the significant external factors that can be associated with dengue distribution should be identified through a comprehensive study and those factors should be included in the ARIMAX model development in order to make more precise predictions.

***Keywords:*** ARIMA, ARIMAX, Dengue

# Modelling Recurrent Event Data: An Application in Arts Graduate Employment

**G. K. Epage*[1]** and **I. T. Jayamanne [1]**
[1] Department of Statistics, University of Colombo, Sri Lanka.
* 2016s15789@stu.cmb.ac.lk

The employability of graduates is a key factor for the development of a country. However, the transition from university education to employment is one of the major issues faced by Arts graduates in Sri Lanka. Graduates change their employments frequently over time. Hence the research aimed to identify the factors associated with the changes in the employments of Arts graduates.

In this study, secondary data were obtained from a primary researcher who collected from a survey done in 2016 for randomly selected Arts graduates who passed out in 2012. At first, a preliminary analysis was carried out using graphical techniques followed by statistical tests to initial screening of the factors associated with the number of jobs.

Poisson regression and Poisson decision tree were fitted to identify the factors associated with changes in employment. Common factors identified from both models were Extracurricular activities and Type of school. Residual deviance of Poisson regression was 155.16 and accuracy of the Poisson decision tree was 65.34%. Considering only the demographic characteristics, it was difficult to identify the main factors associated with the number of jobs pursued by Arts graduates as their job characteristics may also be associated with the changes. Therefore, logistic regression was used to investigate how the employment characteristics are associated with moving out or not from the first employment. Two logistic regression models were fitted by removing missing job characteristics and imputing missing job characteristics. Accuracy of those logistic regression models were 87.42% and 87.24% respectively. Common job characteristics identified from both logistics regression models were the Waiting time of the first job, Type of the first job and Sector of the first job. It was found that most of the Arts graduates try to change their jobs to get a permanent public sector job regardless of the salary of the employments.

***Keywords:*** Recurrent Event, Arts graduates employments

# New Meta-heuristic Approach to Solve Two-Suppliers Three Buyers Stochastic Supply Chain Model

**H. A. D. R. Gunarathne**[1*] and **Z. A. M. S. Juman** [1]
[1] Department of Mathematics, Faculty of Science, University of Peradeniya, Peradeniya, Sri Lanka.
* rajikagunarathne@gmail.com

Integrated suppliers-buyers supply chain management is a special type of nonlinear programming problem in which the objective is to minimize the total system cost. Here, total system cost consists of three main cost components: transportation cost, inventory cost during transportation, and inventory cost at the buyers. The lead time of a particular supplier may be deterministic or stochastic. In many situations, it varies due to many factors such as variations in the times of processing product, inspection, loading, transportation, and unloading. Hence using the stochastic lead time is more reliable. Researchers have given considerable attention to the integrated problems with deterministic lead times and less attention to stochastic lead times. Researchers in the past have developed mathematical models considering the three cost components mentioned above with stochastic lead time and using heuristic solution procedure. Also, they considered the supply and demand values corresponding to particular supply demand points. Here the total supply of all supply nodes should be greater than or equal to the total demand of all demand nodes. The developed model was nonlinear and non-convex thus becomes NP-hard. Therefore, it is quite difficult to find out the solution using traditional algorithms or software. In this research work, for the case of two suppliers and three buyers, the proposed meta-heuristic approach was based on the genetic concept. It was developed to verify whether the existing solution can be further improved or not. The proposed method also reached the solution obtained by the existing approach. The results suggest that solutions obtained from both methods converge to the same local optimal. Hence this method can be used as an alternative approach to solve the two suppliers three buyers stochastic supply chain model.

***Keywords:*** Multi-buyer, Multi-supplier, Meta-heuristic

# Functional Data Analysis of Circadian Rhythms in Core Body Temperature

**S. D. Daluwatumulle [1],** and **G. P. Lakraj [1*]**
[1] Department of Statistics, University of Colombo, Sri Lanka.
* pemantha@stat.cmb.ac.lk

Circadian rhythms are biological internal clocks that tune our bodies to the right time of the day. Biological clocks regulate many functions in our bodies. Core body temperature (CBT) is one such function that can be considered as a standard marker for the biological clock. Therefore, we analysed CBT to gain more insight about this complex biological system of circadian rhythms. We noticed that many of the previous works in literature had used multivariate methodologies. A disadvantage of multivariate techniques is that they cannot consider the natural functional form of functional data objects, and thereby can miss many of the hidden patterns and variations of circadian rhythms. Therefore, we considered circadian rhythms in CBT as continuously observed functions over time and used functional data analysis (FDA) techniques to analyse it. The data used for this research are publicly available. They were obtained by a group of researchers after conducting experiments on male mice, at a research facility at Smith College, Northampton, USA. It includes five categorical variables, and each variable describes a special attribute of a particular mouse. The categorical variables are age, diet, light cycle, genotype, and health variables. The dataset also contains the CBT time series variable. We considered this CBT variable as a functional variable. Past works seem to have only tested for effects from the categorical variables on summary measures of CBT curves, such as periods of the curves. To test if these variables do indeed affect the full CBT curves, we conducted functional analysis of variance methodologies. We found that all the five categorical variables affect the CBT curves. Finally, we used a nonparametric kernel based estimator for posterior probabilities to classify CBT curves. Given a CBT curve of a mouse, these classification models were able to identify the unknown classes of age, diet, and light cycle with an accuracy of 85.96%, 85.96%, and 98.25% respectively. The results also appear to indicate that the model that classifies CBT curves into the relevant age groups can be used to identify the biological age groups of mice, instead of their chronological age groups with further improvement.

***Keywords:*** Circadian Rhythms, Functional ANOVA, Functional Classification

# Factors Associated with the Fatality of Road Traffic Accidents in Matale District

**M. G. S. K. Balasooriya[1*]** and **S. Arivalzahan[1]**
[1] Department of Mathematics and Statistics, Faculty of Science, University of Jaffna, Sri Lanka.
* shanikakalpani94@gmail.com

Globally, road traffic crashes are a leading cause of death and injuries. This motivates us to identify the risk factors which are associated with traffic accident severity. This study focuses on a district in the Central Province of Sri Lanka, Matale. The data has been collected from the police records of the road traffic accidents from 2017 to 2019. The following explanatory variables were considered in this analysis, 'Time'(4 levels: 12 am to 6 am, 6 am -12 pm, 12 pm - 6 pm, 6 pm -12 am), 'Location of the accident'( 2 levels: road or bend), 'Vehicle type'( 3 levels: two-wheelers, three-wheelers, others), 'Age of the driver'(5 levels: 19-25, 26-35, 36-45, 46-55, above 55), 'Reason for the accident' (3 levels: over speed, careless driving, not obeying rules), 'Type of accident'(2 levels: one vehicle involved, more than one vehicle involved), and 'Vehicle condition' ( 2 levels: Good or Bad). The response variable was "Accident severity" (Fatal/Non-fatal). Because of the binary nature of the response variable, Logistic regression and Classification trees were used to identify the factors associated with the fatality of traffic accidents. As per the logistic regression model, the following factors are identified as the significant factors for the fatality of the road traffic accidents, 'Time' (6 pm – 12 am), 'Vehicle type'(two-wheelers), 'Age of the driver' (above 55), 'Type of accident' (one vehicle involved), and 'Vehicle condition'(Bad). Diagnostic tests were performed to check the model assumptions. Further, classification trees added 'Location of the accident' as another associated factor for the fatality. The sample size considered was 310, and 20% of the sample was kept as the test sample to validate the models. The misclassification rate of the classification tree model (17.7%) is higher than the misclassification rate of the logistic regression model (12.9%).

***Keywords:*** Logistics regression, Classification tree, significant factors

# The Sensitivity between the Economic Classifications of the Government Recurrent Expenditure of Sri Lanka

**Venuri De Silva** [1*] and **Rajith Munasinghe** [1]
[1] Department of Statistics, University of Colombo, Sri Lanka
* venuri96@gmail.com

The growth in the recurrent expenditure appears to apply to most countries regardless of their level of economic development. Sri Lanka, being a developing country, requires an effective public expenditure management system where the expenditure should be allocated to different components productively by considering the influence of various aspects on it. In that sense, the identification of the factors closely related to different classifications of the recurrent expenditure that leads to fiscal decisions is vital.

This study aims to develop a predictive model for each of the four main economic classifications of Recurrent Expenditure of Sri Lanka, namely, salaries and wages, interest, pension and social benefits such as "Samruddhi". Auto Regressive Integrated Moving Average model with Exogenous variables (ARIMAX), Seasonal Auto Regressive Integrated Moving Average model with Exogenous variables (SARIMAX) and Vector Auto Regressive (VAR) models were used to build models for forecasting considering each classification individually and residual diagnostics were carried out for each model fitted to check for model adequacy. The insignificant coefficients were removed to try and obtain a better forecasting accuracy which was measured using Mean Absolute Percentage Error.

The study reveals that out of the different macro-economic variables and other variables that are associated with the four classifications, salaries and wages were found to be sensitive to whether the monetary policy of the country is expansionary or contractionary and Interest payments was found to be closely related to the openness of the economy followed by the presence of any natural disasters, the monetary policy stance and the number of strikes occurred in the country. Pension payments were sensitive to the depreciated or the appreciated value of exchange rates and the number of strikes occurred in the country whereas Samrudhi payments were sensitive to the Inflation rate of the country.

***Keywords:*** ARIMAX, SARIMAX, VAR

# Spatio-temporal Analysis of Leptospirosis Disease Incidence in Sri Lanka

**M. A. C. R. Perera [1]** and **C.D. Tilakaratne [1*]**
[1] Department of Statistics, University of Colombo, Sri Lanka.
* cdt@stat.cmb.ac.lk

Leptospirosis is a zoonosis caused by the bacteria Leptospires which retains in the kidneys of infected animals such as rodents. This disease is often misdiagnosed, and early treatment is vital to avoid fatal complications. Leptospirosis incidence is known to depend on location as well as time. Hence this study focused on developing a spatio-temporal model to forecast the future Leptospirosis incidence in Sri Lanka. Monthly Rainfall was incorporated as a covariate in the study. The dataset used in this study consists of monthly Leptospirosis cases, and total monthly rainfall (mm) in the district level from January 2010, up to June 2020. A categorical variable indicating the activities in paddy cultivation has also been derived and used in the analysis. Missing values observed in rainfall were categorized based on their location in the time series and were imputed using the best techniques selected out of several spatio-temporal weighting methods and time series-based techniques. The distribution of Leptospirosis incidence seemed to be limited to Southern and the Western regions of the country in most of the months. Peaks in the disease incidence could be observed in March -April and October -November each year coinciding with paddy harvesting seasons. Leptospirosis incidence was found to have a positive spatial autocorrelation with the rainfall values in the neighboring districts. Leptospirosis peaks could be observed after the peaks in rainfall in many districts. After the detection of spatial and temporal dependency in data, the monthly disease incidence in each district was modelled using three Bayesian Hierarchical models with Conditional Autoregressive (CAR) priors which incorporate different spatial, temporal and spatio-temporal random effects. Based on the test set comprising the latest 20% of the observations, the best forecasting accuracy with a root mean square error of 26.70, and the lowest percentage of underpredictions, which is 15.37% was obtained from the CAR prior which incorporated spatial random effects, temporal random effects, and independent space time interactions for each space-time unit. As implied by the model adequacy checks, adjusting the spatio-temporal structure of the random effects may improve the model further. The posterior distributions obtained for each prediction can be used to gain insights on the future disease incidence in each district and potential outbreaks.

***Keywords:*** Leptospirosis, Bayesian Hierarchical Modeling, Conditional Autoregressive Priors

# Compare the Performance of Neural Network Based Indoor Positioning Techniques

**Lasini Wickramasinghe**[1,2] and **Maheshi B. Dissanayake**[2]
[1] Department of Electronics, Wayamba University of Sri Lanka, Sri Lanka
[2] Department of Electrical and Electronic Engineering, University of Peradeniya, Sri Lanka
* lasini2013@gmail.com

Positioning or location estimation systems are adopted widely in the modern world to locate objects or users. Broadly adopted positioning systems at present such as global positioning system (GPS) or global navigation satellite system (GNSS) are limited to outdoor applications and provide poor location accuracy for indoor positioning with short movement span. Location fingerprinting uses received signal strength indicator (RSSI) to estimate locations of a mobile node in a network. This research area has recently attracted a great deal of attention especially in assisted living applications. One of the main challenges in indoor positioning systems is in regard to correctly estimating the position. Recently machine learning algorithms are tested for this task. Yet, there are significantly less amount of studies which focus on finding the most suitable model for the given application. Through this study we aimed to evaluate and compare the possibility of utilizing RSSI value of a smartphone antenna with the combination of trilateration theory and several neural network(NN) models, such as; radial basis function NN(RBFNN), feed forward back-propagation NN(FFBPNN), cascade forward back-propagation NN(CFBPNN), Elman back-propagation NN(EBPNN) and layer recurrent NN(LRNN) to identify the correct indoor location of a mobile in two dimensional (2D) space. We selected several appropriate statistical accuracy measures; mean absolute error (MAE), sum of squares error (SSE) and root mean square error(RMSE), to estimate the accuracy of the predicates position. The results demonstrated that the RBFNN method outperforms the other NN methods tested, when estimating the indoor positioning, with a MAE of 0.0019, SSE of 0.0015 and RMSE of 0.0071.

***Keywords:*** Indoor positioning, Neural network and RSSI

# A Statistical Study on the Factors Associated with Employment Status among Graduates in University of Jaffna

**D. M. N. N. Kumarasinghe [1]** and **S. Arivalzahan[1*]**
[1] Department of Mathematics and Statistics, Faculty of Science, University of Jaffna, Sri Lanka
imashakumarasinghe@gmail.com

The problem of the grim employment of University graduates is a hot topic of the whole society. The aim of this study was to identify the factors associated with one's employment status among graduates in University of Jaffna, Sri Lanka. The primary data was collected from a sample consisting of 1956 graduates. The variable "Employment Status" (Employed/Unemployed) was considered as a dichotomous response variable and the explanatory variables that have been considered in this study were Faculty (professional degree/non-professional degree), Gender (Male/Female), Mother tongue (Tamil/Sinhala), Class received by the graduates (with a class/without a class) and the grade received by the graduates for GCE O/L English subject (whether it is a A,B pass or C,S,F pass). The main focus of this study was to identify the strongly associated factors on the Employment Status. Due to the binary nature of the response variable, logistic regression was used to develop a statistical model for the Employment Status. Here all the above explanatory variables were found to have significant association with the response variable employability status. Chi-square test for independence among the explanatory variables revealed that except faculty-mother tongue and gender-English significant relationships exist among all other factors. Further, separate statistical models were developed for non-professional degrees. It was found that GCE O/L English is significantly associated with the employability status of the Science and Arts Faculty graduates, and gender is significantly associated with the employability status in the Arts and Management Faculty graduates. Moreover, class received also plays an important role in the employability among Management graduates. However, none of the above factors are important for the employability of the Agriculture Faculty graduates.

***Keywords:*** Logistic Regression, Chi-square test, Statistical Model

# A Generalized Reciprocal Service Cost Allocation Model – for Manufacturing Firms

**M.H.K.M. Hameem[1*]**
[1] Department of Mathematics, University of Colombo, Sri Lanka.
hameem@maths.cmb.ac.lk

This study details the development of two reciprocal service cost allocation models. The first model was developed using a system of linear difference equations and the other with a system of simple linear equations. Both models were introduced for a manufacturing firm with at least one production department and more than one service department. It is assumed that,

A1: at least one service department will serve one or more production departments and all other service departments can serve any department(s).

This is an extensive generalization of a paper presented earlier by the same author. Any set of allocation ratios chosen for the service departments satisfying this new assumption will lead to a matrix of the form $\begin{pmatrix} O & B \\ O & A \end{pmatrix}$, where the matrix $A = (\mu_{ij})$ represents the matrix of reciprocal allocation between service departments and $\mu_{ij}$ denotes the proportion of service department $j's$ overheads assigned to service department $i$ at each allocation. This matrix $A$ is a non-negative square matrix with at least one column sum less than one and all the other column sums less than or equal to one. For a meaningful setup in a manufacturing firm three further assumptions are made.

A2: No service department will serve only itself.

A3: No service department serves only one other service department.

A4: There is no a group of service departments that serves only that group.

To establish unique allocation of service costs to production departments with these models a few important results have been proved under the above assumptions. The first result is when each service department uses less than half of its service for itself, the second if matrix $A$ is a positive or a non-negative irreducible matrix, and the third if $A$ is a non-negative matrix with all entries $a_{ij} < 1$. The third result is new, and it reads 'if a non-negative matrix $A_n = (a_{ij})_{n\times n}$ has all entries less than one where one column sum of $A_n$ is less than one and all other column sums are less than or equal to one, then for all, $n \geq 2$, $|I - A_n| > 0$. Two corollaries to this result has also been proved. In all these results and corollaries unique solution to the models have been established.

***Keywords:*** irreducible matrix, non-negative matrix, reciprocal allocation.

# Impact of Sampling Design and Sampling Weights on Survey Data Analysis

**L. W. Rathuwadu[1*], D.R. Weerasekara[1],** and **I. T. Jayamanne[1]**
[1] Department of Statistics, University of Colombo, Sri Lanka.
* lankadinee@gmail.com

Over the recent years, it is found that the data from complex surveys lead to correlated data, and standard analysis assuming independent data may give incorrect estimates. Many researchers have confirmed that the correct parameter estimates can be obtained with the use of sampling weights and the incorporation of sampling design in analysis. However, most of the analysts still carry out their analyses without taking the sampling weights and the sampling design into account. The main objective of this study was to emphasize the impact of not incorporating sampling weights and sampling design in complex survey data analysis.

To achieve this objective, data from Sri Lanka Demographic and Health Survey (2016) and the Labor Force survey (2018) conducted by the Department of Census and Statistics were used. Both surveys have used two-stage stratified cluster sampling design. Descriptive statistics, regression coefficient estimates, and test statistics of hypothesis testing were computed using three analysis methods namely, (1) ignoring both sampling weights and sampling design; (2) incorporating weights but ignoring the sampling design; and (3) incorporating both weights and the sampling design.

The results illustrated that there are considerable differences in magnitudes between the unweighted and weighted estimates for most of the descriptive statistics, regression coefficient estimates, and test statistics computed. Their standard errors were larger under the third analysis method, compared to first and second analyses methods. P-values differ under the three analysis methods illuminating the potential for Type I and Type II errors in t-tests and chi-square tests, and possibility of reaching a different statistical decision regarding significant variables in the regression context. Due to these notable differences in the outcomes under the third analysis method, this study clearly demonstrates that the impact of not incorporating sampling weights and sampling design in complex survey data analysis is quite considerable. Therefore, the use of sampling weights and sampling design for the survey data analysis is highly recommended to achieve greater benefit from the complex survey data.

***Keywords:*** Complex survey data analysis, Sampling weights, Sampling design

# Investigating Intensity of Tornado Events via Statistical Manifold Learning of Tornado Property Losses

**Thilini Mahanama[1*], Pushpi Paranamana[2],** and **Dimitri Volchenkov [3]**
[1] Department of Mathematics & Statistics, Texas Tech University, TX, USA.
[2] Department of Mathematics & Computer Science, Saint Mary's College, IN, USA.
[3] Department of Mathematics & Statistics, Texas Tech University, TX, USA.
* thilini.v.mahanama@ttu.edu

We examine the relationship between property losses caused by tornadoes and their physical parameters, the tornado path length and width, using data reported by the National Oceanic and Atmospheric Administration in the United States. We observe that statistics of covered property losses cannot be described by a single distribution but rather by a two-dimensional statistical manifold of distributions that may reflect two different mechanisms of property loss covering. Assessing the difference between distributions of losses caused by tornadoes with the different ranges of physical parameters by Kolmogorov-Smirnov's distance, we restore the 2-D manifold by the method of multi-dimensional scaling. Then we define a 'curvature coefficient' that characterizes the contraction and expansion of the derived manifold to explain the complex dynamics of the probability distributions of losses. The regions with negative curvature coefficient identify the ranges of physical parameters for which the extreme tornado events may occur, which helps in assessing compensation strategies.

***Keywords:*** Tornado property losses, Statistical manifold learning, Risk assessment strategies

# Statistical Modelling with Citizen Science Data for Resident Shorebird Populations on the Mornington Peninsula

**Udani A. Wijewardhana[1*], Pragalathan Apputhurai[1], Madawa Jayawardana[2, 3],** and **Denny Meyer[1]**

[1]Department of Health Sciences and Biostatistics, Swinburne University of Technology, Hawthorn, Victoria, Australia.

[2] Peter MacCallum Cancer Centre, Melbourne 3000 Victoria, Australia.

[3] Sir Peter MacCallum Department of Oncology, The University of Melbourne, Parkville 3010 Victoria, Australia.

* uwijewardhana@swin.edu.au

Most Australian shorebirds are in decline due to risk factors such as loss of habitat and human activities. Australian shorebirds occupy and breed in a wide variety of habitats and wetland types. Climate variability has been identified as a possible threat to the biodiversity of shorebirds on the Mornington Peninsula and is likely to apply in both protected and unprotected areas. In this study, we investigate the effects of climate and conservation reserves on shorebird abundance for seven local shorebird species.

In the absence of comprehensive survey data this study used citizen science records of annual data for six resident shorebirds for the Mornington Peninsula from 2010 to 2019 extracted from the Atlas of Living Australia, to assess which species were most likely to be threatened by climate variability and which species benefit most from protected areas. This was done by fitting temporal models using the Integrated Laplace Approximation (INLA) method. We have considered temporal models with Poisson and Negative Binomial distributions. The Poisson distribution has the best fit, as determined by the Deviance Information Criterion (DIC), with the lowest DIC.
The trends for six resident shorebird species were compared to the Australian Pied Oystercatcher, with significantly steeper upward trends identified for the Black-fronted Dotterel, Red-capped Dotterel and Red-kneed Dotterel. Steeper upward trends were observed in protected than unprotected areas for the Black-fronted Dotterel, Masked Lapwing and Red-kneed Dotterel. Only the Hooded Plover showed a significant response to temperature, with lower numbers in warmer years.

This work suggests that, with some limitations, statistical models can be used with citizen science data for monitoring the persistence of resident shorebirds and for investigating factors that are impacting these data. The results for the Dotterel species in protected areas are particularly encouraging, however, it seems that the higher temperatures expected in the future may adversely affect the Hooded Plover.

***Keywords:*** Citizen science data, Temporal models, INLA

# Support Vector Machine Based Named Entity Recognition for Sinhala

**P. S. Mallikarachchi[1]*, S. A. S. Lorensuhewa[1],** and **M. A. L. Kalyani[1]**
[1] Department of Computer Science, University of Ruhuna, Matara, Sri Lanka.
*mallikarachchi9926@usci.ruh.ac.lk

Named Entity Recognition (NER) is an important fundamental subtask in Natural Language Processing (NLP). NER can be simply defined as identifying Named Entities (NE) in natural language text and classifying them into predefined classes. Although it is solved reasonably well for resource-rich languages, it is still a pivotal problem for low resourced languages that needs to be solved. In this day and age, most of the NER research has focused on resource-rich languages such as English. The main reason for neglecting uncommon languages, especially from the South Asian region is the dearth of digital lexical resources. Sinhala is one of those, the mother-tongue of many Sri Lankans and spoken by 20 million people. Due to dissimilarities such as morphological richness, capitalization, highly inflectional nature, tools developed for Western languages cannot be used for Sinhala. As a result of these circumstances, only a few previous works can be found using machine learning methods such as CRF (Conditional Random Field) and ME (Maximum Entropy). That being said there are several other methods in literature belonging to supervised learning paradigm, which provide significant results for parallel language processing tasks. Support Vector Machine (SVM) is one classification algorithm, with a noted performance in NLP tools. In this study, we present a novel SVM-based Name Entity Recognizer with sufficient language features for the Sinhala language. As feature selection is an important phase, we thoroughly focused on both the language dependent and independent features. We conducted three experiments to analyze the behaviour of Sinhala language under different feature combinations and varying the selected parameters. At the end, POS (Part-of-Speech) tag, gazetteer lists, clue words, word length 4 and 5 and window size of 1 was identified as the most prominent feature set with the highest F1 score of 0.60. Although it is below the performance level achieved through CRF, it shows SVM is applicable and also needs further boosting. We believe that the imbalance of the dataset and most of the words belonging to 'Other' category are the culprits for getting varying results with SVM. As future directions, we would like to discuss the boosting option for applying SVM on Sinhala NER task.

***Keywords:*** Named Entity Recognition, Support Vector Machine, Language features.

# A Computer Vision Approach for Medical Report Identification and Management: Case Study-Full Blood Report Information Extraction-Sri Lanka

**H.L.K.S. Hiniduma[1*] and T.R.N. Perera[1]**
[1]Department of Statistics and Computer Science, Faculty of Science, University of Peradeniya, Peradeniya, Sri Lanka
* kaveenh95@gmail.com

Medical reports of patients are considered to contain highly confidential information covering a medical condition for a set period. Patients are given a printed copy of the report and on each occasion of getting medical advice, they are required to bring all medical reports. If the contents of the medical reports are extracted, then the information present in these reports can be used to develop a mobile application which in turn will be used by both the patient and the doctor for disease management. The medical history and the details of the reports will be easily sent to the relevant medical personals through the creation of such an application. This research focuses on a computer vision and transfer learning-based approach where deep learning is used to extract information using a minimum number of medical reports for model training. Initially, the pre-trained object detection models EfficientDet D1 and SSD (Single Shot Detector) were used for object detection. As the dataset is relatively small, data augmentation techniques were implemented to expand the dataset. Using hyperparameter tuning, the learning phase of the models was optimized. By changing the learning rate, optimizer, data augmentation techniques, and the initializer we performed hyperparameter tuning. The optimizers used in this study were the Adam optimizer, RMS Propagation, and the Momentum optimizer. The learning rate of both models was adjusted with values ranging from 0.0002 up to 0.2 until the most optimized model was obtained. The loss curve of the SSD model showed an exponential loss while the EfficientDet model showed a smooth variation. Thus, the SSD model is identified to be the best object detection model which gave the most reliable precision of 83%. Using the results obtained, we utilized OCR (Optical Character Recognition) to convert the detected information into machine-readable text. Using this machine-readable text, a mobile application is suggested where patients can capture an image of their medical reports of which the information will be automatically extracted by the system. Thus, the proposed method in this study demonstrates that deep learning could be used in business cases with minimum training data using transfer learning to achieve real-time performance.

***Keywords:*** deep learning, transfer learning, object detection, optical character recognition

# Stakeholder Preferences for Planning and Management of Successful Marine Protected Areas in Sri Lanka

N D Gunawardena, *J M M Udugama and T P S R Guruge

Department of Plantation Management, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka, Makandura, Gonawila (NWP), 60170, Sri Lanka

*menukaudugama@gmail.com

ABSTRACT

Marine protected areas (MPAs) have become a popular tool for managing human impact on marine resources. MPAs have both a biological and social importance. Hence, usually are planned with special designated zones that exist around coastal areas to preserve marine environments, archeological resources, and sustainable fisheries management. There are four marine protected areas currently recognized in Sri Lanka; Hikkaduwa, Rumassala, Pigeon Island, and Bar reef marine sanctuary none of which are adequately managed resulting in overexploitation. Therefore, the objective of the study was to better understand the factors affecting stakeholder support and preferences for the management of marine protected areas by examining their perceptual and behavioral intentions. A survey was carried out using a semi-structured questionnaire with key stakeholders. Stakeholder perceptions were quantified by posing statements reflecting different dimensions pertaining to MPA management on a Likert scale; (1) Knowledge about MPAs, (2) Biodiversity, (3) Society and Culture, (4) Economy and Livelihood, (5) Legal and Institutional, and (6) Further Development in the Area. A 'Relative Importance Score' (RIS) was calculated for each stakeholder group (1) Sri Lanka Navy (2) Environmental Officials (3) Tourist Service Providers (4) Travelers (5) Scientists (6) General Public (7) Villagers (8) Fishermen (9) Academics and (10) Students for each factor. Factor and Cluster Analyses were performed to analyze the responses. Results revealed that the respondents place the highest importance on 'environment and biodiversity' followed by 'further development'. Among the stakeholders, naval officers and environmental officers placed more concern on conserving the biodiversity in MPAs whereas fishermen and villagers rated creation of livelihood opportunities as the most important factor. Results signal the importance of customized incentive packages and fisher facilities such as provision of better fishing gear for sustainable management. Infrastructure development of the area can attract tourists leading to revenue generating MPAs. It further highlights the importance of involving the local community in planning and assessing the impact of zoning and livelihood expectations in planning and management of MPAs.

KEYWORDS: Sustainable Management, Marine Protected Area, Planning, Stakeholders