PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON APPLIED AND PURE SCIENCES

ICAPS 2021

Volume 1

" Green Technology Towards a Knowledge-based Economy "

29 October 2021

**Faculty of Science
University of Kelaniya
Sri Lanka**

Proceedings of the

International Conference on

Applied and Pure Sciences

(ICAPS 2021-Kelaniya)

Volume 1

29 October 2021

"Green Technology Towards a Knowledge-based Economy"

Faculty of Science
University of Kelaniya
Sri Lanka

Proceedings of the

International Conference on

Applied and Pure Sciences

(ICAPS 2021-Kelaniya)

Volume 1

"Green Technology Towards a Knowledge-based Economy"

© 2021 October

Contents

Editorial Board

Prof. M. D. Amarasinghe-*Chief Editor*
University of Kelaniya

Biological Sciences

Prof. B. M. Jayawardena
University of Kelaniya
Prof. W. U. Chandrasekara
University of Kelaniya
Prof. R. K. S. Dias
University of Kelaniya
Prof. R. M. C. S. Ratnayake
University of Kelaniya
Mr. E. A. A. D. Edirisinghe
University of Kelaniya
Dr. W. M. A. P. Halmillawewa
University of Kelaniya
Dr. H. M. Herath
University of Kelaniya

Physical Sciences

Prof. L. B. D. R. P. Wijesundera
University of Kelaniya
Mr. N. G. A. Karunathilaka
University of Kelaniya
Mr. J. Munasinghe
University of Kelaniya
Dr. R. C. L. de Silva
University of Kelaniya
Dr. D. D. M. Jayasundara
University of Kelaniya

Software Intensive Systems

Prof. W. M. J. I. Wijayanayake
University of Kelaniya
Dr. A. P. R. Wickramarachchi
University of Kelaniya
Dr. S. P. Pitigala
University of Kelaniya
Dr. K. N. S. Warnajith
University of Kelaniya
Dr. I. U. Hewapathirane
University of Kelaniya
Dr. L. Munasinghe
University of Kelaniya

Multidisciplinary Research

Prof. A. Pathiratne
University of Kelaniya
Prof. N. A. K. P. J. Seneviratne
University of Kelaniya
Mr. M. M. Gunawardene
University of Kelaniya
Dr. S. G. V. S. Jayalal
University of Kelaniya
Dr. K. K. K. R. Perera
University of Kelaniya
Dr. K. M. D. C. Jayathilaka
University of Kelaniya
Dr. R. P. Wanigatunga
University of Kelaniya
Dr. D. M. P. V. Dissanayaka
University of Kelaniya

International Editorial Members

Prof. R. C. Woods
University of South Alabama, USA
Prof. F. Konietschke
Charité - Universitätsmedizin Berlin, Charitéplatz 1, Berlin, Germany
Prof. C. R. De Silva
Western Carolina University, Cullowhee, NC 28723
Dr. R. Raghavan
Department of Fisheries Resource Management, KUFOS, Kochi, India
Dr. M. P. Ginige
CSIRO Land and water, Australia
Dr. E. E. L. Mbamyah
Faculty of Medicine and Biomedical Sciences, University of Yaounde1, Cameroon
Dr. H. Kalutarage
School of computing, Robert Gordon University, Aberdeen, UK
Dr. S. Panda
National Institute of Technology Calicut, Kerala, India
Asst. Prof. I. R. Churchill
State University of New York SUNY at Oswego, Oswego, NY
Dr. C. D. Hirwa
Rwanda Agricultural and Animal Resource Development Board, Animal Resources Department, Rwanda

Organizing Committee

Faculty of Science, University of Kelaniya

Dean, Faculty of Science
Prof. S. R. D. Kalingamudali

Conference Chair
Prof. P. A. S. R. Wickramarachchi

Conference Secretary
Dr. D. A. D. A. Daranagama

Track Coordinators
Dr. H. A. C. C. Perera **-** *Biological Sciences*
Dr. C. C. Kadigamuwa - *Physical Sciences*
Dr. I. V. N. Rathnayake - *Multidisciplinary Research*
Dr. A. S. Withanaarachchi - *Software Intensive Systems*

Conference Management Tool Administrators
Dr. I. U. Hewapathirana - *Chair*
Mr. T. D. Kodituwakku

Web Development & Publicity Committee
Dr. W. A. C. Weerakoon - *Chair*
Ms. N. M. T. De Silva
Ms. N. Harischandra

Finance Committee
Ms. N. A. S. N. Wimaladharma - *Chair*
Dr. T. M. M. De Silva

Publication Committee
Prof. W. J. M. Samaranayake – *Chair*
Prof. M. D. M. D. W. M. M. K. Yatawara
Dr. A. L. A. K. Ranaweera
Dr. F. S. B. Kafi

Technical committee
Dr. B. M. T. Kumarika – *Co chair*
Ms. B. B. U. P. Perera – *Co chair*
Dr. S. P. Pitigala
Dr. K. N. S. Warnajith
Dr. W. A. C. Weerakoon
Ms. W. G. D. M. Samankula
Ms. N. M. T. De Silva

Event Management committee

Prof. M. D. M. D. W. M. M. K. Yatawara - *Co chair*

Prof. C. S. K. Rajapakse - *Co chair*

Ms. N. A. S. N. Wimaladharma

Dr. T. M. M. De Silva

Reviewer Panel

Biological Sciences

Prof. C. L. Abayasekera
University of Peradeniya

Prof. M. D. Amarasinghe
University of Kelaniya

Prof. U. S. Amarasinghe
University of Kelaniya (Retired)

Prof. K. P. R. N. Attanayake
University of Kelaniya

Prof. V. P. Bulugahapitiya
University of Ruhuna

Prof. S. Chackrewarthy
University of Kelaniya

Prof. W. U. Chandrasekara
University of Kelaniya

Prof. S. D. M. Chinthaka
University of Sri Jayewardenepura

Prof. C. D. Dangalle
University of Colombo

Prof. N. Deshappriya
University of Sri Jayewardenepura

Prof. B. G. D. N. K. De Silva
University of Sri Jayewardenepura

Prof. W. R. M. de Silva
University of Colombo

Prof. R. M. Dharmadasa
Industrial Technology Institute

Prof. R. K. S. Dias
University of Kelaniya

Prof. S. Ekanayake
University of Sri Jayewardenepura

Prof. U. P. K. Epa
University of Kelaniya

Prof. C. M. Hettiarachchi
University of Colombo

Prof. L. Jayasinghe
National Institute of Fundamental Studies

Prof. G. G. Jayasuriya
University of Peradeniya

Prof. N. Jayathilaka
University of Kelaniya

Prof. B. M. Jayawardena
University of Kelaniya

Prof. B. T. S. D. P. Kannangara
University of Kelaniya

Prof. S. H. P. P. Karunaratne
University of Peradeniya

Prof. D. N. Magana-Arachchi
National Institute of Fundamental Studies

Prof. K. Masakorala
University of Ruhuna

Prof. C. M. Nanayakkara
University of Colombo

Prof. A. N. Navaratne
University of Peradeniya

Prof. C. Padumadasa
University of Sri Jayewardenepura

Prof. D. R. Pandithavidana
University of Kelaniya

Prof. P. A. Paranagama
University of Kelaniya

Prof. A. Pathiratne
University of Kelaniya

Prof. W. A. P. J. Premaratne
University of Kelaniya

Prof. P. A. N. Punyasiri
University of Colombo

Prof. C. S. K. Rajapakse
University of Kelaniya

Prof. R. G. S. C. Rajapakse
University of Peradeniya

Prof. S. M. W. Ranwala
University of Colombo

Prof. R. M. C. S. Ratnayake
University of Kelaniya

Prof. S. P. Senanayake
University of Kelaniya

Prof. S. Senarath
University of Sri Jayewardenepura

Prof. N. A. K. P. J. Seneviratne
University of Kelaniya

Prof. H. L. D. Weerahewa
The Open University of Sri Lanka

Prof. S. R. Weerakoon
The Open University of Sri Lanka

Prof. M. K. B. Weerasooriya
University of Kelaniya

Prof. P. A. S. R. Wickramarachchi
University of Kelaniya

Prof. S. A. Wijesundara
National Institute of Fundamental Studies

Prof. W. M. D. N. Wijeyaratne
University of Kelaniya

Prof. D. M. D. Yakandawala
University of Peradeniya

Dr. S. I. Abeygunawardena
University of Kelaniya (Retired)

Dr. W. P. K. M. Abeysekara
University of Sri Jayewardenepura

Dr. D. T. Abeysinghe
The Open University of Sri Lanka

Dr. R. Abhayapala
University of Sri Jayewardenepura

Dr. R. Amarakoon
University of Kelaniya

Dr. A. P. Attanayake
University of Ruhuna

Dr. W. A. R. T. W. Bandara
University of Kelaniya

Dr. S. Chelvendran
Industrial Technology Institute

Dr. D. D. G. L. Dahanayaka
The Open University of Sri Lanka

Dr. J. W. Damunupola
University of Peradeniya

Dr. W. S. Dandeniya
University of Peradeniya

Dr. D. A. D. A. Daranagama
University of Kelaniya

Dr. M. D. S. T. de Croos
Wayamba University of Sri Lanka

Dr. H. I. C. De Silva
University of Colombo

Dr. M. T. R. Fernando
University of Kelaniya

Dr. P. Godakumbura
University of Sri Jayewardenepura

Dr. A. G. M. J. Gunaratna
University of Kelaniya

Dr. K. M. T. D. Gunasekera
University of Sri Jayewardenepura

Dr. G. D. D. K. Gunasena
University of Kelaniya

Dr. W. M. A. P. Halmillawewa
University of Kelaniya

Dr. H. M. Herath
University of Kelaniya

Dr. D. L. Jayaratne
University of Kelaniya (Retired)

Dr. A. D. Jayasinghe
University of Ruhuna

Dr. C. C. Kadigamuwa
University of Kelaniya

Dr. K. G. U. R. Kumarasinghe
University of Sri Jayewardenepura

Dr. R. Liyanage
National Institute of Fundamental Studies

Dr. D. S. Manamgoda
University of Sri Jayewardenepura

Dr. M. L. A. M. S. Munasinghe
University of Sri Jayewardenepura

Dr. H. A. C. C. Perera
University of Kelaniya

Dr. R. Perera
The Open University of Sri Lanka

Dr. G. Rajapaksa
University of Kelaniya

Dr. I. V. N. Rathnayake
University of Kelaniya

Dr. A. A. L. Ratnatilleke
University of Kelaniya

Dr. W. Subasinghe
University of Kelaniya

Dr. K. M. Thambugala
University of Sri Jayewardenepura

Dr. D. Udayanga
University of Sri Jayewardenepura

Dr. D. N. Udukala
Institute of Chemistry

Dr. L. Undugoda
University of Sri Jayewardenepura

Dr. S. P. Vidanage
University of Kelaniya

Dr. K. Vivehananthan
The Open University of Sri Lanka

Dr. H. P. Wakkumbura
Gampaha Wickramarachchi University of Indigenous Medicine

Dr. R. P. Wanigatunge
University of Kelaniya

Dr. S. Weerasinghe
University of Sri Jayewardenepura

Dr. V. P. A. Weerasinghe
University of Kelaniya

Dr. R. Wimalasekara
University of Sri Jayewardenepura

Dr. Y. S. Wijayasinghe
University of Kelaniya

Dr. W. M. H. K. Wijenayake
Wayamba University of Sri Lanka

Dr. W. R. P. Wijesinghe
University of Peradeniya

Mr. D. M. S. K. Dissanayaka
National Apprentice and Industrial Training Authority

Mr. E. A. A. D. Edirisinghe
University of Kelaniya

Ms. P. Edirisinghe
University of Kelaniya

Mr. M. M. Gunawardena
University of Kelaniya

Mr. M. Niranjan
Tea Research Institute

Mr. K. M. S. Ruvinda
University of Kelaniya

Physical Sciences

Prof. J. P. Arachchige
University of Ruhuna

Prof. M. D. P. De Costa
University of Colombo

Prof. D. S. M. de Silva
University of Kelaniya

Prof. P. S. Hewageegana
University of Kelaniya

Prof. J. K. D. S. Jayanetti
University of Colombo

Prof. K. P. S. C. Jayaratne
University of Colombo

Prof. L. Jayasekara
University of Ruhuna

Prof. P. M. Jayaweera
University of Sri Jayewardenepura

Prof. A. N. Navaratne
University of Peradeniya

Prof. D. R. Pandithavidana
University of Kelaniya

Prof. G. A. K. S. Perera
Wayamba University of Sri Lanka

Prof. P. A. A. Perera
University of Kelaniya

Prof. V. P. S. Perera
The Open University of Sri Lanka

Prof. W. A. P. J. Premaratne
University of Kelaniya

Prof. C. S. K. Rajapakse
University of Kelaniya

Prof. R. M. K. T. Rathnayaka
Sabaragamuwa University of Sri Lanka

Prof. H. H. Sumathipala
University of Kelaniya

Prof. C. D. Tilakaratne
University of Colombo

Prof. K. P. Vidanapathirana
Wayamba University of Sri Lanka

Prof. A. N. Wijayanayake
University of Kelaniya

Prof. L. B. D. R. P. Wijesundera
University of Kelaniya

Dr. R. A. B. Abeygunawardana
University of Colombo

Dr. A. M. T. Amarakoon
University of Kelaniya

Dr. M. D. T. Attygalle
University of Colombo

Dr. N. V. Chandrasekara
University of Kelaniya

Dr. P. M. Colonne
University of Kelaniya

Dr. A. T. Cooray
University of Sri Jayewardenepura

Dr. R. V. Coorey
University of Colombo

Dr. J. N. Dahanayake
University of Kelaniya

Dr. B. S. Dassanayake
University of Peradeniya

Dr. R. S. Dassanayake
University of Sri Jayewardenepura

Dr. M. P. Deeyamulla
University of Kelaniya

Dr. W. A. R. De Mel
University of Ruhuna

Dr. R. C. L. De Silva
University of Kelaniya

Dr. T. M. M. De Silva
University of Kelaniya

Dr. M. C. S. Fernando
University of Ruhuna

Dr. N. C. Ganegoda
University of Sri Jayewardenepura

Dr. W. P. T. Hansameenu
University of Kelaniya

Dr. A. P. Hewaarachchi
University of Kelaniya

Dr. P. K. S. Jayasinghe
University of Ruhuna

Dr. D. D. M. Jayasundara
University of Kelaniya

Dr. K. M. D. C. Jayathilaka
University of Kelaniya

Dr. H. C. Y. Jayathunga
University of Colombo

Dr. H. L. Jayetileke
University of Ruhuna

Dr. C. C. Kadigamuwa
University of Kelaniya

Dr. S. P. D. S. S. K. Karunarathna
Wayamba University of Sri Lanka

Dr. M. N. Kaumal
University of Colombo

Dr. G. H. J. Lanel
University of Sri Jayewardenepura

Dr. U. P. Liyanage
University of Kelaniya

Dr. M. A. M. Maddumaarachchi
University of Sri Jayewardenepura

Dr. M. A. Y. L. Nadeesha
University of Kelaniya

Dr. E. J. K. P. Nandani
University of Ruhuna

Dr. N. A. D. N. Napagoda
Wayamba University of Sri Lanka

Dr. W. C. W. Navaratna
The Open University of Sri Lanka

Dr. A. Pallewatta
University of Kelaniya

Dr. H. R. Perera
University of Colombo

Dr. K. K. K. R. Perera
University of Kelaniya

Dr. R. Perera
Wayamba University of Sri Lanka

Dr. B. G. S. A. Pradeep
University of Ruhuna

Dr. K. D. Prasangika
University of Ruhuna

Dr. L. P. N. D. Premarathna
University of Kelaniya

Dr. R. A. C. P. Rajapakse
University of Kelaniya

Dr. T. P. Rupasinghe
University of Kelaniya

Dr. M. I. G. S. Sampath
Wayamba University of Sri Lanka

Dr. J. A. Seneviratne
University of Kelaniya

Dr. A. W. L. P. Thilan
University of Ruhuna

Dr. W. T. M. A. P. K. Wanninayake
University of Kelaniya

Dr. W. M. K. P. Wijayaratna
University of Colombo

Dr. G. S. Wijesiri
University of Kelaniya

Ms. P. A. D. A. N. Appuhamy
Wayamba University of Sri Lanka

Ms. A. M. C. H. Attanayake
University of Kelaniya

Mr. N. G. A. Karunathilake
University of Kelaniya

Mr. N. W. K. Jayatissa
University of Kelaniya

Ms. B. B. U. P. Perera
University of Kelaniya

Ms. W. G. D. M. Samankula
University of Kelaniya

Software Intensive Systems

Prof. P. Abeygunawardhana
Sri Lanka Institute of Information Technology

Prof. K. Pulasinghe
Sri Lanka Institute of Information Technology

Dr. H. M. N. D. Bandara
University of Moratuwa

Dr. M. F. M. Firdhous
University of Moratuwa

Dr. K. Gunasekera
University of Moratuwa

Dr. S. G. V. S. Jayalal
University of Kelaniya

Dr. S. P. Kasthuri Arachchi
University of Kelaniya

Dr. D. Kasthurirathna
Sri Lanka Institute of Information Technology

Dr. S. R. Liyanage
University of Kelaniya

Dr. D. A. Meedeniya
University of Moratuwa

Dr. R. A. C. P. Rajapakse
University of Kelaniya

Dr. S. Ranathunga
University of Moratuwa

Dr. V. G. T. N. Vidanagama
Wayamba University of Sri Lanka

Dr. N. Wedasinghe
General Sir John Kotelawala Defence University

Dr. D. N. Wickramaarachchi
University of Kelaniya

Dr. J. Wijekoon
Sri Lanka Institute of Information Technology

Dr. A. S. Withanaarachchi
University of Kelaniya

Mr. D. Asanka
Virtusa Pvt Ltd., Sri Lanka

Multidisciplinary Research

Prof. W. U. Chandrasekara
University of Kelaniya
Prof. D. S. M. de Silva
University of Kelaniya
Prof. D. P. Dissanayake
University of Colombo
Prof. U. P. K. Epa
University of Kelaniya
Prof. P. N. Gamage
University of Kelaniya
Prof. U. A. D. P. Gunawardena
University of Sri Jayewardenepura
Prof. J. W. Hewage
University of Ruhuna
Prof. S. Jayakody
Wayamba University of Sri Lanka
Prof. N. Jayathilaka
University of Kelaniya
Prof. B. M. Jayawardena
University of Kelaniya
Prof. M. G. Kularathna
University of Kelaniya
Prof. B. Marambe
University of Peradeniya
Prof. M. M. M. Najim
University of Kelaniya
Prof. C. M. Nanayakkara
University of Colombo
Prof. A. Pathiratne
University of Kelaniya
Prof. W. A. P. J. Premaratne
University of Kelaniya
Prof. H. M. D. N. Priyantha
University of Peradeniya
Prof. C. S. K. Rajapakse
University of Kelaniya
Prof. R. M. C. S. Ratnayake
University of Kelaniya
Prof. M. Vithanage
University of Sri Jayewardenepura
Prof. M. S. S. Weerasinghe
University of Colombo
Prof. M. K. B. Weerasooriya
University of Kelaniya
Prof. P. A. S. R. Wickramarachchi
University of Kelaniya
Prof. A. N. Wijayanayake
University of Kelaniya
Prof. R. D. Wijesekera
University of Colombo
Prof. W. M. D. N. Wijeyaratne
University of Kelaniya
Prof. M. D. M. D. W. M. M. K. Yatawara
University of Kelaniya

Dr. R. A. B. Abeygunawardana
University of Colombo
Dr. R. Abeysekara
University of Kelaniya
Dr. A. M. T. Amarakoon
University of Kelaniya
Dr. R. Amarakoon
University of Kelaniya
Dr. W. A. R. T. W. Bandara
University of Kelaniya
Dr. N. V. Chandrasekara
University of Kelaniya
Dr. W. S. Dandeniya
University of Peradeniya
Dr. D. A. D. A. Daranagama
University of Kelaniya
Dr. M. P. Deeyamulla
University of Kelaniya
Dr. H. I. C. De Silva
University of Colombo
Dr. R. C. L. de Silva
University of Kelaniya
Dr. D. M. P. V. Dissanayaka
University of Kelaniya
Dr. M. Edussuriya
University of Ruhuna
Dr. T. N. B. Etampawala
University of Sri Jayewardenepura
Dr. M. T. R. Fernando
University of Kelaniya
Dr. S. R. Gunatilake
Institute of Chemistry
Dr. A. P. Hewaarachchi
University of Kelaniya
Dr. M. P. N. Janadari
University of Kelaniya
Dr. S. G. V. S. Jayalal
University of Kelaniya
Dr. D. D. M. Jayasundara
University of Kelaniya
Mr. A. Jayawardhana
University of Kelaniya
Dr. A. Jeewandara
University of Kelaniya
Dr. C. C. Kadigamuwa
University of Kelaniya
Dr. H. W. B. Kavinga
University of Kelaniya
Dr. U. P. Liyanage
University of Kelaniya
Dr. M. A. M. Maddumaarachchi
University of Sri Jayewardenepura
Dr. K. M. Mohotti
Tea Research Institute of Sri Lanka

Dr. I. Munaweera
University of Sri Jayewardenepura
Dr. M. A. Y. L. Nadeesha
University of Kelaniya
Dr. A. Pallewatta
University of Kelaniya
Dr. K. P. P. Peiris
Gampaha Wickramarachchi University of Indigenous Medicine
Dr. W. N. N. K. Perera
University of Sri Jayewardenepura
Dr. P. L. S. Peter
University of Kelaniya
Dr. L. P. N. D. Premarathna
University of Kelaniya
Dr. P. Samarasekere
University of Kelaniya
Dr. B. G. N. Sewwandi
University of Kelaniya
Dr. A. Siriwardhana
Monash University, Australia
Dr. S. A. D. H. N. Suraweera
University of Kelaniya
Dr. M. Thomas
University of Peradeniya
Dr. W. D. C. Udayanga
University of Kelaniya
Dr. S. P. Vidanage
University of Kelaniya
Dr. S. M. Vithanarachchi
University of Colombo

Dr. H. P. Wakkumbura
Gampaha Wickramarachchi University of Indigenous Medicine
Dr. W. A. L. C. Waliwita
Gampaha Wickramarachchi University of Indigenous Medicine
Dr. R. P. Wanigatunge
University of Kelaniya
Prof. V. P. A. Weerasinghe
University of Kelaniya
Dr. A. P. R. Wickramarachchi
University of Kelaniya
Dr. P. D. V. C. Wickramarathne
University of Kelaniya
Dr. A. S. Withanaarachchi
University of Kelaniya
Dr. M. R. N. K. Yatigammana
University of Kelaniya
Ms. H. A. H. C. Munasinghe
University of Kelaniya
Mr. K. M. S. Ruvinda
University of Kelaniya
Ms. M. R. F. Ruwaiha
University of Colombo
Ms. M. V. Silva
University of Kelaniya
Mr. T. Weerasinghe
University of Kelaniya

Keynote Speaker's Profile

Prof. Karunaratne graduated from the University of Colombo with a First class in Bachelor of Science Honours degree in Chemistry in 1978. He earned his PhD in Synthetic Organic Chemistry from the University of British Columbia, Canada in 1985 and joined the Department of Chemistry, University of Peradeniya as a senior lecture in the same year.

Prof. Karunaratne was the awardee of several postdoctoral fellowships and he served as a visiting scientist at many prestigious universities and institutes including Uppsala University in Sweden, Mahidol University in Thailand, University of British Columbia in Vancour, Canada and University of Kansas in the USA.

Prof. Karunaratne served as the Head of the Department of Chemistry in University of Peradeniya from 2005 to 2008. He retired from his service as a senior professor in Chemistry at the University of Peradeniya in April 2021. He served as the science team leader at the SLINTEC Academy from 2008

Emeritus Prof. Veranja Karunaratne,

PhD, FRSC, FNAS

Chevalier dans l'Ordre des Palmes Académiques (Knight of the *Order of Academic Palms* (Awarded by the Government of France) 2012).

Emeritus Prof. Veranja Karunaratne serves as the Vice-chancellor of the SLINTEC Academy, Sri Lanka Institute of Nanotechnology.

to 2014 until he became its Associate Director of Science and Strategic Relations in 2014.

Prof. Karunaratne has an excellent research career in the field of nanotechnology. His high impact research includes nanotechnology-based solutions to slow release of fertilizer and biologically important compounds, chemistry of endemic plants, taxonomy and search for new lichen species from Sri Lanka, development of a scalable process for production of TiO_2 from ilmenite sand, natural polymers as substitutes of asbestos, and drug delivery systems containing nanomaterials and nanocomposites.

Prof. Karunaratne has received numerous awards including presidential award, SUSRED award, and many more for his contribution to and excellence in research in nanotechnology.

He has supervised more than 20 PhD and 10 MPhil research students and has authored more than 160 research articles, books, monographs, and book chapters, and the inventor of 17 patents. With an H-Index of 35, he is highest cited chemist in Sri Lanka.

Abstract of the Plenary Speech – Biological Sciences

Biological Sciences – Microbes for Agriculture

Bacteria and fungi have the potential to provided new innovative solutions to address environmental and agricultural challenges. Not only are their ecological function, metabolic capabilities, and adaptability ideally suited to development as environmentally sustainable products to improve agricultural production, they also can also avoid non-target impacts due to their selectivity and specificity. However wider adoption of microbes by agriculture will require several innovative solutions to address market and technological hurdles. This talk will present an overview of the potential for agricultural microbe-based products, the current state of technologies and the market, and future opportunities for research, development and industry adoption.

Dr. Craig Bunt

Professor of Agricultural Innovation
The University of Otago
Dunedin
New Zealand

Many bacteria and fungi microbes are suitable for agricultural uses ranging from pest control to plant growth and establishment enhancement. For example the bacteria *Serratia entomophila* is able to infect the pasture pest grass grub (*Costelytra zealandica*) with amber disease, *Pseudomonas fluorescens* may the roots of some plant species against parasitic fungi and nematodes, and *Bacillus thuringiensis* (Bt) the most commonly used biological pesticide against a wide range of caterpillars, worms, beetles, mosquitoes and flies. The fungus *Beauveria bassiana* is used to control a number of pests such as termites and different beetles. While diazotrophic bacteria such as Rhizobia fix nitrogen inside the root nodules of legumes. Products based on such bacteria and fungi microbes can be broadly divided into three product classes; powders and liquids requiring dilution for spray application, and granule for broadcasting, and seed coatings. These microbe agents can be further classed into 1) those that are more easily formulated due to their spore forming ability, this not only provides survival during the formulation and production process but also on-shelf survival, whereas 2) non-spore forming microbes are much more challenging to formulate and deliver but do possess other positive attributes making them suitable for use.

The challenges associated with non-spore forming microbes such as poor survival during the production process or on-shelf survival does not necessarily rule them out as candidates and compared to the spore-forming microbes there is some evidence that they perform better in the field. How to overcome the production and survival issues of non-spore forming microbes continues to be a focus of research. Various approaches from precise control of moisture during and after manufacture is often a successful strategy, whereas considerable research has also focused on the development of specific strains with improved action along with improved survival.

Ongoing development and industry adoption of agricultural pest control, and plant growth and establishment microbe-based products has historically been impacted by a combination of issues that have contributed to poor industry uptake. The challenge of non-spore former poor survival has led to product failure or poor performance, this has placed acceptance of these products below conventional agri-chemical based products. When poor survival has been addressed challenges with the method and timing of application to ensure the best outcome has given such products the reputation of being less robust than conventional products.

However agricultural must become sustainable and microbe-based products will not only help to achieve this by greatly reducing the issue of chemical residues in the environment and our food, but also offer the capability of better targeting pests and improving plant growth while minimising non-target impacts.

Abstract of the Plenary Speech – Physical Sciences

Semiconductor Industry: Overview, Trends and Challenges

Semiconductor fabrication is a complex manufacturing process involving different technologies and hundreds of steps and equipment. It starts with a substrate and involves multiple deposition, etch, and patterning steps to finally achieve the desired complex device architecture. After that, individual devices/chips are separated and packaged for delivery. Advanced logic and memory devices are evolving continuously to become smaller and faster transistors and memory devices with higher storage capacity. Logic devices are following the traditional Moore's law where the number of transistors in integrated circuit doubles about every two years. Memory devices are evolving to compensate for continuous demand coming from data storage.

Dr. Charith Nanayakkara

Principal Scientist
Semiconductor Technology Development
Applied Materials
Gloucester, MA, USA

Demand for semiconductors has multiplied during the global pandemic due to the high demand coming from key areas of information technology such as personal computers, mobile phones, telecommunication, and data storage. It is mainly driven by increased demand from e-commerce, change in work environments, online learning/teaching, virtual meetings, etc. This has led to a demand for faster computing and a large amount of data storing during the pandemic. At the same time challenges faced by supply chains have made some of the fabrications slower. However, the global semiconductor industry has shown to be financially much stronger during the pandemic delivering a record number of revenues.

Next generation semiconductor device development involves solving complex problems using the fundamental understanding of chemistry, physics, and engineering. One of the key steps involving semiconductor fabrication is deposition. Deposition involves three major deposition techniques. They are Physical Vapor Deposition (PVD), Chemical Vapor Deposition (CVD), and Atomic Layer Deposition (ALD). ALD is the newest deposition technique and is widely acquired by the semiconductor industry.

ALD is a process technology that enables future complex semiconductor device fabrication. It is a thin-film deposition technique that enables depositing thin-films in self-limiting manner with atomic scale deposition control. ALD is a vapor phase film deposition technique with two distinct steps. In the first step, a substrate is exposed to a precursor and is purged to remove any by products and unreacted precursors. Next, the surface is exposed to a co-reactant to complete the surface reaction and purged to remove any by products and unreacted co-reactants. This will result in a layer of a thin-film and by continuing for a number of iterations form a film with controlled thickness. A well-known example is to form an Al_2O_3 layer by exposing a substrate to $Al(CH_3)_3$ and H_2O with N_2 purges in between. Deposition temperature, vapor pressure of the reactants, type of substrate, and reactivity of the precursors and co-reactants determined the film properties and therefore critical to control during ALD process development. Key advantages of ALD are excellent control of film growth, depositing highly conformal films on complex structures, control of film quality, and enabling low temperature processes.

Abstract of the Plenary Speech – Software Intensive Systems

Green Technologies for a Knowledge-based Economy: Software-intensive View

The theme of this conference *Green Technologies for a Knowledge-based Economy* is certainly a relevant to global challenges – especially Climate Change. It is not controversial to state that Climate Change is one of the most significant challenges that the world face today. This global challenge is beyond boundaries of a single country, economy or political landscape. It affects all life on Earth. Addressing this challenge needs global and collective action. Certainly a multi-disciplinary approach and innovative solutions are needed. Software systems and technology can certainly be a part of the solutions and action.

Dr. Rukshan Athauda

Senior Lecturer
School of Electrical Engineering and Computing
University of Newcastle
Australia

Green technologies aim to reduce human's impact on the environment through technological innovations (such as renewable energy) and will be a part of the solution. Technologies themselves are not sufficient, we need widespread adoption, uptake and action. This requires a multi-disciplinary collective efforts. In this talk, an example from adoption of solar installation in residential homes based on multiple stakeholder (i.e. government, energy sector and citizens) in Australia is highlighted.

Our forefathers, especially traditional Sri Lankan village lifestyles embraced sustainable "green" lifestyles. Sri Lanka like any other country has the potential to contribute to this reversing Climate Change. Technology access today is not restricted to a particular country. For instance, Cloud Computing allows access to computing resources irrespective of location. These approaches not only are cost-effective but can be utilised for development of "green" solutions. Also, as countries and governments take on Climate Change agenda such as COP26 UN climate Change Conference, these large scale data centres will be encouraged to move towards using carbon neutral energy consumption modes.

What is needed is innovative design of solutions–systems, adoption and collective action. Let's consider some examples. Impacts of COVID-19, social isolation and technologies such as Zoom have shown us the ability to communicate, collaborate and work without needing to move all participants to a single location. This approach can have a significant impact on CO_2 emissions, traffic and saving time. Zoom is possibly one of the apps that have and the potential for significant reduction in CO_2 emissions. We need to encourage and adopt such efficiencies in our day to day lives.

What is also interesting to observe is that usually the "green" solutions are also the most economical solutions as well. What we need is innovative ways of bringing solutions to practice? Can you think of other examples? Take for example, online payments for utility. A policy of a 1-2% discount if bills are paid online may be all you need to encourage adoption. All of a sudden, this reduces the need for office space, less staff, saves on rent and also has the possibility improve customer service experience.

With software and ICT technologies, we have the capacity to design solutions with the aim of reduce CO_2 footprint in our activities both personally and professionally. For example, an app to track our carbon footprint in our daily activities (and even being rewarded for a lower carbon footprint). We need to design solutions for greener ways to live, work, energy consumption, in

healthcare, entertainment and others. If there is one take-away from this talk, it should to explore ways where we can become more aware, and consider opportunities to use, design and adopt technologies for "greener", sustainable ways of living.

Abstract of the Plenary Speech – Multidisciplinary Research

Scientific Basis for Management Decisions Controlling Arsenic in Abandoned Mines: XAS Based Investigations

Worldwide, historical mining operations operated under drastically different environmental expectations relative to current day. Metalliferous mines regularly operated and ceased with minimal to no expectation to remediate and protect the environment. In most cases, the land defaulted to local or national jurisdictions which were required to remediate and manage environmental issues emanating to nearby watercourses and environments. Legacy mining sites exist globally in enormous numbers. Estimates in the USA are in excess of 500,000 sites, 50,000 in Australia, 10,000 in Japan and the United kingdom, for example. In Australian metalliferous mines, arsenic (As) is a recurring contaminant of critical concern. Arsenic predominantly exists as arsenite (As^{III}) and arsenate (As^V) in the environment. Arsenite is the most toxic inorganic form in contaminated water and 25-60 times more than As^V. Arsenic-containing and As-forming minerals are key

Dr. Dane Lamb

Senior Lecturer,
Chemical & Environmental Engineering,
RMIT University,
Melbourne

for controlling the geochemical cycling of As in the environment through sorption, dissolution and precipitation mechanisms. In general, the rate of As release from these minerals into water is controlled by pH, redox reactions, ionic strength and competing anions. However, in mine sites which tend to be 50 to 100 years in age, As behaviour is controlled largely be Fe-As geochemical phases. A detailed understanding of Fe-As transformations as influenced by on site treatment is need to inform appropriate management decisions. To this end, the fate of As from discrete mineral phases was thus examined as influenced by (a) oxidative dissolution of mineral phases, (b) the abiotic reductive dissolution and (c) the influence of different organic materials and rhizosphere processes. Mineral phases investigated included Tooeleite ($Fe^{III}_6(As^{III}O_3)_4(SO_4)(OH)_4 \cdot 4H_2O$), scorodite ($Fe^{III}As^VO_4.2H_2O$) and arseno-plumbo-jarosite (Beudantite; $PbFe_3(As^VO_4)(SO_4)(OH)_6$). In this study, the solid phase transformations and speciation of Fe and As speciation were examined using X-ray diffraction, scanning and high resolution transmission electron microscopy, and extended x-ray absorption fine structure spectroscopy (EXAFS) (As and Fe *K*-edge) to identify secondary mineralogical transformation. Solid-phase transformation were accompanied by detailed aqueous phase chemistry and speciation. The presentation will detail As and Fe transformations and discuss in the context of improved decision making.

List of Abstracts (Oral Presentation)

Biological Sciences

Physical Sciences

Software Intensive Systems

Multidisciplinary Research

List of Abstracts (Poster Presentation)

Biological Sciences

Physical Sciences

Software Intensive Systems

Multidisciplinary Research

List of Full Papers

Biological Sciences

Physical Sciences

Software Intensive Systems

Multidisciplinary Research

List of Abstracts of Selected Full Papers

Biological Sciences

Physical Sciences

*Selected papers will be published in a special volume.

Abstract No: BO-01

An efficient culture medium for *in vitro* propagation of *Chrysanthemum* sp. using petals as explants

V. L. P. Amarasinghe, P. D. D. M. Panapitiya*, N. D. C. S. Leelarathne and A. I. S. Priyadharshan

Floriculture Research Center, University of Kelaniya, Sri Lanka
deshikapanapitiya@gmail.com*

Chrysanthemum is a floricultural plant with high demand all over the world. To overcome shortcomings in the supply chain due to the slow rate of propagation and severe susceptibility to virus infections, multiple shoot regeneration using tissue culture has become a successful technique for *Chrysanthemum* propagation. Although different explant types can be used for *in vitro* culturing, the number of explants that can be obtained from a single mother plant is limited. Nevertheless, the use of petals (ray florets) as explants can reduce such restrictions since a single flower/flower bud provides a large number of ray florets at a time. Therefore, the objective of the current study was to find an effective culture medium for *in vitro* propagation of *Chrysanthemum* sp. using petals (ray florets) as explants. The basal MS media supplemented with different concentrations of BAP (Benzyl Amino Purine) (1.0 - 5.0 mg/L) and NAA (Naphthalene Acetic Acid) (0.1 and 0.2 mg/L) were used as the culture media and the growth regulator free MS medium was used as the control. The pH of the media was adjusted to 5.8. Surface sterilized petals of partially bloomed flower buds were cultured in media and maintained at 26±4 °C in the culture room under a 14 h photoperiod with irradiance (20 mol/m^2/sec) provided by cool-white fluorescent lights. After 60 days, MS medium supplemented with BAP (1.00 mg/L) and NAA (0.10 mg/L) was identified as the most successful medium for shoot regeneration with 08 shoots derived from a single explant with 11 leaves per shoot. Meanwhile, MS medium supplemented with BAP (5.00 mg/L) and NAA (0.10 mg/L) was identified as the best medium for rooting with 04 roots per shoot/callus with a 7.3 cm root length. Further, media containing BAP (3.00 – 5.00 mg/L) and NAA (0.10 and 0.20 mg/L) were recognized as the media composition which can be used for both shoot and root regeneration at the same time. Even though there was a good root development, the shoot development in these media was not notable. Therefore as the conclusion, MS medium supplemented with BAP (1.00 mg/L) and NAA (0.10 mg/L) can be recommended as a successful medium for both shoot initiation and development while MS medium supplemented with BAP (5.00 mg/L) and NAA (0.10 mg/L) can be used as a successful medium for both *in vitro* root initiation and development of *in vitro* petal culturing of *Chrysanthemum.*

Keywords: BAP, *Chrysanthemum*, Micropropagation, NAA, Petal culture

Abstract No: BO-02

Molecular characterization of Sri Lankan tea [*Camellia sinensis* (L.) O. Kuntze] genotypes with diverse origins using SSR markers for future breeding programmes

J. D. Kottawa-Arachchi[1,2*], M. A. B. Ranathunga[1], R. K. Sharma[3], A. M. T. Amarakoon[4], M. T. K. Gunasekare[5], H. K. Chaudhary[2] and R. N. Attanayake[4]

[1] Plant Breeding Division, Tea Research Institute of Sri Lanka, Talawakelle, Sri Lanka
[2] Department of Genetics and Plant Breeding, Collage of Agriculture, Himachal Pradesh Agricultural University, Palampur, Himachal Pradesh, India
[3] Department of Biotechnology, Institute of Himalayan Bioresource Technology, Palampur, India
[4] Faculty of Science, University of Kelaniya, Sri Lanka
[5] Ministry of Plantations, Battaramulla, Sri Lanka
jeevan.dananjaya@gmail.com*

The tea plant [*Camellia sinensis* (L.) O. Kuntze] is one of the most popular non-alcoholic beverage crops worldwide. Tea germplasm is the most valuable and fundamental resource for breeding high yielding, climate resilient, and quality tea cultivars. Therefore, efforts were made to characterize the existing genetic diversity of Sri Lankan tea using simple sequence repeat (SSR) markers. A total of 91 tea accessions including exotic, estate selections, improved quality and diverse cultivars were selected for the diversity estimations. Eleven informative highly polymorphic SSR markers selected based on inferences of previous studies (EST, miRNA and traits associated SSR markers) were used in this study. Genetic relationships were analyzed by a neighbor-joining (NJ) tree constructed using DARwin software. Genetic structure analysis was performed by the Bayesian clustering model using STRUCTURE analysis and the optimum delta K was generated. Genetic diversity analysis grouped all the accessions into three major clusters. Further, structure analysis complemented the cluster analysis and revealed three genetic populations (China types with Korean origins, Assam types with ASM4/10 ancestral relationship and mixture of different origins) in the Sri Lankan tea germplasm. Newly recommended TRI5001, TRI5002, TRI5003 and TRI5004 cultivars have shown affinities with five Assam introductions and grouped together in the same cluster. Interestingly, five high yielding TRI developed cultivars (TRI2023, TRI2025, TRI3013, TRI3055 and TRI3073) having an ancestral relationship with the parent ASM4/10 were also grouped together. Likewise, seven accessions of Azerbaijan origin were remained together. The estate selections were scattered in the three clusters. The inferences of the current study provide molecular evidence for the genetic diversity and population structuring of the tea germpalsm and will help the selection of the potential parental group for the future cultivar development programme of Sri Lanka.

Keywords: *Camellia sinensis*, Genetic diversity, Simple sequence repeats, Tea breeding

Abstract No: BO-03

Can mangrove blue carbon help counteract climate change?
A case study in Rekawa, Sri Lanka

A. Arulnayagam[*] and J. Park

Department of Convergence Study on the Ocean Science and Technology, Korea Maritime and Ocean University, Busan, Republic of Korea
ahalya.arulnayagam@gmail.com*

Blue carbon to assist climate change has gained recent attention with increasing nature-based mitigation methods. Mangrove ecosystems with their high primary productivity, efficiently sequester carbon in their anaerobic sediment. Carbon sink function of mangrove ecosystems has been acknowledged as a potential tool in climate change mitigation. However, achieving full potential of blue carbon services of mangrove ecosystems requires evidence-based research and reporting to bridge the knowledge gaps. The present study aimed to report the blue carbon potential of mangrove ecosystems in Rekawa lagoon and its' potential contribution to mitigate climate change. Field work was conducted in December 2019, with 10m wide belt transects (n=6) laid across water-land gradient to collect data on mangrove vegetation structure and sediment organic carbon content. Mangrove species along the transect were identified, enumerated, and measured Diameter at Breast Height (DBH) for overstory trees with DBH >5cm. Sediment cores were taken along the same transect to 45cm depths and subsampled to three portions representing sediment in 15 cm intervals. Carbon in above ground plant biomass was estimated with the use of biomass based allometric equations. One portion of sediment samples with known volume was oven dried and measured for bulk density while the rest was measured for total organic carbon (TOC %) with elemental analyzer, which were later used for the calculation of sediment organic carbon (SOC). Organic carbon in plant biomass and SOC together represent total ecosystem carbon (TEC) pool. We identified 10 true mangrove species with DBH ranging from 6.0 to 13.5 cm. The site showed high plant density (18911 no. ha^{-1}) with high diversity (H'=2.03). TEC pool of the site was 209.30 ± 45.40 MgC ha^{-1}. The aboveground, belowground and SOC of the mangroves were (mean $\pm$ SD) 33.64 ± 1.05 MgC ha^{-1}, 13.12 ± 0.41 MgC ha^{-1}, and 162.50 ± 45.20 MgC ha^{-1}. SOC accounted for nearly 78% of the TEC stock. There was gradual increment in SOC stock with increasing depth. If disturbed the site can emit an average of 768.10 ± 67.90 Mg CO_2 ha^{-1}. The site is highly vulnerable to tourism development and urbanization, yet carries relatively higher amounts of carbon in their sediments. This demands for an enhanced awareness and scientific understanding for developing strategies for conservation and restoration of blue carbon pool of this mangrove ecosystem.

Keywords: Mangroves, Blue carbon, Climate change, Mitigation, Conservation

Abstract No: BO-04

Influence of *Pinus caribaea* and *Alstonia macrophylla* invasion on floristic composition of the buffer zone in Kottawa forest

M. A. Dias and R. M. C. S. Ratnayake*

Department of Plant and Molecular Biology, University of Kelaniya, Sri Lanka
ratna@kln.ac.lk*

Kottawa forest is an isolated patch of lowland rain forest and its buffer zone is threatened by invasive alien plants ((IAS). Among IAS, wind dispersed seeds of both *Alostonia macrophylla* and *Pinus caribaea* may invade the forest gaps in the core area of Kottawa forest. The present study aimed to assess the influence of IAS at the buffer zone of the Kottawa forest in relation to the floristic composition of the area. Vegetation sampling was done using randomly selected 11 plots (10 m x 20 m) representing the forest (0.14 km^2) buffer zone area. The girth at breast height (GBH), density, and frequency of plant species were enumerated. The species composition of the forest was completed by identifying the other species found outside the plots. The important value index (IVI = relative density + relative frequency + relative dominance) of species > 10 cm GBH was calculated. The percentage contribution of endemic, exotic and indigenous species to the floristic composition of the area was enumerated and it revealed that 55.1% endemic, 14.3% exotic and 30.6% native species. *Pinus caribaea, Gyrinops walla, Dillenia retusa, Artocarpus nobolis, Cinnamomum verum, Alstonia macrophylla* and *Carissa carandas* are the dominant plant species in the buffer zone. *Agrostistachys hookeri, Shorea congestiflora* and *Dipterocarpus hispidus* are the dominant endemic tree species found in the area. The most dominant species with highest relative basal area are *P. caribaea* and *Artocarpus nobolis.* the most abundant species with high relative density (11.8) is *G. walla* Both *P. caribaea* (IVI - 33.5*)* and *A. macrophylla* (IVI - 2.7) considered as IAS. The present study provides baseline information on the potential risk of *A. macrophylla* invasion and wide distribution of *P. caribaea* for native flora in Kottawa buffer zone. Therefore, the study suggests importance of managing further spread of *P. caribaea* and *A. macrophylla* in the buffer zone of the Kottawa forest with appropriate forest management practices such as assisted natural regeneration.

Keywords: Buffer zone, Floristic diversity, Kottawa forest, Vegetation sampling

Abstract No: BO-05

Importance of using coloured shade fabric in betel (*Piper betle* L.) propagation

K. K. S. Weerasinghe[1], R. G. J. Perera[1], R. P. A. Sandaruwan[1],
P. M. D. U. K. S. Senarathne[1] and J. P. Kirthisinghe[2*]

[1] Faculty of Agriculture, Aquinas College of Higher Studies, Colombo 8, Sri Lanka
[2] Postgraduate Institute of Agriculture, University of Peradeniya, Peradeniya, Sri Lanka
jpkirthi@pdn.ac.lk*

Betel (*Piper betle* L.) is an export agriculture crop and cultivated in an area of 1427 ha in Sri Lanka. The nursery period of traditional propagation method takes 3 months. Therefore, an experiment was conducted to reduce the nursery period using coloured high quality flame retardant, heavy-duty lock stitch knit black and blue coloured shade fabric made specifically for shade covers of 50% and 75% shade. The research was conducted in a grower's field at Wariyapola in the Kurunegala district, during yala season in 2019. Three nodal cuttings were taken for the experiment, from healthy orthotropic branches of high yielding mother vines of variety Maneru. The leaf which was located below the 2nd node was removed and the lowest node of the cutting was buried in the pot filled up to 15 cm with fumigated moist rooting medium. The potting medium was prepared by using equal parts of top soil, sand, cow manure and coir dust. The pots were kept for 21 days in a propagator and survival rate was 96%. Healthy plants were transferred into six treatments. Twelve pots were used for each treatment. High quality lock stitch knit black and blue coloured 50% and 75% shade fabric made specifically for shade covers were used as treatments. 50% and 75% shade coir netting was used as the control. Randomized complete block design was used for the experiment. Duncan's Multiple Range Test was used for mean separation. Shoot height, number of new leaves per cutting, shoot fresh weight, shoot dry weight, leaf temperature, number of roots, root length and root fresh weight were measured. At 75 days after planting of the cuttings in pots, the following results were obtained. The treatment with 50% blue shade was significantly different compared to the other treatments and it gave the longest shoot length of 30 ± 2.1 cm, the highest shoot fresh weight of 39.2 ± 3.3 g and the highest shoot dry weight of 5.8 ± 0.4 g. No significant difference was observed between treatments for number of new leaves per cutting, leaf temperature, number of roots, root length and root fresh weight. The results of the study concluded that 50% blue shade is better for betel propagation using three nodal cuttings, so that it is important to use 50% blue shading material in betel commercial nurseries for better growth of cuttings as it can reduce the nursery period to 75 days and the mortality rate in the field.

Keywords: Betel, Shading material, Propagation

Abstract No: BO-06

Correlation between pest gastropod occurrence and selected environmental variables in agricultural lands in the Nuwara Eliya district, Sri Lanka

K. G. D. D. Thilakarathne[1,2], K. B. Ranawana[3] and S. Kumburegama[3*]

[1]Department of Zoology, Faculty of Science, University of Ruhuna, Matara, Sri Lanka
[2]Postgraduate Institute of Science, University of Peradeniya, Peradeniya, Sri Lanka
[3]Department of Zoology, Faculty of Science, University of Peradeniya, Peradeniya, Sri Lanka
skumburegama@yahoo.com*

Many of the exotic terrestrial pest gastropods introduced to Sri Lanka, either intentionally or accidentally, are well established as pests in agricultural lands, but hardly any studies have been carried out to determine the factors affecting their occurrence. Hence, this study was conducted to determine the correlation between selected environmental factors and density of gastropod pest species in some agricultural lands in the Nuwara Eliya district. A total of 80 agricultural lands were sampled from 2017 to 2019, where each land was surveyed for pest gastropods by establishing ten 1 m^2 sampling plots for a maximum of 15 minutes/plot. Species richness and abundance were recorded in the field and species were identified at the field using available guides. Unidentified species were brought to the laboratory for further identification. Elevation, atmospheric temperature, rainfall, relative humidity and soil pH were measured using a Magellan Explorist 310 portable GPS, a Kestrel 4000nv weather tracker and a HANNA-HI-99121 electronic digital pH meter at each sampling location. Canonical correspondence analysis (CCA), Pearson's correlation and generalized linear mixed model (GLMM) in R studio were used to analyze data. The first two axis of CCA explained 85% of the total variation. Species were ordered along the first axis in the CCA primarily affected by elevation while the second axis affected by rainfall and soil pH. CCA results indicated that the measured environmental factors influencing the occurrence of the gastropod species. For example, *Deroceras laeve* (Muller, 1774), *Deroceras reticulatum* (Miller, 1774), *Milax gagates* (Draparnaaud, 1801) and *Mariella dussumieri* (Gray, 1856) were influenced by the elevation and atmospheric temperature; *Cryptozona chenui* (Pfeiffer, 1847), *Macrochlamys indica* (Godwin and Austen, 1883), *Subulina octona* (Bruguiere, 1789) and *Euplecta emiliana* (Pfeiffer, 1854) were influenced by the rainfall and soil pH; while *Allopeas gracile* (Hutton, 1834), *Leavicaulis alte* (Ferussac, 1822), *Lissachatina fulica* (Bowdich, 1822), *Cryptozona bistrialis* (Beck, 1837) and *Ratnadvipia irradians* (Pfeiffer, 1853) were influenced by the relative humidity. According to the correlation analysis, the gastropod species richness was positively correlated to the daily rainfall (r=0.34, p<0.05); the total species abundance at all the sites were positively correlated to the elevation (r=0.56, p<0.05) and negatively correlated to the atmospheric temperature (r=-0.42, p<0.05). The results of this study indicate that gastropods could become invasive and pests due to changes in climatic and environmental factors whilst causing severe economic losses to agricultural crops in the Nuwara Eliya district. Therefore, the knowledge on the effects of environmental factors, as revealed by the results of this study, can be used to formulate management plans to control the occurrence and distribution of pest gastropods in the Nuwara Eliya district.

Key words: Agricultural lands, Environmental factors, Nuwara Eliya district, Pest gastropods, Sri Lanka

Abstract No: BO-07

Morphological characterization and bioactive properties of selected legumes

W. R. K. Sovis[*] and R. A. S. P. Senanayake

Department of Plant and Molecular Biology, University of Kelaniya, Sri Lanka
soviswrk_bs15170@stu.kln.ac.lk*

Legumes are nutritionally valuable, as a source of proteins with essential amino acids, dietary fibre and complex carbohydrates while low in fat. Therefore, it is important to develop quality improved species that are resilient to climate change, tolerant to adverse abiotic & biotic factors and with high productivity, for the effective utilization of legumes as food crops. Wild relatives of crops are containing a wealth of important traits due to their adaptation to a diverse range of habitats. However, scarcity of information on phenotypic variability and phytochemical properties of these crop wild relatives have hindered the establishment of quality improved legumes. Therefore, the objective of the study was to interpret the relationships of the selected legume species of *Vigna, Phaseolus, Mucuna, Canavalia* and *Lablab* using morphological and chemical characterization and, evaluation of their antioxidant properties. Specimens of fresh plant parts of *Vigna radiata* (S: Mung, E: Green gram), *Vigna unguiculata* subsp. *sesquipedalis* (S: Polon mae, E: Asparagus bean), *Mucuna pruriens* (S: Wanduru mae, E: Velvet bean), *Phaseolus vulgaris* (S: Butter bonchi, E: Butter beans), *Phaseolus* sp., *Phaseolus lunatus* (S: Pothu dambala, E: Lima bean), *Lablab purpureus* (S: Halmassan dambala, E: Hyacinth bean) and *Canavalia ensiformis* (S: Awara, E: Jack bean) were collected from different localities, in Sri Lanka. Selected legume species were characterized using 16 qualitative and quantitative morphological descriptors. Cluster Analysis (CA) was performed to derive phenetic relationships among the species and a clear variation was observed with respect to the important phenetic traits. Total seed protein content was estimated using Lowry assay and Total Phenolic Content (TPC) of seeds was estimated using Folin Ciocalteu method while Total Flavonoid Content (TFC) was estimated by aluminum chloride colorimetric assay. 2,2-diphenyl-1-picrylhydrazyl (DPPH) free radical scavenging assay was used to evaluate the antioxidant properties of seeds. Significant difference was observed in the total protein content, TPC, TFC, and antioxidant properties of the seeds of selected legumes. *M. pruriens* exhibited a comparatively high total protein content (46.82 ± 1.58 mg/g), TPC (40.75 ± 1.74 mg GAE/100g), and TFC (11.76 ± 0.38 mg RE/g) in seeds. *L. purpureus* showed the highest mean % radical scavenging activity (91.42 ± 0.65). *M pruriens*, followed by *V. unguiculata* subsp. *sesquipedalis* contained a high amount of phenolics and flavonoids in the seeds. Findings suggests that, *M. pruriens* can be used as a good protein source in human diet due to high total protein, phenolics, flavonoid contents and antioxidant activity. However, due to heavily haired pods and pubescence plant parts *M. pruriens* is less popular among consumers as a food crop. Therefore, the derived knowledge on morphological relationships can be used in designing breeding strategies for future crop quality improvement programmes to establish cultivars with better consumer preference by eliminating non favored features.

Keywords: Legumes, Wild relatives, Morphological descriptors, Antioxidant properties

Abstract No: BO-08

Effects of *Mimosa pigra* and *Panicum maximum* extracts on the productivity of *Aloe vera*

A. R. B. W. M. C. D. Bandaranayake[*] and R. M. C. S. Ratnayake

Department of Plant and Molecular Biology, Faculty of Science, University of Kelaniya, Sri Lanka
bandaran_bs15258@stu.kln.ac.lk*

Aloe vera has a huge market demand locally and internationally for numerous uses. Organic *A. vera* farming is popular among farmers. Nutrition rich invasive alien plant species can be used for the preparation of organic liquid fertilizers (OLF). In this study, extracts of *Mimosa pigra* and *Panicum maximum,* and *Musa* fruit peels were used to prepare organic liquid fertilizer and it was conducted to evaluate the effects of three concentrations of the above organic liquid fertilizer on the growth and yield performance of *A. vera* under field conditions. Overall, there were five treatments as T1 - (0.50 g/mL of OLF), T2 – (0.75 g/mL of OLF), T3 – (1.00 g/mL of OLF) with TC (control – no fertilizer), and TS (standard – used cow dung, the typical fertilizer applied by farmers for *A. vera*). The pots were filled with a soil medium that contained sand, garden soil and compost (3:1:1 ratio). *A. vera* plants were placed under the shade of *Gliricidia sepium* to provide partial shade conditions. The growth and yield parameters of *A. vera* plants measured were plant height, leaf length, leaf width, leaf thickness, the volume of leaves, number of leaves, number of offsets, fresh weight of leaves, fresh gel weight of leaves, and percentage of gel recovery. Data were collected four months after transplantation and the data were statistically analyzed using one–way ANOVA. The T2 showed the significantly highest growth performances: length of leaves (26.34±2.21 cm), the volume of leaves (14.76 cm^3±3.37), fresh weight of leaves (33.80±4.55 g/plant), fresh gel weight of leaves (24.40±4.50 g/plant), and percentage of gel recovery (67.90% ±5.57) of *A. vera* (One–way ANOVA). These values significantly differed from TC and growth performance higher in *A. vera* with the application of all concentrations of organic liquid fertilizer compared to TS that used by farmers. Since T2 resulted in the highest performance for the economically important growth parameters of *A. vera,* the study revealed that it is the best cultivation practice for *A. vera*. The results have confirmed that *M. pigra* and *P. maximum* can be used for the formulation of organic liquid fertilizer for effective growth of *Aloe vera* as an eco-friendly, low-cost organic liquid fertilizer for the growers.

Keywords: *Aloe vera*, Growth and yield, Invasive alien plant species, Organic liquid fertilizer

Abstract No: BO-09

Evidence for translocation of Weligama Coconut Leaf Wilt Disease (WCLWD) causing phytoplasma through phloem tissues and systemic infection in affected coconut palms

P. H. P. R. De Silva[1], S. A. C. N. Perera[2] and K. P. R. N. Attanayake[3*]

[1]Crop Protection Division, Coconut Research Institute, Lunuwila, Sri Lanka
[2]Department of Agricultural Biology, Faculty of Agriculture, University of Peradeniya, Peradeniya, Sri Lanka
[3]Deptartment of Plant and Molecular Biology, Faculty of Science, University of Kelaniya, Kelaniya, Sri Lanka
renuka@kln.ac.lk*

Weligama Coconut Leaf Wilt Disease (WCLWD) is currently, the most threatening coconut disease especially in Southern Sri Lanka. The pathogen causing WCLWD has been identified as *Candidatus* phytoplasma, which also causes Sugarcane White Leaf or Grassy Shoot disease. Phytoplasma moves through phloem sieve tubes and accumulate in sink tissues. As all phytoplasma are vector transmitted, the primary infection sites are the young leaves. The objectives of this study were to determine the movement of phytoplasma within the WCLWD affected coconut palms and confirm the systemic nature of the infection. Six mild to moderate symptomatic WCLWD coconut palms were selected from a disease-affected site at the Weligama area for tissue sampling. Bud leaves, young inflorescences and root tissues were sampled at each of the two sampling rounds done at one-year interval. All together 12 each of bud leaves, young inflorescences and root samples were subjected to nested PCR using previously published phytoplasma specific universal primers targeting 16S rRNA region after extracting genomic DNA. Out of the total samples tested, PCR was positive for 83% of bud leaves, 25% of young inflorescences and 8% of root tissue samples. Selected positive PCR products of 880 bp size were subjected to Sanger sequencing and BLASTn search results re-confirmed the presence of "Sugarcane White Leaf" or "Sugarcane Grassy Shoot" disease phytoplasma, which was previously identified as the causal agent of WCLWD in all three types of tissues tested with 99-100% similarity. All the sequences obtained from the current study were mostly identical to each other (MZ822428 and MZ822429). The presence of phytoplasma in young inflorescences and root tissues confirmed the movement of phytoplasma from the bud leaf to the other parts of the WCLWD affected coconut palms confirming the systemic nature of the pathogen. Findings of this study is important in planning disease management strategies.

Keywords: Coconut, Nested PCR, Phytoplasma, WCLWD

Abstract No: BO-10

Allelopathic effects of *Prosopis juliflora* (Sw.) Dc. on selected crops and native plants

J. A. C. P. Jayasinghe[*] and R. M. C. S. Ratnayake

Department of Plant and molecular Biology, University of Kelaniya, Kelaniya, Sri Lanka
chathu1995jaya@email.com[*]

Allelopathic effects of exotic plant species in natural and agricultural ecosystems have received increasing attention because of their negative impacts on native plant growth and reduction of crops yields. It was hypothesized that leaf extracts of *P. juliflora* have allelochemicals that could inhibit seed germination and seedling growth of the selected plants. The objective of the study was to investigate the allelopathic effects of the *Prosopis juliflora* leaves on seed germination and seedling growth of selected crops (*Eleusine coracana, Vigna radiata*) and native plants (*Manilkara hexandra, Calophyllum inophyllum*). The stock extract ($100 \, gL^{-1}$) was prepared from *P. juliflora* leaves collected from Bundala National Park after five days of digestion in deionized water. The stock solution was used to prepare dilution series for applications ($10.0 \, gL^{-1}$, $25.0 \, gL^{-1}$, $50.0 \, gL^{-1}$, and $75.0 \, gL^{-1}$). The above concentrations of *P. juliflora* leaf extracts were separately tested for percentage seed germination, shoot lengths, root lengths, and seedling growth of the selected plant species with distilled water as the control. Seed germination percentages, root lengths, and shoot lengths results of the test species were analyzed using One-way ANOVA followed by Tukey's test at $p=005$. The findings indicate that with the increasing concentration of *P. juliflora* leaf extracts, seed germination and seedling growth of *E. coracana, V. radiata* were significantly reduced. The negative effects were more visible in *E. coracana* than *V. radiata*. The lowest germination percentage of *E. coracana* (0.0 %) was observed when seeds were treated with $100 \, gL^{-1}$ and $75 \, gL^{-1}$ and *C. inophyllum* seeds were also not germinated in those concentrations. *Manilkara hexandra* seeds were not germinated in all concentrations of *P. juliflora* leaf extracts. Allelopathy was concentration-dependent and with increasing concentration of *P. juliflora* leaf extract, seed germination and seedling growth of *C. inophyllum* significantly reduced (One-way Anova, $p=0.05$). Hence it showed that *Prosopis juliflora* aqueous leaf extracts have an allelopathic effects on the seed germination and seedling growth of the selected crops and the native plants. Therefore, allelopathic effects of the aqueous leaf extracts *P. juliflora* need to consider in forest management and agriculture.

Keywords: *Prosopis juliflora*, Allelopathy, Seed germination, Seedling growth

Abstract No: BO-11

Potential of potassium polyacrylate polymer and shrimp pond sludge for enhancing water retention capacity of sandy regosols

W. A. K. P. Wijayasinghe[*] and H. M. I. K. Herath

Department of Plantation Management, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka, Makandura, Gonawila (NWP), 60170, Sri Lanka
k.wijayasinghe@gmail.com*

Water retention in soil is vital for the uninterrupted supply of essential nutrients to the plants. Materials that enhance moisture retention in soil are becoming scarce with the present climate change. Sandy regosols is a highly permeable soil type with less water retention capacity (WCR). This study attempts to evaluate the amendment of shrimp pond sludge (SPS) which is a waste material, and potassium polyacrylate which is a super absorbent polymer (SAP) on the water retention capacity of sandy regosols. The treatments were T1 – Control with no added amendments, T2 – Soil with SAP applied at the rate of 0.2 %, T3 – Soil with SAP applied at the rate of 0.4 %, T4 – Soil with SPS applied at the rate of 10 %, T5 – Soil with SPS applied at the rate of 20 %. All the treatments each with three replicates were arranged in a completely randomized design. The WRC was evaluated on a weight gain basis. A microbial growth assay was done to evaluate the effect of these amendments on soil microorganisms. Analysis of variance (ANOVA) was used to analyze the data using R statistical software (version 3.2.4). Initial analysis of soil indicated the organic matter content of this soil is as low as 0.3% which indicates an extremely poor contribution from organic matter content for its WRC and the Initial WRC was 28.9%. Significantly high WRC was shown in 0.4% of SAP amended soil throughout the experiment, while the lowest was shown in the control. The WRC of the treatment of SAP added at the rate of 0.4% soil has been increased to a level of 36.12% which was a 29% increment compared to the control. WRC of the shrimp pond sludge added treatment has been increased by 8% compared to control. There was no significant difference in the microbial population of SAP and SPS amended soils. The results indicate the potential of using SAP and SPS to enhance the water retention capacity in soil.

Keywords: Shrimp pond sludge, Super absorbent polymer, Water retention capacity

Abstract No: BO-12

Investigating the competitive ability of endemic *Osbeckia octandra* with its co-occurrence with invasive *Sphagneticola trilobata* and native weed, *Urena lobata*

N. L. A. Prabodani[*] and M. T. R. Fernando

Department of Plant and Molecular Biology, Faculty of Science, University of Kelaniya, Sri Lanka
prabodan_bs15249@stu.kln.ac.lk*

In Sri Lanka, *Osbeckia octandra* (L) DC. is a widely used valuable endemic herb in Ayurvedic medicine, popular natural remedy among Sri Lankans and an important pollinator plant. Their local populations are disappearing rapidly due to various anthropogenic activities. Further, local roadside habitats of some *O. octandra* populations are under the threat of invasion by several exotic and native weedy species. When the competition exerted by those competitively superior invasive and weedy species become severe, *O. octandra* populations can be threatened for extinction. Thus, the present study was carried out to investigate the competitive ability of *O. octandra* with its co-occurring exotic invasive *Sphagneticola trilobata* (L.) and native weedy *Urena lobata* (L.) species under soil water and nutrient gradients. Pot experiments were conducted with *O. octandra* monocultures as controls and *O. octandra* mixed-cultures with either *S. trilobata* or *U. lobata* as experimental pots to study the inter-specific competition for soil nutrients under three different nutrient levels (low, moderate and high) and for soil water, under two different water availabilities (well-watered and water-stressed). One set of 12 pots (4 pots of *O. octandra*/*S. trilobata*; 1:1 pots+ 4 pots of *O. octandra*/*U. lobata* 1:1 pots+ 4 pots of control pots) was prepared for every assigned nutrient and watering condition. After a five-month experimental period, the mean values of final plant heights, fresh weights, above and below ground dry biomasses of *O. octandra* plants were recorded and obtained data were analyzed by Analysis of Variance (Two-way ANOVA, $P < 0.05$) and Tukey's pairwise comparison using the MINITAB 17 statistical software. According to the results, *O. octandra* plants in monocultures have performed better than the *O. octandra* from mixed cultures under all the tested different nutrient and water availability conditions, indicating that invasive *S. trilobata* and weedy *U. lobata* have significantly higher competitive abilities over endemic *O. octandra* along with the soil nutrient and water continua ($P < 0.05$). Having significantly lower root biomass of *O. octandra* in mixed cultures compared to the monoculture under low nutrient condition ($P < 0.05$), revealed that *O. octandra* has a low phenotypic plasticity. Also, our results revealed that non-invasive *U. lobata* was equally competitive as invasive *S. trilobata* against *O. octandra* under different soil nutrient conditions. Moreover, *S. trilobata* exerted a significantly higher competition than by *U. lobata* on *O. octandra* under well-watered condition ($P < 0.05$), while under water stressed condition *U. lobata* exerted a significantly higher competition than by *S. trilobata* ($P < 0.05$). Our results clearly shown, that the native weedy *U. lobata* has a potential to become invasive locally as *S. trilobata* in future, and suppress the growth of native, less competitive flora. Thus, further studies on invasiveness of native weedy species on endemic species will be needed to investigate.

Keywords: Competitive ability, Endemic, Invasive species, Weedy

Abstract No: BO-13

Antimicrobial activity of selected plant extracts against *Salmonella typhi* and *Escherichia coli* and their phytochemical screening

W. M. A. N. Wijekoon[1], S. M. D. S. Gayathri[1], P. G. I. Dias[1*], N. G. D. Anuradha[1], T. C. Kananke[1], R. M. K. T. Rathnayaka[1], M. G. A. N. Perera[1], R. S. Sabaragamuwa[1], M. N. Wickramaratne[2] and R. M. U. S. K. Rathnayaka[1]

[1]Faculty of Applied Sciences, Sabaragamuwa University of Sri Lanka, Sri Lanka
[2]Faculty of Medicine, Sabaragamuwa University of Sri Lanka, Sri Lanka
gayanidias.d11@gmail.com*

Salmonella typhi and *Escherichia coli* are foodborne pathogens that cause food poisoning, various infections, and sepsis. Emergence of microbial resistance to currently available antibiotics creates a notable curiosity to find novel antibacterial drugs or complementary medicines. *Olax zeylanica* L. (Mella), *Phyllanthus debilis* (Ela pitawakka), *Osbeckia octandra* (Heen bowitiya) and *Artocarpus heterophyllus* (Kos) leaves are edible remedies used by local villagers. All four plants are abundantly utilized in ayurvedic medicine against different ailments. This study aims to evaluate the antimicrobial activity and screen the phytochemicals in these plant leaves. Initially, methanol and ethanol leaf extracts were prepared and then they were concentrated using the rotary evaporator. Antibacterial activity of the plant extracts (10 mg/ml) against *S. typhi* and *E. coli* was evaluated using the well diffusion method (40 μl/well) in Mueller Hinton agar and replicated thrice. Positive (Ciprofloxacin) and negative controls (ethanol and methanol) were also tested. The size of the microbial inoculum was adjusted to the cell count of 6.0×10^8 CFU/ml, approximately using the McFarland standard. Preliminary phytochemical screening was conducted for flavonoids, saponins, steroids, tannins, and terpenoids using standard techniques. Statistical analysis was conducted using two-way ANOVA and Fisher LSD method. The highest average diameter of the inhibitory zone against *E. coli* was recorded for the methanol extract of *O. zeylanica* (0.94 ± 0.02 mm) while the lowest was for *A. heterophyllus* ethanol extract (0.68 ± 0.02 mm). The methanol extract of *P. debilis* showed the highest average diameter of the inhibitory zone (1.79 ± 0.08 mm) against *S. typhi* while *O. zeylanica* ethanol extract showed the lowest diameter (0.59 ± 0.03 mm). The diameters were significantly different ($P<0.05$) among the four plants and different extract types of the same plant. Tannin was detected in *O. octandra*, *A. heterophyllus* and *P. debilis*. Saponin was detected only in *O. zeylanica*. Terpenoids were detected in all other plants except in *P. debilis*. Further analysis with more advance tests is needed to confirm the presence and quantity of phytochemicals with higher accuracy. Since all plants exhibited antibacterial activities, identification of the specific chemical compounds responsible is important for synthesizing plant-based antimicrobials.

Keywords: Antimicrobial, *Escherichia coli*, Phytochemicals, Plant extracts, *Salmonella typhi*

Abstract No: BO-14

Macrobenthic diversity and their potential as bio-indicators in some urban reservoirs in the Western province, Sri Lanka

G. A. C. D. Perera and W. U. Chandrasekara*

Department of Zoology and Environmental Management, University of Kelaniya, Kelaniya, Sri Lanka
upali@kln.ac.lk*

Studies addressing the macrobenthic diversity and their potential as bio-indicators in water quality assessment programmes are scarce in Sri Lanka. In this study, we investigated the macrobenthic diversity in relation to water quality parameters in some urban reservoirs in the Western province in Sri Lanka, and assessed their potential as bio-indicators in water quality assessment programmes. The reservoirs selected for the study were the Ihalagama tank, Peralanda tank, Kesbewa tank, Boralesgamuwa tank, Bolgoda Lake, and the Beira Lake. The abundance of macrobenthic faunas at randomly selected locations (n=9) in each reservoir, and the water quality parameters *viz* temperature, pH, conductivity, total dissolved solids, BOD_5, dissolved nitrates, total dissolved phosphates and alkalinity of the overlying water at each location were measured using standard data collection methods between July, 2020 to January, 2021. The species richness (SR), species heterogeneity (H') and species evenness (J) for the macrobenthic fauna in each reservior were calculated, and the abundance and water quality data were analyzed using ANOVA and PCA as appropriate. Altogether, thirteen macrobenthic taxa namely, *Glyphidrilus* sp., *Limnodrilus socialis*, *Dero* sp., *Stratiomyd* larva, Chironomid larva, *Bellamya* sp., *Melanoides tuberculata*, *Gyraulus* sp., *Lymnaea* sp., *Paludomus* sp., *Thiara* sp., *Ancylus* sp., and *Mesostoma* sp. were recorded from the six reservoirs. The tubificid worm *L. socialis* dominated in all the sediment samples and accounted for more than 94.7% of the total macrobenthic abundance where the highest relative abundance of this species was recorded at the Beira Lake (99.3%). The species richness of the macrobenthic community was the highest at the Ihalagama and Kesbewa tanks (SR=5), while it was the lowest at the Peralanda tank (SR=2). Since the benthic community was mainly dominated by *L. socialis*, the lowest species heterogeneity as well as the species evenness values were recorded at the Beira Lake (H' = 0.05; J = 0.03). Further, the water quality parameters varied among the selected reservoirs, where the Beira Lake registered significantly high BOD_5, dissolved nitrates, and total dissolved phosphates (p<0.05) than the other reservoirs, indicating a higher degree of eutrophication. In addition, the SR, J, and the H' in the studied reservoirs decreased with the increasing levels of BOD_5, dissolved nitrates, and total dissolved phosphates. Therefore, it was concluded that the abundance and diversity of macrobenthic faunas are primarily governed by water quality parameters, and the tubificid worm *L. socialis* can be used as a potential bio-indicator organism in water quality assessment programmes in urban reservoirs.

Keywords: Bio-indicators, Eutrophication, *Limnodrilus socialis,* Macrobenthos, Water quality parameters

Abstract No: BO-15

Avian diversity in some human-altered landscapes in the Gampaha district, Sri Lanka

M. P. Liyanage and W. U. Chandrasekara[*]

Department of Zoology & Environmental Management, University of Kelaniya, Kelaniya, Sri Lanka
upali@kln.ac.lk*

Although diversity and distribution of avifauna have been mostly studied in and around undisturbed and protected areas in Sri Lanka, there is a dearth of studies in human-altered landscapes. The present study, therefore, was carried out to investigate the variation of avifaunal diversity in some human-altered landscapes *viz* garbage dump site (Manelgama village), town area (Kiribathgoda town), coconut cultivation (Gonahena village), paddy field (Weboda village), rubber cultivation (Embaraluwa village), and a fish landing site and market (Negombo town) in the Gampaha district in Sri Lanka. Birds present at each selected landscape were identified and counted following the fixed-radius point count method (n=4 each) between 0700 hrs – 0800 hrs from August 2020 to March 2021. The degree of landscape alteration of each site was measured in terms of the number of buildings, tall trees (5m<), fruit trees, power line posts, TV antennas/disks and sound level concurrent to bird counting. The species richness (SR), species heterogeneity (H') and species evenness (J) of the avifaunal communities in each landscape were calculated. Data on the avifaunal abundance and the degree of landscape alteration were analysed using ANOVA and PCA as appropriate. Altogether, a total of 1126 bird counts were recorded, and the birds belonged into 26 different species. Although characterized by low avian heterogeneity and low species richness, the total abundance of birds was high at highly altered landscapes *viz* garbage dumpsite (n=566; SR=9; H'=1.23), fish market (n=276; SR=8; H'=0.90), and the town area (n=119; SR=5; H'=0.96). The house crow (*Corvus splendens*), intermediate egret (*Mesophoyx intermedia*) and the rock pigeon (*Columba livia*) dominated the six sites with the relative abundances of 33.04%, 28.69% and 18.65%, respectively. It was also found that the abundance of these three bird species were significantly high in the above highly altered landscapes (p<0.05). In contrast, the paddy field recorded the highest H' (2.5), SR (16) and the J (0.90) values. The H', J and the SR of the avian communities were also found to be negatively correlated with the degree of habitat alterations in a way that the avifaunal diversity measures decreased with the increasing habitat alterations by anthropogenic activities. Further, the more tolerant and generalist avian feeders such as house crow, intermediate egret, and rock pigeon can be regarded as bio-indicator species in human-altered landscapes.

Keywords: Avian diversity, *House crow,* Human-altered landscapes, Intermediate egret, Rock pigeon

Abstract No: BO-16

Caspase 3/7 activation during apoptotic cell death of human Rhabdomyosarcoma (RMS) and breast adenocarcinoma (MCF-7) cells induced by different fractions of *Chnoospora minima*

M. D. T. L. Gunathilaka[1], K. W. Samarakoon[3], P. Ranasinghe[2] and L. C. D. 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 a source for the development of anti-cancer drugs. Apoptosis is a form of programmed cell death involved with the elimination of unwanted cells from the body. Among different mechanisms of apoptosis, caspases are a family of protease enzymes playing an essential role in apoptosis. Therefore, the present study was aimed to determine the caspase 3/7 activation in human rhabdomyosarcoma (RMS) and breast adenocarcinoma (MCF-7) cells following treatment with hexane and chloroform fractions of the seaweed species *Chnoospora minima*. The apo-one homogenous caspase 3/7 activity of treated cells was evaluated according to the manufacturer`s instructions (G7790, Promega, USA). Polysaccharide depleted polyphenol-rich methanol extract was sequentially partitioned with hexane, chloroform, and ethyl acetate to determine the cytotoxic activity. Based on the results, hexane and chloroform fractions of *C.minima* were selected to determine the caspase 3/7 activation of human RMS and MCF-7 cells. The caspase 3/7 activation was quantified by relative flurescence unit (RFU). The chloroform fraction ($RFU_{4\ hrs}$:3932.9) of *C.minima* showed prominent activation of caspase 3/7 in RMS cells after 4 h of caspase treatment more than the hexane fraction ($RFU_{4\ hrs}$:2556.6) compared to the standard Staurosporine ($RFU_{4\ hrs}$:3417.5) and cycloheximide ($RFU_{4\ hrs}$:2950.5). In contrast, hexane ($RFU_{3\ hrs}$:1496.9) and chloroform ($RFU_{3\ hrs}$:1464.7) fractions treated MCF-7 cells showed low caspase 3/7 activation, and the highest activity was observed after 3 h of caspase treatment. Hence, it can be concluded that the hexane and chloroform fractions of *C.minima* induce apoptosis in RMS cells more prominently via the caspase 3/7 pathway compared to the MCF-7 cells. Therefore, further studies should be conducted to confirm the activity of caspase 3 and 7 via gene expression analysis.

Keywords: Anti-cancer, RMS, MCF-7, *Chnoospora minima*, Caspase 3/7

Abstract No: BO-17

Status of cattle gastrointestinal parasitism and associated risk factors in Kilinochchi district, Sri Lanka

S. Luxsika* and S. Piratheepan

Department of Animal Science, Faculty of Agriculture, University of Jaffna, Sri Lanka
luxsikasri@gamil.com*

Kilinochchi district is situated in the Northern part of Sri Lanka and the people there traditionally practice livestock and crop integrated farming. This district has a high potential for livestock integrated crop farming practices hence this sector is considered as a major source of income for the farming community. Gastrointestinal parasitism is a condition caused by gastrointestinal parasites, and is a major impediment to livestock production. A cross-sectional study was carried out to quantify the risk factors (age, breed, rearing system, grazing system, deworming and frequency of deworming) associated with gastrointestinal parasitism in cattle in the Kilinochchi district from January 2020 to July 2020. For this study, a total of 106 cattle were selected from four veterinary divisions in the Kilinochchi district. Fecal samples were collected and coprological examinations were done by using standard flotation and sedimentation techniques, and questionnaire survey was conducted with the farmers. The overall prevalence of gastrointestinal parasitic infestation was 89% (n=90). Based on the result of fecal examination and data analyzed from questionnaire survey there was a significant difference between age, breed, rearing system, grazing system, deworming, and frequency of deworming with the prevalence of gastrointestinal parasites ($p<0.05$). Infestation in elderly cattle (>6yrs) was found to be high (33%) compared to the young cattle. The local breed (36%) had a higher infestation level than crossbreed (64%). The highest infestation level was observed in crop-livestock integrated farming systems (67%) and semi-intensive farming systems (62%). Female (78%) cattle were more infected than the male cattle (28%). In this study area, only 68% (n=50) of the farmers were found practicing deworming their cattle; among these cattle, 49% were infected by gastrointestinal parasites. However these cattle were dewormed at different time intervals so that the highest infestation level was observed in cattle that were dewormed at a one-year time interval (33%). Nearly 32% of the farmers were not practicing deworming. Further, most of the cattle in the semi intensive and crop–livestock farming systems were found to be infected by gastrointestinal parasites.

Keywords: Gastrointestinal parasites, Coprological examination, Floatation and sedimentation techniques

Abstract No: BO-18

Infestation and emergence of *Bactrocera dorsalis* (Diptera: Tephritidae) on two varieties of *Mangifera indica* from selected locations in the wet and dry zones of Sri Lanka

W. M. C. D. Wijekoon[1*], G. A. S. M. Ganehiarachchi[2], H. C. E. Wegiriya[1] and S. P. Vidanage[2]

[1]Department of Zoology, University of Ruhuna, Sri Lanka
[2]Department of Zoology and Environmental Management, University of Kelaniya, Sri Lanka
chandanadammika1984@gmail.com*

Bactrocera dorsalis Hendel, (Diptera: Tephritidae) is one of the most serious fruit pests in Sri Lanka. There has been a dearth of documented records of infestation and damages of fruit flies on commercially important fruit varieties in the country. Hence, the present study aims to estimate the percentages of infestations and emergence of *B. dorsalis* on two commercially important mango varieties grown in the wet zone and dry zone in Sri Lanka. The study was conducted from September 2020 to February 2021 in Ratnapura and Embilipitiya. Ratnapura was selected as the study site in the wet zone and Embilipitiya was selected as the study site in the dry zone. In each site, two sub sampling sites were selected. Twenty ripened fruits (per variety) of Willard (Wld) and Karutha kolomban (Kc) were collected randomly from selected trees. Sampling was done once a month and fruits which have already fallen to the ground were collected. Collected fruits were observed for signs of fruit fly infestations by examining fresh oviposition marks visually using a hand lens. Fruits with confirmed infestations were placed in plastic containers with pre-sterilized sand and muslin cloth cover (storing four fruits; same variety, $\approx$ weight, temperature: 25^0 C, RH: 75-85 %) until the emergence of adults. After fifteen days, the average number of adults that emerged per fruit per location was calculated. Two indices; percentage infestations and adult fly emergence were calculated. Mean weight (g) (mean $\pm$ SE) of mango fruits used for the study were (127.47 ± 9.05) g and (203.65 ± 9.5) g for Wld and Kc respectively. The percentages of average infestation were 35% for Wld in dry zone and 30% in wet zone, and for Kc, 24% in dry zone and 20% in wet zone. For both varieties, comparatively high percentage infestations recorded from the dry zone site than that of the wet zone site ($p > 0.05$). The slightly high infestations for both Wld and Kc observed from dry zone site were in October 2020 and February in 2021 (during the season). The average number of adults that emerged per variety was (3.33 ± 0.73) for Wld and (3.83 ± 0.93) for Kc. The average adult emergence significantly varied between dry zone (4.25 ± 1.0) and wet zone (2.92 ± 0.57) sites ($p < 0.05$). This study provides baseline information of infestation and emergence of *B. dorsalis* adults on two commercially important mango varieties in Sri Lanka.

Keywords: *Bactrocera dorsalis*, Infested damage, Adult fly emergence, Mango varieties, Bio-climatic localities

Abstract No: BO-19

Quantifying the environmental impact on coconut cultivation in the low country intermediate zone of Sri Lanka

H. M. T. N. Hansamali and H. M. I. K. Herath*

Department of Plantation Management, Faculty of Agriculture and Plantation Management,
Wayamba University of Sri Lanka
indikaherath@wyb.ac.lk*

Among the critical environmental impacts, the effect on climate change in terms of carbon dioxide emission and the impact on water resources in terms of net water recharge are of paramount importance. Environmental impact indicators provide information to comprehend the extent of the impact on the environment. Eco-verification of agricultural production using environmental indicators is important for understanding its sustainability and to claim premium prices for agricultural products. Among the plantation crops grown in Sri Lanka, coconut is the most widely grown crop with strong social, cultural, and economic ties to the Sri Lankan people. The present study attempts to quantify the environmental impact of coconut cultivations in the low country intermediate zone in Sri Lanka. The impact was objectively evaluated using Combined Environmental Impact Indicator (CEII) which consists of two indices, i.e. Carbon Sequestration Index (CSI) and Water Recharge Potential (WRP). CSI was calculated by determining the total carbon sequestration and dividing it by the total carbon emission by the plantation. Total carbon sequestration of coconut plantations in the intermediate zone was 26.39t C ha^{-1}yr^{-1}. Based on previous findings, the average total carbon emission of coconut plantations has been calculated to be 0.1176t C ha^{-1}yr^{-1} in the intermediate zone. Therefore, the CSI was calculated as 224.24 and the scale score was 3 for CSI, which indicates a significant positive impact in terms of carbon sequestration. (CSI<0 scored as -2; significant negative impact, 0<CSI<1 scored as -1; negative impact, CSI=1 scored as 0; no impact, 1<CSI≤100 scored as 1; some positive impact, 100<CSI≤200 scored as 2; positive impact, 200<CSI≤300 scored as 3; significant positive impact). WRP was calculated by determining the drainage, and taking the ratio of drainage and the rainfall in the considered area. According to the previous studies the drainage was indirectly estimated to 1171 mm yr^{-1} and the average rainfall was quantified to 1701 mm yr^{-1} for the intermediate zone. Therefore, the water recharge potential of coconut plantations was quantified as 0.68 and the scale score was 1 for WRP, which indicates a positive impact on groundwater recharge in the scale of 0≤WRP<0.2 scored as -2; significant negative impact, 0.2≤WRP<0.4 scored as -1; negative impact, 0.4≤WRP< 0.6 scored as 0; no impact, 0.6≤WRP<0.8 scored as 1; positive impact, and 0.8≤WRP<1 scored as 2; significant positive impact. Finally, the CEII was developed by adding the CSI and the WRP together. Therefore, the CEII was quantified as 4 (CSI=3, WRP=1), which indicates a significant positive impact on the environment. These results could be considered as the first approximations of impact assessment of coconut plantations in the intermediate zone, and further verification is needed for other regions.

Keywords: Carbon sequestration index, Coconut, Environmental impact indicator, Groundwater recharge

Abstract No: BO-20

Herbicidal properties of invasive alien plants *Dillenia suffruticosa* and *Prosopis juliflora* against *Brassica juncea* and *Pennisetum polystachion*

W. D. D. Kaushalya[1], N. C. Bandara[2], J. W. Damunupola[3], H. M. S. P. Madawala[3],
K. M. G. G. Jayasuriya[3], D. S. A. Wijesundara[4] and B. M. R. Bandara[2,5*]

[1]Department of Environmental and Industrial Sciences, University of Peradeniya, Peradeniya, Sri Lanka
[2]Postgraduate Institute of Science, University of Peradeniya, Peradeniya, Sri Lanka
[3]Department of Botany, University of Peradeniya, Peradeniya, Sri Lanka
[4]National Institute of Fundamental Studies, Hantana, Kandy, Sri Lanka
[5]Department of Chemistry, University of Peradeniya, Peradeniya, Sri Lanka
bmrbandara@gmail.com*

Synthetic pesticides can cause deleterious effects on human health and the environment. The rapid spread of invasive alien plants (IAPs) threatens biodiversity and the natural and semi-natural ecosystems. A strategy to address these problems is to develop eco-friendly plant-based pesticides from IAPs. In this study, the two IAPs, *Dillenia suffruticosa* (Griff.) Martelli. and *Prosopis juliflora* (Sw.) DC., were evaluated for their herbicidal properties against *Brassica juncea* (L.) Czern. (*Bj*) and *Pennisetum polystachion* (L.) Schult. (*Pp*). The dry leaf powders of IAPs, were separately extracted into dichloromethane-methanol (1:1) using a bottle extractor. The leaf powders and the concentrated leaf extracts were assayed for their inhibitory effects on seed germination and early seedling growth (shoot length, root length and biomass) of *Bj* and *Pp* using a Petri dish assay; 2-methyl-4-chlorophenoxyacetic acid (MCPA) and glufosinate were used as positive controls and distilled water and aqueous dimethyl sulfoxide as negative controls. Each treatment was done on 25 seeds in four replicates, in three trials. The IC_{50} values of the leaf powders and extracts expressed in equivalent amount of leaf powder for the inhibition of seed germination of *Bj* and *Pp* were as follows: 3.70 ± 0.38 and 3.10 ± 0.52 mg cm^{-2} (*D. suffruticosa* leaf powder against *Bj* and *Pp*, respectively); 1.55 ± 0.05 and 0.23 ± 0.06 mg cm^{-2} (*P. juliflora* leaf powder against *Bj* and *Pp*, respectively); 1.47 ± 0.07 mg cm^{-2} (*D. suffruticosa* leaf extract against *Bj*); 1.19 ± 0.53 mg cm^{-2} (*P. juliflora* leaf extract against *Bj*). Both IAPs were more effective on *Pp* than *Bj* (ANOVA, F = 70, p < 0.001). According to the results of the Kruskal-Wallis test, the leaf powders of *P. juliflora* (at 3.52 mg cm^{-2}, $\chi^2 = 25.7$, p < 0.001) and *D. suffruticosa* (at 17.62 mg cm^{-2}, $\chi^2 = 24.3$, p < 0.001) and the leaf extracts of *P. juliflora* (at 5.56 mg cm^{-2}, $\chi^2 = 26.2$, p < 0.001) and *D. suffruticosa* (at 8.27 mg cm^{-2}, $\chi^2 = 25.6$, p < 0.001) displayed more potent inhibitory effects on seed germination than glufosinate (at 4.4 μg cm^{-2}) and MCPA (at 10.6 μg cm^{-2}). Growth parameters of *Bj* and *Pp* decreased with increasing concentrations of leaf powders and extracts of IAPs (one-way ANOVA, p < 0.05). The leaves of *P. juliflora* and *D. suffruticosa* can be exploited to develop eco-friendly herbicides.

Keywords: *Dillenia sufftruticosa*, Herbicidal activity, *Prosopis juliflora*

Abstract No: BO-21

Development and characterization of biodegradable films of cornstarch filled with methylcellulose and gelatin

W. R. A. D. S. Ranasinghe[1], C. K. Jayasuriya[1] and J. K. Premachandra[2]*

[1]Department of Chemistry, University of Kelaniya, Sri Lanka
[2]Department of Chemical and Process Engineering, University of Moratuwa, Sri Lanka
jagath@uom.lk*

Synthetic plastics play a vital role in many applications such as packaging, electrical, electronics, medical, textiles, furniture, and structural applications due to desirable properties like lightweight, high strength, flexibility, and chemical inertness. However, when the products made from many synthetic plastics are discarded to the natural environment it takes a very long time for degradation. This results in environmental pollution. Therefore, the use of biodegradable plastics in place of non-degradable plastics has gained significant interest as one of the main plastic waste management methods. However, biodegradable plastics such as starch and Polylactic acid do not show desired mechanical properties. In this research, it was expected to synthesize biodegradable films with improved mechanical properties using cornstarch (CS) filled with methylcellulose (MC). Microcrystalline cellulose (MCC) was extracted from cotton fibers through alkali treatment and bleaching, followed by sulphuric acid hydrolysis. Then, MCC was converted to MC using dimethyl sulfate in the presence of acetone as the solvent. This conversion was analyzed by Fourier transform infrared spectroscopy (FTIR). Their FTIR spectra showed significant differences in the regions 2960-3650 cm^{-1}, 2780-2950 cm^{-1}, and 960-1160 cm^{-1}, which indicates that the conversion has occurred. The degree of substitution of the methyl group for H in MCC was determined by an acid-base titration and the resulting value was 1.36 ± 0.02. Then, an aqueous solution of MC (0.5 g/100 mL) was prepared. In the presence of water, CS (4% w/v) was dissolved in different amounts of the prepared MC solution in order to have six solutions with the ratio of MC to CS as 0.00%, 0.625%, 1.25%, 3.125%, 6.125%, 12.125% (w/w). Acetic acid (1% v/v) was added to all these solutions. Afterwards, two series of solutions, series 1 and 2, were prepared by mixing 1% and 2% (v/v) of glycerol, respectively, into the resulting solutions. Similarly, the third series was prepared by mixing glycerol (1% v/v) and gelatin (1% w/v). Three series of films were prepared using these solutions following the casting method. The dried films were characterized on physical, chemical, mechanical, and thermal properties. The film with 0.625% (w/w) MC in series 3, showed the highest tensile strength of 14.06 MPa. Films with MC-1.25% (w/w) in each series showed the lowest water absorptivity, swelling, and solubility properties. All the films produced were transparent. The films tend to twist and swell when treated with chemicals such as NaOH, HCl, NaCl, and ethanol. Also, the transparency of some of the films was reduced after this chemical treatment. FTIR analysis, thermo-gravimetric analysis, and differential scanning calorimetry were performed on the films having optimum properties. These films showed thermal degradation between 323-335 °C, melting temperatures between 267-293 °C, and glass transition temperatures between 84-120 °C. The biodegradability of films was determined by performing a soil burial test. After three months, the films had disappeared. It can be concluded that the biodegradable films developed in this study have the potential to replace polyethylene in some short-term packaging applications.

Keywords: Biodegradable, Cornstarch, Gelatin, Methylcellulose, Packaging films

Abstract No: BO-22

Drought risk reduction by small tank cascade systems and isolated small tanks in the dry zone of Sri Lanka: an ecosystem based approach

L. A. Prematilaka[1*], D. Wickramasinghe[1] and S. Vidanage[2]

[1]Department of Zoology and Environment Sciences, University of Colombo, Sri Lanka
[2]Department of Zoology and Environmental Management, University of Kelaniya, Sri Lanka
lihini9531@gmail.com*

Sri Lanka is a proud owner of a flamboyant irrigation based history with a wide array of tanks. A cascade of water tanks (Small Tank Cascade System -STCS) which recycles water to help paddy cultivation, act as the backbone of the dry zone irrigation. The STCS are gaining attention not only as a water source but also as a resource to reduce drought risk in the dry zone. Droughts have been recognized as a major disaster in the Sri Lankan context. Owing to various anthropogenic influences, the occurrence of droughts in the dry zone of Sri Lanka is now rapidly exacerbating. The aim of this study was to investigate how tanks in a STCS and isolated reservoirs contribute to retain water during the dry season. This investigation was carried upon two selected tanks of the Kapiriggama STCS and two selected individual isolated small tanks in the Anuradhapura district of Sri Lanka. The cascade tanks were compared with the isolated tanks to determine whether the two systems differ in minimizing the drought risk in the dry zone. The present study adopted the use of Remote Sensing (RS) and Geographic Information System (GIS) techniques. The analysis was conducted using Normalized Difference Vegetation Index (NDVI) for the years 2006, 2014 and 2018. The NDVI images for the study sites were processed and analyzed for the two driest months of the selected years. The results revealed that the tanks in the STCS contribute more than the isolated small tanks to reduce the risk of droughts by retaining more water during the dry season. During April 2014, the two cascade tanks retained a water extent of 2.14% and 22.92% while the two isolated tanks retained a water extent of only 0%. In addition, during May 2018, two cascade tanks retained a water extent of 0.36% and 0.54% while the two isolated tanks retained a water extent of only 0% and 0.12%. Further, the present study highlights the significance of sustainable management and operation of both cascade and isolated tanks, since a growing body of evidence indicates that both tank systems are under heavy anthropogenic pressure. In addition, our study indicates the successful use of NDVI as a tool to assess water availability in reservoirs which can be beneficial in decision making related to water management.

Keywords: Droughts, NDVI, Paddy cultivation, Small tanks, STCS

Abstract No: BO-23

Effect of oviposition-site deprivation on reproductive performance and life history parameters of dengue vector *Aedes aegypti*

R. A. K. M. Gunathilaka and G. A. S. M. Ganehiarachchi*

Department of Zoology and Environmental Management, University of Kelaniya, Sri Lanka
mangala@kln.ac.lk*

Dengue and dengue hemorrhagic fever is the most important arthropod-borne viral disease that occurs in tropical and subtropical regions in the world. Annually 390 million new dengue cases are being reported from the 128 dengue-endemic countries. *Aedes aegypti* belonging to the family Culicidae is the primary vector that transmits the disease. Since there is no vaccine or a drug to prevent the disease, controlling programs are mainly focused on the vector controlling strategies. The primary vector is a container breeder and the widely used control method, source reduction, interrupts the oviposition of females. This will prevent or delay the oviposition of females leading to oviposition-site deprivation. Therefore, it is hypothesized that oviposition-site deprivation may affect the reproductive performance, life history parameters and longevity of *Ae. aegypti*. Thus, the objective of the study was to determine the effect of oviposition-site deprivation on fecundity, fertility, larval mortality, total larval duration, pupal duration and longevity of *Ae. aegypti*. Oviposition-site deprivation was done by blocking the access to the oviposition substrate. Mosquito batches were allowed to access an oviposition substrate separately on the day of blood feeding, 2, 4, 6 and 8 days after blood feeding. They were regularly fed with a 10 % sugar solution as the energy source. According to the results the mean number of eggs laid by the females subjected to different egg retention periods varied significantly. The highest number of eggs (99.53 ± 5.02) were laid by the females subjected to 8-day egg retention period and it was a 69% increase compared with the females who were not subjected to oviposition-site deprivation. However, the fertility (84.93 ± 0.47), percentage larval mortality (14.33 ± 1.16), total larval duration $(105.60 \pm 2.40$ hours), pupal duration $(41.60 \pm 0.98$ hours) and longevity $(19.40 \pm 0.29$ days) did not show any significant difference (One-Way ANOVA, DF = 4, P > 0.05) with the oviposition-site deprivation. Increase of fecundity leads to an increase of vector population. Therefore, an increase of fecundity will act opposite to the desired goal of source reduction. However, the effect of the oviposition-site deprivation driven increased fecundity to the next gonotrophic cycle is not known. Alternatively, complete elimination of breeding sites in an area may support the mosquitoes to develop adaptations to use alternative breeding habitats such as estuaries. So, from the scientific viewpoint, complete elimination of breeding sites through source reduction may be disadvantageous. Also, oviposition-site deprivation through source reduction alone may not be an effective way to control vector populations of *Ae. aegypti*. Thus, it is important to have a clear knowledge on the effect of oviposition-site deprivation on mosquito physiology, reproductive performance, life history parameters and the longevity of the vector mosquitoes when adopting vector controlling strategies.

Keywords: *Aedes aegypti*, Fecundity, Oviposition-site deprivation

Abstract No: BO-24

A preliminary study on the utilization of coconut paring residue as an antioxidant and a food preservative

G. T. M. Thilakarathna, N. Jayathilaka and K. N. Seneviratne[*]

Department of Chemistry, University of Kelaniya, Sri Lanka
kapilas@kln.ac.lk*

Coconut paring is the brownish outer layer of the coconut kernel, which is removed when desiccated coconut is produced. Coconut Paring Residue (CPR) is the residue remaining after expulsion of coconut oil from the coconut parings. The present study was conducted to evaluate the potential of the ethanolic extract of CPR as an antioxidant mixture capable of preserving edible oils and milk. Phenolic compounds of CPR were extracted using ethanol: water (70:30 v/v) solvent system as 70% ethanol has shown the highest oxygen radical absorption capacity for the phenolic mixture. Total phenolic content and antioxidant activity of CPR extracts were measured using Folin-Ciocalteu and α, α-diphenyl-β-picrylhydrazyl (DPPH) free radical scavenging assays respectively. The potential of the phenolic extract to inhibit lipid oxidation in soybean oil, sesame oil, sunflower oil and palm oil was determined by monitoring peroxides using ferric thiocyanate method. Microbial count was used to evaluate the ability of the phenolic extract to inhibit or delay the action of microorganisms in milk. All the tests were conducted in duplicates. Total phenolic content of the coconut paring residue extract was 1947 ± 12 mg/kg as gallic acid equivalents. The phenolic extract showed higher antioxidant activity between the concentration range 5-90 μg/mL and lower IC_{50} value (10.40 ± 0.36 μg/mL) compared to the ascorbic acid standard. Peroxide values of the phenolic-added oil samples were lower than those of the control with no added extract during the storage time period of 15 days. Colony Forming Units of yeast and molds per mL of milk (CFU/mL) were estimated using test samples with phenolic extract at 200 μg/mL). Milk without phenolic extract served as the control. The initial CFU count in both control and test samples was $4.5 \times 10^4 \pm 2.1 \times 10^4$ CFU/mL and the CFUs on the day two were $4.6 \times 10^9 \pm 1.7 \times 10^9$ CFU/mL and $2 \times 10^8 \pm 1.41 \times 10^8$ CFU/mL, respectively. The results suggest that the phenolic extracts of CPR can be used for improving the shelf life of edible oils and milk.

Abstract No: BO-25

Mosquito larvicidal effect of *Annona glabra* fruit extract on dengue vector, *Aedes aegypti*

N. R. Y. Wijebandara[1], H. A. K. Ranasinghe[1], L. D. Amarasinghe[1*], and S. R. Wickramarachchi[2]

[1]Department of Zoology and Environmental Management,
[2]Department of Chemistry, Faculty of Science, University of Kelaniya, Sri Lanka
deepika@kln.ac.lk*

Annona glabra is a plant of Family Annonaceae and many plant species belong to this family have been intensively studied since they were discovered to contain compounds with important biological properties. These properties include cytotoxic, antitumor, antiparasitic, antifungal, antispasmodic, repellent, and insecticidal activities. Insecticidal effects of plant extracts vary depending on the plant parts (leaf, seed, fruit, bark) used for the extraction. Larvicidal effect of *A. glabra* aqueous extract from leaves and seeds have been evaluated against *Aedes aegypti* mosquitoes in Sri Lanka, and larvicidal effect of fruit is not determined yet. Therefore, the present study was conducted to evaluate the effect of *A. glabra* fruit extract for its larvicidal efficacy on third instar larvae of *Ae. aegypti*. Fresh ripen fruits of *A. glabra* plant were collected from Hunupitiya, (N $06°$ $58.904'$, E $079°$ $54.281'$) in Gampaha district, Sri Lanka. The aqueous crude extract was prepared from powdered *A. glabra* fruits. Seven concentrations were prepared between the range of 3 g/L – 300 g/L. Batches of 25 third instar larvae of *Ae. aegypti* were used for larval bioassays. *Ae. aegypti* mosquito larvae were evaluated in accordance with guidelines of World Health Organization. The experimental setup was repeated four times per each concentration. Probit analysis was used to evaluate the relationship of mortality with the concentration of aqueous crude extract. The *A. glabra* fruit extract showed a dose-dependent effect against *Ae. aegypti* larvae after the 48-hour exposure period. The percentage mortality rates have shown a significant variance among different concentrations ($P = 0.000$). The recorded LC_{50} and LC_{90} values for aqueous crude extract were 87.71 ± 5.41 gL^{-1} and 510.79 ± 12.56 gL^{-1} respectively, after 48 hours of exposure period. Larvicidal activity of *A. glabra* plant is supported by previous literature, where the presence of phytochemicals such as saponins, flavonoids, steroids and tannins have shown combined effects in terms of larvicidal action against mosquitoes. Hence, there is a potential of *A. glabra* aqueous fruit extract as a potential source for the development of an environment-friendly plant-based larvicide against *Aedes aegypti*.

Keywords: Aqueous, Bioassay, Insecticidal, Phytochemicals

Abstract No: BO-26

Determination of cytotoxicity and antifungal activity of different solvent extracts obtained from coconut testa flour of selected Sri Lankan coconut cultivars

K. M. R. U. Gunarathne[1,2], J. M. N. Marikkar[1*], E. Mendis[2], C. Yalegama[3] and L. Jayasinghe[1]

[1]National Institute of Fundamental Studies, Hanthana Road, Kandy, Sri Lanka
[2]Postgraduate Institute of Agriculture, University of Peradeniya, Sri Lanka
[3]Coconut Research Institute of Sri Lanka, Lunuwila, Sri Lanka
nazrim.ma@nifs.ac.lk*

Coconut testa is reported as a rich source of phyto-constituents that claim various bioactivities. In this study, selected bioactivities of flour obtained from partially defatted coconut testa (CTF) of five Sri Lankan coconut cultivars namely, Gon Thembili (GT), Ran Thembili (RT), San Raman Tall (SR), Tall x Tall (TT) and commercial hybrid (COM) were investigated. CTF was sequentially extracted with hexane, ethyl acetate (EtOAc), and methanol (MeOH). The obtained crude extracts were subjected to cytotoxicity assay using the 2nd instar nauplii of *Artemia salina* while the antifungal activity was assessed using TLC bioautographic method against *Cladosporium cladosporioides*. Results showed that the majority of the extracts did not show inhibitory activity against *C.cladosporioide* except for the hexane and EtOAc fractions of COM cultivar. According to the result of the cytotoxicity assay, the hexane, EtOAc and MeOH extracts of CTF of different cultivars showed low to moderate toxicity ($LC_{50} > 2000$ ppm) towards *A. salina* whereas the overall lethality % was found to be dependent on the concentration of CTF extracts within the selected range of 50-2000 ppm. When comparing the results obtained for the highest CTF concentration level (2000 ppm), a significantly ($p<0.05$) higher percentage of lethality was observed for hexane extracts of RT ($33.33\pm5.77\%$), EtOAc extracts of COM ($46.67\pm5.77\%$), TT ($43.33\pm5.77\%$) and MeOH extract of COM ($33.33\pm5.77\%$) compared to other cultivars. The results of this study confirmed the poor antifungal activity of CTF while demonstrating the degree of the potential of CTF to function as a cytotoxic agent and their varied activities among different Sri Lankan coconut cultivars. However, sample preparation method might have affected the results showed by hexane extract as partial defatting may remove potential antifungal and cytotoxic compound up to certain extent. It is clear that selective in-depth studies for cytotoxicity of CTF are needed for further elaborations. However, the results of this study would provide sound preliminary knowledge for future research aspects.

Keywords: Antifungal activity, Coconut testa flour, Cytotoxicity, Percentage of lethality, TLC bioautography

Abstract No: BO-27

Optimization of high-fat diet fed streptozotocin induced Wistar rat model for screening antidiabetic agents

A. S. D. Wickramasinghe[1*], A. P. Attanayake[2] and P. Kalansuriya[2]

[1]Department of Pharmacy, The Open University of Sri Lanka, Sri Lanka
[2]Department of Biochemistry, University of Ruhuna, Sri Lanka
sujeevi123@gmail.com*

High-fat diet (HFD) fed streptozotocin (STZ) induced Wistar rats are frequently used as animal models of type 2 diabetes mellitus for screening novel antidiabetic agents. As the composition of HFD, age and strain of rats, dose of STZ and the intended degree of pathophysiological changes vary among studies, the development of a model that best fits to a particular research setting is pivotal. Furthermore, ensuring the long-term stability and establishment of an adequate biochemical profile of the model are necessities which have been addressed by limited studies to date. This study attempted the development of a model which mimics type 2 diabetes mellitus for screening of novel antidiabetic drugs. Wistar rats were fed with a HFD (60% calories from fat) for four weeks, followed by STZ intraperitoneal injection (30, 40 and 50 mg/kg). Rats with fasting serum glucose >11.1 mmol/L were enrolled for the study. There were five groups (n=10/group); healthy rats, HFD fed rats, HFD+STZ (30 mg/kg) rats, HFD+STZ (40 mg/kg) rats, HFD+STZ (50 mg/kg) rats. The glycemic status of the rats was monitored weekly by the routine conduct of oral glucose tolerance tests. Experimental rats were euthanized after 28 days and blood samples were collected for biochemical investigations. Glycemic status of the model was assessed by determining fasting serum glucose, insulin, glycated hemoglobin (HbA_{1c}) and homeostatic model assessment-insulin resistance (HOMA-IR). Lipid profiles were assessed by determining total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C) and very low-density lipoprotein cholesterol (VLDL-C) levels. STZ induced rats (30, 40 and 50 mg/kg) showed a significant dose dependent increase in fasting serum glucose (by 67, 61 and 136%) and insulin (by 19, 15 and 13%) concentrations ($p<0.05$). HOMA-IR was above 2.5 and increased in a dose dependent manner by 98, 108 and 176% in STZ induced rats (30, 40 and 50 mg/kg). However, only the STZ (50 mg/kg) induced group of rats showed fasting serum glucose concentration of 13.71 ± 1.01 (>11.1 mmol/L) and a significant increase in HbA_{1c} by 66% compared to the healthy rats ($p<0.05$). Further, the STZ 50 mg/kg rats showed stable hyperglycemia throughout the study period. STZ induced rats (30, 40 and 50 mg/kg) also showed a significant dose dependent increase in TC (by 6, 7 and 9%), and TG (by 16, 15 and 23%) respectively ($p<0.05$). However, only the STZ induced (50 mg/kg) group of rats showed significant increase in serum concentrations of LDL-C (by 12%) and VLDL-C (by 16%) compared to the healthy rats ($p<0.05$). Only slight changes in HDL-C levels were observed in the STZ induced groups of rats however, the values were not significant ($p>0.05$). The results revealed that the Wistar rats fed with HFD rich in saturated fat for four weeks followed by a single intraperitoneal dose of STZ (50 mg/kg) would produce stable diabetic model which closely mimic pathophysiological features of type 2 DM characterized by insulin resistance and dyslipidemia.

Keywords: High-fat diet, Streptozotocin, Diabetes

Abstract No: BO-28

In vitro antidiabetic activity of *Spondias pinnata* aqueous extract and encapsulated chitosan-TPP nanoparticles

R. R. Wadasinghe[1*], A. P. Attanayake[2] and P. Kalansuriya[2]

[1] Postgraduate Institute of Science, University of Peradeniya, Sri Lanka
[2] Department of Biochemistry, Faculty of Medicine, University of Ruhuna, Galle, Sri Lanka
ransikawadasinghe@gmail.com*

Spondias pinnata (L. f.) Kurz is a medicinal plant used in complementary medicine. Decoctions prepared using stem-bark of *S. pinnata* find applications in treating diabetes mellitus. However, low bioavailability of bioactive metabolites (polyphenols and flavonoids) and lack of appropriate release of metabolites delimit the antidiabetic activity of *S. pinnata* aqueous extract (SAE). Encapsulation of SAE with chitosan-tripolyphosphate (CS-TPP) could enhance its therapeutic potential and provide controlled release. The objective of this work to determine *in vitro* antidiabetic activity of *S. pinnata* stem-bark extracts and SAE-encapsulated CS-TPP nanoparticles using α-amylase inhibitory, α-glucosidase inhibitory, glucose uptake and glucose adsorption assay. The extracts were prepared by extracting dried and powdered stem-bark of *S. pinnata* into distilled water, acetone, ethyl acetate, dichloromethane under ultrasonication (40 kHz, 37 °C, 30 min) separately. The total phenol content (TPC) and flavonoid content (TFC) of the extracts were determined using Folin-Ciocalteu and aluminium chloride methods, respectively. Based on the results of α-amylase inhibitory assay, SAE was selected for the encapsulation with CS-TPP. The SAE had TPC of 4.18 ± 0.02 mg gallic acid equivalents per gram of dry weight (GAE/g DW) and TFC of 0.37 ± 0.01 mg quercetin equivalents per gram of dry weight (QE/g DW) and showed the highest α-amylase inhibitory activity (IC_{50} 53.34 ± 7.43 µg/mL). The acetone extract had TPC of 34.43 ± 0.35 mg GAE/g DW and TFC of 4.06 ± 0.05 mg QE/g DW and showed the highest α-glucosidase inhibitory activity (IC_{50} 8.82 ± 1.42 µg/mL). The highest glucose uptake and glucose adsorption were shown by acetone extract and aqueous extract, respectively. SAE-encapsulated nanoparticles were prepared from CS-TPP at varying concentrations (0.250, 0.375, 0.500 and 0.625% w/v) of SAE using ionic gelation method under magnetic stirring; the highest encapsulation efficiency ($68.21\% \pm 0.66\%$) and loading capacity ($0.79\% \pm 0.17\%$) were obtained at 0.625% w/v of SAE. Loaded nanoparticles were separated by centrifugation and free polyphenols were determined by Folin-Ciocalteu method. The Z-average particle diameter of SAE-encapsulated CS-TPP nanoformulations was 417 ± 86 nm with polydispersity index of 0.574 and zeta potential of +20.63 mV. The IC_{50} values corresponding to α-amylase inhibitory activity and α-glucosidase inhibitory activity of SAE-encapsulated CS-TPP nanoparticles were 1.10 ± 0.03 mg/mL and 3.16 ± 0.15 mg/mL, respectively. Although the percentage of glucose uptake and adsorption in SAE encapsulated CS-TPP nanoparticles is lower than the crude extract, it had shown 11.59 ± 1.03 % glucose uptake at 5 mM glucose concentration and 1.47 mmol/g glucose adsorption at 100 mM glucose concentration. The SAE, acetone extract and SAE-encapsulated CS-TPP nanoparticles showed higher antidiabetic activity than the positive control, acarbose. Further investigations on the releasing profiles of SAE-encapsulated CS-TPP nanoparticles would reveal the rates at which the active metabolites are released to the media during the timeframes of the conducted assays.

Keywords: *S. pinnata*, Antidiabetic activity, CS-TPP, Particle size, Zeta potential

Abstract No: BO-29

Perceptions of urban residents on the cultural and ecological roles of residential gardens in Gampaha district, Sri Lanka

J. K. W. N. Subashini[1]*, K. Yakandawala[1] and E. S. Minor[2]

[1]Department of Horticulture and Landscape Gardening, Wayamba University of Sri Lanka, Sri Lanka
[2]Department of Biological Sciences, Institute for Environmental Science and Policy,
University of Illinois, Chicago, USA
subashini@wyb.ac.lk*

Urban residential gardens provide recreational, socio cultural and environmental services to urban communities. However, the degree to which the urban residents recognize, and value of these services is unclear where a complex assortment of interacting socio-economic factors govern the perceptions of urban residents towards the role of residential gardens. Due to the limited attention on urban residential landscapes in Sri Lanka, the present study was conducted targeting the urban community in the Gampaha Divisional Secretariat (DS) to evaluate the perceptions towards cultural, environmental and conservation values of the residential gardens. A pre-tested, interviewer-administered questionnaire was used to collect the socio-economic details of 50 randomly selected households located within the 2 km radius of the city center of the Gampaha DS. Perceptions on environmental, cultural and the conservation services of residential gardens were evaluated based on a 5-point Likert scale. The Chi-square test of association was used to identify the significant socio-economic factors that influence the perceptions of the respondents. The majority of the respondents were 51-65 years old (41.7%), followed by >65 years (25%) and 36–50 years old (25%). About 45.8% of the respondents had completed a basic degree qualification, while 41.7% had completed Advanced Level qualification. Retired household heads dominated the sample (37.5%), followed by those occupied in the private sector (29.2%). The highest fraction (32%) of the respondents received a monthly income ranging from USD 400 – USD 600. Stress release/health benefits, pollution control, and aesthetic value of plants/flowers, were ranked as the highest benefits of residential gardens, with mean scores of 4.90, 4.84 and 4.82, respectively. The majority of respondents (84%) strongly agreed with the statement that residential gardens can connect people with nature (Mean Score=4.82). Among the respondents, 24% had a highly positive attitude on the importance of residential gardens as entities of ecosystem conservation, while 34% of the respondents showed a neutral attitude. According to the Chi-square test, income, age, education and employment were significantly associated with the attitudes of the respondents towards the socio cultural services of residential gardens. Meanwhile, only the education was significantly associated with attitudes on the conservation values of residential gardens ($p<0.05$). The results reflect the desire of urban dwellers to experience a pleasant and fresh natural environment even in the middle of an urban lifestyle. Since people tend to feel the nature in the direct and the closest living environment in their everyday lives, residential gardens should be considered as the primary unit of concern in urban green space planning. Hence, understanding people's perceptions of gardens could be help in designing and improving the urban green spaces.

Keywords: Attitudes, Gampaha, Residential gardens, Urban green spaces

Abstract No: BO-30

Bacteriological analysis of egg based-Kottu rotti in selected eateries in Kesbewa, Colombo, Sri Lanka

M. M. P. M. K. Wewagama*, and G. D. D. K. Gunasena

Department of Microbiology, Faculty of Science, University of Kelaniya, Sri Lanka
mahipraba14@gmail.com*

Due to changing needs of urban life, a high demand for ready to eat foods prevails among urban dwellers. Evidently, food borne diseases resulting from ingestion of pathogenic bacteria or toxins are on the rise, causing a threat to public health in urban areas. This research was focused on quantitative and qualitative benchmarking of general hygienic condition and two major foodborne pathogens in a popular ready-to-eat food, "egg based-*Kottu rotti*" against existing local/ international guidelines. Kottu rotti is a famous fast food in Sri Lanka, which is made using *Godambara roti*, vegetables, eggs and/or meat and spices. Twenty-four *Kottu rotti* preparing eateries in Kesbewa area of Colombo district were selected for the study. *Kottu rotti* samples obtained from those 24 eateries were microbiologically analysed as per the SLSI standard criteria. Total Plate Count (TPC) and foodborne pathogens; *Staphylococcus aureus* Count (SAC) and *Salmonella*, were tested as hygiene indicators. Since microbiological guidelines for Ready- to-eat food (RTE) are not yet available in Sri Lanka, our results were compared against the guidelines from New Zealand (NZ) and Hong Kong (HK). Out of 22 test samples, only one had "Unsatisfactory" food quality when compared TPC levels with NZ microbial guideline limits. There were 5 samples with "Marginal" quality and rest of the 16 samples were of "Satisfactory" microbiological quality according to the NZ microbiological guidelines. Out of the results of 22 test samples, only one was "Unsatisfactory" food quality when compared with HK microbial guideline limits. There were 18 samples in the "Borderline" quality and only 3 samples indicated "Satisfactory" microbiological quality according to the HK microbiological guidelines. *Salmonella* was absent in all tested samples. When SAC count compared with NZ guideline, out of 24 successful test results 3 potentially hazardous, 1 unsatisfactory, 3 marginal and 17 in the satisfactory level recorded. Compared with HK guidelines, 3 unsatisfactory, 6 borderline and 15 satisfactory level samples were detected. Post-processing contaminations due to improper storage conditions and poor sanitary practices can be described as major reasons for the unsatisfactory quality of processed foods. Therefore, it is recommended that an effective food quality control services are an essential requirement to ensure a safe and properly prepared food supply to protect the consumers from unsafe and unhealthy food.

Keywords: Egg Kottu rotti, *Staphylococcus aureus*, *Salmonella*, TPC, SAC Ready-to-eat food

Abstract No: BO-31

Antibacterial activity of *Flueggea leucopyrus* Willd

E. D. C. Karunarathne[1*], D. V. Lokuwalpola[2], K. P. A. M. Sandaruwan[2], M. D. Dabarera[3] and D. N. Wanigasekara[4]

[1] Gampaha Wickramarachchi University of Indigenous Medicine, Sri Lanka
[2]Department of Chemistry, Faculty of Science, University of Colombo, Sri Lanka
[3]Department of Pathology, Faculty of Medicine, University of Kelaniya, Sri Lanka
[4]Department of Biochemistry, Faculty of Medicine, University of Ruhuna, Sri Lanka
chandanikarunarathne63@gmail.com*

Fluggea leucopyrus Willd. (Euphorbiacea) known as *'Katupila'* in local dialect is a plant widely used in indigenous medicinal system in Sri Lanka as a remedy for cancers and infectious diseases. Sufficient scientific investigations however are unavailable to rationalize the ethnobotanical and ethnopharmacological significance of the plant. Present study was conducted to investigate the antimicrobial potential of *F. leucopyrus* whole plant extract. The antimicrobial activity of the methanolic extract of *F. leucopyrus* was determined by agar well diffusion method. The extract was tested against five standard bacterial strains and eight clinically isolated bacterial cultures; *Staphylococcus aureus* (ATCC 25923), *Staphylococcus aureus* (ATCC 6538), *Escherichia coli* (ATCC 8739), *Pseudomonas aeruginosa* (ATCC 9027), *Pseudomonas aeruginosa* (ATCC 27853), *Streptococcus pyogenes*, *Klebsiella pneumoniae*, *Proteus mirabilis*, *Enterococcus faecalis*, *Salmonella typhi*, *Bacillus subtilis,* Methicillin Resistant *Staphylococcus aureus* (MRSA) and *Staphylococcus saprophyticus.* The test was triplicated for each microorganism. Ciprofloxacin was used as the positive control while 20% Dimethyl sulfoxide (DMSO) which was used to dissolve the plant extract was used as the negative control. No inhibition of growth was observed in the negative controls and the positive control was able to inhibit the growth of all test bacterial strains used. The growth of *S. pyogenes*, *K. pneumoniae*, *S. typhi*, *B. subtilis*, *E.coli* (ATCC 8739) was not affected by *F. leucopyrus* extract, meanwhile *S. aureus* (ATCC 25923), *S. aureus* (ATCC 6538), *P. mirabilis*, *E. faecalis*, MRSA, *P. aeruginosa* (ATCC 9027), *P. aeruginosa* (ATCC 27853) and *S. saprophyticus* seemed to be susceptible to the extract showing inhibition zone diameters of 12.67 ± 0.58 mm, 12.67 ± 0.58 mm, 15.33 ± 0.58 mm, 9.67 ± 0.58 mm, 13.67 ± 0.58 mm, 12.67 ± 0.58 mm, 11.33 ± 0.58 mm and 13.67 ± 0.58 mm respectively. These preliminary observations suggest that *F. leucopyrus* plant is a potent source of antimicrobial substances. Further studies are required to determine the phytochemicals responsible for the antimicrobial action.

Keywords: Antimicrobial, *Fluggea leucopyrus*, Natural products, Phytochemical

Abstract No: BO-32

Development of alternative flour-based sandwich snack with mushroom filling

K. A. M. Ruparathna[1], P. N. R. J. Amunugoda[2*] and J. M. J. K. Jayasinghe[1]

[1] Department of Food Science and Technology, Faculty of Applied Sciences, University of Sri Jayewardenepura, Gangodawila, Nugegoda, Sri Lanka
[2] Food Technology Section, Industrial Technology Institute, Malabe, Sri Lanka
dr.amunugodapnrj@yahoo.com*

Alternative flours are gaining a higher interest in the bakery industry, since they can be used to offset the negatives of traditional wheat flour and to improve the nutritional value of the bakery products. Composite mixtures of flours obtained from fruits, vegetables, nuts, grains and pulses have been introduced to improve the nutritional profile of snack foods. This trend has substituted wheat flour with the composite flour mixtures of locally available abundant raw materials to rebalance the nutrient profile while preserving the acceptability of the health concerned consumers. Jackfruit (*Artocarpus heterophyllus*), pumpkin (*Cucurbita maxima*) and banana (*Musa acuminata*) are commonly grown crops in Sri Lanka. High productivity, high conversion ratio and possibility of growing in marginal agricultural lands of these crops offer an added advantage for processing. Managing the surplus and value addition are possible solutions to utilize these crops effectively while minimizing the postharvest losses. The objective of this study was to develop a snack using jackfruit, pumpkin and green banana flours and to evaluate its sensory, nutritional and functional properties. Wheat flour and flours from above three crops were mixed in different ratios; wheat flour:jackfruit flour 70:30, 75:25 and 80:20, wheat flour:pumpkin flour 75:25, 80:20 and 85:15, wheat flour:green banana flour 70:30, 75:25 and 80:20. Different mushroom fillings were formulated by changing the proportion of oyster mushrooms and other ingredients. Sensory assessment was conducted to select the best filling formula. The proximate composition of the novel snack was determined following the standard AOAC methods. Methanolic extract of the snack was analyzed for the total phenolic content (TPC), total flavonoid content (TFC) and ferrous reducing antioxidant power (FRAP). The predicted glycemic index (PGI) was determined by starch *in vitro* digestion method. Substitution level of 30% jackfruit, 15% pumpkin and 25% green banana flour layers with the selected mushroom filling offered the acceptable color and textural attributes in the novel snack to impress the consumers. The crude protein, crude fat, total dietary fiber, and total ash of novel snack on dry weight basis were $10.31\pm0.16\%$, $6.18\pm0.01\%$, $8.16\pm0.01\%$ and $2.75\pm0.01\%$ respectively. Its moisture content was $30.77\pm0.03\%$. Newly formulated snack exhibited a high antioxidant potential comparatively to the typical wheat-based bakery products ($GI \geq 70$ on the glucose scale). The TPC, TFC and FRAP values of the novel snack on dry weight basis were 0.31 ± 0.04 mg of gallic acid equivalent per gram, 0.112 ± 0.008 mg of quercetin equivalents per gram and 0.06 ± 0.01 mg of Trolox equivalents per gram respectively. The novel snack exhibited an intermediate GI value of 68, which was a lower value compared to wheat based snacks. Substitution of flours of jackfruit, pumpkin and banana for wheat flour provides opportunities for developing healthier snacks while allowing the consumers to explore new textures, flavors and aromas.

Keywords: Composite flour, Healthy snacks, Postharvest losses, Value addition

Abstract No: BO-33

Occurrence of *Clostridium perfringens* in meat curries available in eating houses in the city of Colombo, Sri Lanka

G. R. Ranasinghe[1], M. L. Perera[2,34*] and I. R. Perera[5]

[1]Microbiology Section, Department of Pathology, Provincial General Hospital, Kurunegala, Sri Lanka
[2] Food Microbiology Section, Medical Research Institute, Colombo 08, Sri Lanka (Alumnus)
[3]School of Dentistry & Oral Health (Alumni), Gold Coast Campus, Griffith University, Queensland, Australia (Alumnus)
[4]Menzies Health Institute, Queensland, Australia (Alumnus)
[5]Oral Health Promotion Unit, The National Dental Hospital (Teaching), Colombo, Sri Lanka
manosha_lakmali@yahoo.com*

Ensuring safe consumption of food without food-borne pathogens is of prime importance in public health across the globe. Spicy and hot meat curries are much popular among Sri Lankans as a main dish served with rice, bread, string hoppers, hoppers, roti and pittu. Aim of this study was to assess the safety in consuming meat curries available for sale in eateries in Colombo city by assessing the presence of *Clostridium perfringens,* that is frequently found in meat curries and meat-based dishes and to investigate the common preventive measures taken against contamination. One hundred (100) eateries were selected randomly as a representative sample of 572 eating houses registered in the Colombo Municipal Council. Subsequently, total of 200 samples comprising 100 chicken and 100 beef curries, were purchased from the randomly the selected eateries. Meat curry samples were processed immediately after collection. Plate counts based on Tryptose Sulfite Cycloserine (TSC) medium and presumptive identification and confirmation tests were employed for isolation and enumeration (Bacteriological Analytical Manual, 2001). *C. perfringens* was detected in 78 (39%) of meat curry samples, 47 (47.0%) chicken curry samples and 31 (31.0%) beef curry samples. Chicken curries significantly haboured ($p < 0.05$), *C. perfringens* due to under cooking which facilitates germination of heat resistant endospores which may proliferate vegetative cells during the prolonged storage at room temperature (at 30^0C).

Keywords: *Clostridium perfringens,* Colombo city, Meat curry samples, Tryptose Sulfite Cycloserine, eat resistant endospores

Abstract No: PO-01

Petchicine, a novel human DNMT enzyme inhibitor isolated from Sri Lankan medicinal plant: An *in-silico* approach

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*

The genetic information of humans has been regulating by various epigenetic mechanisms, which are stable and reversible. DNA methyltransferase (DNMT) is an enzyme that methylates the fifth carbon of the cytosine residue in DNA. Therefore, the methylated DNA interacts with the chromatins through the methyl-binding proteins, which leads to a cancer state. Many recent studies prove that inhibition of DNMT contributes to control cancer growth. Therefore, DNMT inhibitors have been considered as developed anticancer agents. The studies on the inhibition of the DNMT enzyme are an up-and-coming developing area for cancer therapy. Azacitidine is an approved DNMT inhibitor by the Food and Drug Administration. This work focuses on studying the impact of Azacitidine on the stability of the DNMT through computational techniques and, by performing the comparative study, suggest a new potent compound to inhibit the DNMT enzyme. These techniques can be used to investigate atomic-level descriptions of drug binding sites and how the DNMT inhibitors change the enzyme's active site. The crystal structure of the DNMT enzyme was downloaded from the Protein Data Bank, and the structure of Azacitidine was optimized by CBS-QB3 method using the G09W package. The non-toxic new compounds, Petchicine and Ouregidione, were obtained from the Sri Lanka flora database. The docking studies followed by molecular dynamics simulation were carried out to perform trajectory analysis. The results of RMSD, Rg, and hydrogen bond analysis are used to compare the behavior of the DNMT-Petchicine and DNMT-Ouregidione with the DNMT-Azacitidine complex in the aqueous environment. The results reveal that all the DNMT-inhibitor complexes attain a stable conformation during the simulation time. However, the results clearly show that the new compound Petchicine is more effective than the reference inhibitor Azacitidine; therefore, further investigations on Petchicine in future clinical trials would yield more promising results in the treatment of epigenetically caused cancer.

Keywords: Epigenetic modification, DNA methyltransferase, Azacitidine, Sri Lanka flora database

Abstract No: PO-02

Atmospheric chemical composition of bulk precipitation of the vicinity of oil refinery in Sapugaskanda, Sri Lanka

M. M. S. T. Karunarathna, M. P. Deeyamulla* and A. T. Kannangara

Department of Chemistry, University of Kelaniya, Sri Lanka
mpd@kln.ac.lk*

Rainwater quality is critical because it can be used to forecast air quality. The aim of the current study was to investigate the chemical characteristics of bulk precipitation in Kelaniya, Sapugaskanda, and Siyambalape, an area close to an oil refinery in Gampaha District, one of Sri Lanka's most densely populated and urbanized districts. Wet precipitation samples were analyzed for pH, conductivity, Na^+, K^+, Mg^{2+}, Ca^{2+}, F^-, Cl^-, NO_3^-, SO_4^{2-}, Pb, Cu, Mn, Al, Zn, Ni, Cr, Cd, and Fe for a total of 18 samples between 2020 July and 2020 October. The results obtained were compared with 6 samples taken from a background area situated in Kidelpitiya, Meegoda where the anthropogenic influence is minimum. Volume-weighted average concentrations of the major ionic species present in precipitation samples were in the order of $F^-< K^+< NO_3^-< Mg^{2+}< Cl^-< SO_4^{2-}< Ca^{2+}< Na^+$. Neutralization of the acidic species would take place due to the presence of $MgCO_3$ and $CaCO_3$. Other than the anthropogenic sources natural sources were also considered. When considering a marine contribution, SO_4^{2-}/Na^+, Ca^{2+}/Na^+, and Mg^{2+}/Na^+ ratios are higher than the reference value suggesting that contribution of sources be possible other than marine. When considering a soil contribution, SO_4^{2-}/Ca^{2+}, NO_3^-/Ca^{2+}, Na^+/Ca^{2+}, and Cl^-/Ca^{2+} ratios are higher than the reference value suggesting that contribution of sources be possible other than soil. It was also found that Al is the most predominant trace element in the area while Fe is the least (All are in metallic forms not in the ionic forms). Investigation of correlation between major ionic species and elements (Ca^{2+}, SO_4^{2-}, Al, Cu, Zn, and NO_3^-) in the wet precipitation samples identified probable anthropogenic sources such as heavy traffic, biomass burning, large-scale constructions, and waste incineration. The highest correlation between Na^+ and Cl^- is probably due to marine contribution. A comparison between the background and the study area was carried out to identify the difference between the chemical compositions of the atmosphere during the given period suggesting that the area has a higher chemical composition of the species interested rather than the background. Also, this study reveals the effect of the Covid-19 pandemic on the reduction of the chemical composition of such species of the atmosphere in the area of interest. This study reveals that the chemical composition in the atmosphere is strongly dependent on both anthropogenic and natural phenomena around the area of study.

Keywords: Bulk precipitation, Ions, Principal component analysis, Chemical elements, Correlation

Abstract No: PO-03

Fabrication of FTO/CBD-CdS/ED-CdTe/Cu/Au solar cells and boosting its performance by CdCl$_2$ treatment

G. K. U. P. Gajanayake[1], D. S. M. De Silva [1*], H. Y. R. Atapattu[2] and A. A. I. Lakmal[3]

[1]Department of Chemistry, Faculty of Science, University of Kelaniya, Sri Lanka
[2]Department of Instrumentation & Automation Technology, Faculty of Technology,
University of Colombo, Sri Lanka
[3]Department of Physics, Faculty of Science, University of Peradeniya, Sri Lanka
sujeewa@kln.ac.lk[*]

The thin film CdS/CdTe solar cells are promising cost-effective clean energy generating devices against the global energy crisis. Chemical bath deposition (CBD) and electrodeposition (ED) were recognized as being simple and low-cost techniques over a range of growth techniques available for development of CdS and CdTe thin films respectively. The use of aforesaid two techniques successively in fabrication of glass/FTO/CBD-CdS/ED-CdTe solar cells was not reported. This attempt is to do so and moreover, to assess the effect of CdCl$_2$ treatment in performance enhancement of the device produced. In preparation of thin CBD-CdS layers on FTO glass substrate, a bath consisted of Cd(CH$_3$COO)$_2$ (0.033 mol/L), CS(NH$_2$)$_2$ (0.667 mol/L), CH$_3$CO$_2$NH$_4$ (1.0 mol/L) and NH$_4$OH (25%) was employed at 90 ℃. Annealed (375 ℃ for 30 min) CBD-CdS samples were subjected to CdTe deposition by ED system equipped with a three electrodes system. Herein, the CdS thin films were specifically developed enabling them to withstand in a highly acidic bath during the ED process. The ED bath used consisted of CdSO$_4$ (1.0 mol/L) and TeO$_2$ (1.0 mmol/L) at pH 2.3 and 65 ℃. The potential of -0.650 mV was maintained between the reference and working electrodes during each deposition (3 hrs). Samples were sprayed with CdCl$_2$ solution (1.0 mol/L) for 2 s and then annealed (390 ℃ for 15 min). Back contacts (Cu/Au) were deposited on the CdCl$_2$ treated glass/FTO/CBD-CdS/ED-CdTe devices by thermal evaporation. The devices were characterized under the illumination of AM 1.5 (100 mW/cm^2). The efficiencies of the CdCl$_2$ treated devices were found to be higher (6.23%) than untreated ones (2.66%). A significant variation in J$_{sc}$, V$_{oc}$, and FF values was observed in CdCl$_2$ treated devices (24.68 mA/cm^2, 664 mV, and 38.0%) over untreated devices (14.95 mA/cm^2, 531 mV, and 33.5%). The SEM analysis revealed remarkable increment in CdTe grain sizes (~140 nm to ~591 nm) with less grain boundaries in the CdTe sample upon CdCl$_2$ treatment, thus leading to improved photovoltaic performance. This work demonstrated that CdS and CdTe can be synthesized using cost effective methods of CBD and ED respectively and, the FTO/CBD-CdS/ED-CdTe/Cu/Au device efficiency can be significantly improved by the CdCl$_2$ treatment.

Keywords: CdS/CdTe solar cell, Chemical bath deposition, Electrodeposition, CdCl$_2$ treatment

Abstract No: PO-04

An approximate solution to Lane-Emden equation of the polytrophic index three by using Differential Transform Method

A. M. S. K. Aththanayaka and N. A. S. N. Wimaladharma[*]

Department of Mathematics, University of Kelaniya, Sri Lanka
wimaladharma@kln.ac.lk*

Lane-Emden equation is a second order dimensionless non-linear ordinary differential equation which can be used to describe internal structure of a star, the thermal behaviour of a spherical cloud of gas, isothermal gas spheres etc. Self-gravitating spheres of plasma, such as stars, can also be described approximately by using these equations. Lane-Emden equation was solved by using Adomian Decomposition Method (ADM), Homotopy Analysis Method for some values of polytrophic index n. There are exact, analytical solutions for Lane-Emden equation in particular values $n = 0, 1, 5$. Since its non-linearity, the exact solutions cannot be found easily. Differential Transform Method (DTM) is an iterative method with a Taylor series solution gives good approximation in very small region. DTM can be applied for both linear and nonlinear n^{th} derivative functions. In this research, a numerical solution to Lane-Emden equation with $n = 3$ has been found by using Differential Transform Method. To increase the range of convergence of the solution, the Pade approximation has been applied. Pade approximation is a ratio of two McLaurin's expansion of the polynomials. The obtained solution for Lane-Emden equation has been compared with the solutions obtained by using the Fourth Order Runga-Kutta (RK4) method, ODE45 and Forward Euler method, which are effective and accurate methods for solving differential equations. The Einstein-Maxwell equations for a static spherical distribution of matter which is called Electrically Counterpoised Dust (ECD) under gravitational attraction and electrical repulsion can be simplified to the Lane-Emden equation when $n = 3$. It has been shown that the mass of a sphere of electrically counterpoised dust is an increasing function of its radius and it has a maximum value. Since the solution obtained gives us a physically acceptable result, it can be justified that the obtained solution using DTM is acceptable and gives better approximate solution with the form of a polynomial for linear and nonlinear differential equations.

Keywords: Differential transform method, Einstein-Maxwell equations, Lane-Emden equation, Pade approximation.

Abstract No: PO-05

Dynamic of a capillary ridge of free surface flow on an inclined heated plate

K. A. D. S. Nisansala[*] and N. G. A. Karunathilaka

Department of Mathematics, University of Kelaniya, Sri Lanka
sanduninisansala1440@gmail.com*

Formation of capillary ridge on a gravity-driven thin liquid film flowing over a plate is used in lots of commercial applications. Painting and coating, contact lens manufacturing, microchips and microchips fluidic devises are some examples. Capillary ridge forms due to the surface tension, geometrical structure of the flow and the temperature of the fluid. Capillary ridge height varies with the surface tension coefficient, inclination angle and initial thickness. Its height is increased with higher surface tension, steeper inclination angle and bigger initial thickness. In this work, a mathematical model has been developed for a two-dimensional, laminar, incompressible flow of second grade non-Newtonian fluid with temperature-dependent viscosity on an inclined planar plate. Also the capillary ridge height and corresponding velocities, pressure and temperature of the zeroth order expansion are discussed. The thin plate is heated locally and inclined at an angle with the fixed horizontal axis. Simplified Navier-Stokes equations are solved together evolution equation for the description of the liquid thin film height which is derived by using the long-wave approximation. The solution of the resulting equation for the liquid thin film height is approximated using explicit finite difference method on a uniform grid. The solutions are simulated to identify the flow patterns. Capillary ridge height and velocities, pressure and temperature are obtained using the asymptotic expansion. It can be observed that there is an oscillatory behavior of capillary ridge height along the direction of the plate. Furthermore, the upstream of capillary ridges change slightly with the advancement of time and the downstream of capillary ridges do not change with the time. The results indicate that the temperature varies proportionally with the space variable from left end of the domain to the right end of the domain. Behavior of the velocity and the pressure has been discussed in the different directions of fluid flow domain. The results indicate that the velocity component in x direction decreases when negative x approaches to zero and it increases when x increases from zero to the right end of the domain. Velocity component in z direction decreases linearly when x increases. It is also realized that the pressure decreases to zero when negative x increases to zero and the pressure increases when x increases from zero to the right end of the domain.

Keywords: Capillary ridge height, second grade fluid, thin film, locally heated plate

Abstract No: PO-06

Some properties of expanding universe with variable *lambda (Λ)*

E. L. N. L. Karunathilaka and K. D. W. J. Katugampala*

Department of Mathematics, University of Kelaniya, Sri Lanka.
wasantha@kln.ac.lk*

When the Universe is expanding, some of its properties radius, density, volume and total mass would be changed with cosmic time. Those changes can be obtained by using experimental data or solving suitable mathematical models related to the expansion of the Universe. The main purpose of this study is to obtain numerical values of significant properties of expanding Universe by using an appropriate model solution of R (radius of the Universe). Robertson Walker metric and Einstein's field equations were used as major equations to obtain expressions. This research has been initiated with the Robertson Walker metric in spherical polar coordinates, and it was mainly used to obtain the non-vanishing Christoffel symbols and Ricci tensor components to obtain expressions related to the calculations. Furthermore, all the calculations were depended on four-dimensional space-time coordinates. The pressure of the Universe is considered as zero, and the Universe is assumed to be spherical. Three boundary conditions were used to simplify the numerical values and to obtain expressions related to the properties of the Universe. Moreover, the total mass is a combination of dark matter and ordinary matter. Therefore, boundary conditions were used to separate that two matter masses. Then the values for radius, density, volume and total mass of the Universe were calculated as 1.138527×10^{28}cm, 1.4588×10^{-31}gcm^{-3}, 6.1787×10^{84}cm^3 and 9.0135×10^{53}g, respectively. Furthermore, ordinary matter mass was obtained as 2.7041×10^{53}g. These numerical values were similar to the available observed data of the Universe, and they can be used to explain the expansion evidence of the Universe. Hence, the used model solution and the selected redshift value can be used to explain these significant properties of the Universe. The redshift value 1.17 was satisfied the accelerating expansion of the Universe in the present epoch. However, the redshift value can be increased by modifying the solution model of R and then, can be obtained more accurate values. Moreover, this used model can explain not only the present epoch but also the past image and the future image of the Universe.

Keywords: Einstein's field equations, Properties of the Universe, Redshift, Robertson Walker metric

Abstract No: PO-07

A mathematical model to investigate the antimicrobial activity of Ceylon high-grown green tea and black tea against human pathogenic bacteria and yeast species

S. A. Samaraweera[1], J. Munasinghe[1*] and G. D. D. K. Gunasena[2]

[1]Department of Mathematics, University of Kelaniya, Sri Lanka
[2]Department of Microbiology, University of Kelaniya, Sri Lanka
munasing@kln.ac.lk[*]

Ceylon tea has a great demand worldwide and considered as one of the finest tea in the world. Green and black tea are the widely consumed types of tea in general. Tea has many biologically active compounds, and these antimicrobial agents can inhibit the growth of human pathogenic microorganisms. This research focused to derive an appropriate mathematical model to investigate the antimicrobial activity of high-grown green tea and black tea against selected human pathogenic bacteria (*Staphylococcus aureus, Pseudomonas aeruginosa, Bacillus subtilis*) and three yeast (*Candida*) species. The behaviour of the model solutions was analysed graphically and the antimicrobial activity of tea for a given concentration can be found using this model. First, descriptive analysis was carried out to analyse the basic characteristics of the experimental data. Then, using the Interpretative/ Breakpoint criteria provided in the Performance standards for antimicrobial disk susceptibility tests; CLSI, the antimicrobial effects were further discussed. Those results revealed that there was a difference between the two tea varieties and the antimicrobial activity was higher in green tea. Interaction between the two independent variables (tea type, concentration) on the dependent variable (diameter of the inhibition zone) was analysed using the two-way ANOVA test. The results revealed that interaction between two independent variables on the dependent variable was significant in all tested bacteria and yeast species except in *Candida tropicalis*. Then the most suitable mathematical model was developed, model parameters were calculated using experimental data, and values were predicted for the inhibition area of each species of microorganism for both tea varieties independent of each other. The model accuracy was examined using MAD (mean absolute derivation), RMSE (root mean square derivation), and MAPE (mean absolute percentage error) values and using histograms for residuals. The findings showed that the experimental data fitted and agreed with the model. The analytical output of the model was implemented using MATLAB (2018a) and it demonstrated experimentally observed antimicrobial activity. The model can be used to describe the antimicrobial activity of high-grown green tea and black tea at a given concentration against the tested bacteria and yeast species. Further, results revealed that the concentration of tea is directly proportional to the antimicrobial activity up to a certain point, respective to each microorganism, and thereafter no such correlation was observed.

Keywords: Black & Green tea, Inhibition population, Logistic Growth Model, MAPE, Two-way ANOVA

Abstract No: PO-08

Topological indices of some anti-cancer molecular graphs and dendrimer structures

S. L. D. J. Sebastian[*] and K. K. K. R. Perera

Department of Mathematics, University of Kelaniya, Sri Lanka
1024.lakeesha@gmail.com *

Cancer disease are leading cause of death in the world as well as in Sri Lanka. Anticancer drugs and delivery dendrimers are one of the important medicine in curing cancers. Various experiments were performed to avoid the occurrence of the rapid growth of cancer cells. Because of that study of anti-cancer drugs and dendrimers are particularly important. Topological indices are molecular descriptors, which are numerical values associated with the physical properties of the chemical structure of a molecule. Finding the physical properties of a molecule in a laboratory is an expensive exercise as it requires many compounds, drugs and time. Therefore, by calculating topological indices, it is possible to get the necessary knowledge about molecules. The objective of this study is to compute the degree-based topological indices of some dendrimer structures that were not calculated earlier and predict the physical properties of selected anticancer drugs using linear regression models. In this work, various topological indices were defined on some anticancer drugs and dendrimer structures, which enable the researchers to know the physical, physicochemical, and chemical properties associated with them. Here the molecular structures were represented as hydrogen depleted molecular graphs considering the adjacency relationships among atoms as vertices corresponding to the atoms of the molecular graph and edges corresponding to chemical bonds. Zagreb and Randić indices are the commonly used indices around new drug design and improvement in this category. Therefore, in this study, degree-based topological indices such that Hyper Zagreb Index - HZ(G), Reduced Second Zagreb index - RM2(G), Augmented Zagreb Index - AZI(G), Forgotten Index - F(G), Inverse Sum Index - ISI(G) were calculated for Poly amidoamine (PAMAM), Polypropylene imine (PPI), Triazine drug delivery dendrimers. Considering the degree of the end vertices, topological indices were calculated for the dendrimer graph. The edge set of the whole graph was partitioned into several sets around on their degrees at the end vertices beginning from the dendrimer core unit. Finally, derived general formulas to find topological indices in the nth generation of a dendrimer. For anti-cancer drugs, fifteen drugs approved for Brain tumors, Testicular cancer, and Acute Lymphoblastic Leukemia were selected using the degree-based calculations, physical properties such as Boiling point, Melting point, Flashpoint, Molar Polarizability, Molar Volume, and Molar Refractivity were predicted. The most studied topological indices are vertex degree-based topological indices. For anti-cancer molecular graphs, selected Zagreb indices, Randic indices, Forgotten Index, Inverse Sum Index, Shigenhalli, and Kanabur Indices were calculated. Calculation of topological indices according to the edge partition is carried out and a MATLAB code was developed for the purpose. Finally, the linear regression model between the topological index and selected physical property was fitted using Minitab software. The significance of the study was predicted using the Pearson correlation coefficient. All calculated values were greater than 0.5 and most of them were greater than 0.75. Therefore values were highly positively correlated.

Keywords: Anti-cancer drug, Dendrimer, Topology Indices (TI)

Abstract No: PO-09

A mathematical model for the description of the drug distribution in the human body

M. A. G. Madhushika and J. Munasinghe[*]

Department of Mathematics, University of Kelaniya, Sri Lanka
munasing@kln.ac.lk[*]

In pharmaceutical industry, various researches have been carried to discover new drugs and to find effective ways of transporting drugs into target parts of the human body. Oral administration, intravenous and inhalations are the commonly used methods in administering drugs. This research study mainly considers oral administration of a drug in tablet form. Determining the absorption processes of a drug after oral administration to the body is a complicated problem. But mathematical modeling can provide the optimal solutions to various complex problems. The compartment model is the mathematical representation of human organs, created to study the drug distribution. This study describes a four-compartment model for drug distribution in the oral mode. In this study, stomach, small intestine, blood and tissues were used as four compartments. In oral consumption of a drug, absorption into the bloodstream occurs in the stomach and small intestine. The blood carries medicine from the site of absorption to the targeted sites and also to sites of metabolism or excretion, such as the kidneys, the liver. Finally, the drugs are excreted through urine after the metabolic process. Drug absorption rate and drug flow rate were used in developing this mathematical model. The rate of drug movement between compartments was described by first-order kinetics. The drug is absorbed through the stomach when drugs are taken orally but has been neglected in this study because of its small amount of absorption compared with other absorption constants. The formulation of this model is based on the principle of continuity and first-order kinetics. First the mathematical interrelationships between the drug concentration were derived with distribution time and rate constants. Then the first-order differential equation system was derived. This first-order differential equation system was solved using the Laplace transform method to avoid the complication raised while finding the eigenvector in the eigenvalue method. Existing rate constants in the mathematical model take different values for different drugs. The rate constants needed for this study were taken from the clinical trial conducted for paracetamol. The drug used in the current mathematical model was paracetamol. The mathematical model for paracetamol distribution was solved using the 4th order Runge-Kutta method and the solutions were plotted using MATLAB. Here, with higher absorption rate constants, the drug is absorbed faster into the body and with lower absorption rate constants, the drug will be retained within the body as a residue, thereby causing side effects. Hence, when the second dose is administered after six hours, the residual drugs from the first dose were also calculated. The present study helps to estimate the relationship between drug absorption, distribution, and the elimination processes.

Keywords: absorption, compartment model, drug distribution, Laplace transform, Runge-Kutta

Abstract No: PO-10

An analysis of the technical efficiency of protected agriculture in dry zone area of Sri Lanka

H. M. K. Wickramasinghe[*] and D. M. P. V. Dissanayaka

Department of Statistics & Computer Science, Faculty of Science, University of Kelaniya, Sri Lanka
hirunioct11@gmail.com[*]

Efficiency is an important factor in productivity growth. It helps in utilizing scarce resources in an effective manner to derive efficient consumption. Identifying the determinants of efficiency levels is a major task in efficiency analysis. Vegetable Production is the most essential sector of the Sri Lankan economy, but recently the seasonality of production supplemented by the climate change effects has posed a major threat to maintaining a constant year-round vegetable production. Protected Agriculture (PA) is identified as one of the best adaptation methods to increase the productivity of horticultural crops, particularly vegetables. The resources that affect the inefficiency in protected agriculture has contributed to such variations in the productivity across the dry zone area. Technical Efficiency (TE) is used as an indicator to determine whether the output reached at its optimal level in production. Both technical and socio-economic factors may result the inefficiency. On the other hand, if it is possible to identify the characteristics of efficient farmers and inefficient farmers, it would be helpful to improve the efficiency of protected agriculture production. Therefore, the attempt of this thesis is to first estimate the technical efficiency in PA based on the factors which derive efficiency of Protected farming and thereby, investigate the influence of socioeconomic factors of farmers on the efficiency in the dry zone. In comparison to the wet and intermediate zones, the dry zone has the highest vegetable production area in the country with sample resources and there are more protected agriculture farmers in the dry zone area. Therefore, the research study was done using all PA farmers in dry zone area. The data set was gathered from the HARTI and consists of 70 farmers' data from the year 2017, taking into account the population of the dry zone area's geographic location. The stochastic frontier approach has been used to generate technical efficiency estimates using Frontier 4.1 by Coeili (1994). The results of this thesis show that the estimated mean technical efficiency of PA production is 49.64 %. Therefore, there is a 50.36 % scope for increasing technical efficiency in PA by using the present technology. The elasticity of inputs is computed from the estimated Cobb-Douglas production function. A production function is a mathematical expression that describes how the quantity of output changes as a function of the inputs utilized in the process. Which concludes, total labor, total Fertilizer, unit price, access to extension service, and initial cost are statistically significant at 5 percent. This implies that the variables of significance remain an important contribution to the determination of technical efficiency in protected farming in the dry zone areas. The analysis reveals that the sum of the partial output elasticity with respect to all inputs is 159, which indicates an increasing return to scale in PA production. Future, it has been found that age, gender, education, and farm size are statistically significant determinants of technical efficiency. The result of the study indicates that the current use of all production inputs is not at the optimum level. Thus, the study provides guidance in increasing the technical efficiency in Protected agriculture in the dry zone in Sri Lanka.

Keywords: Stochastic Frontier Approach, Elasticity

Abstract No: PO-11

Synthesis and characterization of lanthanide-based nanoparticles for potential biomedical applications

C. R. De Silva[*]

Department of Chemistry and Physics, Western Carolina University, USA
mhdesilva@wcu.edu*

Lanthanide-based nanoparticles show unique luminescent properties including monochromatic light emission, longer luminescent lifetimes, stable and well-defined emission bands, large Stokes shifts, and limited photo-bleaching. Our current research efforts are focused on developing lanthanide-based nanomaterials for biomedical applications including high throughput drug screening and cellular imaging. We have developed organic solvent-based high temperature decomposition methods and aqueous-based microwave-assisted synthetic methods to make nanoparticles with high colloidal stability and monodispersity. Europium metal ion doping was successfully achieved using sodium yttrium fluoride, lanthanum fluoride, calcium fluoride, and zinc oxide crystal matrices. The nanoparticles were characterized using transmission electron microscopy, powder X-ray diffraction, Energy dispersive X-ray, absorption spectroscopy, and luminescent methods. Sodium yttrium fluoride and calcium fluoride matrices produced nanoparticles with a diameter of 20 nm and 40 nm, respectively. The zinc oxide matrix resulted nanoparticles with a diameter of 30 nm. Powder X-ray diffraction studies confirmed that yttrium fluoride, calcium fluoride, and zinc oxide matrices produced nanoparticles with cubic closed packed, cubic, and hexagonal wurtzite crystal packing, respectively. Lanthanide metal ion doping did not significantly alter the basic crystal structure of the nanoparticles. Increasing reactant metal concentrations from 0.02 to 0.065 M decreased the calcium fluoride nanoparticle size from 1000 nm to 66 nm. Luminescent quantum yield was sensitive to the crystal matrix and the europium metal doping levels. The highest luminescent quantum yield of 17 % was observed for 10 % europium-doped sodium yttrium fluoride nanoparticles. All nanoparticle systems exhibited narrow emission bands at 615 nm with a full-width at half maximum around 15 nm upon 340 nm lamp excitation. Preliminary in vitro epifluorescence imaging studies confirmed the uptake of europium-doped zinc oxide nanoparticles by human embryonic kidney (HEK) 293 cells.

Keywords: Nanoparticles, Luminescence, Lanthanides, Imaging, Nano-synthesis.

Abstract No: PO-12

A novel, ultra-fast, robust microelectrodes for real-time detection of heavy metals using fast-scan cyclic voltammetry

R. Abbood, A. S. K. Alkhalaf, J. Xavier and P. Pathirathna[*]

Department of Biomedical and Chemical Engineering and Sciences, Florida Institute of Technology, USA
ppathirathna@fit.edu[*]

Humans are highly vulnerable to being exposed to multiple sources of arsenic and cadmium, such as drinking water, foods, inhalation, and occupational means. The detrimental effects of arsenic and cadmium poisoning are well documented. Electrochemical sensors are more attractive over other analytical tools available for metal detection mainly due to the excellent selectivity, sensitivity, cost, and ease of use by a non-expert in the field. Interestingly, the reported electrochemical sensors for As^{3+} and Cd^{2+} in aqueous samples have been primarily performed with gold-based electrodes or other surface-modified electrode materials such as glassy carbon due to their enhanced sensitivity. However, the fabrication process of these electrodes is complex and expensive. Furthermore, most of these experiments were conducted in extreme pH conditions. Although the data obtained with environmental samples are promising, these tools are not suitable for *in vivo* detection of low concentrations of metals, particularly in the brain, and cannot perform fast measurements. Therefore, in this study, we developed a novel, ultra-fast, and robust electrochemical sensor that can perform real-time detection of As^{3+} and Cd^{2+} with a temporal resolution of 100 ms. Our electrode is fabricated with carbon-fibers, thus making an excellent biocompatible sensor for future *in vivo* studies. We performed our electrochemical measurements with cutting-edge electrochemical technology, fast-scan cyclic voltammetry. We optimized electrochemical parameters (potential window, resting potential, and scan rate) to generate unique cyclic voltammograms to identify As^{3+} and Cd^{2+} at a sub-second temporal resolution. Interestingly, we show that we can measure As^{3+} in the ambient air. We also performed calibration studies, selectivity, and stability studies to evaluate our novel metal sensors. Our preliminary data showcases the power of our tool as an excellent environmental sensor that can detect these two metal ions in aqueous samples. More importantly, these data indicate a great potential for developing this device to perform real-time *in vivo* measurements of metals in the brain.

Abstract No: PO-13

Ultrafast, simultaneous detection of neurotransmitters and heavy metals at four-bore carbon-fiber microelectrodes using fast-scan cyclic voltammetry

M. Laud, M. M. N. Ahmed, J. Penteado, L. Sibert, R. Page and P. Pathirathna[*]

Department of Biomedical and Chemical Engineering and Sciences, Florida Institute of Technology, USA
ppathirathna@fit.edu[*]

Progressive deterioration of brain cells leads to devastating neurological disorders such as Parkinson's and Alzheimer's. Despite the efforts taken by scientists, the pharmaceutical industry, and medical professionals to develop medicines that slow down the progression of the disease, these have become a major global concern. It is known that the etiology of these diseases is multifactorial; however, it is not fully understood yet. In addition to the currently available knowledge of some risk factors such as aging, the fundamentals of some other vital factors remain hidden due to the incompetence of existing methods. In particular, the contribution of heavy metals and the role of co-transmission on these illnesses haven't been explored experimentally in real time yet. Therefore, in this study, we fabricated the fastest four-bore carbon-fiber microelectrode (CFM) that can perform real time, simultaneous measurements of heavy metals and neurotransmitters with a temporal resolution of 100 ms. We used fast-scan cyclic voltammetry (FSCV) as our electrochemical measuring tool to perform fast measurements. Each bore in our novel electrode contains a single carbon-fiber (diameter of 5-7 μm) that acts as a single electrode. We characterized our sensor with dopamine (DA), serotonin (5-HT), ascorbic acid (AA), and Cu^{2+} ions in tris buffer using FSCV. To the best of our knowledge, this is the first time reporting simultaneous measurements of four analytes using FSCV. Interestingly, we find that the sensitivity of CFMs towards Cu^{2+} ions increases in the presence of DA and AA; this may be presumably due to the increased surface-active sites on the secondary film formed by DA, AA, and their products catalyzing the surface adsorption of Cu^{2+} ions. Additionally, we find that 5-HT detection with a bare electrode is not feasible in the presence of Cu^{2+} ions. Most likely, it is because the active sites are already occupied by Cu^{2+} ions, thus, leaving no room for the adsorption of 5-HT molecules. This finding is fundamentally novel and will provide an excellent platform for surface modification strategies for multi-bore CFMs to perform in vivo experiments.

Keywords: Carbon-fiber, FSCV, Metals, Microelectrodes, Multi-bore, Neurotransmitters

Abstract No: PO-14

Electrochemical detection of Cd^{2+} ions in aqueous samples at nanoelectrodes

M. M. N. Ahmed, F. Bodowara, J. Penteado, W. Zhou, J. Xavier and P. Pathirathna[*]

Department of Biomedical and Chemical Engineering and Sciences, Florida Institute of Technology, USA
ppathirathna@fit.edu*

Contamination from heavy metals has been a potent threat to the environment, and its detrimental effects are felt globally. They bio-accumulate through the food chain, thus leaving humans highly vulnerable to overwhelming health hazards. Most traditional metal-detecting analytical instruments necessitate extensive sample pre-treatment processes, consequently, change metal speciation, one of the most critical factors for evaluating metal toxicity. Furthermore, they are cumbersome, require expensive instruments that are less user-friendly, restricting real-time metal monitoring. As a result, the development of a low-cost, portable, and reliable sensor capable of delivering precise information on metal speciation will significantly assist in the efficient implementation of metal mitigation systems. In this study, we utilize ion transfer between two immiscible electrolyte solutions (ITIES) to design a Cd^{2+} sensor. The chemistry at ITIES is governed by Gibbs's free energy of transfer for an ion at the interface of two immiscible solvents. A potentiostat is used to supply the energy required to overcome the energy barrier in the form of potential energy, and the resulting current is measured. ITIES is less complicated as it does not involve electron transfer; hence more attractive over other redox-based electrochemical techniques. A suitable ionophore, which lowers the energy barrier and increases the selectivity, can be added to the organic phase, facilitating the transfer of ions at lower potentials. Our electrode is a borosilicate glass electrode with an inner radius of 300 nm. It follows a hemispherical diffusion regime, owing to its nanoscale interface that allows fast kinetic measurements. An ionophore- 1-10 phenanthroline was used to facilitate the Cd^{2+} transfer across the nano-interface. We performed ITIES based cyclic voltammetry and amperometry experiments with our nanosensor in various matrices, including simple electrolytes like KCl and complicated buffer solutions such as artificial seawater and artificial cerebellum fluid. We also tested the strength of our ionophore against other standard ligands such as Ethylenediamine tetraacetic acid, Nitrilotriacetic acid and Dimercaptosuccinic acid etc. We found out that our electrode shows excellent stability and can withstand the complex matrices without fouling, an attractive feature of an exemplary sensor. We tested our sensor with Cd^{2+} dissolved in a water sample collected from Indian River Lagoon, Melbourne, FL; thus, we showcase our sensor's power as an environmental monitoring tool. To the best of our knowledge, this is the first time reporting a glass electrode with a sub-nano-meter scale for Cd^{2+} detection in a natural environmental sample using ITIES. Our ultra-small electrode will enable us to study the kinetics of ion transfer across ITIES; thus, allowing us to modify the sensor to enhance the sensitivity and selectivity.

Keywords: Cd^{2+}, Electrochemistry, ITIES, Nanosensor, Pollution

Abstract No: PO-15

Use of cuprous oxide thin film semiconductors for dissolved oxygen sensing: A preliminary study

H. E. Wijesooriya, J. A. Seneviratne, K. M. D. C. Jayathilaka and R. P. Wijesundera*

Department of Physics and Electronics, Faculty of Science, University of Kelaniya, Sri Lanka
palitha@kln.ac.lk*

Monitoring and maintaining the quality of water is extremely important as it can severely affect the health of humans as well as animals. Dissolved oxygen is one of the key indications of water quality. Cuprous Oxide (Cu_2O) semiconductor material is an ultra-low cost, environmentally friendly, earth abundant material which is considered as a green alternative to many sensing applications. Therefore, Cu_2O thin film semiconductors could potentially act as a dissolved oxygen sensor due to their unique electrical features. Generally, a significant change in the electrical conductivity is caused by the adsorption of molecules on the surface of Cu_2O semiconductor material. In this investigation, the possibility of sensing dissolved oxygen using Cu_2O thin film semiconductors was explored. Cu_2O thin films were grown using the electrodeposition technique on titanium (Ti) substrates at -200 mV vs Ag/AgCl for 60 minutes in an electrochemical cell containing an acetate bath of 0.1 M sodium acetate and 0.01 M cupric acetate. The temperature of the bath was maintained at 55 °C and stirred at a speed of 50 rev/min. The Ag/AgCl electrode was used as the reference electrode, while the platinum electrode was the counter electrode. Prepared Cu_2O thin films were characterized in two-electrode systems using resistance measurements at ambient conditions in two different Deionized (DI) water volumes of 100 ml and 200 ml while aerating oxygen at a constant rate at the room temperature. Significant linear change in resistance was observed with increasing dissolved oxygen concentration under ambient condition in both cases. In comparison with experiment carried out with 100 ml of DI water volume, it was observed that in 200 ml DI water volume it takes more than twice the time to saturate with oxygen. Furthermore, it was observed that the constant resistance value of the system at the saturation of 200 ml DI water volume was higher than the constant resistance obtained at the saturation of 100 ml DI water volume. This preliminary investigation revealed that Cu_2O thin films could use to monitor dissolved oxygen. However, further investigations need to be performed to optimize the dissolved oxygen sensing property of Cu_2O thin films.

Keywords: Cu_2O, Dissolved oxygen, Electrodeposition, Thin film semiconductor sensor, Water quality

Abstract No: PO-16

Synthesis and characterization of ionic liquid and hydroxyapatite nano-filler based sodium ion conducting gel polymer electrolytes

M. D. M. Nayanakanthi[1]*, H. M. J. C. Pitawala[1] and J. L. Ratnasekera[2]

[1]Department of Science and Technology, Uva Wellassa University, Sri Lanka
[2]Department of Chemical Sciences, Rajarata University, Sri Lanka
mangala_usjp@yahoo.com*

Interesting property such as high abundance and non-toxic character of sodium and high storage capacity and durability of sodium batteries make them an attractive energy storage system and a potential alternative to lithium batteries. Electrolyte is an important component of a battery system that controls electrochemistry between electrodes and affects electrochemical performance of batteries. Presently various types of electrolytes are being commercially used for battery applications but there are many problems associated with these electrolytes. In order to modify the properties of electrolytes, development of composite gel polymer electrolytes (CGPEs) are one of the approaches in that direction, specially it improves electrochemical properties of porous polymer electrolytes. In this work, synthesis and characterization of novel sodium ion-conducting nanocomposite gel polymer electrolytes based on poly(vinylidene fluride-co-hexafluoropropylene) (PVdF-HFP) are presented. The free standing flexible membranes of the CGPEs were prepared from solution-cast method. Nanosized hydroxyapatite (HAp) particles were used as the active filler and 1-butyl-3-methylimidazolium trifluoromethanesulfonate (BMIMTf) ionic liquid (IL) was used as an additive. Various physical and electrochemical analysis were demonstrated to use these membranes as promising electrolytes in rechargeable sodium batteries. Among studied samples, addition of 7 wt.% HAp shows the maximum ionic conductivity with the value of 1.7 mS cm^{-1} at room temperature (~27 $^{\circ}$C). The ion/filler-polymer interactions and possible conformational changers in the host polymer due to dispersion of nano-sized HAp particles were examined by Fourier transform infrared (FTIR) and X-ray diffraction (XRD) methods. Our FTIR results showed considerable changes in the wavenumber regions of 500-700 cm^{-1} and 900-1150 cm^{-1} due to the changes of CF_3 and SO_3 asymmetric/symmetric vibrational bands with HAp particles. In addition, PO_4^{-} anion vibrations of HAp were also influenced by ion-ion interactions mainly for the vibrational bands at 560-640, 963 and 1028 to 1110 cm^{-1}. The collected XRD spectra showed clear crystallinity change with increasing amorphous nature of the CGPEs when nanoparticle addition of 7 wt.%. The main changers were found in the 2θ value between 10 and 30°. The results obtained in the present study have shown that the presence of IL and addition of nano-sized ceramic fillers can be optimized the overall physico-chemical properties of PVdF-HFP based electrospun membranes.

Keywords: Sodium batteries, Nanocomposite gel polymer electrolytes, Hydroxyapatite nano fillers, Ionic liquid, Infrared (IR) spectroscopy, Ionic conductivity

Abstract No: PO-17

Effect of annealing temperature on the wetting properties of electrodeposited Cu$_2$O

M. D. P. A. Shakya, K. M. D. C. Jayathilaka*, R. P. Wijesundera and W. T. M. P. K. Wanninayake

Department of Physics and Electronics, University of Kelaniya, Kelaniya, Sri Lanka
charithkmd@kln.ac.lk*

Surface wettability is one of the important physical parameters, which manifests the affinity of a liquid towards a solid phase. In recent years, controlling the wettability of solid surfaces has drawn significant attention due to its influence in wide range of applications. Cuprous Oxide (Cu$_2$O) is well known as a technologically important material for various fields due to its unique advantages such as low cost, high chemical stability and remarkable electrochemical performance. This work examines the impact of the post annealing temperature on the wetting ability of Cu$_2$O thin films. A set of Cu$_2$O thin films was deposited on Ti substrate at a deposition potential of -200 mV vs saturated calomel electrode (SCE) in an acetate bath containing an aqueous solution of 0.1 M sodium acetate and 0.01M cupric acetate at bath temperature of 60 °C and pH value of 6.5 for 45 min. Potentiostatic electrodeposited Cu$_2$O films were annealed in air at 100 °C, 150 °C, 200 °C, 250 °C, 350 °C and 400 °C for 20 and 40 minute separate time intervals. The surface morphological and structural characterizations of prepared samples were studied using scanning electron microscopy (SEM) and X-ray diffraction (XRD) techniques. SEM (Zeiss evols 15) and SHIMADZU (XD-D1) X-ray diffractometer were used to study the samples. XRD spectral patterns indicated the presence of Cu$_2$O without having any impurity phases. The water contact angles were measured using the sessile drop method in order to investigate the effect of temperature on the wettability of the Cu$_2$O films. The contact angle of Cu$_2$O thin film changed from 110° (non-wetting) to 10° (completely wetting) with the increase in the annealing temperature. The contact angle measurement for cuprous oxide showed a transition of cuprous oxide surface from hydrophobicity to hydrophilicity and the maximum hydrophobicity was observed at 150 ± 1 $^\circ$C. Similar variation and maximum hydrophobicity of the contact angle were observed for both annealing durations (20, 40 minutes). SEM micrographs of electrodeposited Cu$_2$O thin films indicated significant changes in the surface morphology with annealing temperature. Dimension of grains becomes smaller with increasing temperature. This suggests that higher heating temperatures lead to a decrement in the contact angle. Based on the results of the investigation, surface morphology is the primary determinant of the wettability qualities of Cu$_2$O thin films.

Keywords: Cuprous oxide, Contact angle, Electrodeposition, Wettability, Hydrophobicity

Abstract No: PO-18

Investigation of the effect of source temperature on close-spaced sublimated CdTe thin films

A. A. I. Lakmal[1], R. K. K. G. R. G. Kumarasinghe[1], V. A. Seneviratne[1,2] and B. S. Dassanayake[1,2*]

[1]Postgraduate Institute of Science, University of Peradeniya, Peradeniya, Sri Lanka
[2]Department of Physics, Faculty of Science, University of Peradeniya, Peradeniya, Sri Lanka
buddhikad@pdn.ac.lk*

Cadmium telluride (CdTe) is one of the most promising II-VI group semiconductors used to fabricate heterojunction thin-film solar cells. Close-spaced sublimation is one of the best techniques for the deposition of polycrystalline CdTe thin films. In this study, CdTe thin films were deposited on the cleaned FTO glass substrates using the close-spaced sublimation technique by varying the source temperature from 560 °C to 720 °C in steps of 20 °C. The temperature of the substrates, source to substrate separation, and deposition duration were maintained at 540 °C, 4 mm, and 5 minutes respectively. $Ar_{(g)}$ was introduced to the vacuum chamber, keeping the pressure at 7.9 Torr. The deposition was carried out using high purity CdTe powder placed in a graphite crucible. An almost transparent thin CdTe layer was observed at the source temperature of 560 °C. In comparison, a slightly decomposed layer was seen when the source temperature was 720 °C, which could be considered two boundary points in the temperature range selected. The CdTe layer deposited at source temperature 580 °C had a better thickness compared to 560 °C and pinholes could be visible to the naked eye. The average transmittance beyond the absorption edge was decreased with the increment of source temperature. The optical bandgaps of all samples were in the range of 1.48 - 1.50 eV. The crystallinity of the deposited thin films was shown an increasing trend with the increment of source temperature. According to the SEM analysis, the increment of source temperature has led to better grain enhancement. Based on the above characterizations, the optimum source temperature was determined as 660 °C. To further confirm this result, CdS/CdTe full cells were fabricated by depositing the above CdTe layers on thermally evaporated CdS films with back contacts in the order of Cu before Au. Among the CdS/CdTe/Cu/Au cells fabricated for electrical characterization, the highest efficiency was obtained for the source temperature of 660 °C.

Keywords: Cadmium telluride, CdS/CdTe solar cells, Close-spaced sublimation, Source temperature

Abstract No: PO-19

Qualitative review of the photometric data of six ultra-faint dwarf galaxies

B. K. S. Perera[1*], J. V. Wijesekera[2], K. S. Rathnayake[1], H. R. S. Udani[1], P. L. V. J. Sigera[3],
W. C. S. Senarath[1] and P. V. N. D. Wimalaweera[1]

[1] Institute of Astronomy, Sri Lanka
[2] University of Padova, Italy
[3] University of Ruhuna, Sri Lanka
pererashamindika@gmail.com*

This work was based on the main sequence (MS), the sub and red giant branches (SGB & RGB), the horizontal branch (HB), and the blue stragglers' stellar populations of six ultra-faint dwarf (UFD) galaxies: Bootes I (Boo I), Canes Venatici II (CV II), Coma Berenices (Com Ber), Hercules, Leo IV, and Ursa Major I (UMa I). Our findings are based on a combination of high-precision photometry from the Hubble Space Telescope's Advanced Camera for Surveys and isochrones provided by the Dartmouth Stellar Database. According to the results, we found that the proportion of MS stars were higher compared to SGB and RGB, even for older UFD galaxies. Although the metallicities of the six UFD galaxies are essentially identical, Boo I, UMa I, and Hercules have different HB morphologies than CVn II, Leo IV, and Com Ber which is called the second parameter problem. The stellar ages of unknown UFDs in the Local Group can provide information on the mechanisms that regulate star formation in small galaxies during the reionization period if the Local Group comprises multiple unknown UFDs. These UFDs are a major contribution to the assembly of galaxies and the reionization of the Universe. Boo I, Leo IV, UMa I, CVn II, Com Ber, and Hercules show MS star proportions as 0.330, 0.599, 0.584, 0.682, 0.272 and 0.568 respectively, while SGB and RGB proportion are 0.017, 0.044, 0.011, 0.051, 0.007 and 0.034. This may be due to more abundant red dwarf stars.

Keywords: Main sequence, Red Giant Branch, Ultra-Faint Dwarf Galaxies

Abstract No: PO-20

Stability of the performance of inverted P3HT/PCBM based organic solar cells

M. L. A. Weerasinghe[*], W. T. M. A. P. K. Wanninayake, K. M. D. C. Jayathilaka and R. P. Wijesundera

Department of Physics and Electronics, University of Kelaniya, Sri Lanka
weerasingheanjalika@gmail.com*

The organic solar cell extracts and converts solar energy to electricity without environmental hazardous including global warming. Bulk heterojunction (BHJ) structure of the organic solar cells (OSCs) have higher performance than the layered structure. But the main disadvantage of the OSCs is the poor stability of the device. Therefore, this study was focused on the stability of fabricated P3HT/PCBM OSCs. A series of inverted organic solar cells were fabricated on titanium substrate using spin coated P3HT/PCBM, doctor bladed PEDOT: PSS and sputter coated Au. Device characterizations were carried out under AM 1.5 illumination during 20 days. Electrical parameters of open-circuit voltage (V_{OC}), short circuit current density (J_{SC}), fill factor (FF) and power conversion efficiency (PCE) were obtained during 20 days from dark and light I-V measurements. Best device produced V_{OC} of 282 mV, J_{SC} of 2.65 mAcm^{-2}, FF of 0.21 and PCE of 0.15%. The PCE decreased dramatically and became almost constant value of 0.04% within 20 days. FF was constant throughout the 20 days and V_{OC} decreased slightly within 20 days. However, J_{SC} of the device decay from 2.65 mA/cm^2 to 1.0 mA/cm^2 within the considered time duration. Hence, this PCE behavior of the device is due to the loss of J_{SC}. PCE of the organic solar cell is not higher than the silicon solar cell, but it can be improved by changing the geometry of the solar cell, annealing conditions, etc. This instability of the device upon irradiation is due to photochemical and photophysical degradation in the active layer, and the active layer/electrode interface. Further, low J_{SC} is mainly due to the low electron mobility and low exciton diffusion length. Performance of the device can be improved carefully controlling the device fabrication parameters in the inert gas surrounding.

Keywords: OSC, P3HT/PCBM, Bulk heterojunction, Stability

Abstract No: PO-21

Europium-doped calcium fluoride nanoparticles coated with melanocortin stimulating hormone-4 for potential biomedical imaging

C. R. De Silva[1*], M. Fratarcangeli[1], M. R. Rathbone[2] and S. Hendren[1]

[1]Department of Chemistry and Physics, Western Carolina University, USA
[2]Department of Biology, Western Carolina University, USA
mhdesilva@wcu.edu*

Lanthanide-based nanomaterials have promising applications including high throughput drug screening, bio-analytical sensing, and biomedical imaging. Among many lanthanide-based nanomaterials, europium (III) ions are of particular interest in biological assays due to their long luminescent lifetimes, limited photobleaching, monochromatic emission at 614 nm, and large Stokes shifts. Compared to well-known lanthanide-doped matrices such as yttrium fluoride and lanthanum fluoride, calcium fluoride matrix has shown to have promise as an imaging agent due to their greater luminescent efficiency and high biocompatibility. This work focuses on synthesizing novel europium-based nanomaterials and functionalization of the surface of the nanoparticles with a melanocortin stimulating hormone (MSH-4) peptide targeting human cells expressing human melanocortin receptors (hMCRs). A microwave-based synthetic method was optimized to prepare europium-doped calcium fluoride nanoparticles with a controlled size distribution in the 100-120 nm range. The optimized parameters include a pH of 6, reaction time of 30 minutes at a microwave power of 100W. Control over size distribution of the nanoparticles was achieved by adjusting the initial reactant ratios. The nanoparticles were characterized by using powder X-ray diffraction (XRD), dynamic light scattering (DLS), Fourier-transform infrared spectroscopy (FTIR), luminescent spectroscopy (UV-Vis), and transmission electron microscopy (TEM). The melanocortin stimulating hormone (MSH-4) peptide was synthesized using the standard solid phase peptide synthesis method and characterized using LCMS and was determined to be 67% pure. The europium-based nanoparticles were functionalized with the MSH-4 peptide which is an agonist for hMCRs. Further research will be carried out to investigate the potential of using peptide functionalized nanoparticles for biomedical imaging.

Keywords: MSH-4, nanoparticles, biomedical imaging, peptides, lanthanides

Abstract No: PO-22

Luminescent studies of europium (III) fluorobenzoic acid derivatives: Correlating the calculated electronic energies and the experimental luminescent efficiencies through computational studies

C. R. De Silva* and M. Fratarcangeli

Department of Chemistry and Physics, Western Carolina University, USA
mhdesilva@wcu.edu*

Europium (III)-based luminescent complexes promise extensive potential applications in immunoassay technology, high throughput drug screening, organic light emitting diodes (OLEDs), and biomedical imaging. Europium-ligand complexes present unique properties such as monochromatic emission at 614 nm, long luminescent lifetimes enabling time-resolved measurements, minimal photobleaching, and large Stokes shifts. Ligand design for enhancing the quantum efficiency of europium complexes is currently active. For this reason, it is important to understand the electronic mechanisms that allow europium-metal complexes to fluoresce. Here, we report the structural and spectroscopic properties of a series of europium (III) complexes containing fluorobenzoic acid derivatives using density functional theory calculations. Calculations were carried out using the B3LYP method and 6-31G* and 6-311+G** basis sets. Upon increasing the ligand fluorination, the absorption maximum wavelength shows a blue shift. Excited state energy gaps of the complexes were found to be sensitive to the identity and the position of the ligand substituents. A nitro substitution results in a decrement of the vertical excited states, significantly reducing the luminescent quantum yield. The inter-system crossing energy gap is strongly regulated by the position of the ligand substituent. It is significantly reduced by having substituents closer to the metal coordination site. The optimum energy gaps resulting in enhanced luminescent quantum yields were identified. The correlation among the calculated experimental luminescent quantum yields and the calculated electronic energy levels will be discussed to provide insight into designing highly luminescent europium complexes.

Keywords: Europium complexes, excited states, density functional theory, computational chemistry, quantum yield

Abstract No: PO-23

Anthurium disease detector using machine learning techniques

K. M. N. S. Ranasinghe[*] and U. P. Liyanage

Department of Statistics and Computer Science, Faculty of Science, University of Kelaniya, Sri Lanka
nayanahari1995@gmail.com*

There are many problems with planting Anthurium due to diseases. The lack of knowledge about the diseases and identification of the disease correctly, are the major challenges that face by the farmers. Further, some of diseases have no cure, yet must be destroyed before they can be spread. The ways and means of obtaining the essential assistance, for example may be from responsible parties such as Department of Floriculture or Agriculture in Sri Lanka, are limited due to the fact that there is no flexible mechanism to approach their resource personals in efficient manner. Thus, treatment of ill plans becomes hard problem. To overcome these practical difficulties faced by farmers, this study focus to build a mobile application using Android Studio Software to detect the disease through image processing and computer aided models, and thereby, allows farmers to apply disease treatment steps as soon as possible. Using the mobile application, farmers allows to take pictures of disease plant parts, and send for disease detection programs. These programs analyses the images using appropriate machine learning techniques and gives a feedback concerning the disease the plant has. Indeed, correct identification of the plant disease leads to early treatment, and hence the better curing possibilities. The system allows to determine diseases using the images of the Anthurium leaves, flower body, flower nose and the roots of the plants. The system allows to recognize three diseases namely, Bacteria Blight, Rhizoctonia Root Rot and Black Nose Disease. To determine disease correctly, images from all the above mention plant parts are needed. As the disease detection techniques, algorithms using the Convolutional Neural Network (CNN) have been utilized. In particularly, a sequential CNN model namely, LeNet, have been trained and tested using 2962 images. Further, all the images are transformed to gray-scale images to improve the classification rate of CNN algorithms. The models are trained with 10,15,20,30,40,50,75,80 and 100 epochs, and the scenario with 80 epochs performed best in terms of both accuracy and loss values and had the best curve. Based on the image set that has been used, Bacteria Blight, Rhizoctonia Root Rot and Black Nose Disease have been detected with the accuracy of 96.5%, 99% and 98%, respectively. The predicted time is on average less than one second using average computer power utilized in the back end of the system. This accuracy is sufficient for successfully detecting the plant diseases, and thereby, the system that has been engineered will be beneficial for the farmers to manage healthy plant nursery.

Keywords: Anthurium Diseases, CNN, Image Classification, Image Processing, Mobile Application

Abstract No: PO-24

Thermally evaporated copper iodide hole transport layer for CdS/CdTe thin film solar cells

T. Thivakarasarma[1], A. A. I. Lakmal[2,3], B. S. Dassanayake[2,3], D. Velauthappillai[4] and P. Ravirajan[1*]

[1]Clean Energy Research Lab (CERL), Department of Physics, University of Jaffna, Sri Lanka
[2]Postgraduate Institute of Science, University of Peradeniya, Sri Lanka
[3]Department of Physics, University of Peradeniya, Sri Lanka
[4]Western Norway University of Applied Sciences, Norway
pravirajan@gmail.com*

CdS/CdTe thin-film solar cell is a cost effective and reliable photovoltaic device with reported power conversion efficiencies over 22%. Although large-scale thin-film solar panels with efficiency over 18 % are commercially available, it has been reported that the efficiency drops due to copper diffusion to the CdS/CdTe interface. To avoid the Cu diffusion in these devices, Cu-free back contacts have been introduced in the past with reasonable success. This work focuses on studying the photovoltaic performance of CdS/CdTe devices by replacing Cu with copper iodide (CuI). For the device fabrication, the *n*-CdS window layer was fabricated by the chemical bath deposition (CBD) method on a cleaned FTO substrate, and then the *p*-CdTe absorber layer was deposited by closed space sublimation (CSS) on top of the CdS layer at a substrate temperature and source temperature of 580 ˚C and 640 ˚C, respectively in argon gas medium for 25 minutes at 7.9 torr vacuum pressure. In order to study the effect of a CuI hole transport layer on photovoltaic performance of CdTe solar cells, CuI film of varying thicknesses from 5 nm to 30 nm were deposited on the CdTe films by thermal evaporation. After the CuI film deposition, Au layer of thickness 80 nm was thermally evaporated as a back electrode, and then the fabricated device was annealed at 200 °C for 10 min in an N_2 environment. The UV-Visible spectroscopic studies confirmed that bandgap of thermally evaporated CuI hole transporter, chemically deposited *n*-CdS window layer and close spaced sublimated *p*-CdTe absorber layer are 3.0, 2.4 and 1.5 eV respectively. The XRD studies not only confirmed the presence of each layer but also confirmed the phase of thermally evaporated CuI film was hole-transporter (γ-CuI). AFM analysis confirmed the homogeneous well-adhered nature of each layer. Finally, photovoltaic performance of the devices with CuI film of thickness 5 nm to 30 nm was characterized under illuminations of 100 mW/cm² (1 sun) with an Air Mass 1.5 filter. An optimized CdS/CdTe device with CuI thickness of 10 nm showed Power Conversion Efficiency of 6.92 % with J_{SC}, V_{OC}, and FF of 21.98 mA/cm², 0.64 V, and 0.49 respectively.

Keywords: CdS/CdTe thin film solar cells, Hole transport layer, CuI, Cu diffusion

Abstract No: PO-25

L-asparaginase encapsulated poly-l-lysine-graft-poly(ethylene) glycol polymer nanoparticles for therapeutic delivery

R. S. H. Koralege* and K. Goff

Department of Chemistry and Physics, Western Carolina University, USA
rhikkaduwakoralege@email.wcu.edu*

Therapeutic proteins have shown to be effective against a variety of diseases. Unlike traditional small-molecule chemotherapeutics, protein therapeutics can be actively targeted towards malignant cells using cell surface receptors and/or other markers specifically associated with or overexpressed on tumors versus healthy tissue. L-asparaginase (L-ASNase) is a therapeutic enzyme that is widely used for the treatment of hematopoietic diseases such as acute lymphoblastic leukemia and lymphomas since 1970. L-ASNase can destroy asparagine dependent tumors by degrading circulating L-asparagine and destroying malignant cells. L-ASNase has intrinsic drawbacks such as low stability, short circulating lifetime, and low catalytic activity under physiological conditions due to it being a therapeutic enzyme and essentially a protein drug. Immunogenicity of L-ASNase is another major problem with high frequency of hypersensitivity reactions due to the bacterial origin of this protein. ASNase delivered after pegylation (poly(ethylene)glycol)-ASNase) has been shown to improve clinical outcome of this therapy. However, the safety and efficacy of this therapy in older adults is less well established and has shown toxicity in clinical trials. Much effort has been devoted to developing methods to avoid such side effects as well as to increase its in vivo half-life. This research is focused on synthesis, optimization, and characterization of L-ASNase encapsulated nanoparticles for successful delivery of the therapeutic protein. Poly-L-lysine-graft-poly(ethylene) glycol copolymer (PLL-g-PEG) was successfully synthesized and characterized using ^{1}H NMR spectroscopy. L-ASNase encapsulated nanoparticles were formed through electrostatic interaction of the cationic backbone of the PLL-g-PEG copolymer and negatively charged L-ASNase. Average hydrodynamic diameter of these nanoparticles was 114.5 ± 5.66 nm, and they had a zeta potential of 0.436 ± 0.258 mV. Polyacrylamide gel electrophoresis (PAGE) was used to analyze the extent of L-ASNase encapsulation. According to PAGE data, there were no free proteins present in our nanoparticle formulations. These therapeutic nanoparticles are stable in solution at physiological pH conditions up to more than three months and long-term particle stability studies are in progress. L-ASNase catalytic activity experiments are currently in progress to evaluate how encapsulation could affect protein function and will also be presented.

Keywords: Encapsulation, L-asparaginase, Nanoparticles, Protein, Therapeutic delivery

Abstract No: PO-26

Analysis of biogenic amines in grave soil and cadaver dog training aids using gas chromatography mass spectrometry

U. D. N. T. Perera*, and M. R. Wisor

Department of Chemistry and Physics, Western Caroline University, USA
uperera@email.wcu.edu*

In a forensic investigation of a missing persons or a suspected murder, finding human remains plays a vital role. Currently, the most common method to find these remains is the use of human remains detection dogs or HRD dogs. Although, these dogs can distinguish human remains from animal remains, and find human remains buried in significant depths, the scientific basis for this remarkable ability is not well understood. HRD dog's ability to detect human remains depends on the volatile organic compounds (VOCs) produced during the decomposition process. These VOCs contribute to the "smell of death" and the analysis of them is crucial to understand the differences between human and animal decomposition odor. Additionally, some HRD dogs are trained using cadaver dog training aids known as "pseudo corpse" due to the limited availability of decomposing human remains for training purposes. In some studies, these training aids are found to be less effective compared to real human remains. Although biogenic amines like putrescine and cadaverine are present in grave soil and decomposition odor, the presence of these compounds in decomposition odor is not well reported in literature. In previous work researchers have used gas chromatography mass spectrometry (GC-MS) in decomposition odor analysis. These amines often have high basicity, high polarity, and low volatility compared to other VOCs, and they tend to absorb and decompose in the GC column, sample vessels, and injection system making them hard to detect in low concentrations and difficult to analyze using GC-MS. To obviate these problems, the current work focuses on analyzing these amines by derivatizing them followed by the analysis using GCMS. Furthermore, an extraction method is developed to extract amines from soil samples. Three derivatization agents trifluoroacytalacetone (FAA), pentafluoroproponic anhydride (PFPA) and, isobutyl chloroformate (IBCF) were investigated and IBCF showed promising results. This method was used to analyze grave soil samples collected near to a partially decomposed human body and a relatively fresh human body and three commercially available cadaver dog training aids. Cadaverine and putrescine were present in one of the cadaver dog training aids at concentrations of $780. \pm 6$ mg/mL and $1440. \pm 6$ mg/mL respectively. Only cadaverine was present in the second training aid at a concentration of 426 ± 6 mg/mL. One training aid did not contain any amines in detectable levels. Soil obtained near the partially decomposed corpse showed a slightly elevated amount of cadaverine at a concentration of 37 ± 1 mg/g compared to the body that was recently placed which contained 31 ± 1 mg/g of cadaverine. Future work of this research involves the analysis of amines in grave soil during different stages of decomposition.

Keywords: Decomposition odor, derivatization of amines, cadaver dog training aids, biogenic amines

Abstract No: PO-27

Photocatalytic activity of Go/Fe$_3$O$_4$ fabricated by Sri Lankan graphite under visible light irradiation

L. Usgodaarachchi[1] and C. Thambiliyagodage[2*]

[1]Department of Materials Engineering, Faculty of Engineering, Sri Lanka Institute of Information Technology, Malabe, Sri Lanka
[2] Faculty of Humanities and Sciences, Sri Lanka Institute of Information Technology, Malabe, Sri Lanka
charitha.t@sliit.lk*

Graphene oxide (GO) was synthesized using Sri Lankan naturally available graphite by modified Hummer's method. Fe$_3$O$_4$ nanoparticles were synthesized successfully by co-precipitation of Fe^{3+} and Fe^{2+} in a 2:1 molar ratio via the addition of NH$_4$OH. Magnetically separable GO/Fe$_3$O$_4$ nanocomposite was fabricated by synthesizing Fe$_3$O$_4$ nanoparticles in the presence of GO. The synthesized nanocomposites were characterized by X-ray diffractometry (XRD), Scanning electron microscopy (SEM), and FT-IR spectroscopy. The formation of GO was confirmed by the C(002) peak at 9.39° in the XRD pattern. XRD pattern of the nanoparticles confirms the formation of crystalline Fe$_3$O$_4$ nanoparticles, and the diffraction peak corresponds to graphene oxide disappear in the GO/ Fe$_3$O$_4$ due to the absence of the folded structure of graphene oxide. SEM image of GO shows the crumpled and wrinkled lamellae structure of graphene oxide, and the images of GO/ Fe$_3$O$_4$ show the distribution of Fe$_3$O$_4$ nanoparticles with an average size of 107 nm on GO where the folded structure of GO was not present while restacking of the nanosheets, was observed. FT-IR spectrum of GO shows the presence of polar oxygenated functional groups such as carboxylic acid (-COOH), hydroxyl (-OH), and epoxy (-COC-). The photocatalytic performance of the photocatalysts was evaluated on photodegradation of methylene blue under visible light irradiation. The GO/ Fe$_3$O$_4$ shows better adsorption behaviour and excellent photocatalytic activity where it could be successfully used for three cycles without significant activity loss. The rate constant for the degradation of MB (0.0187 min^{-1}) at the first cycle decreased to 0.0101 min^{-1} at the third cycle. The conversion of MB decreased from 98.31% at the first cycle to 92.15% at the third cycle. The drop in the conversion is only 6.16% going from cycle 1 to 3, which could be due to the accumulation of the MB molecules at the pore structure. The obtained high photocatalytic activity could be due to the enhanced charge separation resulted due to the presence of GO sheets and better interactions between GO and Fe$_3$O$_4$.

Abstract No: PO-28

Surface modification of *Leucaena leucocephala* wood biochar using coconut vinegar

M. Udawatta, R. C. L. De Silva[*] and D. S. M. De Silva

Department of Chemistry, University of Kelaniya, Kelaniya, Sri Lanka
russel@kln.ac.lk*

Over the last few decades biochar has emerged as a popular low cost adsorbent for water treatment due to its abundance and cost-effectiveness. Number of studies have reported the efficiency of strong acids such as nitric, sulfuric, hydrogen peroxide, etc. in activating biochar. However, as these chemicals are expensive, corrosive and difficult to be handled by unskilled personnel, use of these chemicals is limited to industrial activation processes. To provide a user friendly economical activation process, this study focused to evaluate the ability of natural coconut vinegar, in activating *Leucaena leucocephala* wood biochar. Coconut vinegar, a common food additive, is a 4 % acetic acid solution in water (4 g acetic acid/ 100 mL vinegar, pH 2.5). *Leucaena leucocephala* is a common, fast-growing tree with light wood and soft foliage. It is widely used for fuelwood. In this study, air dried *Leucaena leucocephala* wood pieces were allowed to burn in a domestic kiln (300 °C, 2 hours) to produce biochar. The activation of biochar was done by soaking it in coconut vinegar for 24 hours followed by oven drying (120 °C, 3 hours). After cooling it was washed with de-ionized water and further dried in oven at 80 °C overnight. Fourier transform infrared spectra exhibited hydration of the C-O-C bridges of the biochar surface introducing new -OH groups and the possible introduction of carbonyl/ester/carboxylic functional groups to the biochar surface after the vinegar treatment. Recently, a positive correlation has been cited among the number of Chronic Kidney Disease of Unknown Etiology patients and the levels of ground-water hardness, in Sri Lanka. Hence, the efficiency of coconut vinegar activated *Leucaena leucocephala* biochar in reducing calcium ions from potable water was tested. Adsorption and desorption studies carried out using column tests showed a 1.7 fold increase of calcium ion adsorption capacity and a 7 fold increase of calcium ion retaining capacity after the vinegar treatment, with compared to the non-activated biochar. Calcium content in solutions was measured using flame photometry. Calcium adsorption capacities of non-activated biochar and activated biochar determined by column tests ranged from 3.10-3.82 mg/g and 5.27-6.68 mg/g respectively while calcium retaining capacities ranged from 0.16-0.22 mg/g and 1.28-1.4 mg/g respectively. Batch studies matched with both Langmuir (R^2 = 0.9761) and Freundlich (R^2 = 0.9785) isotherm models. Maximum adsorption, q_m was calculated as 23.8 mg/g using Langmuir equation. This study concludes that *Leucaena leucocephala* biochar can be activated using coconut vinegar to be used as a safe and cost-effective adsorbent for calcium ion removal from potable water.

Abstract No: PO-29

An analysis on the optimization of the upper convective zone thickness to minimize the surface heat loss of a model salinity gradient pond

N. W. K. Jayatissa[1*], P. A. A. Perera[1] and R. A. Attalage[2]

[1]Department of Physics and Electronics, University of Kelaniya, Sri Lanka
[2]Faculty of Graduate Studies and Research, Sri Lanka Institute of Information Technology, Sri Lanka
jayatissa@kln.ac.lk*

Solar energy is a renewable energy source that provides enough energy to keep the natural cycles alive. Sri Lanka is a country near the equator that has abundant sunlight throughout the year. Solar ponds are a proven technology for storing thermal energy at low temperatures. In general, a solar pond consists of three layers: the upper convective zone (UCZ), the middle non-convective zone (NCZ) and the lower convective zone (LCZ). Part of the incident solar radiation passes through the UCZ and NCZ and is trapped in the LCZ. Unlike the other two layers, the top layer of the pond is directly exposed to the environment. The energy flows associated with the UCZ and their impact on the LCZ were the focus of this experimental study. The solar pond described in the present work is constructed in the premises of the University of Kelaniya, Sri Lanka (Latitude 6.97 N, Longitude 79.91 E). The pond has a surface area of 6 m^2 (3 m × 2 m) and a depth 1.5 m. The bottom of the pond and the walls are properly insulated to reduce energy loss through the walls and bottom. Since the UCZ is exposed to the environment, heat is lost from this area through convection, evaporation and radiation. The average UCZ temperature of the solar pond varies from 27.3 $^{\circ}$C to 31.5 $^{\circ}$C depending on the month of the year. This study shows that the total energy loss (radiation, convection and evaporation) of the upper surface varies between 11 Wm^{-2} and 57 Wm^{-2}. The convective heat transfer coefficient is directly related to the average wind speed, and in this study the wind effect is minimal because the water surface is blocked by the perimeter walls. Therefore, the wind effect is neglected in the energy calculations. The radiant heat loss is estimated to be about 40% of the total energy, assuming an emissivity of 0.83 for water. Since the wind effect was negligible in this study, the estimated evaporative heat loss is about 10% of the total energy. Depending on the solar insolation, energy from the NCZ and the total losses associated with the UCZ determine the heat storage of the UCZ. The easily adjustable parameter of an established solar pond is the thickness of the UCZ. A thicker UCZ can hold more incident solar insolation inside and this causes high temperature values in the zone. High temperature values in the UCZ minimize the conduction of heat transfer from the LCZ to the UCZ, while decreasing surface heat loss by convection and radiation. However, this process reduces the amount of solar radiation entering the LCZ. When the thickness of the UCZ layer was increased from 5 cm to 10 cm, the energy absorption increased from 42% to 47%. Similarly, increasing the thickness to 20 cm, resulted in an additional 6% increase. Therefore, ultimately it affects the LCZ heat storage. On the other hand, reducing the thickness of the UCZ decreases its temperature and allows more insolation to reach the bottom of the pond. Therefore, it is important to optimize the thickness of the UCZ and the results suggested that a thickness in the range 2 to 8 cm is optimal for the operation of the pond.

Keywords: Energy, Layer thickness, Solar Pond, Upper convective zone

Abstract No: PO-30

Data Envelopment Analysis for efficiency assessment of state universities and selected faculties in Sri Lanka

W. M. T. H. Wijesundara[*] and R. A. R. Prabodanie

Department of Industrial Management, Faculty of Applied Sciences, Wayamba University of Sri Lanka, Kuliyapitiya, Sri Lanka
thushi.wijesundara@gmail.com*

Efficiency of public universities is a widely discussed concern which is of significant importance to the well-being and economic prosperity of a developing nation. It is a key performance indicator of an education system which needs to be monitored and improved continuously. Although the efficiency of universities has been widely studied in some countries, no efficiency comparison research has been conducted in the Sri Lankan context. The main objective of this study was to measure the relative efficiencies of the state universities in Sri Lanka from 2017 to 2019 using Data Envelopment Analysis (DEA). Since the universities have different compositions of faculties, the relative efficiencies of Science, Medical and Engineering faculties were separately evaluated. The input variables considered in the DEA models were annual expenditure, academic staff and non-academic staff. The output variables used were graduate output, total enrolments, number of publications in indexed journals, and Webometric ranking. The input-oriented variable returns to scale option in DEA was used, assuming that the inputs can be controlled. A freely available Excel add-in named DEA Solver was used in the analysis. The results of the overall efficiency comparison showed that eight out of fifteen state universities were constantly performing efficiently from 2017 to 2019 while two universities were constantly inefficient during the same period. Overall, 73% of the universities were efficient. The average efficiency scores across all universities from 2017 to 2019 were 0.9681, 0.9707 and 0.9409 respectively. Average efficiency scores of Science faculties for the same period were 0.8127, 0.7928 and 0.8053 respectively. Medical faculty comparison indicated efficiency scores as 0.742, 0.9332 and 0.8126 respectively from 2017 to 2019 while it was 0.9473, 0.9477 and 1 respectively for Engineering faculty comparison. Over the total period, the larger number of non-academic staff has been the main reason for the inefficiency of universities, and the results suggest that it should be reduced in a range from 0.7% to 40%. The number of efficient Science faculties was decreasing from 2017 to 2019. Efficiency comparison of engineering faculties alone indicated that most of them (83%) were efficient whereas only 54% of the medical faculties were efficient according to the comparison. The outcomes of this study are thoroughly based on an analysis performed using the DEA method with a selected set of variables, and owing to the limitations in DEA method, variables and data, the results may not reflect the actual efficiency levels of the universities. However, the study provides an understanding of some inequities in resource allocation and/or utilization among public universities.

Keywords: Efficiency, Input-oriented DEA, University, Faculty, University Performance

Abstract No: PO-31

Modeling open market monthly average retail price of potatoes in Colombo

H. L. A. Weerakoon[*], G. L. L. S. Mendis, K. S. Umagiliya, I. D. D. C. Imbulana and N. V. Chandrasekara

Department of Statistics and Computer Science, University of Kelaniya, Sri Lanka
weerakoo_ps16255@stu.ac.kln.lk*

Potato is a vastly consumed commodity, which is both exported and imported in Sri Lanka in the form of a fresh vegetable or as an ingredient in several processed food products. The availability of potatoes in the market is mainly affected by the quantity supplied to the local market, trade agreements and government policies. A considerable impact is also made by uncontrollable factors such as weather conditions, diseases, and catastrophes. The resulting demand and supply imbalances cause fluctuations in the price levels of potatoes in the market. Hence, capturing such fluctuations onto a suitable time series model for forecasting the potato price levels was considered as the main objective of the study where the findings of the study will benefit to the farmers, retail & wholesale markets, the government and many other stakeholders. The scope of the study was built upon the open market monthly average retail price (per kilogram) of potatoes, centring Colombo. The Central Bank archives, published under the Economic & Social Statistics discipline from January 2006 to December 2018 were used to obtain data. The trend component observed in the original data set was removed using the differencing technique. The cutoff lags at intervals of 12 in the Autocorrelation Function (ACF) plot of the stationary series, limited the candidate models to Seasonal Autoregressive Integrated Moving Average (SARIMA) models as the series exhibits seasonality. Since the SARIMA model with the minimum Akaike's Information Criterion (AIC), hinted the presence of autocorrelation in the residuals, it was replaced by (ARIMA) (4, 1, 3) (0, 1, 3) [12] model which was recognized as a better model of fit. The model validation was done using Root Mean Squared Error (RMSE), Mean Absolute Percentage Error (MAPE) and Mean Absolute Error (MAE) and the corresponding values were 14.74, 8.13% and 12.24 respectively. Since forecasting the retail price of potatoes concerns various interested parties, this analysis would be helpful in decision making and in determining optimal settings for the demand and supply criteria.

Keywords: AIC, ACF, Potato Retail Price, SARIMA

Abstract No: PO-32

Relationship between demographic factors and the misuse of drugs among the students of the Faculty of Science of the University of Kelaniya

K. K. T. Dewanmini[*] and M. A. H. C Munasinghe

Department of Statistics and Computer Science, Faculty of Science, University of Kelaniya, Sri Lanka
dewanmin_ps15184@stu.kln.ac.lk*

Drug abuse has been identified as a global health issue. It can be identified as one of the root causes of destroying peoples' lives and souls. According to the United Nations Office of Drugs and Crime (UNODC, 2015) report, the drug abuse is a rapidly growing global problem that is a threat in all nations, with students in primary, secondary, and tertiary institutions. Considering the Sri Lankan context, findings of the past research have shown that drug usage among university students is increasing. This has a huge impact on their academic performance as well as the productivity of their lives. Many studies have been limited by considering only the consumption of alcohol and smoking. This study has explored the factors affecting the misuse of drugs among university students. The main objective of the study was to identify the relationship between demographic factors and the misuse of drugs among the students of the Faculty of Science of the University of Kelaniya. Another objective of this study was to identify the most common drug among the students and also to identify the drug usage of the students who involved in sports and part time jobs. Data were collected through an online questionnaire survey. Snowball sampling was used as the sampling technique. A descriptive analysis was performed and a binary logistic regression, Support Vector Machine (SVM), and Probabilistic Neural Network (PNN) were used to predict the drug usage. Confusion matrix was used to evaluate the best statistical model. Participants included 220 students from the Faculty of Science of the University of Kelaniya, with a mean age of 23 years (SD =1.17), ranging from 21 to 26 years. The descriptive analysis showed that male drug usage was higher than female drug usage. Also, the drug consumption of the third-year students was higher than the other students. Students whose parents were illiterate showed a higher value of drug consumption than the other students. Also, the drug usage among the students who lived in the hostel was significantly higher than the others. The model fitted using binary logistic regression showed that the male drug usage is 1.899 higher than the females. Compared to others, students engaged with sports were significantly more likely to be drug user. The drug consumption of the students who were doing a part-time job was 1.383 higher than the others. It was also revealed that the most commonly used drug is alcohol. Among the fitted models, SVM Non-Radom spilt model showed the highest accuracy (93.1818%) in predicting drug usage. Based on the results, gender, religion, year of study, involvement of a part-time job, participation in the sports activities, financial support from bursary or mahapola, mother's education level, father's occupation, ethnicity, marital status of the parents were identified as the associated factors of the drug usage among the students. The findings of the study indicate that the young adults who are having a university education are also at risk of drug abuse. Hence it is important to take the necessary steps for prevention. The results of this study has provided justification for university administrators to plan appropriate programs, and policies that could assist students at risk of drug usage and guide students in taking correct decisions.

Keywords: Alcohol, Drug abuse, Drug usage, Students

Abstract No: PO-33

Factors affecting intimate partner violence against women in Sri Lanka

H. M. S. D. Wijekoon[1]* and N. Withanage[2]

[1]Department of Statistics & Computer Science, Faculty of Science, University of Kelaniya, Sri Lanka
[2]Department of Statistics, Faculty of Applied Sciences, University of Sri Jayewardenepura, Sri Lanka
sitharawijekoon95@gmail.com*

Intimate Partner Violence (IPV) against women has become a major health and social drawback in Sri Lanka that causes serious consequences for women's mental and physical well-being as well as their reproductive health. The Sri Lanka Demographic and Health Survey (SLDHS) 2016 reported that a total of 17 percent of ever-married women age 15-49 in the country suffered domestic violence from their intimate partner. This study aimed to develop the Violence Index which measures the level of IPV experienced by a woman in Sri Lanka and to identify the factors that affect IPV against women in the country. A total of 2494 ever-married women age 15-49 who were found to be victims of IPV were selected from the database of SLDHS 2016 which was carried out by the Department of Census and Statistics in Sri Lanka. Characteristics of women, husbands, and their relationships that may influence IPV were considered as the explanatory variables while the estimated Violence Index was taken as the outcome variable. Multiple Correspondence Analysis and the theory of Composite Indicator were applied to develop the Violence Index. The association between the Violence Index and each explanatory variable was examined using the Kruskal-Wallis H test and the Mann-Whitney U test. Gamma regression analysis was carried out to determine the significant factors that affect IPV against women. Results show that the estimated Violence Index represented the lowest level of IPV experienced by a woman as 0.03 and the highest level of IPV experienced by a woman as 10.53. The values of the Violence Index showed a high right-skewed distribution. Religion, woman's education level, woman's married time, woman's participation in making the household decisions, husband's employment status, the age gap between husband and wife, enough money for daily expenses in the house, and household alcohol consumption were the most influential factors for IPV against women in Sri Lanka. The Gamma regression model provided a better prediction on the Violence Index with the mean squared error of 0.9447 and the mean absolute error of 0.5306. This study recommends raising public awareness on the risk and protective factors of IPV and the development of the current policies and new strategies to prevent IPV against women in Sri Lanka.

Keywords: IPV, Sri Lanka, Violence Index, Women

Abstract No: PO-34

Time series forecasting of farm gate prices of fresh coconuts in three major coconut growing areas of Sri Lanka

D. H. N. Perera[1*], K. P. Waidyarathne[2], D. D. M. Jayasundara[1] and A. P. Hewaarachchi[1]

[1]Department of Statistics & Computer Science, Faculty of Science, University of Kelaniya, Sri Lanka
[2]Plant Physiology Division, Coconut Research Institute, Sri Lanka
hirunin28@email.com*

Coconut is a perennial crop with important food value and other endless uses for human beings. Hence, this has led to the emergence of a diversified set of industrial activities. All over the world, Sri Lanka is the fourth largest coconut producing country. The major part of Sri Lanka's coconut production comes from the Coconut Triangle, which consists of Puttalam, Kurunegala and Gampaha districts. Forecasting coconut prices can provide critical and useful information to coconut growers making production and facing real situations and uncertainties of the coconut industry. The objective of this study is to build accurate univariate or multivariate time series models to forecast the farm gate prices of fresh coconut in three major coconut growing areas (Puttalam, Kurunegala, and Gampaha) of Sri Lanka. This study evaluated the times series data on monthly farm gate prices of fresh coconut in the selected districts from January 2009 to December 2019.This paper examines three time series modelling approaches, Autoregressive Integrated Moving Average (ARIMA), Generalized Auto Regressive Conditional Heteroskedasticity (GARCH) and Vector Error Correction (VEC) model. Root Mean Squared Error (RMSE) and Mean Absolute Percentage Error (MAPE) were used to evaluate the performance of fitted models. As the univariate time series approach, ARIMA (1,1,5) and ARIMA (2,1,2) were identified as the better models for forecasting prices of Puttalam and Gampaha based on Akaike Information Criterion (AIC) where RMSE (5.83,5.77) and MAPE (12.60,10.99) respectively. In contrast to the other two districts, Kurunegala showed a non-constant variance with the time, hence GARCH model approach was tested for the particular data series. It was found that all model coefficients were not significant in the GARCH model thus univariate models were not applicable for Kurunegala District. Therefore, multivariate time series model was carried out to find a suitable model. First, the Johansen co-integration test was applied and the results proved that there were two co-integration equations at 5% level of significance. As there were significant cointegration detected between series, VECM was applied in order to evaluate the short run properties of the cointegrated series. According to the lag selection criteria, lag 7 was selected as the optimum lag value. Considering the VEC models, the RMSE and MAPE in Puttalam, Kurunegala and Gampaha were 6.30,5.41,5.85 and 12.81,10.76,11.14 respectively. Results revealed that VECM approach worked well for forecasting Kurunegala price series. Even with long-term equilibrium relationship exists between series, VECM approach was less accurate in defining the relationship in comparison to ARIMA models for Puttalam and Gampaha price series. Therefore, that the study recommends the ARIMA models as the appropriate models to forecast the monthly farm gate prices of fresh coconut in Gampaha and Puttalam districts.

Keywords: ARIMA, Coconut Price, Time Series, VECM

Abstract No: PO-35

Modeling and forecasting inflation in Sri Lanka using VAR models

D. M. I. R. Dissanayake[*] and L. P. N. D. Premarathna

Department of Mathematics, University of Kelaniya, Kelaniya, Sri Lanka
iresha0522@gmail.com *

Inflation is one of the key macroeconomic variables of the country's economy since maintaining economic and price stability is the core objective of the Central Bank of Sri Lanka (CBSL). It is essential to know about future inflation since there is a transmission lag of monetary policy actions. Quantitative inflation forecasting methods will give helpful information on future developments in the economy. Therefore, the development of accurate forecasting models that can be used to describe the dynamic movements of the economy is important in an inflation-targeted regime. Empirical studies have shown that low and stable inflation helps the growth of most economies. The main objective of this study is to model and forecast inflation in Sri Lanka using both the monthly Colombo Consumer Price Index (CCPI) and National Consumer Price Index (NCPI) from January 2009 to December 2020. This study examined the short-term and the long-term forecasts by using both univariate and multivariate models. A descriptive analysis and time series analysis were employed to model and forecast inflation in Sri Lanka. Historical data were obtained from CBSL and the Department of Census & Statistics (DCS). R-studio and E-Views statistical packages were used to develop the models. According to the time series analysis using CCPI, results revealed that there is a short run and long run significant relationship among CCPI, Money Supply (MS), and Gross Domestic Product (GDP). Similarly, forecasting inflation using NCPI, results show that there is a short run and long run significant relationship among NCPI, MS, GDP and Rice Price (RICEP). In this analysis, two models were obtained for CCPI and NCPI. According to the finding of the study, VAR (3) which gives the lowest Root Mean Square Error (RMSE), is the best model to forecast short run as well as long run inflation for Sri Lanka. All roots have modulus less than one and lie inside the unit circle. Therefore, the estimated VAR (3) is stationary. Moreover, the residuals are normally distributed. By incorporation of NCPI to forecast inflation, the accuracy of the results has been further increased in the NCPI than in the CCPI.

Keywords: CCPI, Inflation, NCPI, Time Series Analysis, VAR model

Abstract No: PO-36

Forecasting phenological model for tropical forest species: *Monoon coffeoides*

P. W. G. S. R. Wellassa[1*], U. P. Liyanage[1] and R. M. C. S. Ratnayake[2]

[1]Department of Statistics and Computer Science, Faculty of Science, University of Kelaniya, Sri Lanka
[2]Department of Plant and Molecular Biology, Faculty of Science, University of Kelaniya, Sri Lanka
shaliniw95@gmail.com*

Monoon coffeoides is a forest plant growing a tropical intermediate forest and pollinated by a native species of weevils in Sri Lanka. The longtime survival of both *M. coffeoides* and weevils is governed by its flowering and fruiting phenology. Due to a lack of phenological information implementation of proper conservation and management measures are not possible. The main purpose of this study is to analyze phenological parameters, namely, flower buds, open flowers, leaf flushing, leaf dropping, immature fruits and mature fruits of the *Monoon coffeoides*, to identify their correlation and variation patterns. Further, forecasting of these parameters are important in future forest management. Hence, the study has been extended to investigate the ability to forecast the parameters. Unsupervised learning techniques such as K-means clustering under Data mining are applied to identify similar behaviors among 50 trees of *Monoon coffeoides*. Silhouette width test was used to validate the cluster accuracy. Further, the Cross-correlation analysis was used to identify the relationships between series of phenological parameters with following delay periods as lag phases. The analysis resulted, the delay between flower buds and open flowers is 2 weeks, the delay between leaf flushing and mature fruits is 17 weeks, the delay between open flowers and immature fruits and between immature fruits and mature fruits is 5 weeks. Additionally, it was identified that the flowering and fruiting periods are varied from January to May and from March to August respectively. As the next step, phenological parameters and climate factors have been forecasted using univariate time series models. The accuracy was tested using standard tests: R-squared, Root Mean Squared Error (RMSE), Mean Absolute Percentage Error (MAPE) and Mean Absolute error (MAE). The best-fitted models for each of these parameters are; flower buds: ARMA(2,3)-GARCH(1,1), open flowers : ARMA(2,3)-GARCH(1,1), mature fruits : ARIMA(1,1,1)-GARCH(1,1), immature fruits : ARMA(1,4)-GARCH(1,1), leaf dropping : ARMA(1,1), leaf flushing : ARMA(1,1)-GARCH(1,1), average temperature : ARIMA(1,2,1) and rainfall : ARMA(3,1) respectively. All the models were significant to forecast the values and thereby, these models can be used to forecast phenological parameters.

Keywords: Cluster analysis, *Monoon coffeoides,* Phenological data, Time Series Modeling

Abstract No: PO-37

An anthropometric index to estimate the obesity

H. A. N. S. Tissera[*], M. A. H. C. Munasinghe and D. M. P. V. Dissanayaka

Department of Statistics and Computer Science, University of Kelaniya, Sri Lanka
nishadinisandunika@gmail.com*

Obesity is a disease that occurs when the percentage of body fat has a negative effect on a person's health. As for the World Health Organization's definition, obesity is defined as the condition of the body when the body fat is greater than 25% and 35% for men and women respectively. Obesity is a crucial point to discuss as it has been considered a major nutritional health problem in developed and developing countries. Therefore, many indices have been developed to estimate body fat using various measurements of the body. The objective of this study was to develop a simple anthropometric linear equation (index) that is more accurate than the Body Mass Index (BMI) and other indices which currently use to estimate whole-body fat percentage among individuals. Developing a new index to measure body fat is significant as the current indices fail to measure body fat accurately in some exceptional cases like professional athletes. As for an example, the BMI also does not capture information on the mass of fat in different body parts. Hence developing a new index to measure the body fat level is essential. This study used secondary data from the National Health and Nutrition Examination Survey (NHANES) in 2017-2018. Missing values were imputed by using the multiple imputation techniques. Initially a descriptive analysis was performed to analyze the composition of the sample. It was discovered that the mean fat percentage was 35.416 with a standard deviation of 7.109 and 24.461 with a standard deviation of 7.964 in girls and boys of age 15 to 19 years, respectively. Total fat percentage was considered as the response variable. Simple linear regression models were fitted to find the most correlated variables with the total body fat level. 15 anthropometric indices were generated using transformations on explanatory variables. The best-fitted equation was selected by considering the High Correlation with body fat, Minimum Akaike Information Criterion (AIC), and Highest R^2 value. The accuracy of the index was tested using the test dataset and compared with the accuracy of the current indices. It was revealed that this index measures body fat more accurately than the Body Mass Index (BMI) and Waist-Height Ratio (WHR) with an accuracy of 76.8%. Waist Circumference, Hip Circumference and height measurements used to develop new index. Then the selected variables were used with the age category and gender as explanatory variables to perform a multiple linear regression model to find the determinants of the body fat level. As a further study, the developed index can be improved by adjusting for gender-wise and age-wise to obtain more accurate results.

Keywords: BMI, Body fat, Obesity, WHR

Abstract No: PO-38

Portfolio optimization using machine learning techniques: An application on Colombo stock exchange

I. A. Nakandala[*] and U.P. Liyanage

Department of Statistics and Computer Science, Faculty of Science, University of Kelaniya, Sri Lanka
isurunianuradha715@gmail.com*

Stock market price prediction is a challenging task due to the non-linearity and volatility of the financial data. Thereby, forming a portfolio considering accurately predicted future stock prices becomes an even harder task. As a classical approach, most of the researchers apply statistical techniques as analytical tools in financial time-series data analysis and forecasting. However, due to the dominance of the qualitative factors affecting the financial market and their securities, most of the forecasting and other interpretations have less accuracy. Nevertheless, the recent development of computing algorithms, particularly in the field of data science, gives a better opportunity to develop analytical techniques that accurately handle the high uncertainty and the associated volatility of financial data. In this study, classes of Recurrent Neural Network (RNN) algorithms have been used as data science techniques. In particular, the LSTM (Long-Short Term Memory), a special kind of RNN, is utilized to predict the future stock price returns of the Colombo Stock Exchange (CSE), Sri Lanka. Herein, daily assets prices of 20 companies belonging to the S&P SL20 list, and the list of top 100 ranking companies in Sri Lanka in the year 2020, have been analyzed. In the required forecasting, LSTM has been trained using the daily assets closing prices from 1st of January 2010 to 31st of March 2019. The model accuracy measured by Root Mean Square (RMS) averaged 10%. The formation of the portfolio is based on companies that have the highest stock prices and expected stock returns. As a result of this analysis, 7 companies are selected to form different portfolios. To select a portfolio with the highest return with minimum risk, combinations of 5 companies out of 7, i.e., in total 21 combinations of companies, have been analyzed. In portfolio analysis, Markowitz Model (Mean-Variance Optimization Model), Equal-Weighted Model (EQ) and Monte Carlo Simulation (MCS) have been used. Depending on the selection of companies to the portfolio, the model performances are varied. Thus, the best stock allocation resulting the highest expected return with the minimum risk, given by these three models, is selected as the investment plan. Based on the techniques that have been used, the risk could be controlled in the range of 0.3 to 1.1 values.

Keywords: LSTM Model, Portfolio Optimization, Stock Market Returns.

Abstract No: SO-01

Information security practices and problems among staff members of Sri Lankan universities: a case study of Uva Wellassa University

C. S. D. Ellepola[1*], K. W. S. N. Kumari[2], R. G. Ragel[3] and M. Sandirigama[3]

[1]Department of Computer Science and Informatics, Faculty of Applied Sciences, Uva Wellassa University, Sri Lanka
[2]Department of Science and Technology, Faulty of Applied Sciences, Uva Wellassa University, Sri Lanka
[3]Department of Computer Engineering, Faculty of Engineering, University of Peradeniya, Sri Lanka
chamalie@uwu.ac.lk*

Information Security (IS) has emerged as an essential aspect of all organisations. Universities have an enormous amount of information collected, analysed, and stored daily, which is paramount. Therefore, beyond doubt, information security plays an integral role in the university system. University staff members store vital information on their computers. Furthermore, many academics keep themselves logged into online accounts. Hence, the attackers use these opportunities to carry out attacks that could result in compromising confidential information. Making university staff members aware of information security-related matters and aware of possible threats and countermeasures could lower the levels of IS risks faced by universities. Yet, the number of research conducted to identify the level of awareness regarding information security among university staff members is scarce. Therefore, this research investigated the information security-related practices of the Uva Wellassa University of Sri Lanka staff members. The University's academic and administrative staff members were considered the population, and an online questionnaire was shared among 110 randomly selected staff members. There was a response rate of 87%. The responses were analysed using Minitab statistical software. Cross tabulation and chi-square analysis were performed after coding the responses to identify the association between each other. The study revealed that only 26% of the respondents had a thorough understanding of the concept of information security and 6% of the respondents stated that they had not heard of the term information security. In comparison, the remaining 68% had mentioned that even though they had heard of the term information security, they were unsure what it meant. This reveals that despite having access to the newest technologies and a wide range of information, university employees are not adequately aware of the IS issues and best practices. This study developed a conceptual model which illustrated the relationship between the selected IS practices and the knowledge on information security. The researchers identified three factors (i.e. password protecting confidential documents, checking SSL before entering data, and sharing confidential information through emails) which had an association between them and possessing knowledge regarding IS at a 5% level of significance. The study also identified several factors which had interconnections among each other. The shortcomings associated with the current practices were analysed, and the possible countermeasures such as implementing a proper information technology policy, conducting periodical awareness sessions, etc., were presented.

Keywords: Conceptual model, Information security, Information security awareness, Universities, Uva Wellassa University

Abstract No: SO-02

Mind relaxation chatbot for university students by using dense neural network

H. S. Bopage[*] and W. A. C. Weerakoon

Department of Statistics and Computer Science, Faculty of Science, University of Kelaniya, Sri Lanka
heshanisathmini@gmail.com*

Relaxation is the emotional state of a living being, of low tension, in which there is an absence of arousal that could come from sources such as anger, anxiety, or fear. Technology can be used for mind relaxation. Chatbot is an automated computer software program capable of having intelligent live conversations with people. It is a technology that provides a new way to interact with computer systems. Chatbot responds to user queries in the same language. Chatbot is one of the technologies used successfully in many fields such as education and health field. This study is focused on developing a chatbot model to relax the minds of university students. Since there are already many uses of chatbots for social good, it is a viable solution to create a chatbot capable of encouraging mind relaxing chatbot for university students by adapting the intellect to greater potential. The main purpose of this research is to create a chatbot model to give them comfort and to manage their mental well-being by activating a good listener who is a secret controller through a technological methodology. The intelligent chatbot model was implemented using deep learning algorithm with Natural Language Processing (NLP) techniques. Natural Language Processing requires modeling complex relationships between the semantics of the language. Deep learning facilitates the complexities of the NLP to be easier to model and can stimulate the creation of a chatbot that has a real conversation with a person. Chatbot model was developed using Feed Forward Dense Neural Network (DNN) with two hidden layers. The input layer is the bag of words of the patterns. The number of neurons in the input layer is the same as the size of the vocabulary. Neurons in the output layer represent greeting, feeling, relaxation, advice, motivation and goodbye tags. Then the chatbot tool was trained with a series of counselling conversations. Training phases included intents, tags, patterns and responses. The primary functions of chatbot are to understand the intents of students and to respond to them appropriately. Input and Output are in the form of text. After a successful compilation of code in pyCharm IDE, the model gets trained in 1000 epochs. The developed solution allows for easy deployment and development if changes need to be made. It can be ported virtually in any system that can host a python environment.

Keywords: Artificial Intelligence, Chatbot, Dense Neural Network, Mind Relaxation, Natural Language Processing

Abstract No: SO-03

Text and non-text classification from doctor writing prescription images

M. Subasinghe[*] and M. Ramanan

Department of Computer Science, Trincomalee Campus, Eastern University, Sri Lanka
gayathmamadushi@gmail.com*

The classification of text and non-text block is an important problem in document analysis. This paper focuses on text and non-text classification, which plays a major role in the consequent processes of Optical Character Recognition (OCR). The system consists of binarization using Otsu's method, noise removal using median filter, skew detection and correction using Radon transform, segmentation, feature extraction and text/non-text classification. The proposed method for text and non-text classification is a combination of two techniques: decision rule with density features and Support Vector Machines (SVMs) with Histogram of Oriented Gradients (HOG) features. The text and non-text classification is performed by segmenting the medical prescription image into blocks using a run-length smearing algorithm and projection techniques. Moreover, the classification is performed by using binary SVMs with HOG features and a decision rule by density feature. Experiments have been carried out with a dataset of 50 medical prescription images and achieved classification rates of 92.47% using a decision rule by density feature and SVM with HOG features.

Keywords: SVMs, HOG, Medical prescription image, Text and non-text classification

Abstract No: SO-04

An image processing approach to detect the quality of cinnamon sticks

H. A. C. Sandamali[*] and C. R. Liyanage

Department of Information and Communication Technology, Faculty of Technology,
University of Ruhuna, Sri Lanka
chathurikasanda@gmail.com*

Cinnamon is one of the most important and valuable spices in Sri Lanka. Sri Lanka ranks first in world cinnamon production and has a long-standing reputation in the international market due to its unique quality, colour, flavour, and aroma. While Sri Lanka is a world market leader, meeting quality standards is a major issue Sri Lankan cinnamon exporters face. There are several types of cinnamon grades and different prices for each grade. The selling price of cinnamon will be determined by the most available type of grade in a cinnamon bale. However, in real practice, the quality grades of cinnamon bales are determined through collectors' experience and knowledge, and there is no automated system to accurately identify the quality of cinnamon. Therefore, in some situations, disadvantages arise for the farmers when the majority of sticks in a bale are from a lower grade, where they will not get a suitable price for the higher grade portion. To address these issues, this study presents an image processing method to automatically detect the quality grades of cinnamon quills without any expert knowledge. Mainly, the quality of cinnamon quills will be measured based on the diameter, ash percentage, length, and colour. The current study has developed a model by considering all these four factors. As there are slight differences between each grade, a highly precise solution is needed to detect the grades accurately. Therefore, especially the image collection and pre-processing were done with extra caution. During the phases; calculating the diameter, finding the percentage of patches, and calculating the length, the accuracy of the results were evaluated based on a reference issued by the department of export agriculture, Sri Lanka. This reference contains the standardized values of maximum diameter, maximum patch percentage, minimum length, and the number of sticks per kilogram according to each cinnamon grade. Moreover, the accuracy of the measurement of colour was evaluated against a reference(DSLS 81) supplied by the Sri Lankan Standards Institute. The individual accuracies of each stage were 73, 85, 80, and 68 percent in measuring the diameter, colour, length, and patch percentage, respectively, and the accuracy of the final result was around 65 percent. In conclusion, this model will help to identify the quality of cinnamon quills accurately and efficiently compared to manual measurements.

Keywords: Ash percentage, Cinnamon grades, Color, Diameter, Image processing

Abstract No: MO-01

Computational insight into the antioxidant mechanisms of major catechins found in cocoa: DFT study

W. A. M. Sandaruwan and D. R. Pandithavidana*

Department of Chemistry, University of Kelaniya, Kelaniya 11600, Sri Lanka
dinesh@kln.ac.lk*

Among diverse classes of antioxidants, polyphenolic compounds exhibit important chain-breaking properties to quench reactive radical species which are generated during the oxidative processes of both commercial and biological products. Antioxidants as external supplements are used to maintain the concentration of free radicals as low as possible and to avoid oxidative stress. They are profoundly utilized in the food manufacturing to preserve the quality of the ready-to-eat foods and to improve the shelf life. Among the polyphenolic food products, cocoa is rich in catechins. The three major catechins available in cocoa are (+)-epicatechin, (-)-catechin and dimeric procyanidin. Computational studies of density functional theory (DFT) have been accomplished to explore the antioxidant potential of these catechin molecules. Reaction enthalpy values related to three key mechanisms of basic antioxidant pathways; [1] hydrogen atom transfer (HAT), [2] single-electron transfer - proton transfer (SET-PT), and [3] subsequent proton loss-electron transfer (SPLET) were computationally investigated using B3LYP/ 6-311++G (d, p) and M062X/ 6-311++G (d, p) level of theory. The aqueous phase studies were carried out under the IEFPCM solvation model. The hardness, softness, electronegativity and electrophilicity of antioxidants were computed using HOMO-LUMO energy calculations. According to these computational investigations, it was revealed that the HAT mechanism has demonstrated the lowest set of enthalpies compared to other two reaction mechanisms (SET-PT and SPLET). It was positively obvious that dimeric procyanidin possessed the lowest set of average enthalpies as showing the highest antioxidant potential with compared to the other two catechins. Based on average enthalpies, antioxidant potential of catechins found in cocoa can be placed in the following order of ascending: (-)-epicatechin < (+)-catechin < dimeric procyanidin. Energies of molecular orbitals ($E_{HOMO-LUMO}$) present in these three natural catechins exhibited that dimeric procyanidin molecule has possessed the highest radical scavenging capability as further verifying the "trend of antioxidant potential" observed under the thermodynamic parameters (BDEs, IPs, PDEs, PAs and ETEs) previously computed. It can be concluded that modification of the chemical structure of dimeric procyanidin provides insight into the design of structurally novel, potent antioxidants which will be more economical and beneficial in pharmaceutical industry.

Keywords: Antioxidant, Catechins, DFT study

Abstract No: MO-02

Investigation of heavy metal concentrations and distribution in road dust from large and small urban areas in Gampaha district, Sri Lanka

L. O. Wijesinghe* and W. A. P. J. Premaratne

Department of Chemistry, University of Kelaniya, Kelaniya, Sri Lanka
avanthaaheadpa@gmail.com*

Heavy metal contamination has become one of the major problems in metropolitan areas all around the world. Gampaha district in Sri Lanka is one such hotspot that experiences extensive heavy metal contamination. Road dust contains several types of potential pollutants resulting from diversified anthropogenic sources which are observed commonly in urban areas. Acceleration of anthropogenic activities leads to the increment of heavy metal levels in the earth's crust. Therefore, heavy metal content analysis in road dust is a worthwhile measure to evaluate the pollution level of the environment. This indicates toxic heavy metal levels in living systems and therefore the potential threat to human health. This investigation was carried out by selecting twelve sampling sites from large and small urban areas in the Gampaha district. Sampling sites lie in the GPS range of 6.96920 °N to 7.022829 °N and from 79.912284 °E to 80.049099 °E. Six sampling sites from highly polluted large urban areas in the vicinity of Kandy- Colombo main road (A1) and six sampling sites from less polluted small urban areas away from the A1 main road in Gampaha area were selected. Dust samples were collected by the wiping method and analyzed in triplicate for six consecutive weeks from July to August 2020. There was no significant change in the rainfall during the study period. Samples were analyzed for pH, conductivity, moisture, phosphorous content and organic matter. Contents of five heavy metals Pb, Cu, Zn, Cr and Fe in the samples were determined using Atomic Absorption Spectroscopy (AAS). The factors that favor accumulation of heavy metals in the environment were investigated and analyzed. Fe content in road dust samples from both large and small urban areas was very high (14.2×10^4, 9.5×10^4 mg/kg respectively) The road dust from large urban areas contained reasonably high Pb (71.1 mg/kg) and Zn levels (108.8 mg/kg) compared to the levels in small urban areas (15.1, 86.0 mg/kg respectively). Cr (52.0, 25.1 mg/kg) and Cu (6.8, 0.6 mg/kg) were relatively abundant in almost all the samples. The results revealed that Pb, Cu, Zn, Cr and Fe levels were higher in road dust from large urban areas compared to small urban areas.

Keywords: Heavy metal, Lead, Road dust, Correlation, Toxicity

Abstract No: MO-03

Tea waste derived activated carbon – polyacrylamide composites as a potential agent for the removal of Calcium and Magnesium based water hardness

P. M. Undugoda and Y. L. N. Mathota Arachchige*

Department of Chemistry, University of Kelaniya, Sri Lanka
nadeesha@kln.ac.lk*

Water hardness is caused by dissolved minerals, mostly by Calcium and Magnesium. Hardness in natural water can interfere with day-to-day household activities like laundry, washing, bathing, and personal beauty services. Clothes washed in hard water may look dull and rough. Long-term consumption of hard water can cause kidney dysfunction, which may lead to other diseases such as cerebrovascular disease, diabetes, and others. In this study, Polyacrylamide (PAM) and activated carbon derived from tea waste have been used to prepare a novel adsorbent material at temperature 55 °C, where the prepared polyacrylamide-activated carbon (PAC) composite was used as an alternative and low-cost adsorbent for reduction of Calcium and Magnesium from hard water. Batch experiments were done for both Calcium and Magnesium solutions to find out the influences of different conditions such as adsorbent dosage, initial pH of the solution, temperature, initial concentration, and contact time on the adsorption of each metal. The residual concentrations of Calcium and Magnesium were determined by Atomic Absorption Spectroscopy (AAS). A maximum reduction percentage of 98% was obtained for both Calcium and Magnesium at optimized conditions namely, adsorbent dosage 0.5 g, initial pH 7, temperature 25 °C, initial concentrations of Calcium 71 mg/L, and Magnesium 51 mg/L and contact time 120 minutes. Adsorption processes were analyzed using Langmuir and Freundlich isotherm models, and it has been shown that the adsorption of Calcium was best fitted to the Langmuir model where the adsorbate molecules have equal adsorption energies on the surface. The adsorption of Magnesium was best fitted to the Freundlich model which describes different adsorption energies. The adsorption kinetic studies revealed that the adsorption of Calcium and Magnesium onto the prepared PAC composite is best fitted to the pseudo-first-order kinetic model which assumes the rate of change of solute uptake is proportional to the difference in saturation concentration. Thermodynamic results showed that both adsorption processes were feasible and spontaneous under adsorption conditions. Further, the prepared PAC composite had a greater reduction percentage for Calcium and Magnesium than pure polyacrylamide gel or activated carbon. For both metals, the PAC composite showed a 98% reduction percentage while pure polyacrylamide gel and activated carbon showed only 16% and 75% reduction percentages, respectively. Therefore, prepared PAC composite can be used as a potential adsorbent in removing Calcium and Magnesium from aqueous media.

Keywords: Activated Carbon, Adsorption, Hardness removal, Polyacrylamide, Tea waste.

Abstract No: MO-04

Tourists' intentions and actions on acceptance of tourism technology

D. A. G. Nayanajith[1*] and A. K. A. Damunupola[2]

[1]Faculty of Graduate Studies, University of Kelaniya, Sri Lanka
[2]Faculty of Management, Uwa Wellassa University, Sri Lanka
dagnsrilanka@gmail.com*

Technological innovations simplify and considerably ease most of the time-consuming activities. Nowadays, almost all the industries utilize innovative technologies to improve the services whilst improving the profitability and performance, simultaneously. Acceptance of tourism related technology (AoTT) advancements, is dependent on the particular context. Hence, current research ascertains the significance of types of subjective norms (SN) towards tourists' intentions and actions on AoTT in the context of Sri Lanka. A sample was drawn from the tourists accommodated in the hotels of three renowned hotel chains. Self-administered questionnaires were used for data collection. Questionnaires totaling to 400 were distributed initially and 279 duly completed questionnaire forms were considered for the final data analysis. Theory of reasoned action (TRA) has been adopted for the study and dimensions of the variables were measured by five-point Likert scale. Enabling to test the hypotheses, MANOVA, ANOVA with contrast tests and discriminant function analysis (DFA) were applied. Subsequently, multivariate model was developed gradually and contrast test was performed to analyze further in which, these contrasts represented family SN vs. No SN and friends SN vs. No SN, respectively. Accordingly, as per Pillai's trace and other multivariate statistics along with p values, empirical evidence supported the hypotheses emphasizing the significance of type of SN towards tourists' intentions and actions on AoTT, specifying the importance of friends' SN than that of SN determined by family. Findings will contribute towards theory and practice perspectives in relation to AoTT. Marketers of tourism related technology service providers and tourism application promoters could capitalize on recommendations of family and related other parties with special reference to closely associated travel partners and friends of tourists, enabling to promote technology advancements over eco-tourism, sustainable tourism, wellness tourism, experiential tourism and other sub-sectors. Policy makers, tourism authorities, tourism application/web site developing companies could make use of the recent findings to formulate strategies for the revival of the Sri Lankan tourism industry given the prevalent external and domestic disturbances. Cross-sectional nature and time restrictions were the limitations of the study. Finally, researcher has proposed suggestions for future researches in the area of AoTT.

Keywords: Innovation, Sri Lanka, Service sector, Technology, Tourism

Abstract No: MO-05

Biodeterioration of low density polyethylene by *Montagnula scabiosae*

T. W. N. K. Perera[1], R. N. Attanayake[2] and P. A. Paranagama[3*]

[1]Department of Microbiology, Faculty of Science, University of Kelaniya, Sri Lanka
[2]Department of Plant & Molecular Biology, Faculty of Science, University of Kelaniya, Sri Lanka
[3]Departmment of Chemistry, Faculty of Science, University of Kelaniya, Sri Lanka
priyani@kln.ac.lk*

Endolichenic Fungi (ELF) are a group of fungi adapted to live within lichen thalli. Present study investigates the ability of *Montagnula scabiosae*, an ELF, for biodeterioration of low density polyethylene (LDPE) by determining the activity of three extracellular fungal enzymes, reported to have potential roles in depolymerizing polyethylene, using enzymatic assays. Liquid medium screening assays, using four potato dextrose agar (PDA) plugs (0.5 cm diameter) of ELF cultures, inoculated into Erlenmeyer flasks containing sterile mineral salt medium broth (MSMB). Eight sterile LDPE strips (10 cm x 3 cm) were added into each flask and incubated at room temperature ($28 \pm 2°C$) for 21 days. MSMB flasks with plain PDA plugs and sterile LDPE strips were used as the controls. Solid medium biodeterioration studies also were conducted using three PDA plugs of the ELF cultures inoculated into mineral salt medium agar (MSMA) plates. Eight sterile LDPE strips were aseptically placed on the surface of each MSMA plate and incubated at room temperature for 45 days. MSMA plates with plain PDA plugs and sterile LDPE strips were used as the controls. Both liquid and solid media assays were carried out in four replicates. LDPE biodeterioration was analyzed based on reductions in weights and tensile properties, changes in peaks of Attenuated Total Reflection-Fourier Transform Infrared (ATR-FTIR) spectra, changes in carbonyl index (CI) and Scanning Electron Microscopic (SEM) images. A distinguishable LDPE deterioration ability was shown by *Montagnula scabiosae*, isolated from the host lichen *Pyrenocarp* sp. Results showed that isolate reduced weights of strips by 13.22% in liquid medium and by 12.06% in solid medium. Tensile strength of liquid medium treated strips, reduced by 6.64% and solid medium treated strips, by 3.00%. The control LDPE strips on ATR-FTIR analysis showed four prominent peaks at 2916 cm^{-1}, 2848 cm^{-1}, 1463 cm^{-1} and 720 cm^{-1} and a few minor peaks. Changes visible in the ATR-FTIR spectra of treated strips, manifested new peaks, fluctuations in percentage transmittance and deletions of existing peaks. CI value of the LDPE strips in liquid medium were found to be increased by 2.70% and in solid medium increment was 2.31%. SEM images of treated strips showed erosion zones on LDPE matrix. Qualitative enzymatic assays using Agar plate-based screening methods, indicated the presence of laccase and peroxidases, in this ELF isolate. In the quantitative enzymatic assays, *M. scabiosae* showed laccase, lignin peroxidase and manganese peroxidase activities as 1.07×10^{-7} kat L^{-1}, 1.22×10^{-8} kat L^{-1} and 2.10×10^{-8} kat L^{-1} respectively. Remarkable LDPE deterioration ability shown by this ELF isolate indicates that it has a high potential in degrading LDPE waste.

Keywords: Biodeterioration, Laccase, LDPE, *Montagnula scabiosae*, Peroxidases

Abstract No: MO-06

Tea waste derived activated carbon-polyacrylamide composite as a potential agent for the removal of Chromium and Nickel from aquatic systems

R. M. K. Hemanthi and Y. L. N. Mathota Arachchige*

Department of Chemistry, University of Kelaniya, Sri Lanka
nadeesha@kln.ac.lk*

Water is one of the essential natural resources on Earth, therefore it is essential to protect water from pollution. The chemical contaminants represent the most dangerous types of contaminants found in the water for their persistence and toxicity even at minute concentrations. Chromium and Nickel are among the most toxic heavy metals that pollute water. Contamination of the water resources with these elements would affect the food webs and causes a threat to ecosystem functioning. Among the techniques in use for removing contaminants in water, adsorption is economical and technically feasible to administer. In this study, a new variety of activated carbon (AC) was produced through chemical activation of tea waste. Polyacrylamide-activated carbon composite (PAC) was successfully prepared through aqueous solution polymerization. Thereafter, its adsorption performance was tested for the removal of Chromium and Nickel ions from aqueous solutions and analysis was done using Atomic Absorption Spectroscopy (AAS). Optimization studies were carried out for the adsorbent dosage, treatment time, metal ion concentration, pH, and temperature in the medium. Further, adsorption kinetics, adsorption isotherm and adsorption thermodynamic studies were carried out for both the metal ions. The maximum adsorption of around 97 % by PAC for both Chromium and Nickel was observed when 5 mg/L initial concentration of adsorbate of the two metals was given 1 hour contact time at 25 °C temperature and pH 3, with 0.20 g adsorbent dosage. Further, Chromium adsorption process was fitted well with the Freundlich isotherm model and both Chromium and Nickel adsorption results followed pseudo-second order rate model. It was also observed that both adsorption processes were spontaneous under these conditions. It was concluded therefore, that polyacrylamide-activated carbon composite (PAC), made out of tea waste can be successfully used for the removal of Chromium and Nickel contaminants from aquatic systems.

Keywords: Polyacrylamide, Activated carbon, Adsorption, Chromium, Nickel

Abstract No: MO-07

The future of the government pension expenses: Projecting the cost of the public servant's pension scheme in Sri Lanka

R. L. C. Shyama[*] and T. S. de Silva

Department of Decision Sciences, Faculty of Business, University of Moratuwa, Sri Lanka
shyamac@uom.lk*

Population ageing is projected to increase the pressure on old-age security systems, particularly on non-contributory pension systems, which are fully funded by the government. In Sri Lanka, a country where the population is ageing rapidly, the Public Servant's Pension Scheme is funded entirely by the government and has accounted for about 10% of government expenditure over the last 5 years. Many studies have highlighted the fact that the existing system is inadequate to provide income security for the elderly given its low coverage while the sustainability of the scheme is also at stake given its non-contributory nature and the feature of transferring pension payments to widows or dependents upon the demise of the pensioner. This study aims to project the cost of the Public Servant's Pension Scheme (PSPS) in Sri Lanka to predict the extent of pension burden of the government in future and propose policy recommendations to improve the sustainability of the pension system. This study adopted the method developed by Rannan-Eliya et al (1998) with appropriate assumptions about the future number of pensioners, future public sector wage increases, GDP growth and inflation. The model's parameters are calibrated using the latest information on the age structure of the existing pensioners, wages, government employment and pension payouts, and validated using observed pension costs for the 2016-2020 period. The projection is carried out for the period under consideration is 2021-2026. The results suggest that as the total number of pensioners continues to increase, total PSPS expenditure will continue to rise steadily over the next few years. If the government continues to adjust pensions with each adjustment to government wages, pension spending is expected to increase by 25% over the next 6 years. The paper then considers several simulations by adjusting the extent of wage indexation, retirement age, and the payment of gratuity. The results suggest that the burden on the government can be reduced by an average of 10% and 12% if wage indexation is reduced by a quarter and a half respectively. Moreover, the pension burden can be reduced by 11% and 25% on average if the government increases the minimum retirement age to 60 or 63, respectively. Finally, the temporary elimination of gratuity payments, in addition to being a politically infeasible option, also does not appear to be a fiscally significant change, leading only to an average of 4.8% cost reduction in the next 6 years. While reforms such as shifting to a defined contribution scheme will be needed to ensure the sustainability of this scheme in the long run, reducing wage indexation and raising the minimum retirement age are important short-term policy recommendations to reduce the burden of the PSPS.

Keywords: Non-contributory pensions, Old age income-security, Public Pensions

Abstract No: MO-08

Bioaccumulation potential of tributyltin in mollusks in some harbours 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, Faculty of Applied Sciences, University of Sri Jayewardenepura, Gangodawila, Nugegoda, 10250, Sri Lanka
[2] Faculty of Graduate Studies, University of Sri Jayewardenepura, Gangodawila, Nugegoda, 10250, Sri Lanka
pathmalal@sjp.ac.lk*

The Organotin compound Tributyltin (TBT) is widely used as an antifouling agent in ship paints, and is considered to be one of the strongest neurotoxic xenobiotic substances in the marine environment. It has been widely recognized that exposure to TBT causes the development of male characteristics known as 'imposex', in female mollusks. The present study was aimed to assess if there is a potential of accumulating TBT in the lipid containing body tissues in some mollukan species namely *Crassostrea madrasensis*, *Crassostrea cucullate*, *Perna viridis*, *Perna perna* and *Thais clavigera* inhabiting the Colombo, Dikkowita, Galle, Mirissa, Dewundara, Kirinda, Hambanthota and Trincomalee harbours in Sri Lanka. The TBT concentration (ng kg^{-1}) and the lipid content (%) in lipid containing body tissues were determined in the above species (n=6). The highest concentration of TBT was recorded in *P. viridis* (234±3 ng kg^{-1}) collected from the Dikkowita harbour, while the TBT concentration of this species ranged from 42±0.9 - 226±2.3 ng kg^{-1} in the remaining seven harbours. The TBT concentration was also high in four other molluskan species namely *C. madrasensis* (74±3.7 -181±4.1 ng kg^{-1}), *P. perna* (35±2.4- 126±6.7 ng kg^{-1}), *C. cucullate* (12±8.1- 116±6.5 ng kg^{-1}) and *T. clavigera* (32±1.9 -134±2.3 ng kg^{-1}). The mean TBT concentration and the lipid content showed a significant positive correlation ($P<0.005$). Further, the TBT concentrations were found to be the highest in mollusks that had the highest lipid content in their body tissues: *C. madrasensis* ($P=0.004$), *C. cucullate* ($P=0.02$), *P. viridis* ($P=0.003$), *P. perna* ($P=0.001$) and *T. clavigera* ($P=0.001$). The highest TBT concentration and the lipid content were found both in *P. viridis* and *T. clavigera*. The results suggest that the bioaccumulation of TBT was high in the molluskan species that had the highest lipid content in their body tissues. There is a threat to the molluskan biodiversity in these harbours as a result of TBT exposure and bioaccumulation in the fat tissues.

Keywords: Bioaccumulation, harbours, lipid content, *Perna viridis,* Tributyltin

Abstract No: MO-09

A comprehensive study of COVID-19 pandemic on Ayurveda aspect

W. K. T. Dushmantha[*] and S. K. M. K. Herapathdeniya

Institute of Indigenous Medicine, University of Colombo, Sri Lanka
tharindudush7@gmail.com*

SARS-CoV-2 or the COVID-19 spread around the world and was declared an epidemic. At present specific drugs or vaccines are not available and patients are treated on the basis of symptoms management. Traditional health care can contribute to the prevention of infection in healthy individuals as well as for the treatment of infected patients. COVID-19 pandemic can correlate with the *Janapadodhvamsa* which is eradication of population due to *Aupasargika Roga* (contagious diseases) as per Ayurveda text *Charaka Samhitha* and *Susrutha Samhitha*. The study was conducted by referring to authentic Ayurveda treatises viz. *Charaka* and *Susrutha Samhitha,* online research articles on ResearchGate, PubMed®, Google Scholar, Web of Science with the WHO and local Sri Lankan databases on COVID-19. This study aims to draw out a correlation between COVID-19 and the concepts of Ayurveda and aware of the community with knowledge on the global systems available. Revealed results showed that *Vata* (air), *Jala* (water), *Desha* (land) and *Kala* (season) chronologically become contaminated due to *Adharma* (sinful or unwholesome acts) and *Pragnaparadha* (doing errors intentionally). These factors affected the entire community resulting in widespread diseases like *Kushta* (contact dermatitis), *Jvara* (fever), *Shosha* (TB) etc. They spread via *Prasangath* (coitus), *Gathra Samsparshath* (contact), *Nihshvasath* (expiration) etc. Management of the above diseases is mentioned as *Nidana Parivarjana* (avoiding causes), *Kutipraveshika Rasayana* (quarantine) etc. The aetiopathogenesis, modes of transmission, clinical features and management of the disease and its complications are likely related to that of the diseases such as *Jvara* and *Pranavaha Sroto Roga* (respiratory tract disorders). Finally, can conclude COVID-19 can be comparatively conceded with the Ayurveda concepts of the *Janapadodhvamsa* due to *Aupasargika Roga.*

Keywords: Ayurveda, COVID-19, *Janapadodhvamsa, Aupasargika Roga*

Abstract No: MO-10

Factors effecting on the net interest margins of financial institutions of Sri Lanka

W. M. A. M. Weerasinghe[*] and D. M. Jayasena

Department of Industrial Management, Wayamba University, Sri Lanka
manthila94@gmail.com*

The financial intermediaries, which include licensed commercial banks (LCB), licensed specialized banks (LSB) and licensed finance companies (LFCs) play a major role in Sri Lankan economy. Net Interest Margin (NIM) can be considered as a main aspect of measuring the performance of these financial intermediaries. When comparing with the other countries in South Asia, the NIM in Sri Lanka is much higher. Unlike in other countries, financial system of Sri Lanka has not been able to lower its NIM value. Hence, the objective of this study is to investigate the industry specific and macroeconomic factors for higher NIM in Sri Lanka and in view of LCB, LSB and LFC. In fact, LCB & LSB and LFCs account for more than 70% of assets of the country's financial sector, which is the main reason why we have chosen the above three financial intermediaries in this study. Panel data will be extracted from the individual annual reports of each financial institution between 2009 to 2019. 7 LCB, 3 LSB and 5 LFCs were selected as samples, based on their total assets. The primary regression model includes the two major institutes: bank and finance & leasing sectors. Hence Two multiple regression models were deployed to investigate the determinants of LCB & LSB and LFCs separately. Credit risk, firm size, liquidity assets, earning ability and operational expenses are categorized under industry specific variables, while economic growth, inflation rate and interest rate are considered under macroeconomic variables. The results of the primary regression model obtained from SPSS statistics 25 software shows that interest rate, firm size, economic growth, and credit risk have significant impact with NIM. When considering the two resultant models, only the inflation rate and the economic growth have a positive significant impact on NIM. Moreover, in the LCB & LSB sector, liquidity assets and operational expenses have a positive significant relationship with NIM. However, Credit risk shows a negative significant relationship with NIM. This study indicates that firm size and earning ability are not significant variables for LCB & LSB. But in LFCs, firm size is the only industry specific variable that has a negative significant impact with NIM. Furthermore, the R square value of the primary regression model is 0.764. This shows that only 76.4 percent of total variability of the first model is explained by independent variables. The R square value for the second regression model is 0.730. Hence, 73 percent of the total variation for NIM values can be explained by the fitted model for LFCs. These findings fitted well with previous studies. The findings may help the policy makers as well as the investors to make better decisions while dealing with these financial institutions.

Keywords: Net Interest Margin, Financial Institutions, Sri Lanka

Abstract No: MO-11

Social awareness regarding Ayurveda and traditional medicine preventive measures related to the COVID-19 pandemic in Sri Lanka

T. N. W. M. S. Nanayakkara[1*], W. K. T. Dushmantha[1], K. M. Jansz[1] and Y. S. G. Wimalasiri [2]

[1]Institute of Indigenous Medicine, University of Colombo, Sri Lanka
[2]Unit of Swasthavritta, Institute of Indigenous Medicine, University of Colombo, Sri Lanka
drsanojnanayakkara@gmail.com*

In Ayurveda, *Acharya Caraka* describes causes, prevention and therapeutics for pandemics under *Janapadodvaṃsa. Acharya Susruta* gives detailed accounts on the modes of transmission, aetiopathogenesis and management of *Aupsargika Roga* (contagious diseases). COVID-19 is a direct contacted, contagious disease, transmitted through droplet infection which was initially identified in Wuhan, China. This disease has no specific precise medication or treatment method to date. There was a trend in China to implement traditional preventive measures but the extent to which traditional methods are adopted in Sri Lanka to prevent/ cure COVID 19 infections is not documented. Therefore, this survey was conducted to study the public awareness of Ayurveda and Traditional perception and to identify the types of preventive measures used for the COVID-19 pandemic. A cross-sectional survey was conducted to obtain data from an educational institute in Kandy district and a higher educational institute in Colombo district from June to August 2020. A self-administered questionnaire was used to collect data. It was designed and developed referring to Ayurveda and Sri Lankan Traditional Medical texts. It was validated with subject expertise and samples were selected randomly and the sizes were 50 and 35 respectively. The responses to the study were evaluated by percentages. Of the sample in Kandy, 46 responses were collected out of 50 questioners, 93.6% of them were females and 6.4% were males. 85.1% of the respondents were aware that there are Ayurveda/ Traditional medicines available for pandemics. Results showed that 57.4% have applied *Ferula asafoetida, Acorus calamus* during the pandemic and 91.5% of them knew that they are capable of enhancing immunity. Also, 78.7% of the sample have inhaled medicated steam during COVID-19, out of the 84.6% have used hot water, 30.8% included leaves of *Adhatoda vesica* and 12.8% added leaves of *Ocimum sanctum.* In the sample of Colombo, out of 35 questioners, 30 responses were given the filled forms. Out of all the responses 46.7% were females and 53.3% were males. Results showed that 38.5% have used steam from water boiled with leaves of *Ocimum sanctum, Vitex negundo* and *Adhatoda vesica* during the pandemic and 93.3% of them believe that they are capable of cleansing the respiratory tract. Also, 58.6% of the sample has consumed herbal porridge during COVID-19, 68.2% have used *Murraya koenigii,* 40.9% used *Aerva lanata* and 36.4% added *Centella asiatica*. Results showed that 57.4% have applied external preventive measures during the pandemic and *Ferula asafoetida* and *Acorus calamus* were the commonest among them. Therefore it can be concluded that awareness of the public on preventive measures related to the COVID-19 outbreak is relatively high. Eastern countries have been able to combat this deadly condition effectively using their traditional medicines by enhancing the immunity of the body. Therefore, a treatment protocol from Ayurveda or Traditional medicine can be proposed since there is no specific treatment to cure COVID-19 yet. This survey can be conducted island wide to aware the public of Ayurvedic and Traditional remedies for COVID-19.

Keywords: Ayurveda, Traditional Medicine, COVID-19 pandemic

Abstract No: MO-12

Enhancing mechanical properties of concrete by utilizing lathe waste generated from Sri Lankan lathe industries

W.M.D.H Nawarathna, W.G.A. Pabasara* and D.N. Liyanage

Department of Engineering Technology, University of Ruhuna, Sri Lanka
ayomiwalagedara@gmail.com*

In this modern industrial era, waste is considered as a valuable resource due to the economic benefits achieved through proper utilization. Effective waste utilization is an attractive way to reduce environmental pollution and ensure resource conservation. Lathe waste is an unavoidable waste generated during lathe operations in industries. This creates a significant environmental problem since the limited biodegradability of the fibre. Disposal of this waste in barren land causes ground water contamination creating an unhealthy environment. Fibre-Reinforced Concrete (FRC) is a well-known composite material comprising of cement, sand, coarse aggregate, water & uniformly distributed short discrete fibres. It offers excellent mechanical properties than plain concrete and many other construction materials of similar cost. In common practice, steel fibres, glass fibres, synthetic fibres, and natural fibres are used in FRC to enhance the structural integrity of the concrete. The primary goals of this research work are to examine the potential of incorporation waste lathe scrap replacing the steel fibre used in FRC and determine the improvements of mechanical properties of concrete. M25 concrete grade was selected for this investigation and lathe waste scrap fibre was added up to 2% by weight, at a gap of 0.5% (i.e. 0%, 0.5%, 1%, 1.5%, 2%). The lathe waste collected from the mechanical workshop of Faculty of Technology, University of Ruhuna, and manually cut into smaller pieces ranges in thickness from 0.45 to 1 mm and in length from 15 mm to 50 mm. For each mix, 150 x 150 x 150 mm cubes were cast for the compression strength test and 100 mm x 100 mm x 400 mm beams were cast for the flexural strength test. After casting, the specimen was left for 24 hours. The specimens were then de-molded and kept in a curing tank for 28 days. An analytical comparison was conducted between the compressive strength and flexural strength of plain concrete and lathe waste fibre reinforced concrete specimens. All the tests were carried out in triplets and average values were taken for the analysis. The 1% lathe waste fibre volume fraction reinforcement achieved the highest compressive strength of 52.5% N/mm^2, which was 51% higher than the control sample (34.8 N/mm^2). It was observed that further increase in fibre content beyond 1% substantially declines the compressive strength. The same behavior was observed in the flexural strength that recorded the highest value of 3.05 N/mm^2 at 1% lathe waste content and beyond that flexural strength got reduced. These declines may be since higher fibre content may result in congestion of fibres, thus causing balling effect and inadequate bonding with concrete. According to the results, the optimum volume fraction of fibres was determined to be 1%, at which the maximum properties were achieved. In conclusion, the utilization of waste lathe steel scrap fibres in minor quantities in concrete is an effective and innovative way to enhance the mechanical properties of the concrete and reduce the cost. Further, it is a successful substitute material for factory-made steel fibres while providing a sustainable solution for lathe waste management.

Keywords: Lathe waste fibre, Compressive strength, Flexural strength, Waste management, Fibre reinforced concrete

Abstract No: MO-13

Arsenic contamination in Sri Lankan traditional rice varieties in Anuradhapura district and probabilistic assessment of human health risk through rice consumption

E. M. N. S. Senarathne[*] and E. M. R. K. B. Edirisinghe

Department of Chemical Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka
sathsarasenarathne@gmail.com*

Arsenic (As) is one of major hazardous carcinogen found in foods and identified as a significant public health concern. Diet and lifestyle of Sri Lankans are mainly relied on rice. Nowadays high demand for traditional rice can be distinguished in the market. The study was aimed to determine the As contamination in Sri Lankan traditional rice varieties and to assess the adverse health effect on human through consumption of these varieties. Twenty four rice varieties were collected from local farmers, Anuradhapura district in the North Central province of Sri Lanka. Rice samples were taken without husks and dry weights were considered. Digestion procedure was carried out using microwave digestion system prior to the analysis. Total As levels were detected using Inductively Coupled Plasma Mass Spectrometry (ICP-MS). Results were verified using a certified reference material (NMIJ 7503b) with 98% recovery. As concentration detected between 39.92 ($\pm$ 0.10) μg/kg to 543.00 ($\pm$ 3.10) μg/kg and maximum level was reported in Rathdel while Kuruluthuda showed the lowest concentration. Ten rice varieties including Madathawalu (265.75 $\pm$ 4.34) μg/kg , Dik Wee (257.73 $\pm$ 2.90) μg/kg, Goda Heenati (249.88 $\pm$ 0.50) μg/kg, Rathu Heenati (238.65 $\pm$ 3.40) μg/kg, Kiri Murunga (268.04 $\pm$ 14.96) μg/kg, Hondaruwal (204.09 $\pm$ 6.52) μg/kg, Gurusinghe Wee (251.91 $\pm$ 6.03) μg/kg, Gonabaru (274.86 $\pm$ 2.50) μg/kg, Al Wee (284.71 $\pm$ 7.90) μg/kg and Rathdel (543.40 $\pm$ 3.10) μg/kg exceeded the maximum allowable concentration of As in rice (200 μg/kg). There was a significant difference between As amount of Rathdel with that of all the other varieties ($P<0.005$). Health risk assessment was performed based on the Estimated Daily Intake (EDI) and Hazard Quotient (HQ). EDI for all the rice varieties were within the tolerable daily intake reference limit for As. Noncarcinogenic risk of As was evaluated by HQ value and it was increased in the order, Al Wee < Bada Heenati < Beheth Heenati < Dahanala < Dik Wee < Duru Wee < Goda Heenati < Gonabaru < Gurusinghe Wee < Handiran < Hondaruwal < Kalu Heenati < Kalu Murunga < Kiri Murunga < Kiri Naran < Kurulu Thuda < Madathawalu < Marjuana < Pushparaga < Rath Suwandel < Rathdel < Rathu Heenati < Sudu Heenati < Suwandel. However, all the HQ values were lower than 1 indicating no carcinogenic health risk. Even though ten varieties exceeded the maximum allowable limit, overall health risk assessment confirmed that the consumers are safe to consume rice of these native varieties.

Keywords: Arsenic, Health risk, ICP-MS, Traditional rice

Abstract No: MO-14

Influence of the confinement during the COVID-19 pandemic on lifestyle and dietary behaviour of a group of Sri Lankans

S. A. S. Jayawardana[1*], W. M. P. H. Wijethunga[2], M. A. R. N. Munasinghe[3],
M. A. S. L. Munasinghe[3] and M. R. S. Perera[4]

[1] Food Technology Section, Industrial Technology Institute, Thalahena, Malabe.
[2] Faculty of Applied Sciences, University of Sri Jayewardenepura, Gangodawila, Nugegoda.
[3] Faculty of Medicine, University of Sri Jayewardenepura, Gangodawila, Nugegoda.
[4] Geveo Australasia (Pvt) Ltd, Poorwarama Road, Colombo 05
sachinijayawardana@yahoo.com*

Travel restrictions, lockdowns, isolations and quarantine processes were implemented to reduce the spread of the COVID-19. These protective measures have altered the lifestyles and eating habits of people around the world. This study analysed the lifestyle and dietary behaviour of a group of Sri Lankans during a critical period of the COVID-19 pandemic. Sinhala and English versions of online pre-tested questionnaires were disseminated following the snowball sampling method. Data were collected from 23rd of May 2021 to 14th of June 2021 and statistically analysed. A total of 524 respondents answered the questionnaire and the majority (59.7%) were females. The respondents varied in age from 16 to 85 years and the majority (82.1%) belonged to the age range of 21 to 35 years. The most females were concerned about their diet and experienced altered appetite. Most of the respondents in the age group of 16 to 20 years experienced a higher appetite while the majority among other age groups observed no changes. More than half of the respondents (54.6%) stated that they do not consume their main meals at the same time every day. Most respondents (54.4%) reported a stable body weight. The weight changes were associated with the modifications in appetite ($P < 0.05$) and the number of times they felt hungry in a day ($P < 0.05$). Most of the respondents decreased bread (44.8%) and savoury bakery product (58%) consumption and it can be considered as a positive effect of the COVID-19 confinement. Interestingly, most of the respondents have stated that they increasingly consumed hot beverages (54.8%) and reduced the consumption of frozen and cold food (61.8%). Most of the respondents increasingly consumed homemade food (63.9%) and tried out new recipes (55.5%) while most reduced ordering of prepared food (59%). Among daily routine variations, most of the respondents slept longer (54%) and used mobile phones more (73.1%). Most respondents spent more time with family members (67.4%) and a considerable percentage of the respondents increasingly engaged in home gardening (26.3%) and reading books (31.7%), which can be considered as positive effects of the confinement. However, the engagement in physical exercises was low (51.7%). On mental health, 35.7% of the respondents experienced increased stress levels while 26.3% experienced a reduction. Among the respondents, 27.7% experienced increased anxiety and 27.9% observed reduced depressed moods. Interestingly, most of the respondents (39.9%) felt happier and more peaceful. More than half of the respondents (65%) experienced altered sleeping patterns during the confinement. More than half of the respondents (57.4%) had daytime naps. There was a significant difference ($P < 0.05$) among the age groups regarding the time of sleep. Most of the respondents within the 16 to 35 years age group went to sleep later than usual and most respondents above 46 years of age slept at the same time as before. In conclusion, this study revealed alterations in daily routine, physical exercises, engagement in recreational activities, mental health, sleeping pattern, appetite, body weight and food consumption pattern of a group of Sri Lankans during the COVID-19 pandemic.

Keywords: COVID-19, Eating habits, Lifestyle, Lockdown, Sri Lanka

Abstract No: MO-15

The women's level of awareness regarding shoulder surfing attacks with reference to harassments occur in public transportation

T.D. Samarasinghe[1*], W.N Sellahewa[2] and N.K Samarasinghe[3]

[1]Sabaragamuwa University, Sri Lanka
[2]Uva Wellassa University, Sri Lanka
[3]Cardiff Metropolitan University, United Kingdom
researchassisttds@gmail.com *

Public transportation is a widely used convenient mode of transport in Sri Lanka. People at all levels of society use this mode of transportation to achieve their daily commute. With the demand for public transport, the occurrence of incidents catering to violence concerning women using this service has also increased significantly. Therefore, revitalizing the safety of women using public transportation has become a major obstacle. Although this violence is classified as physical and psychological abuse, with the advancement and the misuse of technology, the amount of violence that women face has considerably increased. These technological misleads have helped to put a different texture to the ways of harassment. The objective of this study is to examine the level of women's awareness about shoulder surfing attacks that transpires to them while using public transportation. Preliminary data was gathered by distributing a well-structured google survey consisting of open and close-ended questions. Convenience sampling technique was used to facilitate sample selection as the questionnaire was dispersed amongst 110 women who belonged to age groups from under age of 20 to over 60. Subsequently, 100 satisfactory responses were accumulated. The data which gathered from over 60 category had to be emitted due to the inaccurate and beleaguered answers which were provided. This issue can be described as a limitation in terms of the data collection technique. Based on the findings, Sri Lankan women (55% from the sample) who consume public transportation are unaware of shoulder surfing attacks and have null comprehension to state whether they have been a victim of this attack. Only 45% of respondents stated that they had a clear understanding that they have experienced or are aware of shoulder surfing attacks. They have encountered Password breaching, social media accounts hacking, identity theft and stealing public photos as post shoulder surfing attacks. Many respondents indicated that they have no acquaintance as to where to report if an incident similar to shoulder surfing occurred. The respondents in use numerous actions to avoid the aforementioned post shoulder surfing attacks such as deactivating the social media accounts, deleting publicly post photographs. The "today" of women has changed drastically due to the rapid transformation and spread of technology which is intertwined with timely commutes. Technology and social media have become an integral part of life. To avoid shoulder surfing attacks the research recommends using biometric security systems such as fingerprint scanners and face detection technologies to provide a quick, easy, and secure way to access accounts without revealing passwords. Additionally recommends conducting workshops to educate women about shoulder surfing, how to identify attacks and respond to them. The outcome of workshops should be taken into consideration when formulating strategies to prevent and intervene in technological harassment which women face while accessing social media in public transportation. Nurture social engineering awareness, directing women to use technology and public transportation services safely. Technological Violence and harassment aiming at women who use public transportation must be engaged solemnly stopped by the authorities.

Keywords: Social engineering, Shoulder surfing, Women harassments

Abstract No: MO-16

A case study of identifying issues, constraints and opportunities of COVID-19 pandemic on vegetable supply chains in Sri Lanka

L. D. I. De Silva[*]

Department of Agricultural Economics and Extension,
Faculty of Agriculture, Rajarata University, Sri Lanka
ldesilvathilini92@gmail.com*

The recent COVID-19 pandemic resulted from the emergence of a disease caused by severe acute respiratory syndrome Corona Virus 2 (SARS-CoV-2). The Vegetable Supply Chains (VSC) have been exposed to unpredicted risks which are followed by the COVID-19 pandemic. On 22nd, March, 2020 the Government of Sri Lanka imposed complete lockdown throughout the island as a measure to control the disease by restricting human mobility. This created a significant impact on VSC by interrupting country-wide distribution of vegetables. During the 52 day-long period with curfew and travel restrictions, closure of markets and hindrances to regional and international food trade and distribution increased vulnerability of fragile VSCs. Due to rising issues of the traditional vegetable supply chain, an immediate alternative strategy was required to be put in place. Objective of this study is to collate relevant information from stakeholders to identify the issues cropped up under pandemic situation and to suggest alternative strategies to overcome the impact on VSCs. Snowball technique was adopted to collect necessary information. Semi structured interviews were conducted with the selected samples. In addition, information was gathered through a literature survey. This study was conducted from 22nd March 2020 to 14th May 2020 and the results indicate the need to adopt novel strategies to reduce the COVID-19 impact on VSCs in Sri Lanka.

Keywords: Agricultural Supply Chain, Logistics, Policy, Vegetable Supply Chain

Abstract No: MO-17

Synthesis and characterization of cinnamon enriched BSA particles with antidiabetic properties

H. M. W. K. Sathsarani, H. G. N. Dewangani and B. M. Jayawardena[*]

Department of Chemistry, University of Kelaniya, Sri Lanka
bimali@kln.ac.lk[*]

Diabetes mellitus is the most common endocrine illness of the current world. Since synthetic drugs exert adverse side effects, scientists have focused more on natural hypoglycemic agents. "Sri Vijaya" cinnamon variety (CCSV) is an accession of *Cinnamomum zeylanicum* that contains considerable amount of hypoglycemic agents. Pressured water extract of the dried quills of CCSV can be used as a liquid form antidiabetic nutraceutical. Due to the higher stability and the easiness of storage and transportation, powder form nutraceuticals are preferred over liquids. But the most powdering techniques decrease the activity of the aqueous extracts. Plant extracts can be encapsulated in nanoparticles to convert them into more stable powder form products with higher biological activity. The objective of the percent study was to develop cinnamon encapsulated Bovine Serum Albumin (BSA) particles as a powder form nutraceutical with higher hypoglycemic activity. In this study four different products were synthesized from aqueous cinnamon extract. Two of them were synthesized using BSA (8.8 % (w/v), pH 5) in the presence of citric acid and ascorbic acid as cross-linking agents separately. The other two products were synthesized using BSA (20 mg/mL, pH 9) in the presence of same cross-linking agents. Products were tested for antidiabetic activity by carrying out alpha-amylase inhibition assay and alpha glucosidase inhibition assay and the results were compared with the results obtained for the crude cinnamon extract and the positive control acarbose. IC_{50} values on both enzymes were calculated using GraphPad prism 8 software. The synthesized BSA particles were characterized for parameters such as water solubility, loading percentage and cinnamon entrapment efficiency. All the obtained data were statistically analysed using Minitab software package. Since the product synthesised using BSA (20 mg/mL, pH 9) and citric acid showed the lowest IC_{50} value on α-amylase enzyme [117.60(±1.73) μg/mL], and the highest water solubility [53.00(±1.00) %], loading percentage [3.69(±0.01) %] and cinnamon entrapment efficiency [77.97(±0.03) %] those conditions were concluded as the optimum conditions that are required to synthesize highly active antidiabetic powder form of nutraceutical from CCSV. The product synthesized using BSA (20 mg/mL, pH 9) and ascorbic acid showed the highest yield [75.36 %] and the lowest IC_{50} value on α-glucosidase enzyme [112.40(±0.57) μg/mL].

Keywords: Cinnamon, Cross-linking agents, Diabetes, Neutraceuticals

Abstract No: MO-18

Selected metal contents of tea produced in different regions of Sri Lanka

R. K. A. N. Harshani and A. M. T. Amarakoon[*]

Department of Chemistry, University of Kelaniya, Sri Lanka
tissa@kln.ac.lk*

'Ceylon Tea' is considered as the best in quality among all the teas produced in the world, becoming one of the main income sources of the country. In some instances, changes in the level of metals in tea and other food had been observed due to many reasons. As the accumulation of heavy metals can cause health risks, frequent analysis is strongly advised by regulating authorities. The objective of this study was to determine selected heavy metal levels in Ceylon tea and to assess whether the contents are safe and also to assess whether there are differences between teas produced in different regions of Sri Lanka. In this study, tea samples (0.500g, 6 samples each from a region) from seven tea growing agro-ecological regions of Sri Lanka, known as, Nuwara Eliya, Dimbula, Uva, Uda Pussallawa, Kandy, Ruhuna and Sambaragamuwa were analyzed for selected metal contents using Flame Atomic Absorption Spectrometry. Microwave digestion was used for sample decomposition. The data were statistically analyzed using Minitab 19 software package. The mean concentration (mg kg^{-1}) of metals analyzed in Ceylon tea samples was found to be as follows: Copper (8.93 to 24.85), Iron (120.3 to220.85), Zinc (24.13 to 45.63), Chromium (4.95 to 8.95), Nickel (6.13 to11.33) and lead content was below the limit of detection in FAAS (0.134). According to the results, metal contents follow the order of Fe > Zn > Cu > Ni> Cr > Pb. However, metal levels in tea did not exceed the levels recommended by WHO. Results of one way ANOVA indicated that there were significant differences in the mean levels of metal in tea among different regions of production. Dendrogram constructed based on metal content showed three clusters with Nuwara Eliya tea clustering into one group. In conclusion, Sri Lankan tea is safe for consumption with respect to the metals analyzed and there were significant differences in metal contents in tea grown in different regions of Sri Lanka. A larger number of tea samples along with the soil samples from each region should be analyzed to arrive at better conclusions on identifying the region of production.

Keywords: Ceylon tea, Heavy metals, Microwave digestion, FAA spectrometry, Dendrogram

Abstract No: MO-19

Evaluation of nutritional composition of peel and seeds of *Flacourtia indica* fruit

J. M. H. M. Jayasinghe[*] and M. K. B. Weerasooriya

Department of Chemistry, University of Kelaniya, Sri Lanka
harshajayasinghe654@gmail.com*

Flacourtia indica is an endangered plant species with high medicinal value. The fruit has been reported as a valuable source of natural products that can treat various diseases and functional disorders. It is commonly called *Ramontchi, Governor's plum, Batoko plum, Madagascar plum* and *Indian plum.* In Sri Lanka, it is called "*Uguressa*". The nutritional content of non-edible portion (peel and seeds) is so far not reported. Hence, analysing the nutritional composition of this non-edible portion is targeted in the current study. We determined moisture, ash, lipid, fibre, protein, carbohydrate and calorie contents of peel and seeds. The results showed that the percentage of moisture, lipid, ash, fibre, protein, and carbohydrate contents of the peel powder were, 15.20 ± 0.267, 9.277 ± 0.165, 13.93 ± 0.488, 9.520 ± 0.0333, 22.41 ± 0.53 and 29.66 ± 0.665 respectively. The calorie value of peel was 291.8 kcal/100g. The percentage of moisture, lipid, ash, fibre, protein, and carbohydrate contents of the seed powder were 8.890 ± 0.200, 0.6517 ± 0.0217, 2.567 ± 0.0246, 50.96 ± 0.484, 17.54 ± 0.309, and 19.39 ± 0.520 respectively. The calorie value of seeds was 153.6 kcal/100g. Findings indicated that peel contains a higher percentage of moisture, lipid, ash, protein, and carbohydrate content than the seeds. Lipid content is very less in the seeds. Due to the presence of a significant amount of carbohydrates in fruit peels, it can be utilized as a carbohydrate source. The percentage of crude fibre content is very much higher in seeds than peel. Thus, *F. indica* seeds can be considered a good source of dietary fibre. Due to high protein content, both peel and seeds can be recommended for value-added food supplements with high protein content. The results of the statistical analysis showed that there is a significant difference ($p < 0.05$) among the total moisture content ($p=0.000$), lipid content ($p=0.000$), ash content ($p=0.000$), crude fibre content ($p=0.000$), crude protein content ($p=0.01$) and carbohydrate content ($p=0.000$) in seed and peel powder. These findings indicate that, *Flacourtia indica* seeds and peel exhibit the potential to be developed as a functional food.

Keywords: *Flacourtia indica,* Fibre content, Nitrogen content, Nutritional composition

Abstract No: MO-20

Qualitative and quantitative analysis of different extracts of *Monochoria vaginalis* (Diya habarala) grown in Sri Lanka

S. D. Hapuarachchi[1*], P. D. S. A. Silva[2], N. D. Kodithuwakku[1] and P. K. Perera[1]

[1]Department of Dravyaguna Vignana, Institute of Indigenous Medicine, University of Colombo, Rajagiriya, Sri Lanka
[2]Department of Pharmacy, Faculty of Allied Health Sciences, University of Ruhuna, Wellamadama, Matara, Sri Lanka
swarnadh@gmail.com*

Monochoria vaginalis, locally known as *Diya habarala* belonging to the family Pontederiaceae is an endemic species with many medicinal uses in Ayurveda and Traditional medicine. This is used to treat dermatological disorders and also an ingredient of *Neelyaadi* oil. Since current trend is to develop quality control parameters for the standardization of herbal drugs; the study was aimed at the establishment of qualitative and quantitative analytical parameters for whole aerial parts of *M. vaginalis*. Plants were collected from Western province, Sri Lanka and authenticated from the National Herbarium, Botanical Garden, Peradeniya, Sri Lanka. Long petioles with leaves except underground parts were obtained. They were cleaned, oven-dried at a temperature below 45 °C until a constant weight was obtained and powdered. Extracts were obtained with distilled water, methanol and acetone. The aqueous extract was obtained by hot Soxhlet extraction while methanol and acetone extracts were obtained by cold maceration. Each was subjected to preliminary phytochemical screening, determination of physico-chemical parameters and High-Performance Thin Layer Chromatography (HPTLC). TLC was run to select the best solvent system for each extract. Normal phase TLC was run for methanol and acetone extracts while reverse phase TLC was run for aqueous extract and HPTLC fingerprints were obtained. Each test was conducted in triplicate and results were expressed as mean±standard deviation using SPSS 25. All extracts contained carbohydrates, terpenoids and flavonoids. Aqueous and methanol extracts contained saponins, phenols, diterpenes and reducing sugars. Proteins were found only in aqueous extract while glycosides and phytosterols were found in acetone extract. Total ash, acid insoluble ash, water soluble ash, loss on drying, extractability in distilled water, methanol and acetone were 14.91±0.29, 6.15±2.92, 8.88±3.28, 11.66±0.65, 23.62±1.04, 17.46±0.17 and 2.89±0.11 % w/w respectively. HPTLC fingerprint of aqueous extract exhibited 9 R_f values; 0.06, 0.14, 0.17, 0.20, 0.40, 0.44, 0.50, 0.75 and 0.82 with distilled water: methanol (4:2). HPTLC profile of methanol extract showed 8 R_f values; 0.03, 0.06, 0.17, 0.24, 0.43, 0.54, 0.83 and 0.90 with methanol: n-hexane: ethyl acetate (6:2:2). HPTLC profile of acetone extract showed 6 peaks with R_f values; 0.03, 0.13, 0.17, 0.24, 0.33 and 0.51 with methanol: n-hexane (8:2). Hence, it is concluded that the above can be used as preliminary quality control parameters of *M. vaginalis* aerial parts grown in Western province, Sri Lanka. Further, it is recommended to use more advanced tools like DNA barcoding in standardization of herbal raw materials.

Keywords: High Performance Thin Layer Chromatography, *Monochoria vaginalis*, Physico-chemical, Phytochemical

Abstract No: MO-21

In vitro antidiabetic activity of fractionated extracts of *Coccinia grandis* (L.) Voigt

K. G. P. Wasana[1*], A. P. Attanayake[1], J. M. S. Jayasinghe[2], T. P. Weeraratna[3] and K. A. P. W. Jayatilaka[1]

[1]Department of Biochemistry, Faculty of Medicine, University of Ruhuna, Galle, Sri Lanka
[2]Department of Chemistry, Faculty of Science, University of Peradeniya, Sri Lanka
[3]Department of Medicine, Faculty of Medicine, University of Ruhuna, Galle, Sri Lanka
piyumi089@gmail.com*

Coccinia grandis (L.) Voigt (Family; Curcurbitaceae) leaves in the therapy of diabetes mellitus has been well legendary in Sri Lankan traditional medicine since antiquity. The present study was aimed to evaluate *in vitro* antidiabetic activity by means of α-amylase, α-glucosidase and DPP-IV inhibitory potential of the selected crude extracts and the fractions of *C. grandis* leaves. The powder of the dry leaves of *C. grandis* were sequentially extracted into hexane, ethyl acetate (EA), methanol and water using maceration. The dry extracts resulted in the sequential extraction were subjected to determine the selected enzyme inhibitory activities. Enzyme inhibition assays were conducted using porcine pancreatic α-amylase, α-glucosidase form *Saccharomyces cerevisiae* and DPP-IV enzyme human recombinant, expressed in S*f*9 cells. Acarbose was used as the standard inhibitor for α-amylase and α-glucosidase inhibitory assays and diprotein A was used as the standard inhibitor for DPP-IV inhibitory assay. The hexane and EA extracts were further fractionated through vacuum liquid chromatography (VLC). The resulted VLC fractions (a total number of six VLC fractions from both extracts) were subjected to the selected *in vitro* antidiabetic assays as mentioned. All quantitative data resulted from *in vitro* assays were analyzed using SPSS software. One way – ANOVA followed by Tukey's test was done for multiple comparisons. Independent sample t-test was performed to compare the mean values between two groups. $p \leq 0.05$ was considered as statistically significant. The percentage yield of the hexane, EA, methanol and water extracts were 2.40%, 2.87%, 2.95% and 5.73% respectively. The hexane and EA extracts showed α-amylase, α-glucosidase and DPP-IV inhibitory activities in significantly lower IC_{50} values compared to the methanol and water extracts. The α-amylase activity of hexane extract (IC_{50} 6.42±0.44 mgmL^{-1}) and EA extract (IC_{50} 9.98±0.85 mgmL^{-1}) was not statistically different from acarbose. α-Glucosidase activity of hexane extract (IC_{50} 2.28±0.08 mgmL^{-1}) and EA extract (IC_{50} 5.92±0.21 mgmL^{-1}) showed no significant differences with acarbose. There were no significant differences ($p > 0.05$) in DPP-IV inhibitory activity of hexane extract (IC_{50} 101.24±2.83 µgmL^{-1}), EA extract (IC_{50} 28.69±1.65 µgmL^{-1}) with respect to the diprotein A. IC_{50} values of the methanol and water extracts were significantly higher than that of the standard compounds in α-amylase, α-glucosidase and DPP-IV inhibitory assays. The fourth VLC fraction collected from the EA extract showed the highest α-amylase (IC_{50} 7.13±0.36 mgmL^{-1}), α-glucosidase (IC_{50} 0.40±0.02 mgmL^{-1}) and DPP-IV inhibitory (IC_{50} 27.71±2.37 mgmL^{-1}) activities compared to the other VLC fractions. The IC_{50} value of the fourth VLC fraction collected from the EA extract was significantly lower ($p = 0.001$) than that of the acarbose (IC_{50} 0.56±0.02 mgmL^{-1}) for α-glucosidase inhibition denoting the importance of further fractionation and isolation of α-glucosidase inhibitors. In conclusion, the hexane and EA extracts resulted from the sequential extraction of *C. grandis* leaves and the fourth VLC fraction of the EA extract exerted considerably high α-amylase, α-glucosidase and DPP-IV inhibitory potential. Further, bioassay guided fractionation is warranted to isolate α-amylase, α-glucosidase and DPP-IV inhibitors from the bioactive fractions of *C. grandis* with an aim of developing new antidiabetic drug leads/pharmaceutical agents in the near future.

Keywords: α-Amylase, *Coccinia grandis*, DPP-IV, α-Glucosidase, Sequential extraction

Abstract No: MO-22

Enzyme-assisted extraction of cinnamon (*Cinnamomum zeylanicum*) bark oil and its effect on extraction yield and quality

S. M. M. C. Sethunga[1*], K. K. D. S. Ranaweera[1], I. Munaweera[2] and K. D. P. P. Gunathilake[3]

[1] Department of Food Science and Technology, Faculty of Applied Sciences, University of Sri Jayewardenepura, Gangodawila, Nugegoda, Sri Lanka
[2] Department of Chemistry, Faculty of Applied Sciences, University of Sri Jayewardenepura, Gangodawila, Nugegoda, Sri Lanka
[3] Department of Food Science & Technology, Faculty of Livestock, Fisheries & Nutrition, Wayamba University of Sri Lanka, Makandura, Gonawila, Sri Lanka
maheshichathuranganee@email.com*

Cinnamon (*Cinnamomumzeylanicum*) is a highly significant spice, native to Sri Lanka and its bark oil is used as a fragrance, flavor in many applications and in the pharmaceutical industry. The volatiles are mainly extracted using traditional distillation methods such as hydro-distillation and steam distillation. In this study, the novel extraction method, Enzyme-assisted Distillation (EAD) is studied to extract the volatile compounds from plant matrices. Aqueous Enzyme solution of Viscozyme and α-amylase were prepared in different concentrations of 0.25%, 0.5%, 1% ((w/w) of raw materials). In the method, the crushed plant materials were soaked in a prepared enzyme solution (pH 4-5) and incubated at 45+2 °C for 90 min followed by hydro-distillation for 6 hours. The same procedure was followed for the control sample without enzyme pretreatment. Cinnamon Bark Oil (CBO) yield was determined for all the samples and GC-MS analysis was carried out to analyze Trans-Cinnamaldehyde Content (TCC) in the prepared samples. The CBO yield and the TCC of the pre-treated samples with enzymes were significantly higher ($P < 0.05$ at 95% confidence level) compared to the control (1.4487±0.0033% CBO yield, 57.095±0.593 % TCC). Amidst various treatments, which were done using different types of enzymes and different concentrations, viscozyme treated sample showed significantly higher CBO yields of 1.6369±0.0019% and 1.6362±0.0022% at 0.5% and at 1% concentrations respectively. TCC was significantly higher in same concentrations of viscozyme; 67.577±0.288% at 0.5% and 67.623±0.080 at 1%. The mixture of viscozyme and α-amylase concentrations showed high CBO yields and trans-cinnamaldehyde content than α-amylase in all concentrations. Therefore, the overall study reveals that viscozyme enzyme is performing better compared to α-amylase enzyme as a pretreatment for cinnamon bark oil distillation. This happens due to the disruption of the cell wall structure in cinnamon after treating with vicozyme, which is composed of cellulase and pectinase than the treatment with α-amylase. Further, the study demonstrated that the 0.5% Viscozyme concentration is the optimum concentration for treating cinnamon bark. The application of Enzyme-assisted extraction substantially improved the oil yield compared to traditional methods. The overall results of this study reveal that EAD could be effectively used in the spice industry to enhance the extraction yield as well as the quality of cinnamon bark oil in an economical way.

Keywords: Cinnamon bark oil, Enzyme assisted extraction, Trans-cinnamaldehyde

Abstract No: MO-23

Correlation between sun protection factor and antioxidant activity, phenol and flavonoid contents of *Ananas comosus* (pineapple) peel

S. M. G. K. Samarakoon[*] and C. S. K. Rajapakse

Department of Chemistry, University of Kelaniya, Sri Lanka
samarako_bs15086@stu.kln.ac.lk*

UV radiation can be categorized into three as UV-A (320 – 410 nm), UV – B (280 – 320 nm) and UV-C (200 – 280 nm) where UV-B radiation is considered as one of the main causes of skin damage leading to sunburn and skin cancers. Skin care products such as sunscreens are commonly used to reduce harmful effects of radiation as they absorb or reflect UV-B radiation and help prevent sunburn. Development of sunscreen formulations containing plant-based photoprotective agents is recently being explored as they also possess antioxidant properties and considered to be safer than the synthetic agents. Therefore, the aims of this study were to explore the possibility of using *Ananas comosus* (Pineapple) peel as source rich in phytochemicals with photoprotective properties and determine the correlation between Sun Protection Factor (SPF) and antioxidant activity, phenol and flavonoid contents of methanolic extract of pineapple peel. Firstly, the chemical constituents of the pineapple peel were extracted into methanol by Soxhlet extraction and it was sequentially partitioned into hexane, dichloromethane (DCM) and 50% methanol. SPF of all three fractions of methanolic extract of pineapple peel was determined by UV-Visible spectrophotometric method and Mansur equation. Antioxidant activity of the fractions were determined by α-diphenyl-β-picrylhydrazyl (DPPH) free radical assay. Total Phenolic Content (TPC) and Total Flavonoid Content (TFC) were assessed by Folin-Ciocalteu method and Aluminium Chloride colorimetric methods, respectively. Correlation between SPF and antioxidant activity, TPC and TFC was determined by the Pearson's method. All the fractions of methanolic extract exhibited UV-B absorption properties and their SPFs were between 4.95 and 29.74. Among them, DCM fraction showed the highest SPF of 29.74 ± 0.03 at 1 mg/mL. The study also revealed that there is a strong positive correlation between SPF and TPC ($r = 0.6366$), a very strong positive correlation between SPF and TFC ($r = 0.9497$) and a very weak positive correlation between SPF and antioxidant activity ($r = 0.095$) suggesting that phenols including flavonoids in pineapple peel may contribute to its strong photoprotective potential. As the DCM fraction showed the highest SPF, it was partially purified by column chromatography and analyzed by GC-MS and the results revealed that the pineapple peel was rich in chemical constituents with known bioactivities including antioxidant activity. Since there is a synergistic act of UV-B protection with radical scavenging activity of phytochemicals, the phenolics in peel of pineapple can be considered as a promising natural additive for enhancing photoprotective properties in sunscreen formulations.

Keywords: GC–MS analysis, Sun protection factor, Sunscreen, UV radiation

Abstract No: MO-24

Phytochemical screening and antioxidant potential of three underutilized fruit species in Sri Lanka

R. P. I. V. Somasiri, H. M. Herath*, R, M. C. S. Ratnayake and R. A. S. P. Senanayake

Department of Plant and Molecular Biology, University of Kelaniya, Sri Lanka
harshi@kln.ac.lk*

Syzygium caryophyllatum (L.) Alston. (S: Dan), *Cynometra cauliflora* Linn. (S: Namnam) and *Antidesma ghaesembilla* Gaertn. (S: Bu ambilla) are three underutilized fruit species found in Sri Lanka. This research was carried out to determine the phytochemicals and *in vitro* antioxidant potential in methanol and acetone fresh fruit extracts of the three underutilized species. Methanolic and acetone extracts of edible parts of the ripe fruits were prepared and the presence of polyphenols, flavonoids, tannins and saponins in the extracts was studied using qualitative assays. Then, the total phenolic contents of the fruit extracts were determined by Folin-Ciocalteu method. Gallic acid was used as the standard and the results were expressed as milligrams of gallic acid equivalents per gram of fresh sample (mg GAE/g FW). The antioxidant activities of the extracts were determined using the 1,1-diphenyl-2-picrylhydrazyl (DPPH) free radical scavenging assay. Phenolic contents and antioxidant activities of the fruits were statistically analyzed using Two-way ANOVA and compared using Tukey's pairwise comparison. The qualitative analysis of the extracts of the three fruits revealed the presence of polyphenols, flavonoids and saponins. Tannins were reported only from methanolic and acetone extracts of *S. caryophyllatum* and acetone extract of *C. cauliflora*. The highest total phenolic contents were recorded from the acetone extract of *C. cauliflora* (27.77±0.08 mg GAE/g FW) followed by the methanolic extract of *S. caryophyllatum* (26.93±0.09 mg GAE/g FW). The phenolic contents of both extracts of *A. ghaesembilla* were significantly low (2.66±0.01-3.98±0.01 mg GAE/g FW). The methanolic extract of *S. caryophyllatum* had the highest DPPH free radical scavenging activity (57.52±0.10%) followed by the methanolic extract of *C. cauliflora* (41.74±0.24%). From the two extracts of *A. ghaesembilla*, the acetone extract showed the highest antioxidant activity (15.88±0.52%). From the two solvents used to prepare the fruit extracts, methanol was the best for *S. caryophyllatum*, while for *C. cauliflora* both solvents would be beneficial. Acetone will be a better solvent to study the phytochemicals of *A. ghaesembilla*. Revealing the phytochemicals and antioxidant properties of these fruits will be useful for better utilization and commercialization of these fruits in future.

Keywords: *Antidesma*, Antioxidant activity, *Cynometra,* Phytochemicals, *Syzygium*

Abstract No: MO-25

Recombinant protein overexpression, purification and In silico analysis of Maf protein

R. B. L. Dharmawickreme[*] and C. Witharana

Department of Biochemistry and Molecular Biology, Faculty of Medicine, University of Colombo, Sri Lanka
dharmawickremebhagya@gmail.com*

Unlike the days when large amounts of animal and plant tissue or tissue fluid were needed to obtain a small amount of protein, recombinant protein technology has revolutionized as a go to approach to obtain purified proteins. With the development of new protocols, engineered bacterial strains, and plasmids, the recombinant protein expression has become efficient and widely available, allowing cost-effective production of specific proteins for scientific and applied purposes including industry, diagnostics and therapeutic applications. Though in theory, the steps appear simple, challenges can be at any level in practice impeding successful protein expression. Therefore, understanding the importance of contributions to the field, our objective was to overexpress recombinant *maf* gene, purify the protein, and In silico analysis. Multicopy associated filamentation (*maf)* gene of *Caldimonas manganoxidans* MS1, moderately thermophilic bacteria identified and characterized from MahaOya hot water springs in Ampara district, Sri Lanka and successfully cloned in pET28a (+)/*E. coli* BL21(DE3) system in a previous study was used for the overexpression of recombinant Maf protein. Glycerol stocks of the expression host *E. coli* BL21 (DE3) pLysS cells harboring the recombinant *maf* gene were acquired from -80^{0}C, revived by growth in LB agar plates and confirmed with polymerase chain reaction with primers specific to the *maf* gene. Bioinformatics analysis carried out using NCBI tools confirmed the identity of maf gene PCR product sequence with a 99% sequence similarity with the *maf* gene of *Caldimonas manganoxidans* (NZ_KB905929.1). The overexpression of the recombinant Maf protein was induced at the mid exponential phase of growth by the addition of isopropyl-ß-D thiogalactopyranoside (IPTG) to a final concentration of 1mM. Overexpressed recombinant Polyhistidine tagged Maf protein was purified using MagneHis ™ Protein purification system with paramagnetic precharged Nickel particles. The protein structure was predicted using Swiss Model software of ExPASy while errat procheck and Ramachandran plot validated the structure, revealing approximately 94.4% of the amino acids in the favored region. Sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE) with protein visualization by Coomassie Brilliant Blue R-250 staining indicated a single band at around 22kDa complying with the molecular weight expected by bioinformatics analysis. Therefore, in the present study recombinant Maf protein was successfully overexpressed, purified and verified with SDS PAGE analysis and bioinformatics analysis, providing prospects for scale up and further functional analysis of the recombinant protein.

Keywords: Recombinant protein, Maf, Overexpression, Purification, In silico analysis

Abstract No: MO-26

Antioxidant activity and protein precipitating ability of peel extract of *Nephelium lappaceum* Linn. (Rambutan)

A. K. D. M. Binuwangi[*] and C. S. K. Rajapakse

Department of Chemistry, University of Kelaniya, Sri Lanka
amugoda_2019@kln.ac.lk*

Nephelium lappaceum Linn. (Rambutan) peels, one of the tropical agricultural wastes, have been identified as a rich source of polyphenols with antioxidant properties. Plant phenolic compounds can interact with protein molecules and the polyphenol-protein complexes enhance the antioxidant capacity of polyphenols and therefore influences the bioaccessibility of phenolics. This study was aimed to determine the antioxidant activity and the bovine serum albumin (BSA) protein precipitating ability of peel extract of Rambutan (*Nephelium lappaceum*). Fresh Rambutan fruits of Malwana special variety were collected from a commercial cultivation in the Western province, Sri Lanka. Chemical constituents in dried, powdered Rambutan peels were extracted using cold extraction (extracting solvents = methanol, ethanol, and ethyl acetate) (6 days, 37° C) and methanolic soxhlet extraction (6 hrs, 60 °C) separately. Antioxidant activity and total phenolic content (TPC) of freeze-dried extracts were determined using 1,1-diphenyl-2-picryl-hydrazyl (DPPH) free radical scavenging assay and Folin-Ciocalteu assay, respectively. The correlation between antioxidant activity and TPC was analyzed using Pearson's correlation. Since the methanolic crude extract obtained from cold extraction was rich in phenolics, it was fractionated into hexane, dichloromethane (DCM), ethylacetate, and aqueous methanol, and their protein precipitation ability was determined using Bradford assay. Among the crude extracts, the highest percentage yield was obtained from soxhlet extraction (34.5 %). Methanolic cold extract had the highest TPC (332.56 ± 1.20 mg GAE / g of extract), and ethylacetate crude extract had the lowest TPC (210.13 ± 3.20 mg GAE / g of extract). Further, antioxidant activity of soxhlet extract (IC_{50} = 9.70 ± 0.50 μg/mL) and methanol (IC_{50} = 8.20 ± 0.35 μg/mL) and ethanol (IC_{50} = 8.31 ± 0.50 μg/mL) cold extract was significantly higher (p < 0.05) than that of synthetic antioxidant BHT (IC_{50}=13.92 ± 1.19 μg/mL). Statistically significant (p < 0.01), a strong positive correlation was observed between DPPH radical scavenging activity and the TPC with Pearson's correlation coefficient (r) of 0.99. Hence, the results suggested a potential for the utilization of peels *N. lappaceum*, as a nutraceutical enriched with natural antioxidants. According to results of protein precipitation potential of fractions, the highest percentage of BSA precipitate was observed (88.54 ± 0.92 %) in the ethyl acetate fraction. Thus, this study identified that Rambutan peel polyphenols have an affinity to bind with BSA at pH 4.5 *in-vitro* and the antioxidant activity of Rambutan peel extract would be masked by polyphenol–protein precipitation to some extent. Therefore, further studies should be necessary to isolate, purify, and identify polyphenols in Rambutan peels with their protein precipitation potentials to understand the mechanism of phenolic-protein interactions and their industrial applications.

Abstract No: MO-27

In vitro antioxidant, anti-inflammatory and anti-cancer activities of plant extracts used in Ayurvedic medicine

C. C. J. Munasinghe[*], H. Hapugaswatta, K. N. Seneviratne and N. Jayathilaka

Department of Chemistry, University of Kelaniya, Sri Lanka
chathumunasinghe0@gmail.com*

Traditional medicine may provide leads for potential new therapeutics. Sri Lanka is home to numerous plant species with reported anti-cancer properties according to traditional medical practices. Further, polyphenolic compounds extracted from various plant products have been reported to exhibit antioxidant, anti-inflammatory and anticancer activity. In this study we assessed the antioxidant, anti-inflammatory and anti-cancer potential against acute myelogenous leukemia (AML) in several ayurvedic plant species; *Nigella sativa* (Kaluduru) seeds, *Hemidesmus indicus* (Iramusu) roots, *Adenanthera pavonina* (Madatiya) seeds and *Murraya koenigii* (Curry leaves). These plant species have already reported of possessing anti-cancer activity against different cancer types. The main objective of this study is to determine the anti-cancer activity of theses plant extracts against AML. All the plant parts were thoroughly cleaned, dried, grounded into fine powder and bioactive compounds were fractionated into different solvents. The Total phenolic content (TPC), antioxidant activity, anti-inflammatory activity and cytotoxicity against AML were evaluated using Folin-Ciocalteu assay, 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay, Ferric reducing power antioxidant assay, protein denaturation inhibition assay and Cell TiterGo viability assay using THP-1 cells as a model for AML. *N. sativa* (kaluduru) aqueous extract showed the highest TPC; 3.14 ± 0.01 mg GAE/g dry weight (after tannin removal) and 2.92 ± 0.01 mg GAE/g dry weight (after protein removal), *H. indicus* (iramusu) aqueous extract recorded the highest DPPH radical scavenging activity and ferric reducing power and *N. sativa* (aqueous extract), *A. pavonina* (madatiya) ethanol extract and *M. koenigii* (curry leaves) methanol extract showed significantly high values ($p<0.05$) for the anti-inflammatory activity compared to other tested extracts. *H. indicus* (aqueous extract) showed the highest cytotoxicity against THP-1 cells with the lowest IC_{50} value (0.37 ± 0.01 mg/mL). All the tested extracts showed more than 50% inhibition of THP-1 cells at the highest tested concentration (15 mg/mL). All the tested plant extracts showed presence of polyphenols with antioxidant, anti-inflammatory and cytotoxic properties. However, the TPC as determined by Folin Ciocalteu assay does not explain the resulting cytotoxicity against AML cells. Further studies are needed to assess whether the observed anti-leukemic activity is due to cytotoxicity that would affect healthy cells and to assess whether the observed activities are specific against AML.

Keywords: Anti-cancer activity, Ayurvedic plant extracts, Antioxidant activity, Acute myelogenous leukemia

Abstract No: MO-28

In vitro anti-inflammatory and antioxidant activities of Paspanguwa decoction and its constituents

H. M. R. Madushani and C. C. Kadigamuwa[*]

Department of Chemistry, University of Kelaniya, Sri Lanka
cckadigamuwa@kln.ac.lk[*]

The Paspanguwa herbal formulation is commonly consumed as a traditional medicine in Sri Lanka. Paspanguwa consists of five ingredients, namely the rhizome of *Zingiber officinale* (Inguru), leaves and stem of *Hedyotis corymbosa* (Pathpadagam), dried berries of *Solanum xanthocarpum* (Katuwalbatu), dried stem of *Coscinium fenestratum* (Venivalgata), and dried seeds of *Coriandrum sativum* (Koththamalli). The importance and objective of this study was to prove the antioxidant and anti-inflammatory properties of traditionally used decotion, Paspanguwa claimed to have. In the present study, water extracts of the individual ingredient and the Paspanguwa decoction were screened for their total soluble phenolic content (TPC), total soluble flavonoid content (TFC), 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity, and their ability to inhibit protein denaturation (anti-inflammatory activity). The highest and the lowest TPC was seen in Coriander and ginger as 12.76 ± 1.00 and 7.89 ± 0.86 mg Gallic acid equivalent/g dry weight, respectively. The highest and the lowest TFC was seen in Katuwalbatu and Pathpadagam as 778.19 ± 1.40 and 282.14 ± 1.49 μg Catechin equivalent/g of dry weight, respectively. The lowest and the highest IC_{50} values for the DPPH assay was seen in Paspanguwa decoction and Katuwalbatu as 253.4 ± 8.2 and 609.7 ± 5.6 μg/mL, respectively, while the standard ascorbic acid showed 111.0 ± 6.1 μg/mL. The highest and lowest reducing power percentages were seen in Paspanguwa decoction and coriander as 94.74 ± 1.31 and 22.95 ± 0.96 while the standard ascorbic acid showed 109.89 ± 0.96. The ability to inhibit protein denaturation varied in the order of: Acetylsalicylic acid (standard) > Paspanguwa decoction > ginger > coriander > Venivalgata > Katuwalbatu > Pathpadagam at all the three concentrations (625, 1250, and 2500 μg/mL). These results suggest that Paspanguwa water extract is a good source of antioxidants with TFC and TPC with a higher ability to inhibit protein denaturation. Our findings corroborate with the previous in vitro studies of the antioxidant activity of Paspanguwa. However, our study is the first to reveal the anti-inflammatory action, total flavonoid content, and reducing power of the Paspanguwa herbal formula. Further, this study validated the use of Paspanguwa as a good source of antioxidants together with anti-inflammatory activity in traditional Ayurvedic medicine.

Keywords: Anti-inflammatory, Antioxidant, DPPH, Flavonoid, Phenolic

Abstract No: MO-29

Evaluation of the effect of oxidizing and reducing agents on trypsin inhibitory activity of *Vigna mungo* seeds (Black Gram)

J. D. M. S. Jayasinghe[1], U. S. D. Chandrasena[1], K. D. K. P. Kumari[2], S. Rajapakse[3] and T. S. Suresh[1*]

[1]Department of Biochemistry, Faculty of Medical Sciences, University of Sri Jayewardenepura, Sri Lanka
[2]Department of Basic Sciences, Faculty of Allied Health Sciences,
General Sir John Kotelawala Defence University, Sri Lanka
[3]Department of Molecular Biology and Biotechnology, Faculty of Science, University of Peradeniya, Sri Lanka
sugandhika@sjp.ac.lk*

Trypsin is one of the widely distributed serine proteases in living organisms, which is involved in vital physiological functions. In spite of its involvement in survival of the organisms, it was reported that trypsin is associated in pathogenesis of different type of human cancers. Therefore, trypsin inhibitory proteins have been gained attention as a potential treatment strategy against such cancers. Seeds of legumes have been recognized as potential natural resources of trypsin inhibitory proteins. Black gram (*Vigna mungo*) is a popular legume cultivated in Sri Lanka and Field Crops Research and Development Institute of Sri Lanka (FCRDI) has released a novel breed of black gram called Anuradha. The attempts were made to assess trypsin inhibitory activity (TIA) of its seeds and characterization of the active trypsin inhibitory proteins for future discovery of anticancer agents. The objectives of the present study was to evaluate the effect of oxidizing and reducing agents on the activity of trypsin inhibitory proteins present in seed of the local variety and to investigate the ionic nature of active proteins using ion exchange chromatography. Fresh mature seeds of variety Anuradha were collected from FCRDI and the crude protein extract (20%) of milled seeds was prepared using distilled water. The TIA of the extract was assessed by the method explained by Kunitz (1947) with slight modifications. To evaluate the effect of oxidizing and reducing agents on TIA, the seed extract was incubated with hydrogen peroxide (1-2%, v/v), dimethyl sulphoxide (1-5%, v/v) and varying concentrations of β-mercaptoethanol for 30 minutes, followed by the measurement of TIA. To discover the ionic nature of the active proteins, the crude protein extract was fractionated by ion exchange chromatography using positively charged Diethylaminoethyl cellulose as the stationary phase. The column was washed with phosphate buffer (pH 7.4) and then eluted with 1 M NaCl. The absorbance of each eluted fraction was measured at 280 nm. The TIA was assessed for the fractions with highest absorbance values. The TIA activity of the crude protein extract was $73.21 \pm 0.29\%$. In the presence of the oxidizing agents, dimethyl sulfoxide and hydrogen peroxide the TIA of the test extract was $59.91 \pm 0.69\%$ and $27.08 \pm 0.34\%$ respectively. The activity of seed samples incubated with 0.1 M, 0.5 M, 1 M and 2 M of β-mercaptoethanol was $70.72 \pm 0.23\%$, $58.63 \pm 0.53\%$, $46.31 \pm 0.72\%$ and $39.47 \pm 0.44\%$ respectively. Ion exchange chromatography resulted one fraction with high protein content at pH 7.4 which exhibited $3.12 \pm 0.62\%$ of TIA. The TIA of the washing fraction was $35.46 \pm 0.08\%$. The results of the present study revealed that Dimethyl sulfoxide decreased the TIA in a moderate level while hydrogen peroxide caused a drastic decrease. Increasing concentration of the reducing agent β- mercaptoethanol gradually decreased the TIA of the test sample. The observations of column chromatography indicated that the seed sample of black gram contain active trypsin inhibitory proteins which exist in an anionic or neutral form in pH 7.4.

Keywords: Trypsin inhibitory activity, Black Gram, *Vigna mungo*, oxidizing agents, reducing agents

Abstract No: MO-30

Physicochemical, techno-functional and hypoglycemic properties of selected wheat flour substitutes

M. M. K. D. Ranasinghe[1], S. M. D. S. Gayathri, P. G. I. Dias[1], N. G. D. Anuradha[1], T. C. Kananke[1*], M. G. A. N. Perera[1], R. M. K. T. Rathnayaka[1], R. S. Sabaragamuwa[1], M. N. Wickramarathne[2] and R. M. U. S. K. Rathnayaka[1]

[1]Faculty of Applied Sciences, Sabaragamuwa University of Sri Lanka, Belihuloya,70140, Sri Lanka
[2]Faculty of Medicine, Sabaragamuwa University of Sri Lanka, Ratnapura,70000, Sri Lanka
thilini@appsc.sab.ac.lk*

Wheat flour is one of the major refined carbohydrate sources consumed by Sri Lankans. However, long term consumption of such refined starch sources is linked with a high prevalence of various non-communicable diseases, such as obesity, heart disease, and type 2 diabetes. Therefore, the consumers are now concerned about the potential of using wheat flour substitutes for healthy food recipes. The present study was conducted to find the possibility of utilizing *Musa paradisiaca* (Ash plantain), *Cycas cricinalis* (Cycas) and *Caryota urens* (Kithul) flour types as wheat flour alternatives. The Cycas flour was prepared from the fruits of *C. cricinalis* and the fruits were sun dried for 3-4 days to remove toxicity before milling. The Kithul flour was extracted from the stem of *C. urens*. The Ash plantain flour was prepared using well ripened fingers of *M. paradisiaca*, followed by blanching, drying and milling. The proximate composition, techno-functional and hypoglycemic properties of prepared flour substitutes were determined and compared with wheat flour. The proximate compositions were determined using AOAC approved protocols on a dry matter basis. The pH, water activity, Water Absorption Capacity (WAC), Oil Absorption Capacity (OAC), and swelling properties were determined using appropriate physical and chemical methods. *In vitro* starch-hydrolyzation method was used to evaluate the Hydrolysis Index (HI), predicted Glycemic Index (GI), and Glycemic Load (GL). Among the flour types considered, the lowest crude fat content was observed in *C. urens* ($1.96 \pm 0.23\%$) while the lowest total carbohydrate content was observed in *C. cricinalis* ($33.15\pm0.75\%$). All flour substitutes showed significantly (at $P<0.05$) less carbohydrate contents compared with that of wheat flour. Further, *M. paradisiaca, C. cricinalis, C. urens* showed significantly ($p<0.05$) high fiber contents compared to wheat flour. The WAC and OAC of the three flour substitutes were significantly higher than the wheat flour (at $p<0.05$). The highest WAC and OAC were observed in *C. urens* and *C. cricinalis*, respectively. Although wheat flour reported the highest swelling capacity, it was not significant (at $p<0.05$) compared to that of other flour types. The lowest predicted HI and GI was observed in *M. paradisiaca*. However, the HI and GI values (143.93 ± 0.88, 118.73 ± 0.48) of *C. urens* were higher than that of wheat flour (100 ± 4.55, 94.61 ± 2.5), respectively. The GL values of alternative flour types were significantly (at $p<0.05$) lower than wheat flour (63.48 ± 1.68) and the value of *C. cricinalis* (26.68 ± 0.63) obtained the least. Accordingly, *C. cricinalis* and *M. paradisiaca* have great potential to be used as a substitute for wheat flour. However, further investigations are to be done to find the best proportions of flour composites to formulate different food items.

Keywords: Glycemic index, Glycemic load, Hypoglycemia, Type 2 diabetes, Wheat flour substitutes

Abstract No: BP-01

Bioactive compounds in *Dioscorea alata* L. (Raja ala) tuber cooking water collected under two common cooking methods

H. M. R. Amarasekara and S. R. Wickramarachchi[*]

Department of Chemistry, Faculty of Science, University of Kelaniya, Sri Lanka
suranga@kln.ac.lk*

Nutritional compounds in yams may leach out to the cooking water under most traditional domestic cooking. Finding alternative uses of these waste waters without discarding, will maximize the health benefits of these yams. This study aimed to quantify the bioactive compounds in the cooking water collected during boiling of *Dioscorea alata* L. tubers under two domestic cooking methods. Raja ala yams were diced and boiled in water using conventional boiling (CB) in a closed stainless-steel pot for 45 minutes and using pressure cooking (PC) in a pressure cooker type autoclave for an overall period of 30 minutes. The cooking water of both methods was collected, filtered, and concentrated by evaporating at 70°C to obtain the solid crude product. Aqueous solutions of the crude product (30 mg/mL) of CB (Crude-CB) and PC (Crude-PC) were prepared and subjected to qualitative phytochemical analysis. Further, they were assayed for total phenolic content (TPC), total flavonoid content (TFC), and total anthocyanin content (TAC). Antioxidant activity of each crude product was determined using 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay and total antioxidant activity (TAA) was determined using the phosphomolybdenum assay. A correlation between the antioxidant activity and TPC, TFC and TAC of the samples was developed using the Pearson's correlation method. Phytochemical screening of crude-CB and crude-PC samples showed the presence of alkaloids, flavonoids, phenols, saponin, tannins and coumarins and an absence of proteins, thus indicating the presence of nutritional compounds in cooking water collected under both cooking methods. Crude-CB $(14.713 \pm 1.039$ mg GAE/g FW) showed a significantly higher TPC than that of crude-PC $(9.848 \pm 0.548$ mg GAE/g FW) whereas the TFC of crude-PC was higher than crude-CB suggesting that the leaching out of phenolic compounds including flavonoids are significantly affected by the cooking method. Both methods, however, showed no significant difference in TAC extraction implying that the loss of anthocyanins from the yam is similar when either of the two cooking methods are is employed. IC_{50} values of crude-CB $(209.014 \pm 10.428$ µg/ml) and crude-PC $(371.615 \pm 8.982$ µg/ml) samples showed moderate activity in the cooking water. TAA of crude CB and PC samples were 0.917 ± 0.016 and 0.707 ± 0.002 mg GAE/mg FW respectively. Antioxidant assays showed higher activity in CB samples over the PC, suggesting that a higher amount of compounds with antioxidant activity have been leached out under the CB method than PC method. The strong correlation observed between TPC versus DPPH activity (IC_{50} value) (r= -0.856) and TAA (r = 0.811) of the samples confirms that the phenolic compounds that have leached out into the cooking water possess antioxidant activity. Finally, it can be concluded from the overall results that although the leaching out of phenolics and antioxidants into cooking water is inevitable under both cooking methods, a greater loss takes place under CB than the PC method.

Keywords: Antioxidants, Boiling, *Dioscorea alata* L., Phenolics, Pressure cooking

Abstract No: BP-02

Level of survival and growth performance of three lettuce (*Lactuca sativa* L.) varieties in an automated raft aquaponics system

S. K. Madarasinghe*, K. M. W. Rajawatta, R. D. A. K. Ranasinghe, I. L. P. Subasinghe, M. G. H. Dilhara, G. L. H. R. Navodya and K. A. S. Mihiranga

Department of Biosystems Technology, University of Ruhuna, Matara, Sri Lanka.
sandunikm89@gmail.com*

Aquaponics are famous as a soil-less culture for crop production. This study aims to determine the most suitable lettuce variety for automated Raft Aquaponics Systems by experimenting on the survival and growth rates of three lettuce varieties, commonly grown in soil-less culture. The experiment was carried out in two automated raft aquaponics systems, established under the same automated greenhouse conditions in the Faculty of Technology, University of Ruhuna, Kamburupitiya in a completely randomized manner. Three lettuce varieties (i.e. Green Cos (GC), Romaine F1 Hybrid (F) and Rocket (R)) were used to determine the most suitable variety for raft aquaponics systems. Plants were maintained under nursery conditions for two weeks and transferred to the grow beds where each grow bed contained seven randomly placed pots per variety. Plant height and leaf chlorophyll content of each variety were measured in weekly intervals while the number of leaves were counted on a weekly basis. Plants of both GC and R varieties survived throughout the period with 100% survival, while the F variety did not survive after 40 days. Thus F variety cannot be recommended for raft aquaponics systems due to its low survival rate. However, both GC and R varieties showed a continuous increase in leaf number and plant height throughout the period. Nevertheless, R variety showed a better plant growth than GC variety, maintaining higher plant height (R - 26.6±0.8 cm, GC - 25.0±1.0; $p<0.05$), revealing that R variety to be the best for aquaponics systems. However, the leaf number was not significantly different ($p>0.05$, tested with Chi-square test) in R and GC varieties. Moreover, R variety maintained a significantly higher chlorophyll level than GC from the initial stage (R - 19.6±1.8, GC - 6.3±0.4 SPAD units; $P<0.05$) throughout the period. Higher chlorophyll content in R is indicative of its higher photosynthetic capacity and thereby greater yield with a better energy budget. Based on the observations, Rocket variety can be recommended for raft aquaponics systems over Green Cos and Romaine Fi Hybrid varieties to get the best lettuce harvest.

Keywords: Growth performances, Aquaponics systems, Chlorophyll, Lettuce

Abstract No: BP-03

Impact of potting mixture and size of cutting on propagation of betel (*Piper betle* L.)

M. Lakshi[1], K. Vithusan[1,] W. K. S. Chandrasiri[1], R. G. J. Perera[1] and J. P. Kirthisinghe[2*]

[1]Faculty of Agriculture, Aquinas College of Higher Studies, Colombo 8, Sri Lanka
[2]Postgraduate Institute of Agriculture, University of Peradeniya, Peradeniya, Sri Lanka
jpkirthi@pdn.ac.lk*

Betel is an export agriculture crop grown as an intercrop throughout Sri Lanka. The Sri Lankan betel growers are disorganized and not adhering to standard production practices recommended by the Department of Export Agriculture. Generally, about 50% of the cuttings qualify for field planting due to poor cultural practices. Therefore, the study was conducted to identify the optimum size of a cutting and a low cost potting mixture for obtaining best quality nursery plants for field planting. The study was conducted at Vairavapuliyankulam in *Vavuniya* District during Yala season in 2019. Nine treatment combinations with three fumigated potting mixtures of top soil: sand: cattle dung: coir dust 1:1:1:1 (control/ M_1), top soil: sand: cattle dung: paddy husk 1:1:1:1 (M_2), top soil: sand: cattle dung: sawdust 1:1:1:1 (M_3) and three sizes of cuttings of three nodal (N_1), four nodal (N_2) and four nodal with apical bud (N_3), were used for the experiment. The cuttings were treated with a fungicide mixture (copper sulphate and lime) for 2 minutes followed by Rootone®. The experiment was triplicated. Data were collected at 3, 6 and 8 weeks after planting (WAP) of cuttings. At 8 WAP in four nodes cuttings with the apical bud in potting mixture of top soil: sand: cattle dung: coir dust 1:1:1:1 had the longest new shoot length of 8.1 cm, highest fresh weight of new shoot of 121 mg, highest dry weights of new shoot 18.1 mg, highest number of roots of 21 per plant, per plant root length of 13 cm and highest root dry weight of 2 mg. There was no significant difference observed between potting mixtures of M_2 and M_3. This study revealed that coir dust cannot be replaced by sawdust or paddy husk. Four nodes cuttings with the apical bud (N_3) produced better plants than the three nodal (N_1) and four nodal (N_2) cuttings without an apical bud in M_1 potting mixture.

Keywords: Cattle dung, Coir dust, Paddy husk, Sawdust, Size of cutting

Abstract No: BP-04

Assessing the suitability of treatments for successful karyotyping of selected *Phalaenopsis* cultivars

Y. K. D. D. Thathsarani[*] and R. A. S. P. Senanayake

Department of Plant and Molecular Biology, University of Kelaniya, Sri Lanka
thathsar_bs15282@stu.kln.ac.lk*

Orchidaceae is considered as one of the largest flowering plant families and has acquired the attention of researchers in different aspects i.e., taxonomy, phylogeny, phytogeography, etc. In the family Orchidaceae, the genus *Phalaenopsis* has been attracted the eye of the global floriculture industry due to its specific commercial traits. Therefore, this genus has obtained a significant proportion of the global market as both pot plants and cut flowers. Hence, it is important to develop hybrids with specific commercial traits to meet the demand. Generally, the gene-trait interaction is the key point of the development of hybrids. Consequently, it is important to understand the chromosome morphology and the correlation between the chromosomes and the floral characteristics. Therefore, karyotyping based on modern and classical cytogenetic approaches in *Phalaenopsis* cultivars would reveal significant information associated with gene-trait interaction. However, the knowledge gap in chromosome characters of *Phalaenopsis* cultivars has hindered the development of quality improved cultivars with attractive traits. Therefore, it is important to infer the relationships of karyotypes with the chromosome characteristics and the ploidy levels of selected commercially valuable *Phalaenopsi*s cultivars grown in Sri Lanka. Furthermore, it is important to assess the suitability of treatments for successful karyotyping. In this study, potted plants and tissue cultured specimens of four *Phalaenopsis* cultivars were selected, based on consumer demand. Tissue cultured specimens were obtained from the Floriculture Research Center, University of Kelaniya. The squashing method with 2 mM 8-hydroxyquinoline pretreatment at 3 different temperatures (16 °C, 18 °C and 20 °C) for 4 hours was used in chromosome preparation at mitotic division stages of the root tip cells. Both Feulgen staining and aceto-orcein staining were used as staining protocols in chromosome spread preparation. In chromosome spread preparation, tissue cultured specimens performed better than the specimens of potted plants. Pretreatment with 2 mM 8-hydroxyquinoline at 18 °C followed by aceto-orcein staining was successful for tissue cultured white *Phalaenopsis* cultivar in obtaining chromosome spreads at mitotic metaphase. Hence, pretreatment of tissue cultured plants with 2 mM 8-hydroxyquinoline at 18 °C and aceto-orcein staining can be suggested as suitable treatments for successful karyotyping of white *Phalaenopsis* cultivars.

Abstract No: BP-05

Syntheses and evaluation of chalcone derivatives as urease inhibitors against *Helicobacter pylori* and their antioxidant behavior

M. L. F. Nusfa and M. J. Gunaratna*

Department of Chemistry, Faculty of Science, University of Kelaniya, Sri Lanka
medhagunaratna@kln.ac.lk*

Urease is a nickel containing enzyme that catalyzes the hydrolysis of urea into ammonia and carbon dioxide, thus providing nitrogen in the form of ammonia for the growth of plants. Enzyme urease is found in bacteria, fungi, and some plants, whereas it is absent in humans. This urease activity can result in an abnormal release of ammonia causing various diseases in humans. Thus, the release of ammonia by the bacterium *Helicobacter pylori* is responsible for causing peptic ulcers and gastric cancers in humans. This had led to the discovery of urease inhibitors as a remedy for peptic ulcers. Despite the discovery of many urease inhibitor molecules, only a few have reached clinical testing stage. This research was focused on the syntheses and evaluation of urease inhibitory activity of chalcone derivatives against *Helicobacter pylori* as well as their potential as antioxidants. Chalcone is an aromatic ketone that forms the core in many compounds with a wide range of therapeutic activities. Due to its open-chain model, it can readily undergo modifications in its skeletal structure. In this study, chalcone derivatives were synthesized using the Claisen-Schmidt condensation method and the structures were confirmed using their melting point ranges and FT-IR spectra. Synthesized compounds were tested for urease inhibitory activity using the indophenol method, and their antioxidant properties were studied using DPPH radical scavenging assay. Among the five synthesized compounds, compound [(*E*)-1-(4-methoxyphenyl)-3-(2-nitrophenyl)-prop-2-en-1-one] showed a significant anti-urease activity (IC_{20} 0.678 ± 0.125 mg/mL, IC_{20} – concentration of sample needed to show a 20% inhibition), but it was exceptionally low compared to that of the standard inhibitor, thiourea (IC_{20} 0.034 ± 0.002 mg/mL). A significant antioxidant activity was observed for the compound [(*E*)-3-(1H-indol-3-yl)-1-(4-methoxyphenyl)-prop-2-en-1-one] (IC_{20} 11.01 ± 1.109 mg/mL) even though it was lower than that of standard ascorbic acid.

Keywords: Urease enzyme, Chalcone, Urease inhibition, Antioxidant activity

Abstract No: BP-06

Proximate analysis on nonedible portions (fruit peels and seeds) of pomegranate cultivars grown in Sri Lanka

T. I. Punchipatabendi[*] and M. K. B. Weerasooriya

Department of Chemistry, Faculty of Science, University of Kelaniya, Sri Lanka
ishankatt94@gmail.com*

Pomegranate (*Punica granatum* L., family Punicaceae), because of its high nutritional and nutraceutical value, is a very popular fruit crop among growers and consumers worldwide. Nonedible portion (peel and seed) is reported to be a rich source of biomolecules of immense health significance. Though, nutritional value of fruit juice is being reported and little is known about peel and seed. Hence, the study was targeted at evaluating proximal composition of fruit peel and seed of pomegranate cultivars, *Kalpitiya hybrid*, *Daya* and *Nimali.* Under proximal analysis, moisture content was analyzed using oven drying method, ash content using a muffle furnace, lipid content using Soxhlet extraction, fiber content using acid and alkaline digestion, nitrogen content using Kjeldahl distillation method and carbohydrate content was calculated using an equation. Corresponding proximal analysis values for peel were ranged from $11.3067 \pm 0.017\%$ to $15.196 \pm 0.217\%$ for moisture content, from $44.79 \pm 4.37\%$ to $58.05 \pm 3.46\%$ for carbohydrate content, from $1.2613 \pm 0.01172\%$ to $3.358 \pm 0.113\%$ for ash content, from $0.91 \pm 0.09\%$ to $1.41 \pm 0.14\%$ for lipid content, from $11.73 \pm 0.41\%$ to $19.60 \pm 0.84\%$ for crude protein content and from $12.66 \pm 1.25\%$ to $15.23 \pm 0.87\%$ for fiber content. While corresponding proximal analysis values for seed were ranged from $7.7033 \pm 0.0893\%$ to $8.202 \pm 0.0552\%$ for moisture content, from $7.227 \pm 0.40\%$ to $26.54 \pm 2.76\%$ for carbohydrate content, from $1.352 \pm 0.00917\%$ to $4.008 \pm 0.535\%$ for ash content, from $16.24 \pm 0.53\%$ to $21.50 \pm 1.29\%$ for lipid content, from $16.24 \pm 0.33\%$ to $33.30 \pm 4.16\%$ for crude protein content and $28.05 \pm 0.13\%$ to $32.50 \pm 1.59\%$ for fiber content. *Kalpitiya hybrid* peels and seeds had the highest ash, lipid, protein and fiber content, whereas *Daya* peels and *Nimali* seeds had the highest carbohydrate content. *Daya* seeds and *hybrid* peels had the highest fiber content. Thus, study herein revealed that lipid and protein contents are higher in seeds than the peels, whereas carbohydrate and fiber contents are higher in peels than seeds. Also, peels and seeds exhibit significant percentages of nutritional values comparative to the dry weight, which bears the potential to develop into healthy food ingredients, nutraceuticals that can be used in many applications in food industry.

Keywords: Peel, Pomegranate, Proximal analysis, Seed

Abstract No: BP-07

Evaluation of *in vitro* bio-controlling efficacy of *Trichoderma virens* against plant pathogenic fungi; *Fusarium oxysporum*, *Colletotrichum gloeosporioides* and *Lasiodiplodia theobromae*

D. T. I. Dissanayake, T. D. Kodituwakku and B. T. S. D. P. Kannangara[*]

Department of Plant and Molecular Biology, University of Kelaniya, Kelaniya, Sri Lanka
sagarikadpk@kln.ac.lk*

Fungi are one of the major causative agents of plant diseases. They damage plants by causing cell death or by causing plant stresses. Chemical fungicides which are commonly used to control fungal pathogens reported to cause a negative impact on human health and environment, despite their high efficiency in controlling the pathogens. Therefore, the use of bio-controlling methods has been recognized as a sustainable, healthy and eco-friendly alternative. Among the available bio-control agents, *Trichoderma* species have emerged as very promising fungal bio-control agents against fungal pathogens of plants. They are capable of inhibiting pathogenic fungi utilizing an array of mechanisms involving mycoparasitism, antibiosis, rhizosphere competition, enzyme production, and induction of plant defense mechanisms. The present study was aimed on studying the capability of *Trichoderma virens* (KP985643.1) in controlling three plant pathogenic fungi (*Fusarium oxysporum*, *Colletotrichum gloeosporioides*, and *Lasiodiplodia theobromae* – obtained from the Department Culture Collection) under *in vitro* conditions. The biological controlling ability of *T. virens* against the test pathogens was evaluated using the dual culture method and through the microscopic observations of hyphal interactions in slide cultures. Selected test pathogens were tested against *T. virens* by exposing them to the volatile and non-volatile compounds produced by *T. virens*. Percentage inhibition of each pathogen was determined after a 6-day incubation period. Results of the dual culture test showed that *F. oxysporum* and *L. theobromae* have been significantly controlled (i.e. 60.90% and 80.28% respectively) by *T. virens* after 6 days. *C. gloeosporioides* was moderately controlled (i.e. 44.58%) when compared to other pathogens. Volatile components produced by *T. virens* moderately inhibited the growth of *C. gloeosporioides* (i.e. 46.98%). In contrast, volatile components of *T. virens* were not successful in controlling *F. oxysporum* and *L. theobromae*. Non-volatile components produced by *T. virens* significantly controlled the growth of *L. theobromae* (i.e. 61.05%) when compared to *F. oxysporum*, which reported only a moderate inhibition (i.e. 41.45%). Unanticipatedly, growth of *C. gloeosporioides* was not observed in control plates even after repeated attempts, probably due to the loss of the viability of the original *C. gloeosporioides* culture after a prolonged storage period. The slide culture technique clearly showed the efficiency of *T. virens* in controlling *L. theobromae* (but not the other pathogens) by the means of producing coiling structures. Based on these results, it can be concluded that *T. virens* has the potential of controlling the selected test pathogens by producing volatile and non-volatile components under *in vitro* conditions. Moreover, *T. virens* is capable of controlling *L. theobromae* using hyphal interactions. However, further research is needed to determine other mechanisms adopted by *T. virens* against the selected pathogens and to investigate its bio-controling ability against a wide range of other fungal pathogens.

Keywords: Bio-control, Dual culture, Non-volatile, *Trichoderma virens*, Volatile

Abstract No: BP-08

Feeding habits of silky shark (*Carcharhinus falciformis*) landed in Negombo fishery harbour and an account on fishing vessels and gears used to catch them

H. M. S. G. Karunanayaka and H. A. C. C. Perera[*]

Department of Zoology and Environmental Management, University of Kelaniya, Sri Lanka.
chinthap@kln.ac.lk*

Silky shark (*Carcharhinus falciformis*) is one of the most common shark species captured as a target fishery or as by-catch in various regions in the world. Information about the feeding habits and predatory behaviour of silky sharks is important, as it determines the survival and abundance of other marine species, and also helpful in ecosystem management and sustainable utilization of shark fishery. The present study investigates the feeding habits of silky sharks and evaluates some aspects of the silky shark fishery based on 32 silky sharks caught by single-day and multi-day boats, and landed at the Negombo fishery harbor from August to September 2020. The total length of each silky shark landed was measured to the nearest 0.1 cm, and the body weight was measured to the nearest 0.1 kg using a measuring tape and an electronic balance respectively. Stomach samples of each shark were analysed for stomach contents and the extent of stomach fullness. Stomach contents were identified to the lowest possible taxon and grouped into three categories. Data on the vessel size, gear type, bait type, etc. used were collected by interviewing the multi-day and single-day boat skippers. Forty-eight (48) fishing vessels were observed during the study period. The total length (TL) of the sampled silky sharks ranged between 50-285 cm and weight ranged between 3.5-75 kg. Stomach fullness was classified under five-categories; empty (40.6%), one-fourth filled (40.6%), half-filled (3.1%), three-fourth filled (6.3%) and full (9.4%). Occurrence of prey items in stomach contents were identified as fish remains (84.21%), arthropod remains (15.79%) and molluscan remains (5.26%). Milkfish (*Chanos chanos*), *Amblygaster* sp., *Sepia* sp., *Decapterus* sp., *Auxis* sp. and crab tissue segments. Of the 48 vessels inspected, 27.1% were single-day boats while 72.9% were multi-day boats. Higher percentage of silky sharks were caught by multi-day boats (77.6%) than by the single-day boats (22.4%). The boats were further identified as UN1, UN2A, UN3A and UN4 using standardized measurements. The fishing gears used by the boats were gillnet (45.8%) and longlines (54.2%). The number of silky sharks caught by longlines were higher (61.2%) than by gillnets (38.8%). The by-catch species caught in the fishing gear were identified as other shark varieties, billfishes and rays. The results of the present study also revealed that the diet of the silky shark mainly constitute of fish.

Keywords: Feeding habits, Longline, Percentage frequency of occurrence, Silky shark, Stomach contents

Abstract No: BP-09

Ecotourism as a strategy for sustainable natural resource management in Meemure forest region; Sri Lanka

L. D. I. De Silva[*]

Department of Agriculture Economics and Extension, Faculty of Agriculture,
Rajarata University, Sri Lanka
ldishanthi95@gmail.com*

Ecotourism based on sustainable use of natural resources provides opportunities to diversify pathways for income generation, employment, environment conservation and preservation/ enhancement of aesthetic value of landscapes. Ecotourism has been defined as the responsible travel to natural areas that conserves the environment and sustains the wellbeing of the local people, while compromising the regional development mechanism, environment, socio cultural, economic and education. Meemure is a fascinating village with a favourable climate located in the Knuckles mountain range which is mostly covered with tropical rainforests. This study attempts to identify the strategies for sustainable natural resource management that strengthen ecotourism based in Meemure village and surrounding areas. The primary objective of this study is to assess the efficacy of natural resources management strategies currently in practice. This study revealed that absence of alternative livelihoods and therefore, over-exploitation of natural resources has impacted sustainability of natural resource- base of the area. Relevant primary data were collected using structured questionnaires, interviews, observations and discussions. Secondary data/ information available in research papers, articles, journals and newspapers were also gathered for the purpose. Tourism related activities such as camping, hiking and expeditions create stress on the natural resources. Analyses reveal that ecotourism are unsustainable and therefore unsustainable due to lack of proper planning and management of the natural resources that contributes to environmental and cultural deterioration. Unscrupulous establishment of recreational areas, infrastructure and garbage dump sites had contributed to deforestation and erosion, thus threatening ecological sustainability of the area.

Keywords: Ecotourism, Natural resource, Sustainability

Abstract No: BP-10

DNA barcoding as a tool for conserving endemic orchids in Sri Lanka

S. M. Ashroff* and N. L. Bandara

Institute of Biochemistry, Molecular Biology and Biotechnology, University of Colombo
saraashroff@gmail.com*

Orchidaceae is a well-known family of flowers, consisting of more than 30,000 species worldwide. In Sri Lanka, there are over 188 species, including one endemic genus and 55 endemic species. According to the National Red List of Sri Lanka, 71% of the orchid species are categorized as threatened, of which 2%, 9% and 29% are categorized under the critically endangered possibly extinct CR(PE), critically endangered (CR) and endangered (EN), respectively. Additionally, three endemic orchid species have been grouped under the data deficient category (DD) due to lack of knowledge on current basic information. Abundance of endemic orchids in their natural habitats is declining at an alarming rate. Hence, it is required to take immediate action for their conservation. Although legal restrictions have been enacted, one of the main threats that affects the survival of endemic orchids is trafficking. Exporting orchid plants collected from the wild under false names in export permit documents is a common practice. Unavailability of a precise, scientific species identification techniques has severely affected the efficiency of the prevention of wildlife trafficking in Sri Lanka. DNA barcoding provides a platform for accurate species identification without using morphological traits. It uses relatively a small, standardized DNA fragment as a tag to define a species. Eleven endemic orchid species with comprehensive morphological description were selected for this study to develop DNA barcodes. DNA was extracted from young leaves by using the cetyltrimethylammonium bromide (CTAB) method and the DNA was amplified using polymerase chain reaction (PCR) using the primers for the two plant barcoding regions, chloroplast *matK* and nuclear ribosomal ITS. DNA sequences were obtained by performing bi-directional sequencing using the Sanger sequencing method. The resultant consensus sequences obtained were compared against pre-existing sequences of similar orchid species in the NCBI database. DNA barcodes were developed for the ITS sequences of 9 species and the *matK* sequences of 8 species. The developed DNA barcodes were submitted to the Barcode of life database (BOLD). This method does not require flowers to be inspected or expert taxonomic knowledge to identify suspected plant samples. Further, identification can be done with small tissue samples obtained from any part of the plant, and the process is fast and reproducible.

Keywords: Conservation, DNA barcoding, Endemic orchids

Abstract No: PP-01

Forecasting the chilli production in Kurunegala district

S. Kajanthan[*], P. Selvarajah and A.W.F. Mufliha

Faculty of Technology, University of Jaffna, Sri Lanka
kajanthans@univ.jfn.ac.lk*

In Sri Lanka about 27.1% of its working population is engaged in agriculture, which occupies about 7.54 % of the Gross Domestic Production (GDP). Chilli plays a major role in sustainable agriculture production. However, due to climatic changes, the pattern of chilli production has changed drastically during the past few decades in the Kurunegala district and has severely affected agricultural production. Therefore, this study aims to detect the pattern of the production and forecast and predict the factors impacting on the production during both Yala and Maha seasons from 2001 to 2019. Yearly production of Chilli had been decreasing during Yala and Maha seasons. But, there had been a big change in the production during the Yala season from 2014 to 2017. And also there was a change in the Chilli production level during Maha season from 2013 to 2019. Due to the volatility in the yearly production, a best time series model is selected for forecasting the Chilli production. It was founded that, a best time series model ARIMA (0, 1, 1) fitted for forecasting the Chilli production during the Yala season and ARIMA (0, 1, 2) model fitted for forecasting the chilli production during the Maha season. Moreover, the adequacy of the fitted best model has been tested using Ljung-Box test and Correlation matrix test. Both seasons, the long-term future forecast production values have increased. Another study was carried out to find out the significant factors affecting the productivity of the chilli in both the Yala and Maha seasons. Temperature, rainfall, relative humidity and cloud cover are the significant factors of affecting chilli production. The multiple linear regression analysis shows that temperature, relative humidity and cloud cover have been the significant factors of the chilli production during the Yala Season and the rainfall has been a significant factor of chilli production during Maha season. Kurunegala is categorised under an intermediate zone, therefore all climatic parameters affect a medium level and they help to achieve maximum production of crops that are cultivated in this district.

Keywords: Augmented Dickey-Fuller test, Autoregressive integrated moving average (ARIMA) model, Forecasting, Ljung-Box test, Multiple linear regression.

Abstract No: PP-02

A study about the food literacy in relation to health among students in the Faculty of Science, University of Kelaniya Sri Lanka

H. K. K. Fernando[*] and M. A. H. C. Munasinghe

Department of Statistics and Computer Science, Faculty of Science, University of Kelaniya, Sri Lanka
fernando_ps15191@stu.kln.ac.lk*

Food literacy is a relatively new and arising concept around the globe. Past studies have demonstrated positive associations between food literacy and healthy dietary behaviors such as increased consumption of fruit and vegetables, preference for healthy food, and decreased frequency of consumption of processed food. In such context, focusing on food literacy is a promising approach as insufficient nutrition affects students' health and academic success. Students may have competent knowledge regarding nutritional requirements. However, the transition to university life provides them a lot of freedom to choose the type and also the quantity of food they eat. The majority of the universities have dining facilities that provide a variety of food options, which can cause to initiate either good or bad eating behaviors. This study was conducted to explore the concept of food literacy because it relates to overall well-being from the attitude of young Sri Lankan adults who recently transitioned to independent living. Three hundred eighty-three students who were studying at the Faculty of Science of the University of Kelaniya were considered as the sample by using the stratified random sampling method using each degree course as the stratums. Data were collected using an online questionnaire. A descriptive analysis was conducted and a logistic regression was fitted to find the association between food literacy and other socio-economic factors by taking the healthy situation as the response variable. Accuracy of the fitted model was tested by obtaining the confusion matrix. It was found that the precision of the overall model is 78.3%. Height, weight and the residence during the university period were discovered as the significant factors. Results of the study have also shown that while young adults value "healthy" eating, they are at a risk for leaving their family homes because of the lack of necessary food literacy required to make healthy food choices and to sustain healthy food relationships. These results have also suggested that significant challenges exist in obtaining and utilizing food literacy, which appears to influence food choices, health, and well-being. Furthermore, findings specify that young adults could potentially have the advantage of expanding their views on food to encompass cultural knowledge, environmental stewardship, and family connectedness. This study has added worth to the present literature by discovering the factors related to food literacy and well-being from the perceptions of young Sri Lankan University adults. Moreover, this study has shown that young adults may not be equipped with the necessary food literacy to navigate complex food environments.

Keywords: Food literacy, Food handling, Nutrition, Well-being, Young adults

Abstract No: PP-03

Developing regression models to estimate leaf area of split/ partially split fronds of coconut seedlings

K. M. U. Gunarathe[1*], K. P. Waidyarathne[1] and D. D. M. Jayasundara[2]

[1]Department of Statistics & Computer Science, Faculty of Science, University of Kelaniya, Sri Lanka
[2]Plant Physiology Division, Coconut Research Institute, Sri Lanka
umayangigunarathne@gmail.com*

Leaf area (LA) is an important parameter measuring plant growth as it is highly responsive to the environment. Evaluation of leaf area is essential in plant research as it also helps in estimating plant productivity with net assimilation rate and total photosynthetic area of leaves. Coconut is a major plantation crop widely grown in Sri Lanka. To date, there is no non-destructive method of measuring leaf area of partially/fully split leaves of coconut seedlings. This is a drawback in coconut research as measuring LA is highly time consuming in the field. Therefore, the aim of this study was to determine an easy, accurate, cost-effective, and non-destructive formula to estimate leaf area of split/partially split leaves in 1 - 3 years old seedlings of three commonly grown coconut hybrids; Tall*Tall (TT), Dwarf Green*Tall (DT), and Dwarf Yellow*Tall (DY). Sixty leaf samples were randomly collected from each hybrid from the nurseries of Coconut Research Institute of Sri Lanka. Leaf parameters including maximum length (A), distance between two tips (B), midrib height (C), average length of first two leaflets (D), average length of last two leaflets (E), average length of middle three leaflets (F), average width of middle three leaflets (G), width between middle two leaflets (H), width between first two leaflets (I), and number of leaflets ((J) were collected from each frond. Actual leaf area was measured by LI-COR 3000 electronic leaf area meter. Linear polynomial model and multiple linear regression (MLR) analysis was used to define leaf area estimation models using different variable selection techniques such as the best subset method. Data were normalized (for TT and DY) and log-transformed (for DT) to satisfy the model assumptions. The lowest MSE and the highest R^2 values were considered to evaluate the results of the polynomial model and MLR approach. Models with better combinations of variables were developed for both TT and DY varieties by the best subset method. The polynomial model was carried out with the product of F, G, and H variables as an independent variable for DY variety as it did not produce satisfactory results with MLR analysis. Accordingly, the study revealed that the leaf area of Tall*Tall variety was best represented by the equation, Area (TT) = 0.46* (A) - 0.23*(E) + 0.54*(G) with 86% R^2 and 0.15 MSE. The best regression model for DY variety acted for; Area (DY) = -0.96 + 1.09*(A) − 0.59*(E) + 0.14*(B) + 1.22*(G) + 0.72*(F). This model had 94.3% R^2 as accuracy and 0.01 MSE. The adjustment with product of F, G and J represented 80.63% R^2 value, and 0.006 MSE for leaf area of DT hybrid. The model was ln (area) = 2.10 + 0.52*(ln (FGJ)). Neural network approaches with the same parameters will be evaluated to further improve the accuracy of the formula estimating leaf area.

Keywords: Dwarf Green*Tall, Dwarf Yellow*Tall, Leaf area, Regression model, Tall*Tall

Abstract No: PP-04

Survey on the acceptance of online education in state universities of Sri Lanka during the COVID-19 pandemic situation

K. R. T. S. Mahanama*, A. R. W. Mohamed, R. A. S. Wickramarathne, G. P. N. M. Pathirana, H. H. D. Kumara, M. P. R. L. Pathirana, M. P. A. T. Wickramanayaka, S. L. H. Gunawardena, M. J. R. Dias, M. I. Ihsan, K. D. Kaushalya and M. S. M. S. Kumara

Department of Statistics and Computer Science, Faculty of Science, University of Kelaniya, Sri Lanka
mahanama_ps17117@stu.kln.ac.lk*

Online education is a mode of electronically facilitated distance education method. Due to the COVID-19 pandemic situation, global educational institutions transformed into online platforms. As a developing nation, Sri Lanka had to make a rapid transition from face-to-face to the online teaching-learning process. According to the Department of Census and Statistics, Sri Lanka, only 22.2% of households owned desktop or laptop computers (2020). Consequently, the availability and accessibility of infrastructure to transform into an online education platform are at a question. Hence, to appraise this current situation based on students' points of view, a sample survey was conducted to explore the acceptance of online education mechanisms in state universities of Sri Lanka during the COVID-19 pandemic situation. As a first step, a pilot study was conducted on 44 undergraduates, who were selected by convenience sampling. With the experience of the pilot survey, the final questionnaire was fine-tuned with 27 questions, and it was delivered to the undergraduates in 14 state universities employing the snowball sampling technique. Based on observation of the pilot study, the required minimum sample size was found to be 570 with a margin of error of 0.04. Finally, a descriptive analysis was performed using 574 responses using Minitab software. Most of the students are more inclined to use online lectures (33%) and videos (55.3%). From 64.2% who had online sessions for practical courses, 38.9% are dissatisfied. Even though 36.3% had faced network problems, regular and usual participation figures were approximately 70%. 57.6% of the respondents in the sample are females, and among them, a higher percentage (44.8%) were participating in online lectures regularly compared to that of males (25.4%). The majority of the student has complained of difficulties in health problems (81%), inability in raising questions (64.9%), understanding course contents (86.9%), and heavy workload (89.4%). Overall, comparisons of face-to-face and online lectures revealed that the majority preferred face-to-face lectures (43.8%), and a significant proportion accepted both study modes (39.3%). On average, the acceptance of online education is ranked 2.86 on a scale of 1 (highly reject) to 5 (highly accept). Based on the findings, it is recommended to strengthen the interactions between students and lecturers, conduct break-through room assignments during the lectures, and use multiple communication platforms. In addition, student grievances can be accommodated by relaxing deadlines on assessment, aiding of educational, technical, and financial needs.

Keywords: COVID-19 pandemic, Descriptive analysis, Minitab, Convenience sampling, Snowball sampling

Abstract No: SP-01

Comparative study of neural network based speech recognition algorithms for Sri Lankan accent

J. K. D. R. Jayasekara[1], M. V. M. Jayathilake[2*] and S. V. S. Gunasekara[1]

[1]Department of Information Technology, CINEC Campus, Sri Lanka
[2]Sri Lanka Institute of Advanced Technological Education
mekala@sliate.ac.lk*

Speech recognition is a technology which involves processing and interpreting human speech into a written format. Advancements in technology have led to the development of sophisticated speech recognition algorithms with the use of neural networks, machine learning and artificial intelligence. Automatic Speech Recognition (ASR) is being used worldwide for developing various applications including automated devices to communicate with humans such as Alexa, Siri and Artificial Intelligence Chatbots. Several machine learning algorithms, Natural Language Processing (NLP) techniques, Hidden Markov Models (HMM) and neural networks are used to create the foremost speech recognition systems. However, most speech recognition algorithms are yet to overcome the many barriers which come along with the technology. Variations in pronunciations and accents, lack of fluency, speech clarity, speed of speech and language technicalities are just few of the challenges faced by modern day speech recognition algorithms. These problems are magnified in lesser-known languages and accents. The purpose of this research is to compare the accuracy of multiple speech recognition systems for unexplored accents such as the Sri Lankan accent. A comparison was conducted between three leading neural-network based speech recognition systems regarding their accuracy in recognizing speech spoken in a Sri Lankan accent. The primary objective of this study was to determine the system which applies the most efficient algorithm for recognizing speech with language nuances. Google Cloud Speech-to-Text, Mozilla DeepSpeech and CMU Sphinx were the three systems used in the research comparison. Quantitative secondary data was used to analyse existing speech recognition systems and their accuracy in interpreting speech in English accents. Furthermore, experimental research was conducted using primary audio data gathered using different speakers. Six selected sentences were converted to a verbal format in the form of individual audio files in the .wav format. Two versions of Sri Lankan accents were recorded for each sentence. An algorithm was designed in the Python language to calculate the Word Error Rate (WER) for each system and determine the one with the lowest error rate. Word Error Rate is a metric used to calculate the accuracy of text transcribed by speech recognition systems. The mean WERs obtained were 0.86, 1.05 and 0.59 for Mozilla DeepSpeech, CMU Sphinx and Google Cloud Speech-to-Text respectively. While the results provide conclusive evidence that the Google Cloud ASR system is the best at identifying speech in a Sri Lankan accent, it could be clearly observed that all three systems encountered difficulties when recognizing homophones and words with contradictory pronunciations. The outcome of this research indicates that although speech recognition systems have had major improvements over the years, there are still a lot more enhancements to be done in order to provide accurate and efficient speech-to-text transcriptions. The systems should be trained with larger and miscellaneous datasets which include speech from diverse languages and accents. As of now, the Google Cloud speech recognition system displays optimal performance when interpreting speech in Sri Lankan accents.

Abstract No: SP-02

Hybrid feature based fish classification using support vector machines

I. Perera *, S. Sanjika and M. Ramanan

Department of Computer Science, Trincomalee Campus, Eastern University, Sri Lanka
ishanidilu@gmail.com*

Fish recognition is one of the important tasks under object detection due to its prominence in oceanography or marine science. This paper proposes a method for multi-class classification using the hybrid feature and support vector machines (SVMs) to recognize fish species. This study proposes the various steps of fish spices classification: (i) binarization using Otsu's method; (ii) noise removal using median filter; (iii) boundary detection using horizontal and vertical projection technique; and (iv) feature extraction and classification using SVMs. The Hybrid feature is a combination of geometric features and texture features using Histogram of Oriented Gradients (HOG). The geometric features that are extracted, are the aspect ratio of the fish image, density, the perimeter of the fish image and the number of curves. The data set consists of 10 different fish spices, and 20 samples of each spice are considered in the experiment. One-Versus-One (OVO) yields a recognition rate of 81.67%, One-Versus-All (OVA) yields a recognition rate 86.67%, and unbalanced decision tree (UDT) shows a better recognition rate of 93.33% using the hybrid features. The test results show that the accuracy of using geometric features and texture features to classify and recognize fish spice images is better than that of the development system using geometric features or texture features.

Keywords: SVMs, HOG, UDT, Geometric features, Fish Species Classification

Abstract No: SP-03

Automatic fashion recommendation system

P. K. P. G. Panduwawala[*] and M. T. De Silva

Department of Statistic and Computer Science, University of Kelaniya, Sri Lanka
pkpgpanduwawala@gmail.com*

The fashion industry has a clear opportunity to act differently, pursuing profit and growth. The female fashion industry is one of the industries that quickly changes. By using social media, an idea about the changes and the new trends in the female fashion industry can be taken. The findings of this study contribute to a better understanding of the fashion industry by providing current trends in clothing types and colors. It allows the fashion industry's garments to guide the industry in times of need, resulting in a better trend for the industry. To provide a solution for the female fashion industry to gain an understanding of the trend of clothing types and colors in female fashion. The proposed platform has been implemented using techniques such as web scraping and *Convolutional Neural Networks (CNN)*. In the proposed solution, first, download the images from *INSTAGRAM* using *web scrapping*. After that, the female images were filtered by applying a CNN using the *Keras* library. Then cloth type and cloth color are predicted by two different CNN algorithms. The system presents the predicted result using *Graphical User Interface (GUI)*.Using that can give quick results of the changes in the female industry using this platform. According to the findings, the percentages of accuracy were recorded as 82.0% for female image filtering, 83.2% for clothing type in the fashion industry, and 80.2% for clothing color prediction respectively. The predictions were made in less than 0.5s, hence the proposed system is useful for providing instant changes to female fashion trends to the fashion industry with high accuracy. With the results of this study, It can be concluded that the developed model provides a reliable and accurate platform to gauge multiple gradients of current trends in the female fashion industry based on the Sri Lankan actresses' images on Instagram.

Keywords: Convolutional Neural Networks, Fashion MINIST, Female image classification, Web Scrapping

Abstract No: MP-01

Screening for microplastics in surface waters of Badulu Oya, Sri Lanka

S. A. S. Senarath[1], D. T. Udagedara[1*] and A. P. Abeygunawardena[2]

[1]Department of Applied Earth Sciences, Faculty of Applied Sciences, Uva Wellassa University,
[2]Department of Animal Science, Faculty of Animal Science and Export Agriculture,
Uva Wellassa University, Badulla, Sri Lanka
tharangau@yahoo.com*

Recent research reveals that microplastics (MPs) (< 5 mm in diameter) are a widespread contaminant in both freshwater and marine ecosystem. These MPs can adversely affect human health and sustenance of aquatic organisms by their flow through the aquatic food webs. Therefore, in order to protect the environment and biota from their detrimental impacts it is important to detect MPs in water and remove them in an economical manner. This study is focused on the occurrence, quantification, and spatial distribution of MPs in the surface waters of Badulu Oya, Sri Lanka. Badulu Oya is a tributary of river Mahaweli and originates from Namunukula hills which is in the central highlands and it caters immensely to water needs of humans, and therefore, securing its water quality is of great importance. The present study aims to quantify the presence of MPs in Badulu Oya and identifying their potential sources and sinks of in this river basin. Twelve sampling sites were selected and samples were collected using a surface water sampling net (Neuston type). The samples were subjected to wet sieving, wet peroxide oxidation, density separation and finally microscopic examination. The types of MPs present were further confirmed using Fourier- Transform Infrared (FTIR) spectroscopy. MPs were categorized according to density, size, shape and color. MPs were grouped into five classes based on their size and shapes, and 13 color categories. Surface waters of Badulu Oya, contains large numbers of MPs and most of the MPs were less than 1 mm in size. FTIR spectrum analysis revealed that plastic litter around the Badulu Oya is the major source of MPs. The highest MPs concentrations were found near the Badulla solid waste dumpsite. Presence of MPs on average 16.83 ± 4.24 items per m^3 therefore indicates a critical level of micro-plastic pollution in Badulu Oya.

Keywords: Microplastic, Surface water

Abstract No: MP-02

Application of cleaner production technique in small scale tea industry in Sri Lanka

A. G. D. Rasangi and D. M. Jayasena[*]

Wayamba University of Sri Lanka, Kuliyapitiya, Sri Lanka
duneeshyarasangi95@gmail.com*

This study explored the cleaner production techniques that can be used in the small and medium-scale tea sector in Sri Lanka. Sustainability of the sector has become a big question due to persisting climate change, socioeconomic changes, unstable financial positions, and the lack of knowledge of modern technology. This paper investigates the possibility of adopting Cleaner Production (CP) practices in the small and medium-sized tea industry from the land preparation stage to the manufacturing stage along with the tea supply chain. The paper reviewed the material and energy flow analysis of the Sri Lankan tea industry in order to identify CP opportunities and make recommendations to minimize negative environmental impacts. Data were collected from small-scale (less than 0.8 ha) tea farmers, transporters/drivers involved in tea leaf transportation, and small and medium scale (SME) factories in the southern Province of Sri Lanka. The sample consists of 100 farmers, 60 tea transporters and 5 SME factories. To gather data from farmers and transporters, questionnaires were used. Interviews also were conducted and observations were made to gather information from selected factories. The results show that the monthly average raw tea leaf yield per hectare was 1233 kg. Further, to produce 1 kg of black tea, generally, 4.5 kg of fresh tea leaves, less than 20 mins. of human energy, and 0.89 kWh of energy (electricity) is required. Besides, an average of 819.5 kg of chemical fertilizers is used per ha per year. Results indicate that opportunities are available to adopt five cleaner production options to reduce the environmental footprint of small-scale tea industry of Sri Lanka. They include growing tea with seeds instead of vegetatively propagated basket tea plants, using machines to pluck tea, automate movement of tea from withering to rolling section, improve knowledge of tea cultivators on more effective cultivation and caring techniques , ensure worker safety and opportunities to acquire better skills relevant to tea industry, introducing mechanisms to improve the link between raw leaf suppliers and the factory, introduce environmentally friendly inputs such as organic fertilizer and recycled organic waste and water and use of biodegradable material instead of polythene. These measures may contribute to optimize material energy and water usage by small and medium scale sector and therefore to environmental sustainability,

Keywords: Tea Industry, Cleaner Production, Environmental sustainability Supply chain, Small and Medium Scale (SME)

Abstract No: MP-03

Financial feasibility of waste paper recycling: A case from Sri Lanka

G. M. Indunil* and W. A. R. T. W. Bandara

Department of Zoology and Environmental Management, University of Kelaniya, Sri Lanka
mihirigunasekara5@gmail.com*

Sri Lanka has been facing many social, environmental, and economic challenges due to wastage of resources including papers. Recycling waste papers can be identified as a profitable venture in addressing waste paper to ensure resource recovery. The largest state-owned printing entity in Sri Lanka produces 600 tons of paper waste per annum and the majority is disposed as waste. The objective of this study is to assess the financial feasibility of installing a paper recycling plant in which the process involves waste paper shredding and pulping, screening, deinking, bleaching and rolling. To assess the financial feasibility of plant installation, a cost-benefit analysis was carried out considering the currency conversion rate of 1US$ = 200 LKR. Cost-Benefit Ratio (CBR), Net Present Value (NPV), and Internal Rate of Return (IRR) were calculated. This study assumed; recycled waste papers are used to make file covers only with the market price of one file cover is 3.95 LKR, price of the file covers as well as the cost of electricity, water, maintenance, and labor are constant throughout the year, proposed paper recycling process operates 16 hrs. per day/20 days per month, machines operate in two shifts with 4 skilled professionals and 6 unskilled laborers in each shift, production of the 1st year of the project is 50% from its full production potential, and the whole recycling process operates manually. The estimated minimum land extent to install the paper recycling plant is 10 perches from the printing premises. Related data were collected from a world-recognized paper recycling machine manufacturer and by interviewing four professionals in the paper recycling industry. CBR of the proposed paper recycling plant at the existing printing entity is 1.09, NPV is 11,230,770.65 LKR at the 10% discount rate, and the IRR value is 32%. Calculated CBR, NPV, and IRR values justified the financial feasibility of the proposed paper recycling plant in the State Printer's premises. As paper recycling consumes a considerable amount of water, installing a recycling water plant, proper management of work schedules, and diversifying recycled paper products can help to further reduce the project costs.

Keywords: Cost Benefit analysis, Paper Recycling Plant, Waste paper

Abstract No: MP-04

Selection, usage, and disposal of personal care and cosmetic products in Sri Lanka; an environmental and health concern

S. G. Gamage[*] and M. G. Y. L. Mahagamage

Centre for Environmental Studies & Sustainable Development, The Open University of Sri Lanka, Nawala, Nugegoda, Sri Lanka
sachith08@yahoo.com*

Personal care and cosmetic products have become an essential aspect of the lifestyle as individual awareness of health, hygiene, and appearance have enhanced considerably. As a result, personal care products and cosmetics are among the most utilized products in the present world. Due to high demand and cost-effectiveness, developers have adapted new manufacturing processes, chemicals, and novel ingredients, including heavy metals and microplastics. Further, the disposal of empty plastic packages has also created an alarming environmental concern. However, consumer knowledge and attitudes towards these products and their disposal play an important role in preventing and managing negative impacts arising from it. Therefore, the present study was conducted to understand the attitudes and knowledge of consumers on personal care and cosmetic product in Sri Lanka. To collect the necessary information, product observation and an online survey for three hundred respondents (300) were carried out from January to June 2021. The majority of the respondents were female (58%), and 71% represented the 18-65 age group. Results revealed that toothpaste (99.6%), face wash (63%), and skin creams (62%) were the most used products among the participants, while 63% used cosmetic products for their day-to-day life. However, 29% of the participants experienced adverse effects (skin rashes, pimples, allergies) when using personal care products and cosmetics. It was noted that most of the respondents (94%) remove applied products from their bodies by washing and 69% disposed of their wastewater into a wastewater gully, where 31% released wastewater into the municipal wastewater system or natural water bodies. Results revealed that discarding into municipal garbage trucks (42%), burning (31%), and open dumping (23%) are the most popular options for the disposal of empty packages. Interestingly, many participants were educated on heavy metals (91%) and their effects (88%), where only 42% knew about microbeads/microplastics. The present study revealed gaps in consumer knowledge, waste disposal, wastewater removal processes, and the suitability and health effects of cosmetics and personal care products. Therefore, relevant authorities, product developers, and consumers should work together to control and minimize the environmental pollution and possible health effects arising from using and disposing of these products. Further, it is suggested to educate consumers, enforce extended producer responsibility policies, improve waste management /recycling facilities, encourage sustainable packaging, and revise/enforce existing legal regulations.

Keywords: Cosmetics, Heavy metals, Microbeads, Personal care products, Waste disposal

Abstract No: MP-05

Development of a liquid fertilizer system from bio-slurry waste and natural resources: A case study on early growth of chili (*Capsicum annum* L.)

B. D. P. S. Ranaweera[1,2], W. A. L. S. Karunawardana[2], D. T. Abeysinghe[3] and W. A. P. J. Premaratne[1]*

[1]Department of Chemistry, University of Kelaniya, Kelaniya, Sri Lanka
[2]National Engineering Research and Development Centre of Sri Lanka, Ekala, Ja-Ela
[3]Department of Chemistry, The Open University of Sri Lanka, Nawala, Nugegoda
jeewa@kln.ac.lk*

Hydroponics or soil-less culture is a technology for growing plants in nutrient solutions that supply elements needed for optimum plant growth with or without use of an inert medium to provide mechanical support. Hydroponics offer opportunities to provide optimal conditions for plant growth and therefore, higher yields can be obtained as compared to open field agriculture. Here we aim to develop a liquid fertilizer system using a bio-slurry waste obtained from biogas reactor, selected animal waste, wood ash and dolomite. Five liquid biofertilizer systems (M_1, M_2, M_3, M_4 and M_5) were developed by mixing different ratios of bio-slurry waste obtained from biogas reactor, cow dung, poultry waste, wood ash and dolomite. A control experiment was carried out with Albert solution, a commercial chemical liquid fertilizer. The liquid fertilizer systems were tested using 12 Chili (*Capsicum annum* L.) plants in each treatment and treated with a continuous hydroponic cultivation system for 12 weeks in triplicate. The pH in hydroponic systems varied from 6 to 8. At the end of the 12 weeks' plant growth was monitored by measuring the height of the plant. Chili plants grown in fertilizer mixture M_4 (bio slurry waste: 36.0 L, cow dung: 600.0 g, poultry waste: 600.0 g, wood ash: 75.0 g, dolomite: 75.0 g) gave the highest growth rate (50.3 ± 3.0 cm) and the highest harvest (28.8 ± 1.2 g) among the five developed biofertilizer systems. This M_4 fertilizer system has the highest N (49.0 ± 0.2 ppm), P (9.9 ± 0.1 ppm) and K (434.2 ± 0.8 ppm) content. Fertilizer system M_1 which has only bio-slurry waste showed the lowest growth rate (37.4 ± 1.6 cm) and the lowest harvest (16.1 ± 0.6 g). M1 has the lowest nutrients content (N: 28.3 ± 0.1 ppm, K: 349.0 ± 0.7 ppm, P: 4.5 ± 0.1 ppm) among the five liquid fertilizers. The control, Albert solution which has N (10.6%), K (16.3%) and P (9.3%) showed a growth rate of 46.0 ± 5.4 cm and a harvest of 30.1 ± 1.6 g. Therefore, it can be concluded that added natural ingredients improve the effectiveness and quality of the liquid fertilizer with high content of nutrients. Therefore, M_4 liquid fertilizer system has the potential to be developed as an economical, effective, eco-friendly fertilizer system for the hydroponic cultivation of chili plants compared to commercial chemical liquid fertilizers.

Keywords: liquid biofertilizer, natural resources, bio slurry, dolomite, hydroponic culture system

Abstract No: MP-06

Influence of domestic cooking on the levels of bioactive compounds and antioxidant activity in green leafy vegetables

H. G. N. Dewangani and B. M. Jayawardena[*]

Department of Chemistry, University of Kelaniya, Sri Lanka
bimali@kln.ac.lk*

Green leafy vegetables (GLVs) are a rich source of natural antioxidants and polyphenols. These phytochemicals play an important role in the daily diet in Sri Lanka. Most GLVs are cooked prior to consumption to make GLVs more palatable and digestible. However, cooking alters the physical and chemical properties of GLVs and it may affect the levels of nutrients and bioactive compounds. In traditional meal preparations locals add scraped coconut and spices in the preparation of GLVs. Here, the effects of boiling and cooking of Asiatic pennywort (*Centella asiatica*), Manioc leaves (*Manihot esculenta*), Amaranthus (*Alternanthera sessilis*), and Sesbenia (*Sesbania grandiflora*) were explored by measuring antioxidant activity (AO) and total phenolic content (TPC) of raw, boiled (6 min) and cooked (80 ± 10°C for 8 min) GLVs according to the Sri Lankan domestic cooking style. Total phenolic content (TPC) and antioxidant (AO) activity of GLVs were evaluated using the Folin–Ciocalteu method and diphenyl-1-picryl-hydrazyl (DPPH) radical scavenging assay respectively. The results revealed that raw *Manihot esculenta* had the highest AO activity (0.076 ± 0.001 mg/mL) and TPC content (61.14 ± 0.04 mg GAE/g) among all the GLVs analyzed (p< 0.001), but shows a significant reduction (p<0.001) with boiling (AO: 0.149 ± 0.001 mg/mL, TPC: 25.04 ± 0.03 mg GAE/g) and cooking treatment (AO: 0.267 ± 0.001 mg/mL, TPC: 31.95 ± 0.04 mg GAE/g). The radical scavenging activities of both raw and boiled GLVs were in the order of *Manihot esculenta* > *Alternanthera sessilis* > *Centella asiatica* > *Sesbania grandiflora*. Boiling and cooking treatments significantly reduced the TPC and AO content (p< 0.001). This study revealed that a 6 min boiling treatment significantly decreased (p < 0.001) the TPC of all GLVs studied. The AO activity of amaranthus and *Centella* was significantly improved by boiling, whereas it decreased for manioc and sesbania samples (P < 0.001). However, boiling caused a greater loss of AO and TPC than did cooking with scrapped coconut. The present findings suggest that the Sri Lankan style of cooking with scrapped coconut may be a better cooking method of choice to improve the health-promoting properties of GLVs by conserving the bioavailability of antioxidants and dietary polyphenols of the four leafy vegetables investigated in this study.

Keywords: Antioxidant activity, Green leafy vegetables, total phenolic content, DPPH, radical scavenging capacity

Abstract No: MP-07

Predicting the tensile properties of low carbon reinforced Sri Lankan TMT steel bars within the manufacturing stages

K. G. Alahapperuma[1*] and N. Nandhakumar[2]

[1]University of Vocational Technology, Sri Lanka
[2]Ashok Steel Private Limited Company, Sri Lanka
gayanthi111@yahoo.com*

Steel is the most widely used category of engineering metals, mainly due to its favourable mechanical and processing properties as well as the reasonably low cost. Steel properties should be maintained within acceptable ranges within manufacturing stages also, as per the specified standards. In Sri Lanka, for steel concrete reinforcing bars, chemical composition, physical parameters and mechanical properties should be complied with according to Sri Lanka Standard, 375: 2009. Usually, the chemical composition of steel is tested during melt stages, and mechanical properties are tested for finished products. Tested mechanical properties essentially include tensile properties, while tested physical parameters include mass per unit length. Though all, chemical composition and specified properties need to be tested to comply with product requirements, there are instances in steel manufacturing processes where approximate values of mechanical properties are sufficient, when quick analyses are involved during in-process inspections. Data science techniques can be used to determine the mechanical properties of steel, enabling steel manufacturers to save valuable quality assurance time and manpower spent on experiments. Therefore, the objective of this study is to predict tensile properties of yield strength (YS), ultimate tensile strength (UTS), elongation at maximum force (EMF) and elongation at fracture point (EF) with the use of chemical composition and physical parameters, as input variables. Forty mechanical test reports based on SLS 375: 2009 standards were collected from a steel manufacturing organisation, for 12 mm nominal diameter, thermo-mechanically treated (TMT) concrete reinforcing bars. Each test report is of 15 samples from the respective batch as per the standard requirement and consists of corresponding chemical composition and physical parameters also. Multiple regression analysis was applied, using Minitab software for each batch separately, to predict YS, UTS, EMF and EF, and mass per unit length and percentages of carbon and manganese were the input variables. According to the results, linear relationships were derived, and YS, EMF and EF show positive correlations with C percentage; UTS shows negative correlations with all the variables. It is noted the P–value of each variable is greater than 0.05, implying that association in each case is not statistically significant, and this might have occurred due to the encountered limitations such as the quantity of the test reports used, calculation of chemical composition for each batch instead for each sample, not focusing on non-linear relationships, assumption of all process parameters to remain unchanged for all batches of the products, considering only major chemical elements of the composition during the study etc. Apart, instead of considering Mn content as an independent variable, carbon equivalent value would have been considered. However, since approximate values are sufficient, each of the derived linear relationships can be used to determine each tensile property during in-process quick analysis. Further improvements and modelling can be used to obtain more accurate relationships, and this research was an initiation of the approach to reduce the time consumption during the in-process inspection.

Keywords: Chemical composition, Low carbon reinforcing steel bars, Mass per unit length, Multiple linear regression analysis, Tensile properties

Abstract No: MP-08

Plastic waste management strategies in Sri Lanka: Kandy and Colombo municipalities

K. R Gunasekera[*], D. P. M. H. S Dissanayake, G. A. H. T Dilrukshi, J. A. Dissanayake, L. G. S. Sandanisha and V. P. A. Weerasinghe

Department of Zoology and Environmental Management, University of Kelaniya, Sri Lanka
kithmee09@gmail.com*

Plastic waste is a growing issue in Sri Lanka and has much room for improved management strategies. To implement proper plastic waste management, it is important to identify the plastic content present in a waste sample, the composition of plastic waste types and people's perspectives on this. This study was aimed to analyze plastic waste composition at household level and municipal level as well as to select suitable plastic waste sorting techniques for different plastic waste management strategies. Data were collected from the Kandy (KMC) and Colombo (CMC) municipalities to analyze people's perspectives on plastic disposal practices and to investigate the different plastic types (Polyethylene Terephthalate (PET), High Density Polyethylene (HDPE), Polyvinyl Chloride (PVC), Low Density Polyethylene (LDPE), Polypropylene (PP), Polystyrene (PS) and other) included in a plastic waste sample. Based on the responses of the selected households, KMC waste collection service was more satisfactory in comparison to the CMC. The most abundantly used plastic types in household level were LDPE, PET and PS while the plastic types in a plastic waste sample analyzed at the waste collection sites of the municipalities showed similar abundance. A SWOT analysis was conducted on a selected set of plastic waste sorting techniques; manual sorting, density separation, air classification, electrostatic separation and sensor-based sorting. A questionnaire survey based on increased number of households in KMC and CMC is necessary to get the people's perspective precisely. Plastic waste composition at the household as well as municipal level should be investigated weekly or monthly to get the temporal variation of plastic waste generation.

Keywords: Plastic waste, Composition, Disposal, Management, Sorting techniques

Abstract No: MP-09

Effect of hydroxyapatite nanoparticles on liver enzymes

T. P. Gamagedara[*], and A. N. Dunuweera

Department of Basic Sciences, Faculty of Allied Health Sciences, University of Peradeniya, Peradeniya,
Sri Lanka
piumnilg@ahs.pdn.ac.lk*

Global demand for bone grafts is always very high. Nano-scaled hydroxyapatite (HA) has displayed unique functions in bone grafting than microscale HA. Nanoparticles (NPs) will interact with proteins present in biological fluids. For the assessment of biological responses to NPs, protein adsorption onto NPs in the biological medium can be considered as an important factor. HA NPs can be distributed in the body with blood circulation and mainly accumulated in the lungs, liver, and spleen. Enzyme compatibility of HANPs was evaluated using the liver enzymes such as alanine aminotransferase (ALT), aspartate aminotransferase (AST), and alkaline phosphatase (ALP). The enzyme extractions were mixed with the laboratory synthesized HANPs in 7 different weights (0, 0.005 g, 0.010 g, 0.020 g, 0.030 g, 0.004 g, and 0.050 g) separately. The activities of ALT, AST and ALP were measured according to the guidelines provided along with the kit, BIOLABO with using a goat liver as a model for a human liver sample. Data were analyzed using SPSS (Version 23 for Windows). A two-sample t-test was carried out for the determination of significant differences ($p \leq 0.05$) between the means. Since no statistically significant difference ($p < 0.05$) was observed between the mean activity of enzymes AST, ALT, and ALP with and without HANP (control), it is concluded that HANP does not affect the activity of all three enzymes significantly. Increasing amouts (g) of HANP however, resulted an increase in the activity of the liver enzymes.

Key words: Hydroxyapatite nanoparticles, Biological responses, Liver function, Enzyme activity

Abstract No: MP-10

Role of graphene oxide in urease-immobilized biosensor for heavy metals: molecular interaction analysis

S. Suthaharan[*], A. Santhiran and E. Yogenthiran

Department of Chemistry, University of Jaffna, Sri Lanka.
ssivanujan@univ.ac.lk*

The accumulation of toxic heavy metals like Cu^{2+}, Cd^{2+} and Pb^{2+} is a major health risk in ensuring quality and safe access to drinking water. Due to high toxicity caused by these metal ions there is a conspicuous requirement to quantify them swiftly on site at trace levels. Biosensing mechanisms are proven for potential heavy metal toxicological monitoring in recent years. Graphene-based materials become potential source for such sensing tools. Present blind docking-based investigation reports the candidacy of graphene oxide (GO) for heavy metal biosensing applications. Urease-urea enzyme-mediated biosensor model has been contemporarily investigated to quantify heavy metal contamination levels in pollution monitoring sectors. It is aimed to elucidate binding energies and molecular interactions between GO with urease enzyme and urea with GO to explore the potential of the GO, whether as an enzyme immobilizer or as an active sensing material using blind docking tools and method. Docking results revealed that GO plays a significant role in urease-assisted system. The strongest binding affinity of the stable conformation of urease-GO interaction is -12.4 kcal/mol and primarily dominated by electrostatic interactions. In addition, hydrogen bonding and hydrophobic interactions were also elucidated. Selective amino acids of the chain C of the protein Urease dominate the protein-ligand interactions. The most stable mode showed no root mean square deviation (RMSD) while the least stable one showed higher RMSD values A prospect of direct sensing mode of urea by GO was also studied where urea-GO interaction is solely dominated by conventional hydrogen bonds with a much lower binding affinity of -3.6 kcal/mol at the most stable pose. The relatively small difference between the strongest and the weakest binding affinity values of urea-GO complex indicate that urea binding can take place at possible GO sites with relatively same strength. Overall present in silico studies of GO interactions in the urease-urea heavy metal biosensing system portrait the fitness of GO as a potential biosensor material.

Keywords: Graphene oxide, Heavy metal detection, Urease, Molecular docking, Biosensor

Abstract No: MP-11

Assessing knowledge, attitude and practices towards household e-waste management: A case study of householders in Gampaha district, Sri Lanka

A. S. T. Athukorala* and P. A. A. U. Jothirathne

Department of Industrial Management, Faculty of Applied Sciences, Wayamba University, Kuliyapitiya, Sri Lanka
sahanithanuja@gmail.com*

This study aimed to assess the knowledge, attitude and practices of householders towards e-waste management in Gampaha District. Due to the current economic status and high rate of urbanization, Gampaha District was selected to study and it was based on a quantitative approach. Primary data were collected through pre-tested a structured questionnaire. Then, 400 questionnaires were distributed among households and the response rate was 85%. Mobile phones, desktop computers, laptops, cameras, and other electronic appliances were the types of e-waste considered in this study. The analysis demonstrated that 71.1% of respondents were aware of e-waste although 51.3% did not receive proper education on e-waste. 93.2% of the participants were not aware of government rules and regulations on e-waste and 81.4% did not know the e-waste collection centers in their area. 96.2% of householders tend to change their electronic devices and move into new devices due to damages. 22% of householders store their waste electronic and electrical equipment at home and the rest of the people dispose of them by exchanging them for new devices (15%), dumping (10%), sell to recyclers (17%), donate (5%), sell to individuals (16%), discard with household waste (7%) and burning (8%). Furthermore, the knowledge score of the participants was calculated using the eight questions about knowledge, the score of zero was given for incorrect answers and one was given for correct answers. Hence, the maximum Knowledge score was eight. A score less than 3 was considered poor, 3-5 moderate and above 6 was good. Results revealed that 48.38% of the respondents have good knowledge about e-waste. "The continuous increase in e-waste is a problem for Sri Lanka", "Everyone is responsible for the e-waste at their home", "I refrain from buying new device as long as they can use the old one", "They need to be aware of the materials in the electronics they use", "I would like to provide e-waste to the equipment manufacturer free of charge for eco-friendly recycling" and "If the cost of recycling is included in the cost of production, I would like to pay more for the equipment" were the six questions used to evaluate the attitude of the householders towards e-waste management and those were considered as indicators to assess attitude. The attitude score was assessed by applying a four-level Likert scale (strongly disagree-disagree-agree-strongly agree) such that the minimum score was 4 and the maximum score was 24. The average of an individual's total score is considered for the categorization of the attitude level. It disclosed the necessity to change the attitudes of the household members over the e-waste management activities. Hence, the findings provide valuable insights for the government and for the responsible authorities on the requirement of installing effective steps to promote knowledge and attitude level of the citizen about the household e-waste management activities and socio-demographic based promotional and training activities will be more productive. Furthermore, results indicate that respondents dispose their e-waste using unsustainable practices and hence cause damages to the environment.

Keywords: Attitude, E-waste management, Householders, Knowledge, Practices

Conference Paper No: BF-01

Effect of edible sugar on *in vitro* growth and organogenesis of *Dendrobium bigibbum* x *Dendrobium* Thailand Black

V. L. P. Amarasinghe, P. D. D. M. Panapitiya*, N. D. C. S. Leelarathne, A I.S. Priyadharshan and R. A. S. P. Senanayake

Floriculture Research Center, University of Kelaniya, Sri Lanka
deshikapanapitiya@gmail.com*

Abstract

The most popular propagation method of *Dendrobium* is *in vitro* micropropagation. However, using laboratory-grade sucrose as the carbon source in micropropagation is expensive for small-scale producers. Present study is aimed to assess the performance of edible sugar as an alternative carbon source to develop an effective, low-cost medium. Protocorm like bodies (PLBs) and plantlets of *Dendrobium* hybrid (*Dendrobium bigibbum* x *Dendrobium* Thailand Black) were cultured on basal MS medium containing different concentrations of sugar; 0.0, 15.0, 30.0, 45.0, 60.0, 75.0 and 90.0 g/L, (T_1-T_7). A modified MS medium (T_8) containing sugar (30.0 g/L), BAP (2.5 mg/L) and NAA (0.5 mg/L) was also used to determine whether there is a comparable effect of sugar individually and when combined with plant growth regulators (PGRs). Growth performance was evaluated in regular intervals. MS medium containing sugar (45.0 g/L) was identified as the best medium for the growth and organogenesis of PLBs resulting in the highest weight accumulation of 20.31 g and 35 plantlets regeneration from 1.00 g of PLBs after two months of incubation. MS medium supplemented with 60.0 g/L of sugar was identified as the most successful medium for the plantlet growth with 17 of mean leaf generation, 33 of mean root generation and an average root length increment of 1.5 cm after four months of incubation. In conclusion, edible sugar can be recommended to use as a sucrose supplement for a cost-effective medium to promote successful *in vitro* growth and development of the *Dendrobium* hybrid even with the absence of PGRs.

Keywords: Dendrobium, Edible sugar, *In vitro*, Organogenesis, Plant growth regulators

Introduction

Orchids have a high floricultural and economic value in the global floriculture industry. It is mostly because of their long-lasting shelf life, attractive diverse floral morphology (cut flower and pot plant) and herbal value. Among thousands of orchids, *Dendrobium* is the most popular floriculture product in the global market with high consumer demand (Khuraijam et al., 2017). Naturally, Dendrobiums are propagated sexually through seeds and asexually through vegetative propagation techniques as division, back bulbs and offshoots. However, it is essential to develop a suitable method for quick regeneration to address the demand in the market. *In vitro* plant regeneration offers a feasible propagation method for orchids and can be utilized for the year-round and rapid propagation of orchids. Therefore, growers use tissue culture as a rapid micro propagation technique to overcome this challenge in the mass production of selected high-quality traits (Young et al., 2011).

Among different types of culture media used in *in vitro* propagations, Murashige and Skoog (MS) medium, developed in 1962 (Murashige and Skoog, 1962) is one of the most efficient medium used in *Dendrobium* production with better performance (Teixeira et al., 2015). The appropriate nutrient composition in the medium is the most critical factor in plant tissue culture, while the carbon source is one of the major components required for high energy demanding developmental processes like embryogenesis and organogenesis (Yaseen et al., 2012). Several studies have been done to evaluate the performance of different carbohydrate types that are used to fulfill the carbon requirement of plants in tissue culture. Nambiar and Maziah (2012) reported that glucose, fructose and sucrose produced a higher fresh weight of protocorm like bodies (PLBs) of *Dendrobium* Alya Pink variety among six types of sugar tested (galactose, mannitol, sorbitol, glucose, sucrose and fructose). Further, Zahara et al. (2017) has reported that sucrose is mostly used as the carbon source instead of glucose, fructose or dextrose as alternatives. In most studies, a sucrose concentration of 20-30 g/L is used as the standard concentration of carbon source for the successful growth of plantlets *in vitro* (Ferreira et al., 2010). However, several studies have reported that concentrations of sucrose in *in vitro* media affect differently on growth parameters. While, some studies have reported that production of PLBs is inhibited by higher concentrations of sucrose (Udomdee et al., 2013). Further, in most modified tissue culture media, plant growth regulators are used to achieve unique performances throughout the production. Concentrations of naphthalene acetic acid (NAA) and 6-benzyl amino purine (BAP) individually and as a combination has shown varied effects on different stages of tissue culture (Maharjan et al., 2020).

Therefore, the present research aimed to study the effect of edible sugar as the sucrose component in MS medium on growth performance, effective growth and organogenesis of Dendrobiums. Further, it was aimed to find whether there is a comparable effect of sugar individually and in combination with plant growth regulators on the growth and development of Dendrobiums.

Methodology

Plant material

Seeds of a *Dendrobium* hybrid (*Dendrobium bigibbum* x *Dendrobium* Thailand Black) were grown on basal MS medium for 06 months under *in vitro* conditions. The regenerated PLBs were separated and used for the experiment to evaluate the effect of sugar on organogenesis. Regenerated plantlets were transferred to basal MS medium supplemented with NAA (0.5 mg/L) and BAP (2.5 mg/L) and maintained for 03 months under 20 mol/m^2/sec 14 h photoperiod at 26±4 °C. Plantlets with 2-3 cm height containing 2-3 nodes were used to evaluate the effect of sugar on the growth and development of plantlets.

Culture media preparation

Basal MS medium (T_1 – T_7) supplemented with different concentrations of edible sugar (0.0, 15.0, 30.0, 45.0, 60.0, 75.0, 90.0 g/L) and a modified MS medium (T_8) containing sugar (30.0 g/L), BAP (2.5 mg/L) and NAA (0.5 mg/L) were used as eight different treatments. The MS medium (T_1) without sugar (0.0 g/L) was used as the control. The pH of the media was adjusted to 5.8.

Evaluation of the growth of PLBs

Six months old PLBs (1.00 g per replicate) were cultured in the replicates of all the eight treatments (T_1 – T_8). The cultures were maintained under 20 mol/m^2/sec 14 h photoperiod at 26±4 °C. After one month of culturing, growth parameters were observed and recorded as, fresh weight of PLBs and the number of plantlets per PLB that have been regenerated. Cultures were maintained for two months and growth parameters were evaluated as fresh weight of PLBs, number of plantlets per replicate PLB, number of leaves per plantlet and number of roots per plantlet. Sub culturing was carried out at every 04 weeks interval.

Evaluation of plantlet growth

In each treatments (T_1 – T_8), 15 plantlets having 2-3 nodes and 2-3 cm height were cultured in five culture bottles (three plantlets per bottle). The cultures were maintained under 20 mol/m^2/sec 14 h photoperiod at 26±4 °C. After one month and four months period of culturing, growth parameters; plantlet height, number of leaves, number of roots, leaf diameter and root length were recorded. Sub culturing was carried out at every 04 weeks interval.

Statistical analysis

Completely Randomized Design (CRD) method was used and five replicates per treatment were used for both PLBs and plantlets. The results were analyzed using one-way ANOVA and Turkey's mean comparison test using the Minitab (19.0) statistical software.

Results and Discussion

After one month of incubation in MS media supplemented with different concentrations of edible sugar as the sucrose supplement, the highest increment of fresh weight of PLBs was observed in four different treatments which were T_3, T_4, T_5 and T_8. But after two months of incubation, the highest weight accumulation of 20.31 g from 1.00 g of PLBs was observed in MS medium supplemented with 45.0 g/L of sugar followed by the treatment T_8 which contained sugar 30.0 g/L, BAP (2.5 mg/L) and NAA (0.5 mg/L) (Table 1).

Table 1. *Effect of different concentrations of edible sugar on the growth and organogenesis of PLBs of the Dendrobium hybrid.*

Treatment	Sugar Concentration (g/L)	After 30 days		After 60 days			
		Fresh Weight (g)	No. of plantlets	Fresh Weight (g)	No. of plantlets	Mean no. of leaves per plantlet	Mean no. of roots per plantlet
T_1	0.0	1.40 b	1.2 ab	1.30 c	0.2 b	0.2 c	0.0 a
T_2	15.0	3.80 ab	8.6 ab	12.41 b	16.2 ab	2.8 a	0.0 a
T_3	30.0	5.60 a	11.2 a	17.10 ab	25.6 ab	4.0 a	2.6 a
T_4	45.0	5.40 a	11.2 a	20.31 a	35.2 a	2.8 a	5.6 a
T_5	60.0	4.00 a	10.8 a	13.55 ab	36.2 a	2.2 ab	5.2 a
T_6	75.0	1.40 b	1.2 ab	3.11 c	3.8 b	0.8 bc	0.0 a
T_7	90.0	1.40 b	0.2 b	1.46 c	0.0 b	0.0 c	0.0 a
T_8	30.0+PGR	5.00 a	11.0 a	19.04 ab	33.0 a	2.6 ab	0.0 a

PGR – Plant Growth Regulators - BAP (2.5 mg/L) & NAA (0.5 mg/L)
Values within the same column followed by the same letter are not significantly different as determined by Tukey's mean comparison test ($p \leq 0.05$).

According to Rafique et al. (2020), 5% (50.0 g/L) sucrose level was found to be the best in all the cases followed by 3% (30.0 g/L) and 7% (70.0 g/L) after 60 days of incubation for *Dendrobium sabin* H. variety. Same study reported that zero growth of fresh weight after 20, 40 and 60 days of incubation were observed in MS medium containing sucrose at the levels of 0.0 g/L and 130.0 g/L. In the current study, almost no growth of PLBs was observed in MS medium containing sugar at the concentrations of 0.0, 75.0 and 90.0 g/L after one and two months of incubation. With the absence of sucrose in the culture media, there was no carbon source to support the growth of calluses during the photosynthesis and it would result in a lack of adaptability to be autotrophic. Meanwhile, high sucrose concentrations could also have created a hypertonic environment in culture media, adversely affecting the availability of other required nutrients for the growth of calluses (Rafique et al., 2020 and Zahara et al., 2017).

When considering the organogenesis from PLBs of the *Dendrobium* hybrid, the highest number of plantlets (11.0) was observed in treatments T_3 (sugar, 30.0 g/L), T_4 (sugar, 45.0 g/L), T_5 (sugar, 60.0 g/L) and T_8 (sugar, 30.0 g/L + plant growth regulators) after 30 days of incubation while after 60 days of incubation, that ranking could be observed in the treatments T_4, T_5 and T_8. Meanwhile, no rooting was observed in any treatment after 30 days of incubation. After 60 days of incubation the best rooting was observed in the treatment T_4 supplemented with 45.0 g/L of sugar and it was not significantly different from the values of treatments T_3 and T_5. The highest average number of leaves per plantlet was observed in MS medium supplemented with 30.0 g/L sugar (treatment T_3) and that was not significantly different from the observation of treatments T_2 (sugar, 15.0 g/L) and T_4 (sugar, 45.0 g/L) (Figure 1). All the above results showed that treatment T_4 (45.0 g/L) has shown the best observations in all the tested parameters including fresh weight accumulation of PLBs, regeneration of plantlets, leaf formation and root formation resulting in the best overall organ development from PLBs after two months of incubation in *in vitro* conditions. Similar observations concerning the number of plantlets were reported by Rafique et al. (2020) with the highest number of plantlets in MS media containing 5% (50 g/L) sugar followed by 0%, 1.5%, 3%, 7%, 9%, 11% and 13%. However, in contrast to that, there was no effect of sucrose concentration on root formation of *Dendrobium* during *in vitro* propagation according to Faria et al. (2004).

Talukder et al. (2003) have reported that the best shoot proliferation, root formation, leaf formation and increment of shoot length and the least time requirement for regeneration were obtained from MS medium supplemented with a combination of BAP (2.5 mg/L) and NAA (0.5 mg/L) for orchids. Therefore, in this study, the above combination of plant growth regulators was used to compare the effect of growth hormones and the optimized sugar level on the organogenesis of PLBs of the *Dendrobium* hybrid. After 60 days of incubation, T_8 resulted in successful organogenesis similar to treatment T_4 only in the fresh weight accumulation, shoot generation and leaf formation but T_8 did not induce the root formation as the T_4 (sugar, 45.0 g/L). It can be due to the inhibition effect of auxins on root formation. The results showed that an optimized amount of edible sugar (45.0 g/L) would induce/motivate more organogenesis including both shooting and rooting in PLBs of the selected *Dendrobium* hybrid when compared to the plant growth regulators.
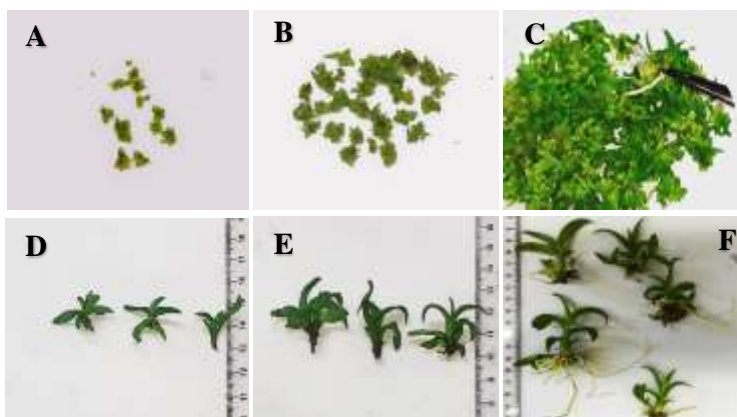
Figure 1. *In vitro growth and organogenesis of Dendrobium hybrid. PLBs grown in MS medium containing 45.0 g/L sugar; A) at initial stage, B) after one month of incubation and C) after two months of incubation. Plantlets grown in MS medium containing 60.0 g/L sugar; D) at initial stage, E) after one month of incubation and F) after four months of incubation (1 unit of scale = 1.0 cm).*

Referring to the effect of edible sugar on *in vitro* plantlet growth of the *Dendrobium* hybrid, no significant difference in any measured parameter relevant to the development of shoots and leaves was observed between treatments after one month of incubation (Table 2).

Table 2. *Effect of different concentrations of edible sugar on the growth and development of plantlets of the Dendrobium hybrid.*

Treatment	Sugar concentration (g/L)	After One Month					After Four Months				
		Mean difference of plantlet height (cm)	Mean difference of number of leaves per plantlet	Mean difference of number of roots per plantlet	Mean difference of leaf diameter (cm)	Mean difference of root length (cm)	Mean difference of plantlet height (cm)	Mean difference of number of leaves per plantlet	Mean difference of number of roots per plantlet	Mean difference of leaf diameter (cm)	Mean difference of root length (cm)
T_1	0.0	-0.5 [a]	-5.4 [b]	-0.9 [b]	-0.1 [a]	-0.1 [a]	-1.5 [c]	-7.6 [b]	-3.1 [c]	-0.5 [c]	-0.6 [b]
T_2	15.0	0.1 [a]	1.7 [a]	0.6 [ab]	0.0 [a]	0.0 [a]	0.0 [bc]	3.9 [ab]	3.3 [bc]	0.0 [bc]	0.2 [ab]
T_3	30.0	0.2 [a]	2.6 [a]	2.2 [ab]	0.1 [a]	0.0 [a]	1.1 [a]	9.7 [a]	17.2 [abc]	0.4 [a]	1.1 [ab]
T_4	45.0	0.3 [a]	3.6 [a]	3.4 [a]	0.0 [a]	0.3 [a]	0.8 [ab]	10.1 [a]	17.1 [abc]	0.3 [ab]	1.5 [a]
T_5	60.0	0.0 [a]	1.1 [a]	0.9 [ab]	0.1 [a]	0.0 [a]	0.6 [ab]	16.7 [a]	32.5 [a]	0.4 [a]	1.5 [a]
T_6	75.0	0.0 [a]	1.3 [a]	2.0 [ab]	0.0 [a]	0.0 [a]	0.2 [ab]	3.0 [ab]	19.2 [abc]	0.2 [ab]	1.5 [a]
T_7	90.0	0.1 [a]	0.8 [a]	1.4 [ab]	0.1 [a]	0.2 [a]	0.6 [ab]	7.1 [ab]	26.9 [ab]	0.2 [ab]	1.4 [a]
T_8	30.0 +PGR	0.1 [a]	4.1 [a]	0.6 [ab]	0.1 [a]	0.1 [a]	0.8 [ab]	14.6 [a]	2.8 [bc]	0.6 [a]	0.3 [ab]

PGR – Plant Growth Regulators - BAP (2.5 mg/L) & NAA (0.5 mg/L)
Values followed by the same letter are not significantly different as determined by Tukey's mean comparison test ($p \le 0.05$).

However, after four months of incubation, significant differences in all the parameters were observed when all the treatments were compared. Among them, the significantly highest increment of shoot length (1.1 cm) was observed in treatment T_3. However, the other two parameters relevant to the development of shoots; leaf formation and the increment of leaf diameter, have shared the significantly highest values with different treatments. The best leaf formation was observed in treatments T_3 (9.7/plantlet), T_4 (10.1/plantlet), T_5 (16.7/plantlet) and T_8 (14.6/plantlet) while the best growth of leaf blades could be observed in treatments T_3 (0.4 cm), T_5 (0.4 cm) and T_8 (0.6 cm). When considering the leaf formation and the increment of leaf diameter together, treatments T_3, T_5 and T_8 had a similar effect. Therefore, the best treatment for the development of shoots and leaves of the *Dendrobium* hybrid could not be determined. Also, the difference between the effect of sugar and plant growth regulators on the development of shoots and leaves could not be identified. However, according to Talukder et al. (2003), the best shoot proliferation (1.90/explant), leaf formation (4.25/plantlet) and the increment of shoot length (0.472 cm) and the least time requirement for regeneration were observed with the supplement of BAP (2.5 mg/L) combined with NAA (0.5 mg/L). Further, MS medium supplemented with BAP (0.5 mg/L) and NAA (0.5 mg /L) has given the optimum seedling growth and shoot formation (Pant and Thapa, 2012) in *Dendrobium* cultures.

When considering the root formation, after one month of incubation, the highest difference in the number of roots (3.4/plantlet) was observed in MS medium supplemented with sugar at a level of 45.0 g/L. After four months of incubation, the best root formation (32.5/plantlet) was observed in treatment T_5 supplemented with 60.0 g/L of sugar. Further, the significantly highest increment of root length (1.5 cm) was observed in treatments T_4, T_5, T_6 and T_7 after four months of incubation though there was no significant difference of this parameter between different treatments after 30 days of incubation. However, when considering both root formation and root length increment together, only the treatment T_5 (sugar, 60.0 g/L) has performed well after four months of incubation. Therefore, the sugar concentration of 60.0 g/L in MS medium is more suitable to generate and develop roots from plantlets of the *Dendrobium* hybrid under *in vitro* conditions. Similar observations have been reported by Ferreira et al. (2010) by showing the highest root formation in Vaccine and Went medium containing sucrose at a concentration of 60.0 g/L after five months of incubation.

According to the observations, treatments T_3, T_5 and T_8 have affected similarly on the development of shoots and leaves while the treatment T_5 had the best performance on rooting. By considering these two major observations, it is suggested that the treatment T_5 can be used for the better growth and development of shoots and roots together (Figure 1). Further, it can be suggested that an optimized level of sugar (60.0 g/L) would induce more growth and development including shooting and rooting in plantlets of the *Dendrobium* hybrid when compared to the plant growth regulators.

Since, plantlets in the T_1 were dying due to the absence of a carbon source in the medium, no growth and only decaying was observed. Therefore, minus values were observed with all the parameters of the T_1 and the values increased with time as decaying continued with time.

Conclusion

According to the findings of the present research, basal MS medium containing 45.0 g/L of edible sugar has performed well for efficient growth and organogenesis of PLBs of the *Dendrobium* hybrid (*Dendrobium bigibbum* x *Dendrobium* Thailand Black), while MS

medium with an edible sugar concentration of 60.0 g/L showed the best *in vitro* growth and development of plantlets of the hybrid. Further, edible sucrose (sugar) can be used as an alternative carbon source to replace laboratory-scale sucrose and also a balanced level of edible sugar can be used as an alternative for plant growth regulators in a low-cost MS medium for successful *in vitro* growth and development of the *Dendrobium* hybrid.

References

Faria, R. T. D., Rodrigues, F. N., Oliveira, L. D. V., & Müller, C. (2004). In vitro Dendrobium nobile plant growth and rooting in different sucrose concentrations. *Horticultura Brasileira*, *22*(4), 780–783. https://doi.org/10.1590/s0102-05362004000400023

Ferreira, W. D. M., Suzuki, R. M., Pescador, R., Figueiredo-Ribeiro, R. D. C. L., & Kerbauy, G. B. (2010). Propagation, growth, and carbohydrates of Dendrobium Second Love (Orchidaceae) in vitro as affected by sucrose, light, and dark. *In Vitro Cellular & Developmental Biology - Plant*, *47*(3), 420–427. https://doi.org/10.1007/s11627-010-9311-x

Khuraijam, J.S., Sharma, S.C., & Roy, R.K. (2017). Orchids: Potential Ornamental Crop in North India. *International Journal of Horticultural & Crop Science Research*, *7*, 1-8. https://www.ripublication.com/Volume/ijhcsrv7n1.htm

Maharjan, S., Thakuri, L. S., Thapa, B. B., Pradhan, S., Pant, K. K., Joshi, G. P., & Pant, B. (2020). In vitro propagation of the endangered orchid Dendrobium chryseum Rolfefrom protocorms culture. *Nepal Journal of Science and Technology*, *19*(1), 39–47. https://doi.org/10.3126/njst.v19i1.29737

Murashige, T., & Skoog, F. (1962). A Revised Medium for Rapid Growth and Bio Assays with Tobacco Tissue Cultures. *Physiologia Plantarum*, *15*(3), 473–497. https://doi.org/10.1111/j.1399-3054.1962.tb08052.x

Nambiar, N., Tee, C., & Maziah, M. (2012). Effects of organic additives and different carbohydrate sources on proliferation of protocorm like bodies in "Dendrobium" Alya Pink. *Plant Omics,* 5(1), 10–18. https://search.informit.org/doi/10.3316/informit.007685026363388

Pant, B., & Thapa, D. (2012). In vitro mass propagation of an epiphytic orchid,Dendrobium primulinum Lindl. through shoot tip culture. *AFRICAN JOURNAL OF BIOTECHNOLOGY*, *11*(42). https://doi.org/10.5897/ajb11.3106

Rafique, R., Fatima, B., Usman, M., Sh. Iqbal, M., Ul Hasan, S. Z., Kh. Shabbir , Rasheed, M., Iqbal, M., Mushtaq, S., & Rasheed, M. (2020). Effect of sucrose on in vitro callogenesis, embryogenesis and organogenesis of Dendrobium sabin H. *International Journal of Modern Agriculture*, *2*(1), 43 - 47. https://doi.org/10.17762/ijma.v2i1.14

Talukder, S., Nasiruddin, K., Yasmin, S., & Hasan, L. (2003). Shoot Proliferation of Dendrobium Orchid with BAP and NAA. *Journal of Biological Sciences*, *3*(11), 1058–1062. https://doi.org/10.3923/jbs.2003.1058.1062

Teixeira Da Silva, J. A., Tsavkelova, E. A., Ng, T. B., Parthibhan, S., Dobránszki, J., Cardoso, J. C., Rao, M. V., & Zeng, S. (2015). Asymbiotic in vitro seed propagation of Dendrobium. *Plant Cell Reports*, *34*(10), 1685–1706. https://doi.org/10.1007/s00299-015-1829-2

Udomdee, W., Wen, P. J., Lee, C. Y., Chin, S. W., & Chen, F. C. (2013). Effect of sucrose concentration and seed maturity on in vitro germination of Dendrobium nobile hybrids. *Plant Growth Regulation*, *72*(3), 249–255. https://doi.org/10.1007/s10725-013-9856-x

Yaseen, M., Ahmad, T., Sablok, G., Standardi, A., & Hafiz, I. A. (2012). Review: role of carbon sources for in vitro plant growth and development. *Molecular Biology Reports*, *40*(4), 2837–2849. https://doi.org/10.1007/s11033-012-2299-z

Young, G. D., Rowe, B., & Runkle, E. (2011). *Propagating Orchids.* Floriculture and Greenhouse Crop Production, Michigan State University. https://www.canr.msu.edu/resources/propagating-orchids

Zahara, M., Datta, A., Boonkorkaew, P., & Mishra, A. (2017). The Effects of Different Media, Sucrose Concentrations and Natural Additives on Plantlet Growth of Phalaenopsis Hybrid "Pink." *Brazilian Archives of Biology and Technology*, *60*(0). https://doi.org/10.1590/1678-4324-2017160149

Conference Paper No: BF-02

Observations on Sri Lankan *Hypoxylon*: a comprehensive morphological study on *H. anthochroum*, *H. flavoargillaceum*, and *H. piceum*

P. L. E. S. Palapathwala, A. Ganeshalingam and D. A. Daranagama*

Department of Plant and Molecular Biology, University of Kelaniya, Sri Lanka
anupamad@kln.ac.lk*

Abstract

Most of the *Hypoxylon* species are saprobic and usually one of the earliest species to colonize the deteriorated wood. The species of *Hypoxylon* belonging to the family Hypoxylaceae exhibit a large diversity of fungi in tropical countries like Sri Lanka. However, research on the identification and classification of Hypoxylaceous species is scarce in Sri Lanka. The present study was aimed towards the identification of Sri Lankan Hypoxylaceous species and to produce a stable classification for species nomenclature based on a reliable approach using distinguishable morphological characteristics. An assessment of hypoxylaceous fungi was carried out in the Pilikuththuwa lowland wet zone forest area in Sri Lanka and several *Hypoxylon* species were identified morphologically, using both macroscopic and microscopic characteristics including features of stromata, ascomata, asci, ascospores, the colour of KOH extractable pigments and culture characteristics. Based on the results the identity of *H. anthochroum*, *H. flavoargillaceum*, and *H. piceum* were confirmed by morphology.

Keywords: Fungi, Morphology, Taxonomy

Introduction

Genus *Hypoxylon* (Bull.) was described in the family Xylariaceae in previous classification systems (Ju & Rogers, 1996; Stadler, 2011; Lee & Whalley, 2000). Based on a multigene analysis of ITS and β–tubulin genes and morphology of asexual morphs, *Hypoxylon* was transferred to the family *Hypoxylaceae* (Ascomycota, Xylariales) with its other related genera (Daranagama et al., 2018; Wendt et al., 2018). Recently the genus *Hypoxylon* was divided among several other genera in previous classification systems, as well as newly erected genera, due to their stromatal anatomy, and the multi-DNA locus genealogy. For example, Lambert et al. (2019) accommodated a new genus *Hypomontagnella* following morphology and chemotaxonomic studies along with multigene phylogeny. With this addition, *Hypomontagnella* now comprises five species including *Hypomontagnella monticulosum*.

Morphological identification is the basic step of fungal species identification. Species in the genus *Hypoxylon* have a characteristic feature, which is the presence of KOH extractable pigments due to their secondary metabolites. In the precise identification and characterization of fungi, target regions of the ribosomal DNA genes subjected to amplification and sequencing have become a promising tool (Bitzer et al., 2008; Triebel et al., 2005). However, due to the slow evolution of protein-coding genes such as RNA polymerases (RPB1, RPB2) and β-tubulin, they are more effective in inferring distant phylogenetic relationships among species (Hongsanan et al., 2017; Daranagama et al., 2018; Wendt et al., 2018).

Although a small country in its landmass, Sri Lanka has a great biodiversity of fungi. However, information available on Sri Lankan fungi is scattered. In Sri Lanka, the studies on fungal diversity were initiated before the 1800s and the first Sri Lankan fungi to be recorded were *Peziza ceylonische* and *P. lembosa* (Karunarathna et al., 2012). From there, several mycologists carried out several studies on Sri Lankan fungi. According to Karunarathna et al. (2012), current information suggests only a little more than 2,000 species of Sri Lankan fungi are presently known although the diversity can be several folds higher than that. Research on identification, taxonomy, and phylogeny of Hypoxylaceous species is scarce in Sri Lanka though there are a few studies carried out to characterize species of *Hypoxylon* (Kuhnert et al., 2014, Palapathwala et al., 2019). The present study is a part of the major study conducted by Palapathwala et al. (2019). This paper will provide a major contribution towards the identification and nomenclature of Sri Lankan hypoxylaceous fungal species while producing a stable morphological classification for species.

Methodology

Fresh specimens of species of *Hypoxylon* (3-5 specimens representing each species) were collected on the track to the caves of Pilikuththuwa lowland wet zone forest, located just 30 miles from Colombo, in Gampaha district from decaying wood material lying on the ground, based on the macro morphological features, during May-July 2018. Collected hypoxylaceous fungal species were morphologically characterized while surface colour, colony colour, and KOH extractable pigments were recorded. Ascomata of collected fungal species were observed using the stereomicroscope (Olympus SZ61 model, Philippines). Microscopic characters of asci and ascospores were observed using Phase Contrast Microscope (Olympus CX41 model, Tokyo, Japan). The apical ring of the ascus was stained using Melzer's reagent. Microphotography was taken using Olympus DP 26 Mega Pixel camera fitted to the Phase Contrast Microscope (X400 magnification) (Olympus CX41 model, Tokyo, Japan). Measurements of stromata (n=10), perithecia (n=10), asci (n=20), and ascospore (n=20) were taken from material mounted in water and the mean values were used in the description. Measurements were made with the Tarosoft (R) Image Framework Program and images used for figures were processed with Adobe Photoshop CC version 18.0 (Adobe Systems Inc., The USA). To isolate fungi, the upper surface of any fruiting bodies was excised using a sterilized scalpel blade. Pure cultures were obtained either from single spore or multispore isolation (Chomnunti et al., 2014; Daranagama et al., 2015). The cultures were maintained at 27 °C in Malt Extract Agar (MEA) in the laboratory. Morphological identification of the collected and isolated species was done using the previous literature and the morphological keys by Ju and Rogers (1999), Kuhnert et al. (2014), and Daranagama et al. (2018).

Results and Discussion

In this section, three species of *Hypoxylon* are described with illustrations and pictorial guides for identification.

Hypoxylon anthochroum Berk. & Broome J. Linn. Soc., Bot. 14: 122. 1873.

Saprobic on decaying dicot bark. Stromata Superficial, black, effuse-pulvinate, plane, conspicuous (Figure 1f), KOH extractable pigments dull green (70) (Figure 1e). *Ascomata* 47.2 x 36.6 μm, roughly spherical (Figure 1d). *Asci* Cylindrical, 8-spored, 93.9 μm in total length 4.1 μm broad, spore-bearing part 58.2 μm, stipe 35.7 μm (Figure 1a, b). *Ascospores* 7.8 x 3.4 μm, dark brown to brown, ellipsoidal-inequilateral, broadly rounded ends, sigmoid germ slit, nearly spore-length (Figure 1c).

Culture characteristics - smooth, velvety, primrose (65) (Figure 1h), symmetrical edges, reverse olivaceous dull (69), with concentric rings (Figure 1g).

Material examined - 7 ⁰ 03' 50.2147" N and 8 ⁰ 03' 01.1160" E, 25 May 2018, herbarium = UKBH012, Daranagama and Palapathwala, HYXL 012, living culture = UKBC012.
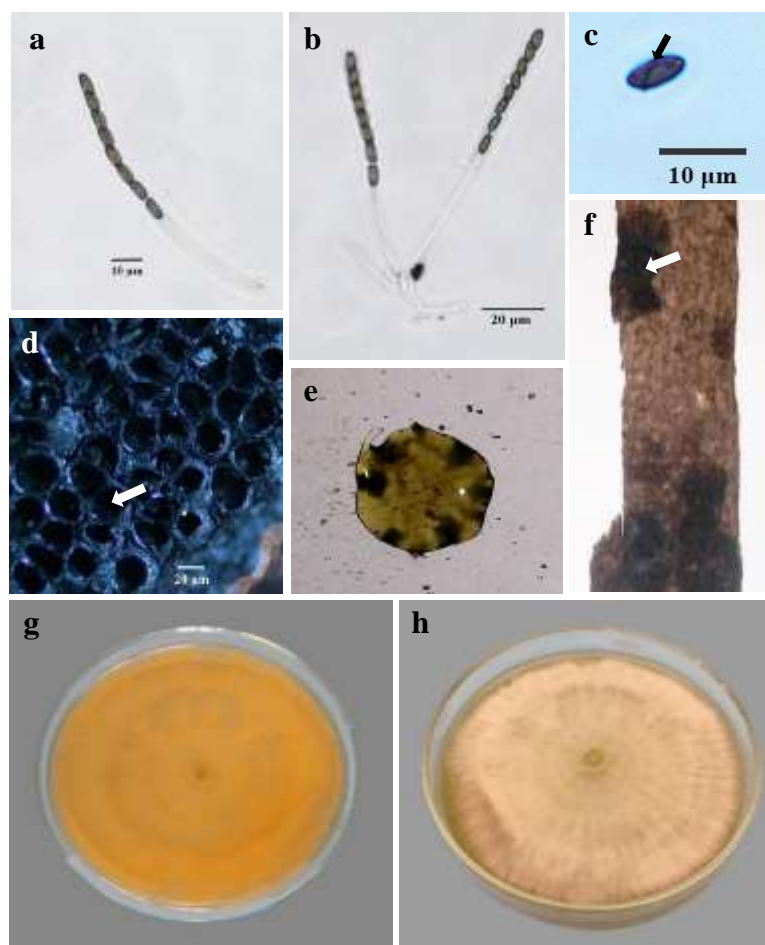
Figure 1. *Morphological features of Hypoxylon anthochroum; **a, b** Asci, **c** Ascospore (germ slit shown by arrowhead), **d** Cross section of stromata showing ascomata (shown by arrowheads), **e** KOH extractable pigment, **f** Appearance of stromata on substrate (shown by arrowhead), **g** Lower surface of the culture and **h** Upper surface of the culture on MEA.*

Hypoxylon flavoargillaceum J. H. Mill., in Chardón & Toro, *Monograph Univ. Puerto Rico*, Series B 2: 200 (1934).

Saprobic on decaying dicot bark. *Stromata s*uperficial, inconspicuous, surface brown vinaceous (84) (Figure 2f), KOH extractable pigments greenish glaucous (90) (Figure 2e). *Ascomata* 185.2 x 158.2 μm, spherical to hemispherical (Figure 2c). *Asci* Cylindrical, 8-spored, 114.6 μm in total length x 4.4 μm broad, spore-bearing part 62.7 μm, stipe 51.9 μm (Figure 2a, b). *Ascospores* 8.0 x 3.8 μm, light brown to brown, ellipsoidal-equilateral, broadly rounded ends, uniseriate, unicellular, sigmoid germ slit, nearly spore-length (Figure 2d).

Culture characteristics - plane, sepia (60) to dark vinaceous (82) mycelia, pale vinaceous (85) centre, with forming concentric rings after 20-25 days (Figure 2h), reverse brown vinaceous (84) (Figure 2g).

Material examined - 7 ^{0} 03' 50.2126" N and 8 ^{0} 03' 01.1008" E, 29 June 2018, herbarium = UKBH016, Daranagama and Palapathwala, HYXL 016, living culture = UKBC016.
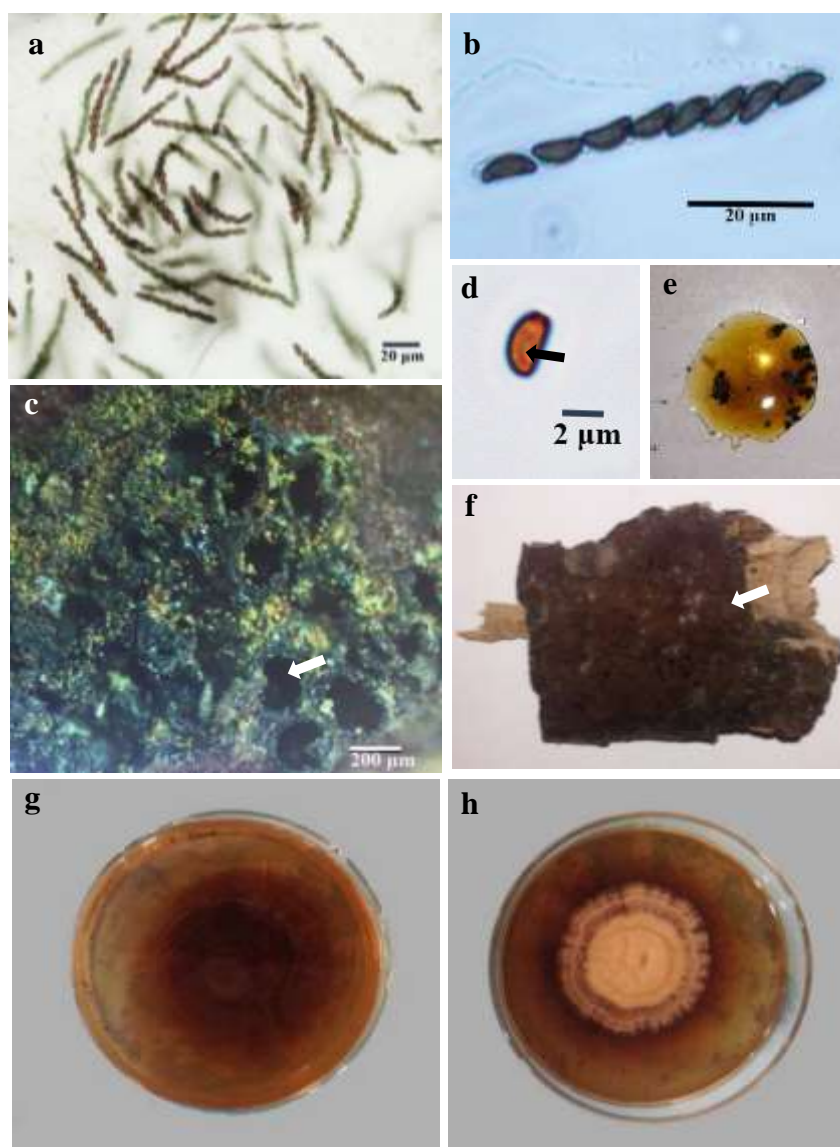
Figure 2. *Morphological features of Hypoxylon flavoargillaceum; **a, b** Asci, **c** Cross section of stromata showing ascomata (shown by arrowheads), **d** Ascospore (shown by arrowhead), **e** KOH extractable pigment, **f** Appearance of stromata on substrate (shown by arrowhead), **g** Lower surface of the culture and **h** Upper surface of the culture on MEA.*

Hypoxylon piceum Ellis, *Am. Nat.* 17(1): 194 (1883).

Saprobic on decaying dicot branches. *Stromata* superficial, conspicuous, dense, surface dark black (Figure 3f), KOH extractable pigments dark herbage green (68), dull green (70) (Figure 3d). *Ascomata* 256.4 x 214.8 μm, spherical (Figure 3e). *Asci* Cylindrical, 8-spored, 81.2 μm in total length x 3.9 μm broad, spore-bearing part 49.5 μm, stipe 31.8 μm (Figure 3a, b). *Ascospores* 6.4 x 2.8 μm, dark brown, ellipsoidal-nearly equilateral, uniseriate, unicellular, broadly rounded ends, straight germ slit, spore-length (Figure 3c).

Culture characteristics - smooth, soft, plane, vinaceous buff (86), primrose (65), (Figure 3f), reverse vinaceous (84), sepia (63) with straw (46) margins, with symmetric edges (Figure 3g).

Material examined - 7 ^{0} 03' 50.2151" N and 8 ^{0} 03' 01.1068" E, 20 July 2018, herbarium = UKBH027, Daranagama and Palapathwala, HYXL 027, living culture = UKBC027.
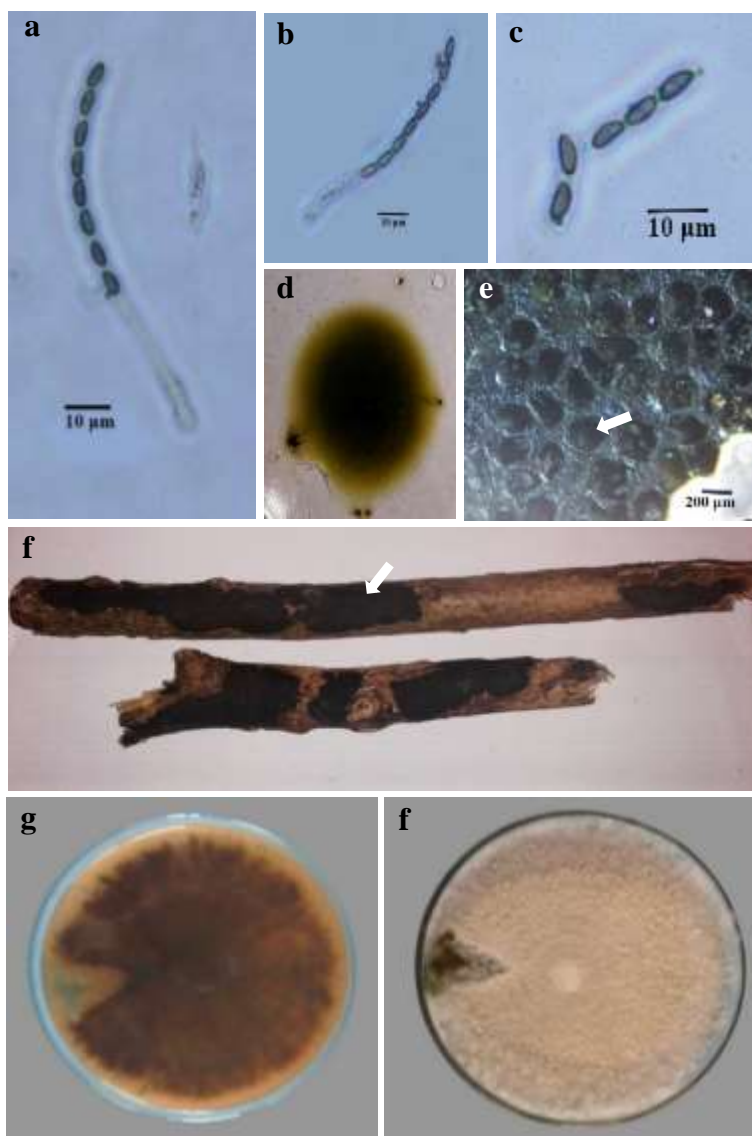
Figure 3. *Morphological features of Hypoxylon piceum; **a, b** Asci, **c** Ascospore, **d** KOH extractable pigment, **e** Cross section of stromata showing ascomata (shown by arrowheads), **f** Appearance of stromata on substrate (shown by arrowhead), **g** Lower surface of the culture and **h** Upper surface of the culture on MEA.*

Conclusion

Based on the results, Pilikuththuwa low land wet zone forest exhibits a high diversity of *Hypoxylon* species with clear morphological variations, which can be used as an identification tool in classification, during the cases where it is failed or difficult to conduct the molecular analysis. *H. anthochroum, H. flavoargillaceum,* and *H. piceum* are recognized by new combinations of teleomorphic morphological characters. Even though in this study the morphological characters were helpful in the identification of three described species, it is recommended to carry out a molecular analysis to find out whether the genealogy is fully in agreement with phenotype-derived traits.

Acknowledgement

References

Bitzer, J., Læssøe, T., Fournier, J., Kummer, V & Decock, C. (2008). Affinities of *Phylacia* and the daldinoid *Xylariaceae*, inferred from chemotypes of cultures and ribosomal DNA sequences. *Mycological Research*, 112(2), 251–270. DOI 10.1016/j.mycres.2007.07.004

Chomnunti, P., Hongsanan, S., Aguirre-Hudson, B., Tian, Q., Peršoh, D., Dhami, M. K., Alias, A. S., Xu, J., Liu, X., Stadler, M & Hyde, K. D. (2014). The sooty moulds. *Fungal Diversity,* 66(1), 1–36. DOI 10.1007/s13225-014-0278-5

Daranagama, D. A., Camporesi, E., Tian, Q., Liu, X., Chamyuang, S., Stadler, M & Hyde, K. D. (2015). *Anthostomella* is polyphyletic comprising several genera in Xylariaceae. *Fungal Diversity*, 73(1), 203-238. DOI 10.1007/s13225-015-0329-6

Daranagama, D. A., Hyde, K. D., Sir, E. B., Thambugala, K. M., Tian, Q., Samarakoon, M., McKenzie, E., Jayasiri, S., Tibpromma, S., Bhat, J., Liu, X & Stadler M. (2018). Towards a natural classification and backbone tree for *Graphostromataceae, Hypoxylaceae, Lopadostomataceae* and *Xylariaceae*. *Fungal Diversity,* 88(1)**,** 1–165. DOI 10.1007/s13225-017-0388-y

Hongsanan, S., Maharachchikumbura, S. S. N., Hyde, K. D., Samarakoon, M., Jeewon, R., Zhao, Q., Al-Sadi, A. M & Bahkali, A. H. (2017). An updated phylogeny of Sordariomycetes based on phylogenetic and molecular clock evidence. *Fungal Diversity*, 84(1), 25–41. DOI 10.1007/s13225-017-0384-2

Ju, Y. M., & Rogers, J. D. (1996). A revision of the genus *Hypoxylon*. American Phytopathological Society (APS Press).

Karunarathna, S. C., Udayanga, D., Maharachchikumbura, S. N., Pilkington, M., Manamgoda, D. S., Wijayawardene, D. N. N., Ariyawansa, H. A., Bandara, A. R., Chukeatirote, E., McKenzie, E. H. C & Hyde, K. D. (2012). Current status of knowledge of Sri Lankan mycota. *Current Research in Environmental & Applied Mycology,* 2(1), 18–29. DOI 10.5943/cream/2/1/2

Kuhnert, E., Heitkämper, S., Fournier, J., Surup, F & Stadler, M. (2014). Hypoxyvermelhotins A–C, new pigments from *Hypoxylon lechatii* sp. nov. *Fungal Biology,* 118(2), 242–252. DOI 10.1016/j.funbio.2013.12.003

Lambert, C., Wendt, L., Hladki, A. I., Stadler, M & Sir, E. B. (2019). *Hypomontagnella* (Hypoxylaceae): a new genus segregated from *Hypoxylon* by a polyphasic taxonomic approach. *Mycological Progress*, 18(1), 187-201. DOI 10.1007/s11557-018-1452-z

Lee, Y & Whalley, A. J. S. (2000). The genus *Hypoxylon*, Wood Decay Fungi – I. Teleomorph of Hypoxylon Section. *Mycobiology*, 28(1), 5-10. DOI 10.1080/12298093.2000.12015715

Palapathwala, P. L. E. S., Daranagama, D. A., Abeywickrama, K & Kannangara, S. (2019). New records of *Hypoxylon hypomiltum* and *Hypomontagnella monticulosa* from Pilikuththuwa lowland wet zone forest, Sri Lanka. *Studies in Fungi*, 4(1), 135-145. DOI: 10.5943/sif/4/1/17

Stadler, M. (2011). Importance of secondary metabolites in the Xylariaceae as parameters for assessment of their taxonomy, phylogeny, and functional biodiversity. *Current Research in Environmental & Applied Mycology*, 1(2), 75–133. DOI 10.5943/cream/1/2/1

Triebel, D., Peršoh, D., Wollweber, H & Stadler, M. (2005). Phylogenetic relationships among *Daldinia*, *Entonaema* and *Hypoxylon* as inferred from ITS nrDNA sequences. *Nova Hedwigia*, 80, 25–43. DOI: 10.1127/0029-5035/2005/0080-0025

Wendt, L., Sir, E. B., Kuhnert, E., Heitkämper, S., Lambert, C., Hladki, A., Romero, A., Luangsȧard, J., Srikitikulchai, P., Peršoh, D & Stadler, M. (2018). Resurrection and emendation of the Hypoxylaceae, recognised from a multigene phylogeny of the Xylariales. *Mycological Progress,* 17(1), 115–154. DOI 10.1007/s11557-017-1311-3

Conference Paper No: PF-01

Product recommendation model for supermarket industry based on machine learning algorithms

U. B. P. Shamika* and A. D. De Silva

Department of Statistics and Computer Science, Faculty of Science, University of Kelaniya, Sri Lanka
shamikapawani137@gmail.com*

Abstract

Recommendation activities automatically display products or content that might interest customers based on previous user activity. Recommendations help customers directly to identify the relevant items that they might otherwise not know. The product recommendation model determines which products are suggested to a consumer, depending on that consumer's shopping history. The main objective of this research was to develop a product recommendation model by considering the shopping history of consumers. The supermarket data used in the study contain customer details, transaction details, and product details. The product recommendation model was built using three machine learning techniques such as the Long Short-Term Memory algorithm, Convolutional Neural Network algorithm, and Collaborative Filtering algorithm. The obtained accuracies of the proposed model with respect to Collaborative Filtering, Long Short-Term Memory and Convolutional Neural Networks are 78%, 54% and 56% respectively. According to the accuracy values the Collaborative Filtering algorithm is more suitable to build the product recommendation model than the Long Short-Term Memory algorithm or Convolutional Neural network.

Introduction

Most people fulfill their daily needs from supermarkets. A grocery list is an integral part of the shopping experience of many consumers (Tahiri§*, Bogdan, & Makarenkov, 2019). Many online stores use product recommendation systems for their consumers such as Amazon online shopping store by considering product similarity. But according to the conducted literature review, it does not exist any product recommendation system for Sri Lankan supermarket industry based on consumer shopping history. The main objective of the research is to recommend shopping list to consumer by considering his/her past shopping behavior. This research developed the product recommendation model using different machine learning techniques and then identified the most suitable machine learning method to develop a product recommendation model for supermarkets. Then using the best machine learning algorithm, identifying the most frequently bought products of each consumer.

There is an existing product recommendation model that built using combination of the Long Short-Term Memory (LSTM) algorithm and Convolutional Neural Network (CNN) algorithm. (Tahiri§*, Bogdan, & Makarenkov, 2019), introduced a product recommendation model using a combination of LSTM and CNN. But the accuracy of that model was 49%. This research develops a product recommendation model using the

LSTM algorithm and CNN machine learning algorithm separately. The Amazon company currently uses a product recommendation system for its consumers. Amazon examines for each of the user's purchased and rated items where the algorithm attempts to find similar items, then aggregates the similar items and recommend them to the users (Linden, Smith, & York, 2003). (Linden, Smith, & York, 2003) built the recommendation model using the Collaborative Filtering (CF) algorithm. Further they suggested to apply these recommendation algorithms for targeted marketing, both online and offline in the future.

Methodology
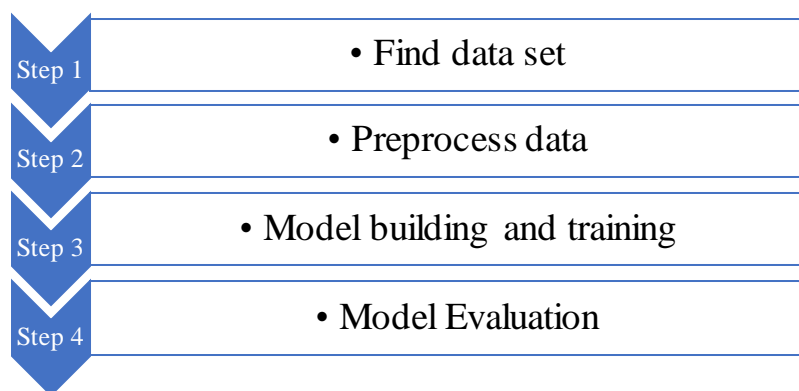
Figure 1. Method that is been used in the study.

Methods

Machine learning is the study of mimic the human brain into a machine. Machine learning facilitates computers in building models from sample data to automate decision-making processes based on data inputs. This research used three machine learning techniques to build the recommendation model separately.

Long Short-Term Memory Algorithm

The LSTM is a type of Recurrent Neural Network that achieves a state-of-the-art result on challenging prediction problems. Sequence prediction problems have been around for a long time with the recent breakthroughs that have been happening in data science, is found that for almost all these sequence prediction problems, LSTM networks (Brownlee, 2017). The LSTM model has three regulators(gates) as input gate, forget gate, output gate. The Input gate controls the extent to which a new value flows into the cell and the forget gate controls the extent to which a value remains in the cell. The output gate controls the extent to which the value in the cell use to compute the output activation of the LSTM unit. Recurrent Neural Network is suitable to develop a recommendation model as that model gets current input as past output. But the Recurrent Neural Network model cannot keep the long duration of memory but, the LSTM can keep the long track of memory. As a result, develop a recommendation model using LSTM Algorithm.

Convolutional Neural Network Algorithm

The CNN is a deep neural network designed for processing structured arrays of data. CNN are widely used in computer vision. While focused on feedforward networks, CNN are more often utilized for classification and computer vision tasks. They are comprised of

node layers, containing an input layer, one or more hidden layers, and an output layer. Each node connects to another and has an associated weight and threshold. If the output of any individual node is above the specified threshold value, that node is activated, sending data to the next layer of the network. Otherwise, no data is passed along to the next layer of the network (Education, 2020).

Collaborative Filtering Algorithm

The CF is a way that the recommendation systems filter information by using the preferences of other people. CF algorithm on the other hand, doesn't need anything else except users' historical preference on a set of items. Because it's based on historical data, the core assumption here is that the users who have agreed in the past tend to also agree in the future. In terms of user preference, it usually expressed by two categories. Explicit Rating is a rate given by a user to an item on a sliding scale, like five stars for Titanic. This is the most direct feedback from users to show how much they like an item. Implicit Rating suggests user's preference indirectly, such as page views, clicks, purchase records, whether to listen to a music track, and so on (Luo, 2018).

Materials

This research used Python 3 as the programming language to preprocess the data set and build the model and used the Jupiter framework to develop the model.

Data set

Download the online data set from (vasudeva, 2019) to develop the model. Data Contain in three tables named customers, transactions, and item data. Customers table contains Customer ID, the age range of customers, marital state, home type, family size, number of children, and income of customers. The Transaction table contains transaction date, customer ID, item ID, quantity, selling price, and discounts. The Item data table contains item id, brand, category, and item name. There are 761 customers on the customer details spreadsheet and 74067 products in the product details spreadsheet.

Data Preprocessing

Data preprocessing refers to using the processed data to build the recommendation machine learning model. An online data set is used to analyze the shopping history of customers individually. After cleaning the data set with eliminating missing and null values the remaining 482 customers' data was considered. Then the remaining customer details were merged with their transaction details to prepare the required dataset. There remain 89401 data and considered only 30000 transaction details to build the product recommendation model. The dataset was split into 80% of data as training data and 20% of data as testing data. The product recommendation model using the training data set and testing data set was used to evaluate the model.

The Neural Network algorithm gets only numeric values and must provide features with data set. For example, the customer features as in non-numeric data types, and in order to build the Neural Network machine learning models it requires to change those non-numerical values into numerical values. Therefore, python 3 was used to implement the above-mentioned task as follows.

***Table 1.** Assigned values for age ranges*

Age ranges	Assigned value
18-25	0
26-35	1
36-45	2
46-55	3
56-70	4
70+	5

***Table 2.** Assigned values to marital state*

Marital State	Assigned value
Single	0
Married	1

Collaborative Filtering algorithm considered Customer ID, product ID, and how frequently bought that product as only inputs. Therefore, the data set was updated by getting the frequency of products to each consumer using python script.

Build the model and evaluate to take the output

Build Product recommendation model using three machine learning techniques LSTM, CNN, and CF with 10 epochs and evaluate the models using testing data set.

Results and Discussion

Model evaluation outcome for LSTM

By adjusting validation split to 0.2, it was able to employ 10 epochs with the default batch size of 50. For every validation loss inside the model, the units were set to 20 in the early callback method. Figure 1 depicts the validation of LSTM. The validation accuracy of this model was 54%.

```
eval_model = model.evaluate(x_test, y_test)
eval_model

188/188 [==============================] - 179s 953ms/step - loss: 0.1335 - acc: 0.5447

[0.133506640791893, 0.5446666479110718]
```

***Figure 2.** Model test of LSTM*

Figure 3 depicts the connection between the accuracy of the training set and the validation set for each epoch. The graph shows that the accuracy of the training set has

risen and after gone down and in the same value, and validation sets has in the same value with each epoch. The greatest accuracy of the model was reached each epoch in our investigation.
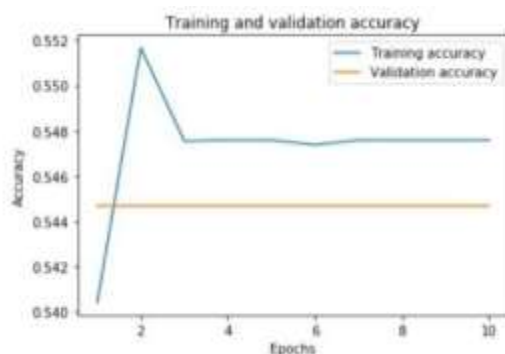
Figure 3. Model test of LSTM

Model evaluation outcome for CNN

By adjusting validation split to 0.2, we were able to employ 10 epochs with the default verbose of 1. For every validation loss inside the model, the dense were set to 100,50, and 2 in the early callback method. Figure 2 depicts the evaluation of CNN. The validation accuracy of the model was 56%.

Figure 4. Model test for CNN

Figure 5 depicts the connection between the accuracy of the training set and the validation set for each epoch. The graph shows that the accuracy of the training set is in the same value with each epoch and validation set has risen and after that has gone down and then risen value. It is not always necessary to consider the validation learning curve's last data point with the best accuracy of the model. The greatest accuracy of the model was reached each epoch in the investigation.
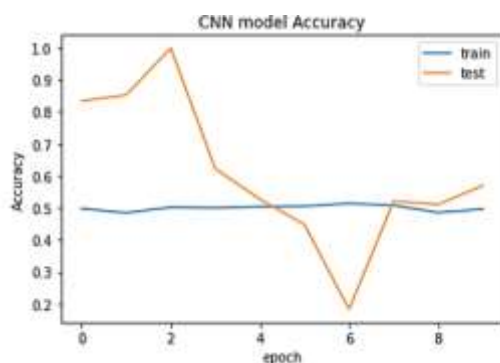
Figure 5. Accuracy graph, training vs validation in CNN

Model evaluation outcome for CF

By adjusting validation split to 0.2, it was able to employ 10 epochs Figure 3 depicts the evaluation of CF. The validation accuracy of CF is 77%.

Figure 6. Validation of CF

Figure 7 depicts the connection between the accuracy of the training set and the validation set for each epoch. The graph shows that the accuracy of the training set has risen and after that in the same value, and validation set is in the same value with each epoch. The greatest accuracy of the model was reached each epoch in our investigation.
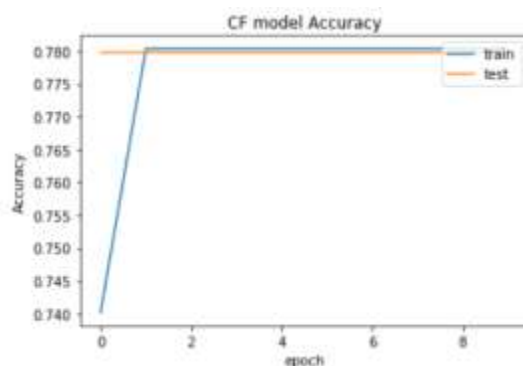
Figure 7. Accuracy graph, training vs validation in CF

Conclusion

The main objective of the study is to provide a recommended product list to Sri Lankan supermarket consumers considering their shopping behavior. This research developed product recommendation model used in machine learning Algorithms. In addition, compared different machine learning techniques and identified the most suitable machine learning algorithm to build the product recommendation model. Since the objective was to develop the model focusing on the Sri Lankan community, it was required to collect data from the Sri Lankan supermarkets. But unfortunately, due to the COVID 19 pandemic situation and the stipulated policies in the supermarkets, they rejected to provide the required data. As a result, used an online dataset as a dummy dataset to build the product recommendation model. The product recommendation model developed using three machine learning techniques, LSTM, CNN, and CF algorithms using online data set. The validation accuracy of the LSTM model is 54%, the accuracy of the CNN model is 56%, the accuracy of the CF model is 78%. According to the validation values we may suggest that CF as the most suitable machine learning algorithm to develop a product recommendation model in Sri Lanka. (Tahiri§∗, Bogdan, & Makarenkov, 2019) built product recommendation model by combining CNN and LSTM, but the accuracy was 49%. This research conclude that the CNN product recommendation model was more accurate than combination of CNN and LSTM recommendation model Future work suggests developing a product recommendation model for the supermarket by combining

CF with another machine learning technique and train the CF model used in Sri Lankan supermarket transaction dataset.

References

Brownlee, J. (2017, 05 25). *A Gentle Introduction to Long Short-Term Memory Networks by the Experts*. (Machine Learning Mastery) Retrieved 06 10, 2020, from https://machinelearningmastery.com/gentle-introduction-long-short-term-memory-networks-experts/

Education, I. c. (2020, 10 20). *IBM*. (IBM) Retrieved 08 20, 2021, from https://www.ibm.com/cloud/learn/convolutional-neural-networks

Linden, G., Smith, B., & York, J. (2003). *Amazon.com Recommendations Item-to-Item Collaborative Filtering*. Washington: IEEE INTERNET COMPUTING.

Luo, S. (2018, 12 10). *Introduction to Recommender System*. (towards datascience) Retrieved 03 11, 2021, from https://towardsdatascience.com/intro-to-recommender-system-collaborative-filtering-64a238194a26

Tahiri§∗, N., B. M., & Makarenkov, V. (2019). *An intelligent shopping list based on the application of partitioning and machine learning algorithms.* (SCIPY: PROC. OF THE 18th PYTHON IN SCIENCE CONF.

vasudeva. (2019, 11 15). *Predicting Coupon Redemption*. Retrieved from kaggle: https://www.kaggle.com/vasudeva009/predicting-coupon-redemption

Conference Paper No: PF-02

Effect of chitosan concentration on gelation of chitosan/ nanohydroxyapatite/ Na$_2$CO$_3$ composite

P. S. D. Perera and S. U. Adikary*

Department of Materials Science and Engineering,
Faculty of Engineering, University of Moratuwa, Sri Lanka
suadi@uom.lk*

Abstract

An injectable in situ forming chitosan/nanohydroxyapatite/Na$_2$CO$_3$ (chitosan/nHA/Na$_2$CO$_3$) composite gel was investigated to study its gelation time. This study used locally synthesized chitosan as the polymer material to synthesis chitosan thermosensitive gel. The sol-gel phase transition was primarily examined. We found that chitosan/nHA/Na$_2$CO$_3$ sol with 1.6% of chitosan has required coagulant performance. The lower concentration of chitosan had reported longer gelation behavior while the higher concentration of chitosan exhibited unstable behavior. The surface morphology of the chitosan/nHA/Na$_2$CO$_3$ composite depicts the structure of polymer gel composite. Scanning electron microscope confirmed the presence of hydroxyapatite on the chitosan matrix, indicating chitosan/nHA polymer gel composite was a suitable polymer substrate for injectable gel systems. EDX spectra shows the Ca/P value of the synthesized nano-hydroxyapatite to be 1.67. It was confirming the presence of nanohydroxyapatite on the composite. The kinetic study of this gelation process will make it possible to adjust the properties of the chitosan/nHA/Na$_2$CO$_3$ composite gel. The gelation temperature was carried out at body temperature (37 ^{0}C).

Keywords: Chitosan, Chitosan/nHA/Na$_2$CO$_3$ composite, nanohydroxyapatite.

Introduction

There has been a noticeable increment towards the improvement and use of polymer hydrogel biomaterials for the repairing and re-establishment of damaged bone tissue due to their biocompatibility, osteoconductivity, biodegradability, injectability and enhanced bone regeneration ability[1]. These polymer hydrogels can be used as growth ingredients to target tissues through injection. These hydrogels are liquid state at the time of injection and turn into a gel at the body temperature and pH. Therefore these hydrogels have the ability to restore bone defects and form the required shape[2]. The formulations based on chitosan can be held liquid at room temperature and turn into a hydrogel in situ at body temperature in a short period.

Natural bone is a complex with hydroxyapatite while hydroxyapatite salts are well-known biological agents. Hydroxyapatite (HA) is a mineral form of calcium apatite with the formula Ca$_5$(PO4)$_3$(OH), present in bone and teeth. Bone is made mostly of HA crystals deposited in a collagen matrix. Hence 65 to 70% of the mass of bone is HA[13]. Many researchers have reported that chitosan hydroxyapatite composites possess a good bonding ability with surrounding tissues. The present approach is to synthesize chitosan/hydroxyapatite composite materials using mechanical mixing. The arrangement

of polymer solutions with hydroxyapatite can improve the mechanical properties of the gel system.

Chitosan ((1-4)-2-amino-β-D-glucose) was synthesized by the deacetylation of chitin, which is naturally found in the exoskeleton of shellfish, including crab, lobster, and shrimp [3]. The non-polar behaviour of chitosan is a major disadvantage in the industrial approach [7]. It is slightly soluble in organic acids [8] and only dissolves in acidic conditions because the positively charged amino groups available in the chitosan have been increased. Therefore, the polysaccharide chains repel each other to accomplish stability by disbanding [8].

This study aims to develop an injectable biopolymer using chitosan/nanohydroxyapatite composite coagulated by Na_2CO_3. The nano-hydroxyapatite and chitosan are known as the primary aggregates of the system. Therefore, the objective of this work is making new formulations combining calcium phosphate compounds with chitosan, to avoid the longer gelation time, frequent migration of bioceramic particles(hydroxyapatite) from the implant site, reducing potential damage to soft tissue in the vicinity of the implant and improving biodegradability, biocompatibility, curing properties and injectability. Hence, we started to evaluate the effect of chitosan concentration as our first step and the ability of using chitosan/nHA/Na_2CO_3 composite for biomedical applications. This proposed gel is expecting to work under physiological pH and it is remaining as a solution during injection and it turns into gel at body temperature for short time.

Methodology/materials and methods

Chitosan and nanohydroxyapatite was synthesized by the method developed by Adikary et al. The gel mixtures were made mixing Na_2CO_3 with chitosan and nano-hydroxyapatite with several concentrations.

The chitosan–hydroxyapatite solution with a concentration of 1.2% to 2.0% were prepared dissolving chitosan (1.8g) into 6% acetic acid (50ml) and hydroxyapatite(1.5g) into 6% acetic acid (50 ml) with stirring for 5 minutes to get a perfectly transparent solution at the temperature of 37^0C and prepared Na_2CO_3 (2.4g) in 6% acetic acid solution(50ml) will be mixing at 37^0C. Afterwards, the experimental mixtures will be stirring gently to yield an elastic, ideal, and thermosensitive chitosan gel. Repeating the above process by changing the initial concentrations of aggregates as followed by Table 1. To investigate the time-dependent mechanical properties of the gel, chitosan/nanohydroxyapatite samples were placed in a beaker together with Na_2CO_3 solution. When the reagent was added, the viscosity was immediately determined with a commercial viscometer (Brookfield LVDV-II digital viscometer with the LV-4 spindle, at 12 rpm, Viscosity data were logged every other second for at least 15 min.

Table 1. *Chitosan/nHA/Na₂CO₃ process parameters.*

Reference number	% of chitosan	Chitosan/g	HA/g	Na_2CO_3/g	Acetic acid/ml
1	1.2	1.8	1.5	2.4	150
2	1.4	2.1	1.5	2.4	150
3	1.6	2.4	1.5	2.4	150
4	1.8	2.7	1.5	2.4	150
5	2.0	3.0	1.5	2.4	150

Gel morphology

The morphology of the chitosan/nHA/Na_2CO_3 gel was examined by scanning electron microscope(SEM). The gel was placed in sterilized petri dish and placed vacuum oven at 37 ^{0}C for 48 h for complete dry. The dried gels were cut with a sharp blade to expose the internal microstructure, placed on double sided tape, and sputter-coated with gold for SEM at 5.0 kV by using a Carl Zeiss ECO D8 scanning electron microscope. The surface and longitudinal sections were observed.

FTIR Spectroscopic analysis

The structural changes in chitosan (A) and the complex of chitosan/nanohydroxyapatite/sodium carbonate(B) were characterized by Fourier transformed infrared (FTIR) spectroscopy (Bruker Alpha-T) in the range of 1000 to 4000 per cm.

Results and Discussion

  I.   Gelation time

The gelation time (t_{gel}) was determined by the rheological measurements of the final mixture. The t_{gel} has been determined from dynamic viscosity slope experiments. The time associated with the t_{gel} is depicted by a dramatic increase in the complex viscosity. The chemical reaction influences the molecular structure of polymers. Furthermore, rheological properties of polymers depend on the molecular mobility.

In our work, the final concentration of chitosan was always above 1% (w/v), which is more than the critical concentration of chitosan that Boucard et al had proved. Figure 1 shows the average gelation time for chitosan/nHA/Na_2CO_3 hydrogels formed by using Na_2CO_3 as an initiator. The range of chitosan concentrations tested was 1.2–2.0%. Experimental observation proves that a concentration of 1.6% produced the best solid gel. The control sample with 0% Na_2CO_3 did not undergo a sol-gel phase change and remained as a solution until the end of the observation. The concentration and amount of acetic acid solutions in all groups were unchanged.
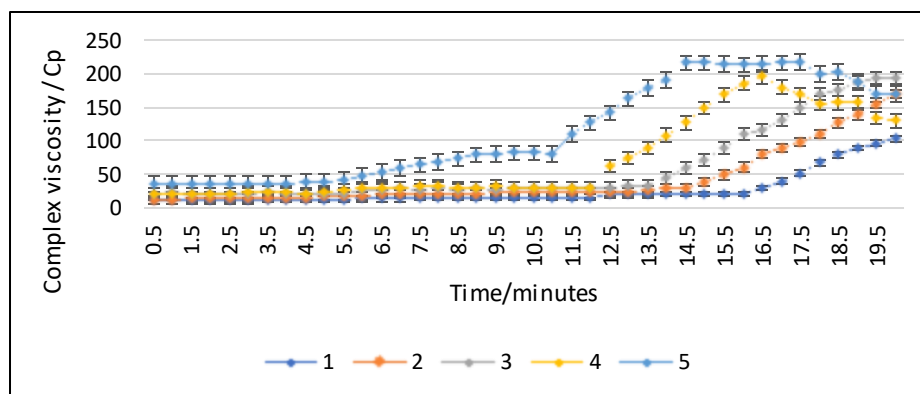
Figure 1. *The graphical represent of complex viscosity vs time in linear viscoelastic regime.*

To observe the sol-gel phase change behaviour of chitosan solutions at physiological body temperature, we measured the gelation time a 37 ^{0}C by the rheological method. Figure 1 proves the average gelation time of chitosan hydrogel at 1.6% of chitosan concentration and a hydrogel was formed in approximately 750 sec.

Table 2. *Chitosan/nHA/Na$_2$CO$_3$ gelation parameters.*

Ref. number.	Concentration of chitosan/ww	Average Gelation time/ seconds
1	1.2	930
2	1.4	835
3	1.6	750
4	1.8	645
5	2.0	510

Ref. number 1 and 2 describe the viscosity change of the resulting system versus time. This behavior depicts the degradation and cyclic behavior of polymer composite system across sol-gels. Samples 3,4 and 5 depict the viscosity nearly constant through the experiment.

II.   Gel morphology

The examination of the morphology of chitosan/nHA/Na$_2$CO$_3$ composite by SEM to determine the typical structure of the gels also because of the gelation mechanism. Fig. 2 show a SEM micrograph of the chitosan/nHA/Na$_2$CO$_3$gel after removal of water.

It is evident that nanoparticles of hydroxyapatite, some of which were approximately spherical in shape. These may be nano-hydroxyapatite particles formed in situ. Tiny mineral particles such as hydroxyapatite-coated polymer gel substrate provide the initial matrix, which is useful in the development of injectable gels for bone tissue engineering applications.
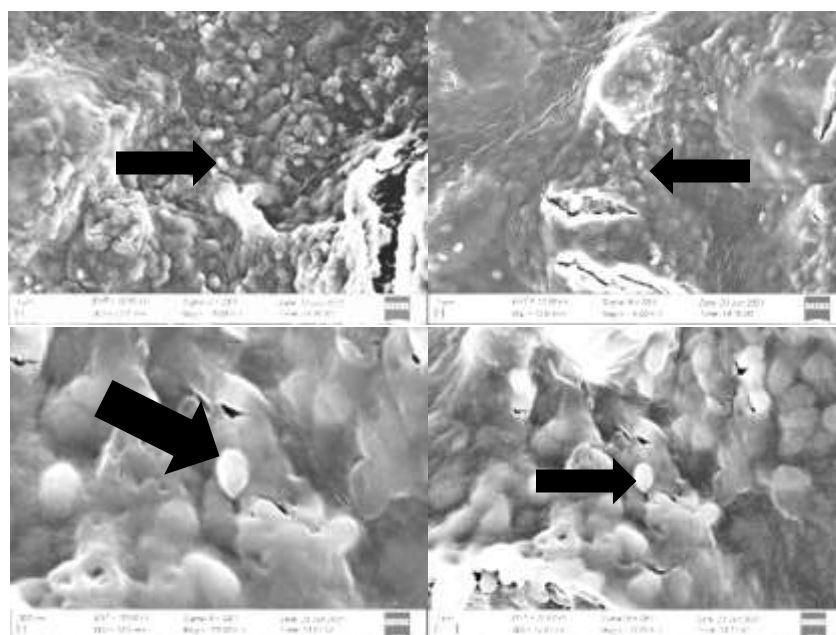
Figure 2. *SEM images of the cross-sectional morphologies of oven dried chitosan/nHA/Na$_2$CO$_3$ composite with 1.6% chitosan. Magnifications are 5.0 K x, 5.0 K x, 25.00 K x, 15.00 K x. The arrows indicate the possible hydroxyapatite nanoparticles.*

In Figure 3, the EDX spectra recorded on the examined chitosan/nHA/Na$_2$CO$_3$ are shown below. The presented spectrum proves the Ca/P value of the synthesized nano-hydroxyapatite to be 1.67 (16).
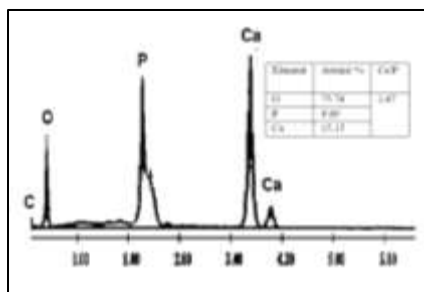
Figure 4. *EDX spectrum of nano-hydroxyapitate.*

III.   FTIR spectra of chitosan and chitosan-sodium bicarbonate complex

The obtained infrared spectra is shown in Figure 4. The intermolecular and intramolecular hydrogen bonds create amino and hydroxyl groups, the OH stretching vibration and NH stretching vibration, which were located around 3438 cm^{-1} , fused into a broad intense band at 2922–3600 cm^{-1} in the FT-IR spectrum of chitosan (A). Whose characteristic absorption spectrum includes these peaks [3]. The spectrum of the complex (B) shows a completely different absorption peak at 3431 cm^{-1}, appearing as a broad peak, which indicates that the hydrogen bonds between the amino and hydroxyl groups were destroyed, thus showing obvious OH or NH stretching vibrations. The two absorption peaks at 1628 cm^{-1} and 1564 cm^{-1}, which are represent amide bonds, are also characteristic peaks of chitosan (A) [14]. In the complex (B), these two characteristic peaks still exist but with a slight shift (1568 cm^{-1} and 1416 cm^{-1}), indicating the existence of a –NH–CO– structure in the complex.
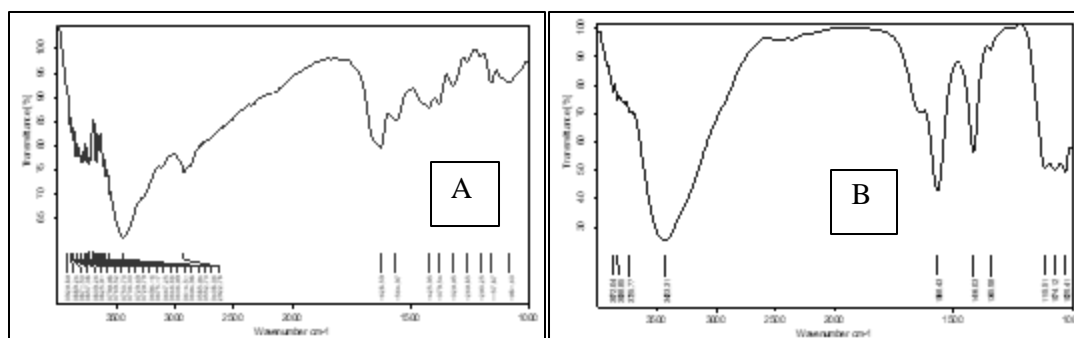
Figure 4. *(FT-IR) spectra of chitosan (A) and complex of chitosan/nHA/sodium carbonate (B).*

Conclusion

These preliminary studies indicate that the chitosan/nHA/Na$_2$CO$_3$ gel exhibit extended gelation time and with several modifications and improvements, this might have potential use in bone tissue engineering applications. In addition, rheological measurement indicated that the initial concentrations of chitosan have a significant effect on the gelation process and degradation of the resultant composite by unstable behaviors of composites which are above 1.6% of chitosan concentration.

Acknowledgment

References

Fangfang Li, Yang Liu, Yun Ding, Qiufei Xie (2014). A new injectable in situ forming hydroxyapatite and thermosensitive chitosan gel promoted by Na2CO3: Soft Matter, 10, 2292. https://pubs.rsc.org/en/content/articlelanding/2014/sm/c3sm52508b

Jianying, Q. Xiaomeng, W. Jie, S. Chang, S. Jinsong, G. Zhenghong ,X. Jian, J. Jinsong, S. A Novel Complex of Chitosan–Sodium Carbonate and Its Properties: Mar. Drugs 2018, 16, 416. https://www.science.gov/topicpages/j/jing+wang+wei.html

Kudryavtsev, P. (2020). Modelling of kinetics and structure formation at sol-gel transition: International Journal of Petrochemical Science & Engineering: 5(1), 49–54. https://medcraveonline.com/IPCSE/IPCSE-05-00121.pdf

Khaled R. Mohamed , Hanan H. Beherei, Zenab M. El-Rashidy, (2014). In vitro study of nano-hydroxyapatite/chitosan–gelatin composites for bio-applications: Journal of Advanced Research, Volume 5, Issue 2, Pages 201-208. https://www.sciencedirect.com/science/article/pii/S2090123213000325

Sewvandi, G.A. Adikary, S. U. (2012). Synthesizing and Characterization of Natural Biopolymer Chitosan Derived from Shrimp Type, Penaeus monodon: Tropical Agricultural Research Vol. 23 (3): 272 -276. https://www.researchgate.net/profile/Galhenage-Sewvandi

Yang, S.; Shao, D.; Wang, X.; Hou, G.; Nagatsu, M.; Tan, X.; Ren, X.; Yu, J. Design of Chitosan-Grafted Carbon Nanotubes: Evaluation of How the –OH Functional Group Affects Cs+ Adsorption. Mar. Drugs 2015, 13, 3116–3131. https://pubs.acs.org/doi/full/10.1021/es104047d

Younes, I.; Rinaudo, M. Chitin and Chitosan Preparation from Marine Sources. Structure, Properties and Applications. Mar. Drugs 2015, 13, 1133–1174. https://pubmed.ncbi.nlm.nih.gov/25738328

Jiang, Y.; Fu, C.; Wu, S.; Liu, G.; Guo, J.; Su, Z. Determination of the Deacetylation Degree of Chitooligosaccharides. Mar. Drugs 2017, 15, 332. https://europepmc.org/article/MED/26114886

Mourya, V.K.; Inamdar, N.N. Chitosan-modifications and applications: Opportunities galore. React. Funct. Polym. 2008, 68, 1013–1051. https://www.sciencedirect.com/science/article/pii/S1381514808000461

Riva, R.; Ragelle, H.; des Rieux, A.; Duhem, N.; Jérôme, C.; Véronique Préat, V. Chitosan and chitosan derivatives in drug delivery and tissue engineering, In Chitosan for Biomaterials II.; Jayakumar, R., Prabaharan, M., Muzzarelli, R.A.A., Eds.; Springer: Berlin, Germany, 2011; pp. 19–44. https://www.tandfonline.com/doi/full/10.3109/21691401.2013

Antonino D. Q.; R.S.C.M.; Lia Fook, B.R.P.; de Oliveira Lima, V.A.; de Farias Rached, R.Í.; Lima, E.P.N.; da Silva Lima, R.J.; Peniche Covas, C.A.; Lia Fook, M.V. Preparation and Characterization of Chitosan Obtained from Shells of Shrimp (Litopenaeus vannamei Boone), Mar. Drugs 2017, 15, 141. https://www.sciencedirect.com/science/article/pii/S2214785320402767

Habibah, TU; Salisbury, HG (January 2018). "Biomaterials, Hydroxyapatite". PMID 30020686. Archived from the original on 2020-03-28. Retrieved 2018-08-12. https://wikimili.com/en/Hydroxyapatite

Conference Paper No: PF-03

Dynamically driven a Helmholtz cage for ground testing of attitude determination and control system (ADCS) of nanosatellites

H. H. S. Dasuni[1*], U. L. Zainudeen[1], M. T. N. Perera[2], G. A. N. S. Gunasekara[2], D. W. D. L. Silva[3], R. A. D. K. Sampath[3], M. T. L. Dayarathna[3], P. M. T. R. Wijebandara[3] and C. S. J. Wijenayaka[3]

[1]Department of Physical Sciences, South Eastern University of Sri Lanka
[2]Department of Electrical and Electronic Engineering, University of Peradeniya, Sri Lanka
[3]Communication Division, Arthur C. Clarke Institute of Modern Technologies, Sri Lanka
duzhewawasam@gmail.com*

Abstract

ADCS is one of the subsystems of nanosatellites that goes through ground testing before launching. By emulating magnetic fields experienced by nanosatellites in their orbits is modelled by a Helmholtz cage made of three pairs of orthogonally connected Helmholtz coils. The magnetic field in a certain orbit was modeled by implementing algorithms using the World Magnetic Model (WMM) in MATLAB (2018b). Using MATLAB Aerospace Toolbox, implemented algorithm acquired the orbit's magnetic field as components in 3-axes which could be assigned to the three sets of coils in the Helmholtz cage. One of its three coils was selected and supplied a current through an Arduino-based driver. The resulting magnetic field at the center of the coil was measured by Honeywell's HMR2300 magnetometer by increasing pulse width. Using this data, a relationship between pulse width and the created magnetic field was obtained. For modelling the orbital magnetic field inside the cage, the magnetic field experienced by a Nanosatellite in its orbit was calculated using the implemented algorithm by taking a Two-Line Element (TLE) dataset. The pulse widths related to the magnetic field values in one particular axis throughout one period of the Nanosatellite were calculated using the derived relationship and the related current variation was applied to the corresponding coil. The magnetic field created by the coil was measured and plotted. The plotted expected magnetic field variation and the experimentally implemented magnetic field variation are fairly similar and within the range of the Earth Magnetic Field. While the theoretical variation was smooth, the experimental variation had discontinuities.

Keywords: ADCS, Helmholtz cage, Nanosatellites, TLE, WMM

Introduction

An artificial satellite is an object that has been placed into an orbit with a purpose. Since 1957, the first artificial object place in orbit around the earth, thousands of various artificial satellites are sent to space for different purposes such as Earth observation, communication, Navigation, weather and disaster detection, Telemedicine, Space telescopes, Space station and etc. (Theoret, 2016).

When a Nanosatellite is launched into an orbit, it rotates about its centre of gravity called "tumbling" which is a 3-axis spinning around its centre caused by gravitational forces acting on the antennas and satellite body and the disturbances created by magnetic fields. Due to tumbling, satellites are unable to perform their duties effectively. To prevent this, a subsystem called Attitude Determination and Control System (ADCS) was introduced to satellites to detumble itself to perform their missions with accuracy. Within the shortest

period, the detumbling process must be arranged to steady the satellite according to the mission. So, to determine the satellite's attitude, the ADCS system consisted of sensors that gather data on the orientation of the satellite. One of those onboard sensors is a magnetometer which collects 3-axes real-time data of the Earth Magnetic Field (EMF) of a satellite's orbit. Implementations have been done to control the detumbling of Cube satellites (CubeSats) since their capabilities differ from bigger satellites. B-Dot Algorithm is such an implementation to determine the angular rate of the satellite and detumble it using three orthogonal magnetic torquers which produce electromagnetic fields to stabilize the deviation of the satellite after orbital insertion by passing a current through each actuator coil (Regulinski, 1962 & Want 1998).

Within the last decade, CubeSats got popularized over bigger satellites due to lower cost, a shorter period for fully building and testing. But the problem is not having a facility to investigate the performance of real-time 3-axes magneto torquers for the ADC System within Sri Lanka. So, this ADCS of CubeSats must go through a ground-testing before it is launched into the actual orbit. Therefore, a system that is capable of simulating a uniform region of a magnetic field that the satellite will be experiencing in its orbit should be built for ground testing.

The specific objectives are to generate a real-time on-orbit magnetic field for any CubeSat anywhere at any time using MATLAB coding and Simulink as well as to power up the cage and supply the current as a Pulse Width Module (PWM) to the X-coil of the Helmholtz cage through the driver circuit and compare the theoretical values and experimentally implemented values.

This research was carried out for a RAAVANA – 1, which was launch to space by Sri Lanka in 2019. It's a 1U CubeSat which has a 10 cm length on each side. The Biot-Savart law implies that the radius of the coils, and the distance between the coils, is proportional to the size of the magnetic field volume that should be produced. Therefore, a cubic contact magnetic field of 20 cm on each side of the volume was necessary to be generated to cover the whole volume of the CubeSat and more.
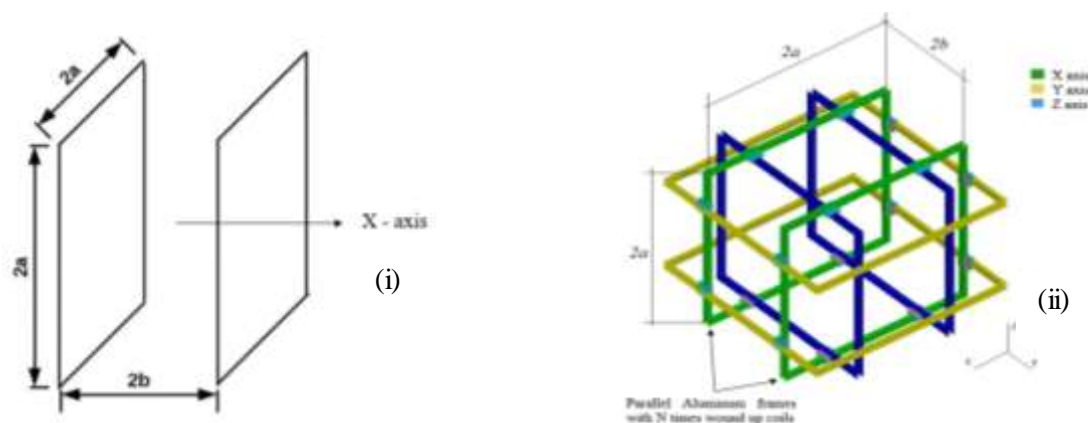
Figure 1. (i) X-axis square Helmholtz coil pair (ii) The Helmholtz cage design (Cayo 2019)

When there is a pair of identical circular magnetic coils parallel to each on the same axis, the setup of these coils is called the Helmholtz coil pair proposed by the German physicist Hermann von Helmholtz (1821-1894). Instead of a plane magnetic field, they generate a uniform volume magnetic field along the axis (Theoret, 2016). A wider uniform field can be generated by utilizing square coils instead of circular coils (Regulinski, 1962 & Want

1998). And it got greater central accessibility and the computations of the field are easier than circular coil pairs (Want 1998).

By using the traditional form of the Biot-Savart law, the scale of applicability was broadened up while implementing it to the Helmholtz Cage. So, a Helmholtz cage can be designed to create such a dynamic and uniform magnetic field using three pairs of orthogonally connected Helmholtz coils (Theoret 2016, Mahavarka 2018 & Pastena 2002).

Keplerian elements are a set of parameters used to express an orbit of an Earth-orbiting satellite. Therefore, these are called orbital elements or orbital parameters. This set of elements consisted of eight parameters that demonstrate the size, shape and orientation of the orbit (Rogers 2008). The TLE set is the way the above orbital elements are presented to describe the location of an Earth-orbiting satellite. A TLE includes three lines which can be divided into two parts. The first line shows the name and the other two lines express the "address" of the referring satellite (Chatters 2009). The inputs of the algorithm are based on the TLE dataset which describes the location of a satellite using Keplerian Elements. Many fitted reference frames consist of a group of unit length, right-handed and three correlatively perpendicular vectors which is called "Dextral Orthonormal Triad" to express the position and the orientation of a satellite (Hughes 2012).

Based on three reference frames which are Perifocal Coordinate System, Earth-Centered Inertial (ECI) frame and Earth-Centered Earth Fixed (ECEF) frame the position and the orientation of a satellite are expressed here.

Methodology/materials and methods

Software and Hardware
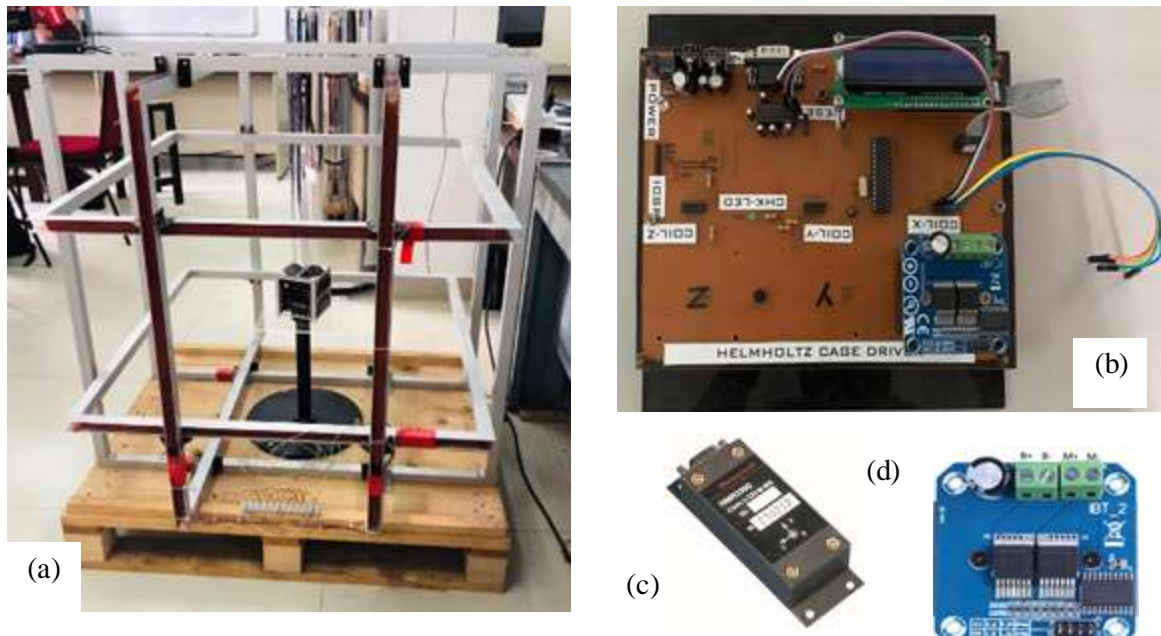
Figure 2. (a) The Helmholtz cage design, built at Arthur C. Clarke Institute for Modern Technologies (b) The Driver Circuit (c) HMR2300 Smart Digital Magnetometer (d)BTS7960 High Current H-Bridge module

MATLAB (2018b), Arduino - 1.8 and Realterm_2.0.0.70 were the software utilized. The algorithms were implemented using MATLAB (2018b). The magnetic field in a certain orbit can be modeled using the World Magnetic Model (WMM) in the MATLAB Aerospace Toolbox when the orbit information is given. Mainly four hardware were used in case of emulating the on-orbit magnetic field into the Helmholtz cage.To measure magnetic fields and communicate with a computer HMR2300 Smart Digital Magnetometer was used. The Realterm_2.0.0.70 software was used for this purpose. A BTS7960 High Current H-Bridge module was applied for taking a PWM signal as input and making a current output according to the duty cycle of the PWM signal. A Driver circuit was made for supplying the current to the cage. To code the motor driver, Arduino - 1.8 was used. Finally, the Helmholtz Cage was the test subject.

Calculation of the orbital coordinates (Longitude, Latitude & Altitude/ LLA) from TLE.

```
0 Raavana-1
1 44330U 98067QF 19345.06705768 .00006175 00000-0 99589-4 0 9998
2 44330 51.6387 201.0952 0006480 22.9331 337.1948 15.54365198 27497
```

First of all, the above TLE of RAAVANA–1 was downloaded as a text file. To Extract the necessary Keplerian Elements, the TLE file was read using the Common TLE format. Then those extracted six elements were given as the inputs for the further coding procedure. Then the Epoch and the Greenwich sidereal time (θ_G) were calculated. Then Two frame transformations were done in order to calculate the inputs for WMM using the following equations.

Perifocal frame equation-

$$\begin{bmatrix} X_{perifocal} \\ Y_{perifocal} \\ Z_{perifocal} \end{bmatrix} = \frac{a(1-e^2)}{1+e\cos\upsilon} \begin{bmatrix} \cos\upsilon \\ \sin\upsilon \\ 0 \end{bmatrix} \qquad \text{where,} \\ a \text{ - Semi major axis} \\ \text{of the orbit}$$

First from Perifocal to ECI was performed to determine the eccentric (e) and true anomaly (v) using the equation below.

$$\begin{bmatrix} X_{ECI} \\ Y_{ECI} \\ Z_{ECI} \end{bmatrix} = \begin{bmatrix} \cos\Omega & -\sin\Omega & 0 \\ \sin\Omega & \cos\Omega & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos i & -\sin i \\ 0 & \sin i & \cos i \end{bmatrix} \begin{bmatrix} \cos\omega & -\sin\omega & 0 \\ \sin\omega & \cos\omega & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} X_{perifocal} \\ Y_{perifocal} \\ Z_{perifocal} \end{bmatrix}$$

where,
Ω - Right Ascension of Ascending Node; ω - argument of perigee; i - Orbital Inclination

Then from ECI to ECEF frame transformation was done as follows.

$$\begin{bmatrix} X_{ECEF} \\ Y_{ECEF} \\ Z_{ECEF} \end{bmatrix} = \begin{bmatrix} \cos\theta_G & -\sin\theta_G & 0 \\ \sin\theta_G & \cos\theta_G & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} X_{ECI} \\ Y_{ECI} \\ Z_{ECI} \end{bmatrix}$$

Then an algorithm was created to evaluate the three inputs (LLA) which express the position of the satellite at any point of the orbit using the ECEF coordinate system. Finally, the LLA coordinates were set into the WMM as inputs and derive the orbital magnetic fields experienced in one period of the orbit.
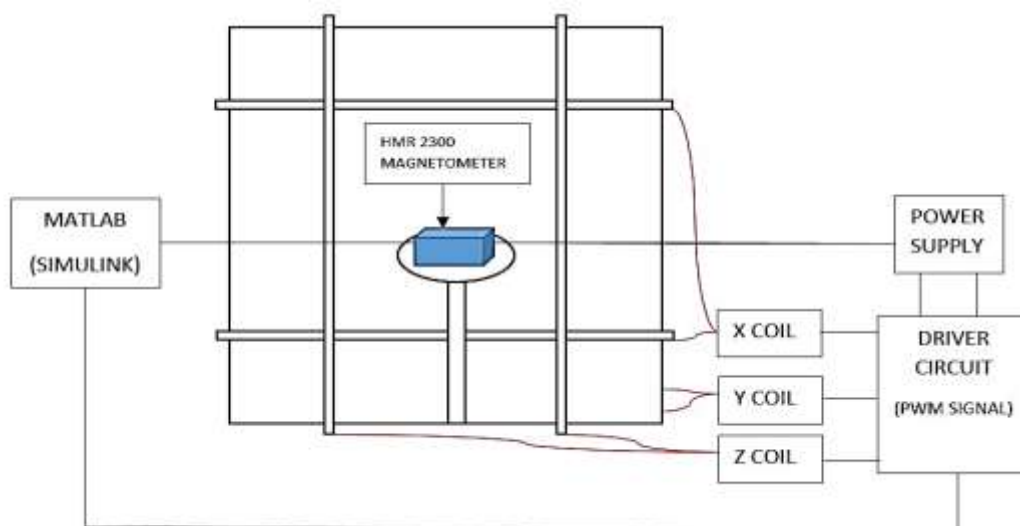
Figure 3. *The fully-equipped experimental setup.*

All the hardware was connected like the above experimental setup. Here only one coil was focused. The driver circuit was connected with the cage and the magnetometer. Then the whole setup was connected to a power supply and a Cathode Ray Oscilloscope to supply the power to the cage and take the real-time readings of the centre of the cage using the Magnetometer. For the driver circuit, 12 V and 6 A were given. The selected coil was supplied with 10 V and 0.15 A of a current through the Arduino-based driver which can vary the provided current according to the pulse width of a rectangular pulse. By getting the PWM scale 0 to 255, the resulting magnetic field at the center of the coil was measured by magnetometer by increasing pulse width 5 by 5. The magnetic fields created by the coil were measured and plotted against the pulse widths. Using that, a relationship between the pulse width and the created magnetic field was obtained.

Emulation of the magnetic field inside the Helmholtz cage.

After deriving the relationship between the pulse width given to the current driver and the generated magnetic field, the pulse widths required to create the orbital magnetic field generated by the algorithm using the TLE data set were calculated. Next, those pulse widths were supplied to the current driver to generate the orbital magnetic field inside the Helmholtz cage. Finally, the generated magnetic field was measured and recorded. Then the graph of experimentally generated X-axis magnetic field was plotted throughout one period of the Nanosatellite. Finally, the experimental and theoretical graphs were compared.

Results and Discussion

This graph shows the real-time on-orbit x-axis magnetic field (B_x) of RAAVANA – 1 satellite for the chosen TLE over a period along the orbit. It was found that the X components of the EMF (B_x) of this orbit ranges from 1.014×10^4 to 3.228×10^4 nanotesla.
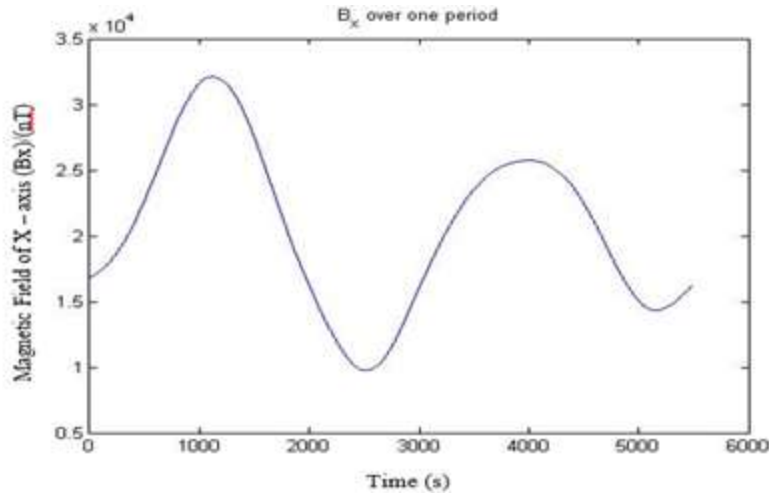
Figure 4*. The graphs (theoretical) of the real-time on-orbit x-axis magnetic field (Bₓ).*

According to the experiment, variation of B_x with the increment of PWM value was observed to be linear as shown below.
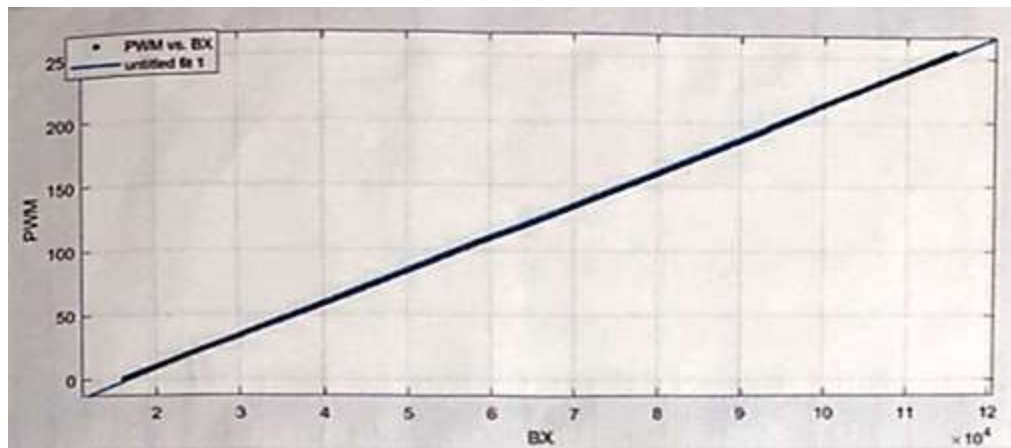
Figure 5. *Characteristics Bx with the PWM of the X-axis coil pair of Helmholtz cage.*

So, the following linear relationship between PWM and B_x was obtained using the above graph.

$$PWM = (0.0026)B_x - 43.4330$$

Using this relationship, by giving the calculated B_x values using the implemented algorithm by reading the TLE, the pulse widths were obtained. Then the experimental graph was plotted for the B_x values given for the newly generated pulse width values using the above relationship for one period of the CubeSat. It was found that the X components of the EMF (B_x) of this orbit ranges from 0.901×10^4 to 2.958×10^4 nanotesla.

X axis => Time (s)

Y axis => Bx (nT)
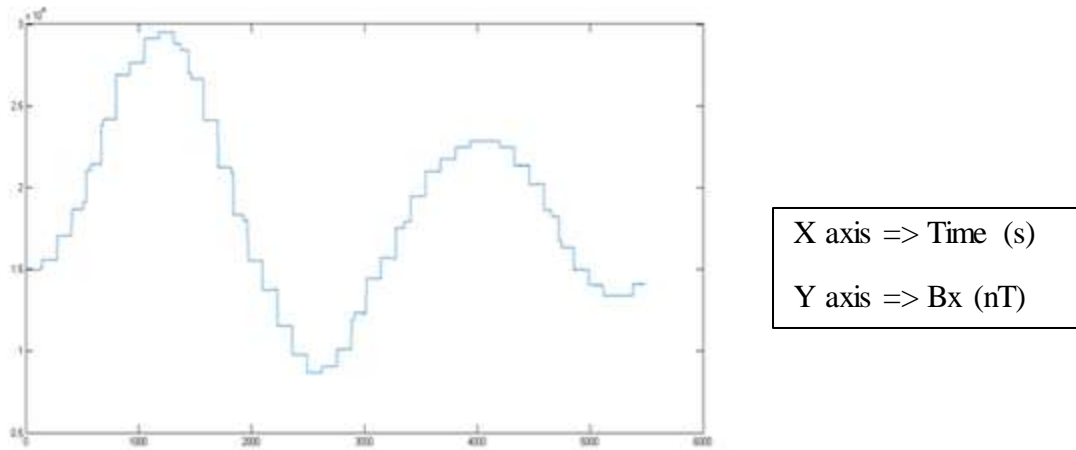
Figure 6. The experimental graph of x-axis magnetic field (Bₓ) for a period.

Comparing the above theoretical and experimental graphs below, it is shown that the shapes of the graphs are similar and lie within an approximately simal range. The slight changes might have happened because of the magnetic field disturbances from the devices, equipment around due to lack of proper experimental facility of a cleanroom.
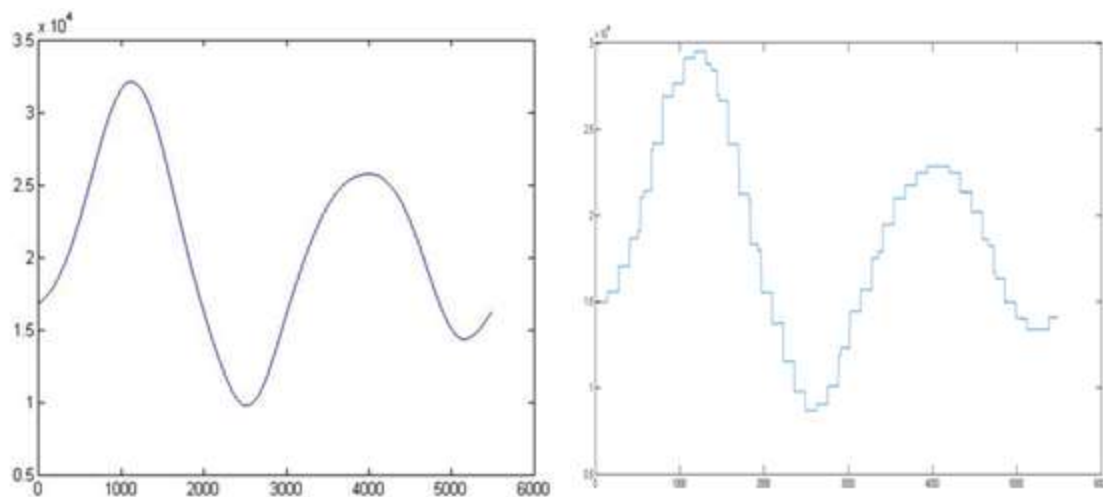
Figure 7. The theoretical graph (left) and the experimental graph (Right).

Conclusion

This research focuses on emulating the magnetic fields experienced by CubeSats in their orbits utilizing a Helmholtz cage for ground testing of the ADCS of Nanosatellites. By implementing the algorithms using MATLAB (2018b) to analyze the required magnetic fields inside the cage for one of the three coils is successful since the plot of the expected magnetic field variation and the experimentally implemented magnetic field variation of the selected coil (X–coil) were found to be fairly similar Since both ranges of the theoretical and experimental are from 1.014×10^4 to 3.228×10^4 nanotesla and from 0.901×10^4 to 2.968×10^4 nanotesla respectively. So, it concludes the relationship between the pulse width and the created magnetic field was obtained is linear and correct. Since the graphs of the orbit of the RAAVANA – 1 satellite are presenting accurate information, this method can be used to calculate the Longitude, the Latitude and the Altitude for any TLE of any CubeSats at any time. It was found that the total EMF of this orbit ranges from 2.103×10^4 to 4.419×10^4 nanotesla. The previous studies on EMF show it varies from

the average of 2.5×10^4 to 6.5×10^4 nanotesla [3]. So, the resultant magnetic field is almost exactly within the limits. The slight changes might have occurred because of the devices, equipment around due to lack of proper experimental facility of a cleanroom. By calculating the magnetic field experienced by a CubeSat in the orbit using the implemented algorithm by reading a TLE dataset can be concluded as a suitable modelling method for the Helmholtz cage. Therefore, this whole process will be able to implement as an emulating the magnetic fields experienced by CubeSats in their orbits utilizing a Helmholtz cage for ground testing of the ADCS of Nanosatellites.

Acknowledgment

References

Theoret, N. (2016). *Attitude Determination Control Testing System (Helmholtz Cage and Air Bearing).* http://scholarworks.wmich.edu/honors_theses/2783%0AThis

Regulinski, T. L. (1962). The Air Force Institute of Technology. *IRE Transactions on Education*, 5(2), 117–118. https://doi.org/10.1109/TE.1962.4322266

Chulliat, A., W. Brown, P. Alken, S. Macmillan, M. Nair, C. Beggan, A. Woods, B. Hamilton, B. Meyer and R. Redmon, 2019. *Out-of-Cycle Update of the US/UK World Magnetic Model for 2015-2020: Technical Note, National Centers for Environmental Information, NOAA*. doi:10.25921/xhr3-0t19

Want, P., Shtessel, Y., Wang, Y. (1998). *"Satellite Attitude Control Using only Magetorquers"*. University of Alabama. IEEE. p. 500-504.

Mahavarkar, Prasanna & John, Jacob & Dhapre, Vijay & Dongre, Varun & Labde, Sachin. (2018). *Tri-axial square Helmholtz coil system at the Alibag Magnetic Observatory: Upgraded to a magnetic sensor calibration facility. Geoscientific Instrumentation, Methods and Data Systems.* 7. 143-149. 10.5194/gi-7-143-2018.

Pastena, M., Grassi, M. (2002). *"Optimum Design of a Three-Axis Magnetic Field Simulator"*. University of Naples. IEEE Transactions on Aerospace and Electronic Systems, Vol. 38, No. 2

Cayo, Eber & Pareja, Josue & Ramos Arapa, Patricio. (2019). *Design and implementation of a geomagnetic field simulator for small satellites.*

Rogers L., (2008). *It's ONLY Rocket Science, An Introduction in Plain English*. New York. Springer.

Chatters E.P., Eberhardt B., & Warner M. S., (2009). *Orbital Mechanics.* Air University Press.

P. C. Hughes (2012). *Spacecraft Attitude Dynamics.* Mineola, N.Y.: Dover Publications.

Conference Paper No: PF-04

Current density dependent removal of aqueous Cr(VI) by electrocoagulation

D. S. Chandima and A. M. C. Herath*

Department of Chemical Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka
ajithch037@gmail.com*

Abstract

Electrocoagulation (EC) is a proven green technology for the remediation of potentially toxic metalloids and metal ions contaminated water and waste water. The EC performance was carried out on a laboratory scale batch mode reactor using Al as anode and cathode for the removal of 5 ppm of Cr(VI) in synthetic water prepared with 150 ppm of Ca^{2+}, 50 ppm of Mg^{2+} and 5 ppm of F^- ions. The results showed that the removal efficiency of Cr(VI) increases with increasing both electrocoagulation time and the current density. At current densities, 4 mA/cm^2, 2 mA/cm^2 and 1 mA/cm^2, removal efficiencies were 98%, 93% and 48% respectively after 140 minutes at initial pH of 6.0. Energy consumption of EC process was found to be 6.57 kWh/m^3, 1.84 kW h/m^3, and 0.56 kW h/m^3 in the same order of decrease in current densities. The EC process gives promising results towards the removal of Cr(VI) at a low consumption of energy, making the process attainable and possible to scale up.

Keywords: Electrocoagulation, Batch-mode reactor, Al electrodes, Cr(VI) removal, Energy consumption

Introduction

The contamination of ground water by heavy metals has become a world-wide problem due to their harmful effects on human, aquatic and other terrestrial life in the environment. Among the causative hazardous heavy metal, chromium is considered to be of higher priority due to its toxicity. Chromium species could enter the environment from both natural and anthropogenic sources (Gallios, 2007, Deng et al., 1996) and exists in the environment in two main oxidation states as hexavalent chromium, Cr(VI) and trivalent chromium, Cr(III) (Krishnani, et al,. 2006). Cr(VI) is well pronounced as carcinogenic and mutagenic agent while Cr(III) at very low levels is an essential element in humans which is less toxic (Hu et al., 2009). Cr(VI) is abundantly used in chemical, refractory and metallurgical industries and discharged from the effluents of chromium smelting and mining, chrome plating, dyeing and leather, etc. (Zhang et al., 2018, Bhatti et al., 2009).

Speciation of Cr in water depends on initial concentration and pH. $Cr_2O_7^{2-}$ is the most predominant species of Cr(VI) at pH 6.0 and at high Cr concentration while at pH 2.0 - 4.0, Cr(VI) exist as $HCrO_4^-$. At pH higher than 6.0, CrO_4^{2-} is the predominant form. Due to toxicity of Cr(VI), maximum allowed total chromium concentration level in drinking water, has been announced as 0.1 mg/L by EPA (Environmental Protection Agency) (Hu et al., 2009). The most common approach for the removal of Cr(VI) is treating under alkaline conditions (Bhatti et al., 2009). Adsorption, ultrafiltration, ion exchange, reverse osmosis, membrane separation, electro dialysis, and electrochemical treatment are the other viable technologies demonstrated for efficient removal of Cr(VI) (Hu et al., 2009,

Zhang et al., 2018, Bhatti et al., 2009, Golder, et al., 2007). All these methods require multi-step process and a post-treatment for promising results (Hernández, et al., 2012).
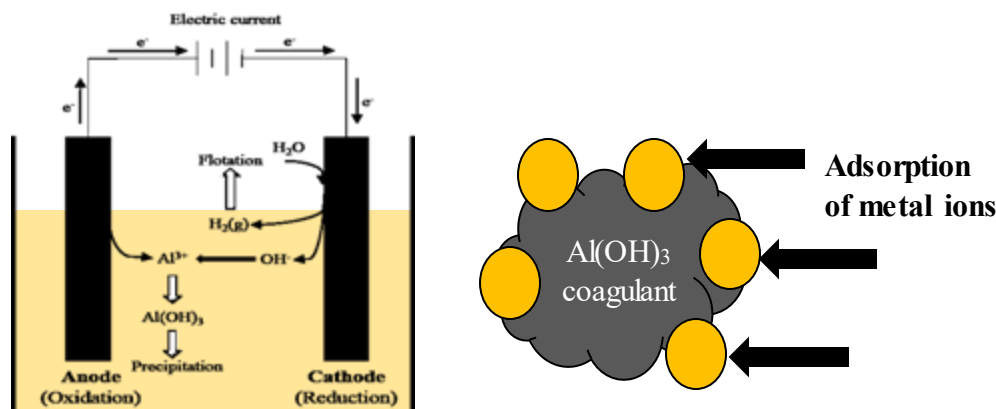
Figure 1. Insitu generation of Aluminium hydroxide during electrocoagulation process.

Electrocoagulation (EC) is a proven low cost and an effective technology for the removal of hardness, fluoride and heavy metals in contaminated water at a practically higher efficiency (Radjenovic et al., 2015). EC is based on the generation of coagulant species in situ by electro oxidation of sacrificial anode materials, Al/Fe triggered by electric current applied through the electrodes (Jean, et al., 2017). The metal ions generated by electrochemical dissolution of the anode spontaneously undergo hydrolysis in water. Depending on the pH, various coagulant species including monomeric and polymeric aluminum hydroxides with different compositions are formed and are capable of removing pollutants by adsorption/settling mechanism (Gomesa et al., 2007).

EC process offers many advantages such as easy construction and operation, removes a variety of pollutants, no need for controlling pH, free of hazardous chemicals, low sludge production and the sludge produced is more acid-resistant, more stable and can be separated easily through filtration (Hernández et al., 2012).

Methodology/materials and methods

A batch type reactor was designed and fabricated using 4 mm acrylic sheet with an area of 8 cm×8 cm and a height of 35 cm. Aluminium electrodes were used as sacrificial electrodes, arranged in monopolar configuration. Two electrodes were positioned vertically with spaces of 10 mm. The plates have rectangular geometry with the dimensions 75 mm×200 mm×4 mm. The total effective surface area of an electrode immersed in synthetic water was 150 cm^2. The electrodes were connected to a direct current power supply providing voltage in the range of 0-30 V (TENMA 72-2930) and electrical current in the range of 0-6 A. During the EC process, contaminant solution was agitated continuously using magnetic stirrer (AREC f20510011) with rotational speed of about 600 rpm.

All chemicals used in the study were analytical grade and procured from Sigma Aldrich and were used as received. For ICP-MS analysis, traceable grade nitric acid was used in sample preparation. Cr(VI) solution was prepared from stock solution of (500 ppm) of $K_2Cr_2O_7$. Synthetic water was prepared using deionized water, and the composition of the ions present in synthetic water was 150 ppm Ca^{2+} ions, 50 ppm Mg^{2+} ions and 5 ppm F^- ions. Electrolysis was carried out using a batch mode reactor containing 1.5 L of the synthetic water spiked with 5 ppm chromium solution. Before each experiment each

electrode surface was mechanically polished with sand paper, soaked in 15% HNO_3 and rinsed with distilled water to ensure the surface reproducibility. Electrocoagulation was carried out for 180 minutes under three current densities 4 mA/cm^2, $2mA/cm^2$ and $1mA/cm^2$ for the electrochemical removal of hexavalent chromium. Samples were withdrawn in each and every 10 minutes and filtered using syringe filters (0.45 μm pore size) and analyzed by ICP-MS (Perkin-Elmer Nexion 2000). The initial conductivity of the solution was around 900 μs/cm. The change in pH and conductivity was monitored throughout the process using a multiparameter analyzer (HANNA HI5522-02). Analysis was carried out in triplicates to minimize standard errors of the experiments.

Results and Discussion

Current density is the key parameter which determines the rate at which electrocoagulant is injected to the solution and has a significant impact on chromium removal efficiency. To investigate the effect of current density, a series of experiments was carried out at pH 6.0 followed by three current densities 4 mA/cm^2, 2 mA/cm^2 and $1mA/cm^2$. The removal efficiencies of chromium were 98%, 93% and 48% respectively after 140 minutes of EC process.

The removal percentage (%) of chromium was calculated by using the following equation:

$$Removal\ \% = \frac{C_0 - C_e}{C_0} \times 100\%$$

Where C_0 is the initial concentration of Cr(VI) and C_e is the equilibrium concentration of Cr(VI) in supernatant (Hu et al., 2009).

Figure 2. *Effect of current density on Cr(VI) removal from its initial concentration of 5 ppm during the electrocoagulation process at pH 6.0*

$$Wc = \frac{I \times M \times t}{Z \times F}$$

Where Wc is the weight of Al released from the electrode, I is the current in A, t is the time (s), M is the atomic weight, Z is the charge involved for the generation of Al^{3+} and F is the Faradays constant (96485.3 C/mol) (Vasudevan et al., 2010). The amount of chromium adsorption increases with the increase of adsorbent concentration as

determined ,0.91 kg/m^3, 0.45 kg/m^3, and 0.23 kg/m^3 followed by the current densities 4 mA/cm^2, 2 mA/cm^2 and 1mA/cm^2 respectively, which indicates that the increased amount of colloidal Al(OH)$_3$ provides more adsorption sites for chromium adsorption.

Table 1. *Weight of different Al species generated during the EC process*

Current density (mA/cm^2)	Applied current (A)	Weight of Aluminium generated during EC (g)	Weight of adsorbent (Al(OH)$_3$) generated during EC (g)	Residual Al in the solution (g/L)	Dry weight of the sludge produced (g)
4	0.60	0.46	1.35	0.014	1.67
2	0.30	0.23	0.67	0.010	0.83
1	0.15	0.11	0.33	0.008	-

Table 1 shows the theoretical yield of Al released and Al(OH)$_3$ formed during EC process at different current densities. The experimental measured value of residual Al in the solution increases with increase in current density. The dry weight of sludge measured (1.67 g) at the highest current density is higher than the calculated amount of Al(OH)$_3$ (1.35 g) due to association of additional weights from CaCO$_3$, Mg(OH)$_2$, chromium and fluoride.
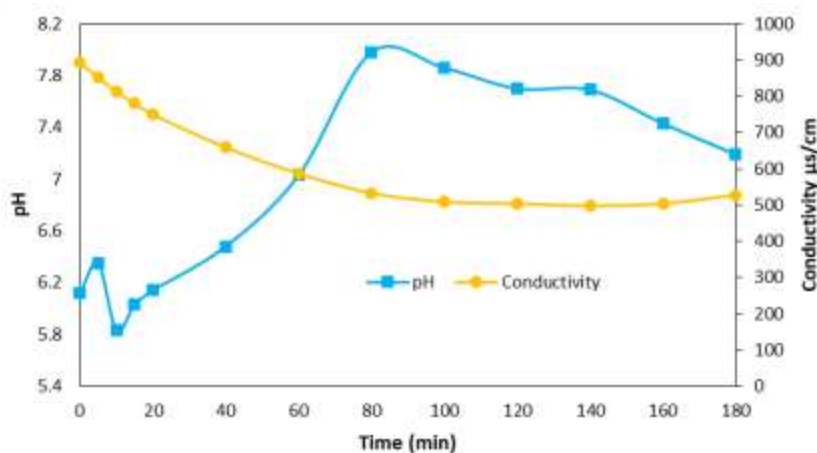
Figure 3. *Conductivity and pH variation of Cr(VI) removal from its initial concentration of 5 ppm during the EC process at pH 6.0 at current density 4 mA/cm^2*

The same trend of slow decrease in conductivity during EC process was noticed at three different current densities (Fig. 3-5). This variation is attributed to removal of Ca^{2+}, Mg^{2+} and F$^-$ and Cr(VI) ions as insoluble colloidal form of Aluminium hydroxide. A distinct pH variation with time at the lowest current density of 1 mA/cm^2 compared to that of at two higher current densities (Fig. 3-5) was observed.
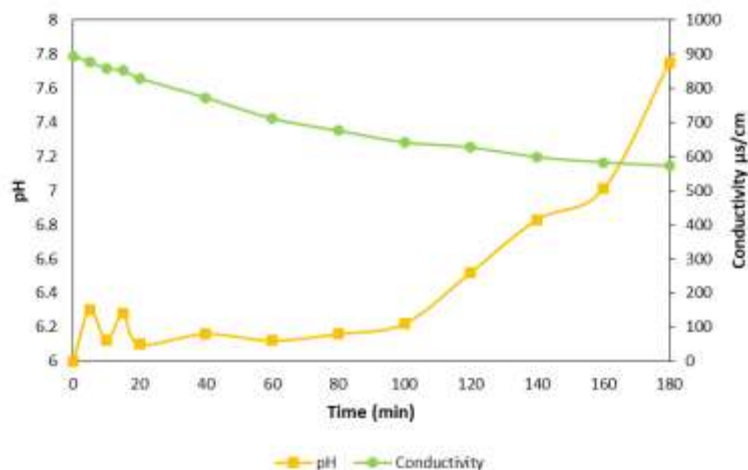
Figure 4. *Conductivity and pH variation of Cr(VI) removal from its initial concentration of 5 ppm during the EC process at pH 6.0 at current density 2 mA/cm^2*
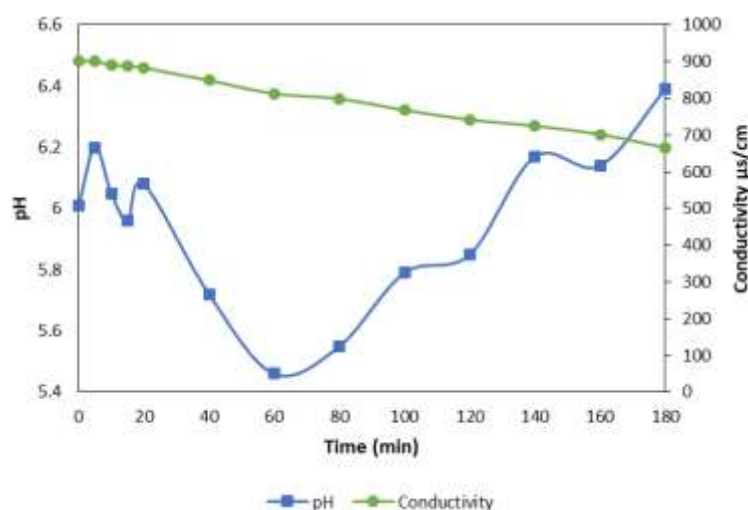
Figure 5. *Conductivity and pH variation of Cr(VI) removal from its initial concentration of 5 ppm during the EC process at pH 6.0 at current density 1 mA/cm^2*

The decrease in pH at the lowest current density (Fig. 5) during the initial stage of the EC process could be attributed to generation of H$^+$ ions due to water oxidation at the anode. The subsequent increase in pH with time at high current density during EC process is attributed to higher rate of formation of hydroxyl ions at the cathode but the concentration is regulated as hydroxides are removed as insoluble $Mg(OH)_2$ and $CaCO_3$ and $Al(OH)_3$.

In electrochemical technology energy consumption is one of the most important factor to be considered (Jung, et al., 2015). Energy consumption (E) (Ghosh, et al., 2011; Un et al., 2013, Hashim, et al., 2017) during the EC process was calculated by the following equation 3:

$$E = \frac{I \times V \times t}{Vol.}$$

Where E is the electrical energy consumption (kW h/m^3), I is the current (A), V is the potential (V), t is the electrolysis time (seconds), and Vol. is the volume of solution (m^3).

174

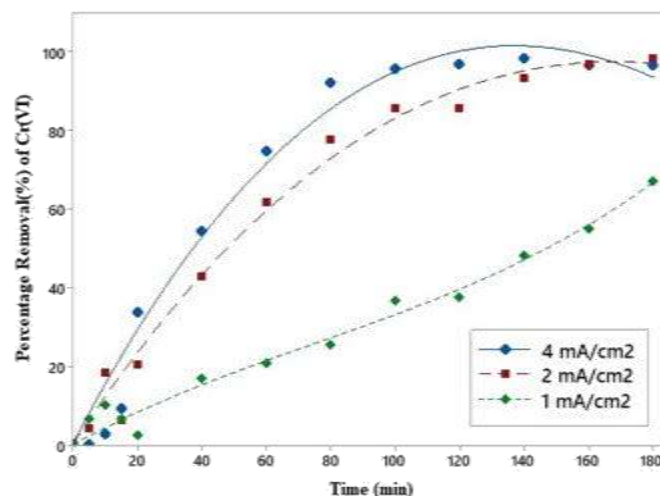**Table 2.** *Energy consumption of energy on Cr(VI) removal from its initial concentration of 5 ppm during the electrocoagulation process at pH 6.0*

Current density (mA/cm^2)	Applied current (A)	Applied potential (V)	Energy Consumption (kW h/m^3)	Energy Consumption ratio
4	0.60	5.47	6.57	3.57
2	0.30	3.07	1.84	3.28
1	0.15	2.37	0.56	1.00

Energy consumption values tabulated in Table 2, depicts that the energy consumption is directly proportional to the applied current and when the applied current was doubled energy consumption increased more than 3 times of the lowest current density.

Conclusion

The results show that Cr(VI) can be removed with 98% efficiency at the current density of 4 mA/cm^2 after 140 minutes of the EC process. When the applied current density is increased more adsorbent with more binding sites to Cr(VI) is generated causing highest removal of Cr(VI). Low energy consumption makes the electrocoagulation process economically viable for applications in contaminant removal from water.

Acknowledgment

Reference

Gallios, G. P., &Vaclavikova, M. (2007). *Removal of chromium (VI) from water streams: a thermodynamic study. Environmental Chemistry Letters,* 6(4), 235–240. https://link.springer.com/article/10.1007/s10311-007-0128-8

Hu, J., Wang, S.W., Shao, D.D., Dong, Y.H., Li, J.X., Wang, X.K., (2009). *Adsorption and Reduction of Chromium(VI) from Aqueous Solution by Multiwalled Carbon Nanotubes. The Open Environmental Pollution & Toxicology Journal,* 1: 66-73. https://benthamopen.com/ABSTRACT/TOEPTJ-1-66/ 10.2174/1876397900901010066

Zhang, X., Fu, W., Yin, Y., Chen, Z., Qiu, R., Simonnot, M.-O., & Wang, X. (2018). *Adsorption-reduction removal of Cr(VI) by tobacco petiole pyrolyticbiochar: Batch experiment, kinetic and mechanism studies. Bioresource Technology,* 268, 149–157. https://doi.org/10.1016/j.biortech.2018.07.125

Bhatti, M. S., Reddy, A. S., & Thukral, A. K. (2009). *Electrocoagulation removal of Cr(VI) from simulated wastewater using response surface methodology. Journal of Hazardous Materials,* 172(2-3), 839–846. https://doi.org/10.1016/j.jhazmat.2009.07.072

Hernández, M. C., Barletta, L., Dogliotti, M. B., Russo, N., Fino, D., & Spinelli, P., (2012). *Heavy metal removal by means of electrocoagulation using aluminum electrodes for drinking water purification, Journal of Applied Electrochemistry volume 42, pages809–817.* https://link.springer.com/article/10.1007%2Fs10800-012-0455-8

Radjenovic, J., David L. Sedlak, (2015). *Challenges and Opportunities for Electrochemical Processes as Next-Generation Technologies for the Treatment of Contaminated Water, Environ. Sci. Technol,* 49 11292−11302. https://doi.org/10.1021/acs.est.5b02414

Jewel A.G. Gomes, Praveen Daida a, Mehmet Kesmez a, Michael Weir a, Hector Morenoa, Jose R. Parga, George Irwin, HyltonMcWhinney , Tony Grady , Eric Peterson , David L. Cocke, (2007*). Arsenic removal by electrocoagulation using combined Al–Fe electrode system and characterization of products, Journal of Hazardous Materials* B139 220–231. https://doi.org/10.1016/j.jhazmat.2005.11.108

Vasudevan, S., Lakshmi, J., & Sozhan, G. (2010). *Studies on the Removal of Arsenate by Electrochemical Coagulation Using Aluminum Alloy Anode. CLEAN - Soil, Air, Water,* 38(5-6), 506–515. https://doi.org/10.1002/clen.201000001

Hashim, K. S., Shaw, A., Al Khaddar, R., Pedrola, M. O., & Phipps, D. (2017). *Iron removal, energy consumption and operating cost of electrocoagulation of drinking water using a new flow column reactor. Journal of Environmental Management,* 189, 98–108. http://dx.doi.org/10.1016/j.jenvman.2016.12.035

Deng Y, Stjerntrom M, Banwart S (1996) *Accumulation and remobilization of aqueous chromium(VI) at iron oxide surfaces: application of thin-film continuous flow-through reactor. J Con-tam Hydrol* 21:141–151. https://doi.org/10.1016/0169-7722(95)00039-9

Krishnani, K.K., Ayyappan,*S., (2006)Heavy metals remediation of water using plants and lignocellulosicagrowastes, Rev. Environ. Contam. Toxicol.* 188 59–84. https://link.springer.com/chapter/10.1007/978-0-387-32964-2_2

NepoHakizimana J.N., BouchaibGourich, Chafi,M., Stiriba,Y., Vial,C., Drogui, P., Naja,J.,(2017) *Electrocoagulation process in water treatment: A review of electrocoagulation modeling approaches, Desalination* 404 1–21. https://doi.org/10.1016/j.desal.2016.10.011

Vasudevan,S., Lakshmi, J., Sozhan,G., (2009).*Studies on the Removal of Iron from Drinking Water by Electrocoagulation – A Clean Process, Clean,* 37, 45. https://doi.org/10.1002/clen.200800175

Jung, Y., Yoon, Y., Kwon, M., Roh, S., Hwang, T.-M., & Kang, J.-W. (2015). *Evaluation of energy consumption for effective seawater electrolysis based on the electrodes and salinity. Desalination and Water Treatment,* 57(22), 10136–10145. https://doi.org/10.1080/19443994.2015.1040272

Golder, A., samanta, A., & ray, S. (2007). *Removal of trivalent chromium by electrocoagulation. Separation and Purification Technology,* 53(1), 33–41. https://doi.org/10.1016/j.seppur.2006.06.010

Conference Paper No: PF-05

Mobile learning application usability: A pattern mining approach

D. D. M. Dolawattha[1*] and H. K. S. Premadasa[2]

[1]Department of Geography, Faulty of Social Sciences, University of Kelaniya, Sri Lanka
[2]Centre for Computer Studies, Sabaragamuwa University of Sri Lanka
ddmd@kln.ac.lk*

Abstract

User satisfaction is very important for mobile learning applications to provide the maximum academic outcome. Hence evaluating mobile learning systems is important to test their usability. Most of the previous studies used statistical approaches to test the usability of learning systems. The main objective of this study is to evaluate the usability of the mobile learning system using a data science approach. To evaluate the proposed mobile learning system, responses for a questionnaire were obtained from 100 system users After applying several preprocessing steps, the responses were evaluated using two pattern mining algorithms: Apriori and FP-Growth. According to the results, the Apriori algorithm shows 94% system usability while the FP-Growth algorithm ensures 93% system usability. It confirms the proposed mobile learning system's usability. Furthermore, it was observed that this pattern mining-based approach can be successfully applied in usability evaluation for learning systems.

Keywords: M-learning apps, M-Learning, Pattern mining, System evaluation, Usability

Introduction

Mobile learning (ML) can be defined as a learning mechanism that uses diverse learning contexts with social collaborations and interactions through personalized handheld equipment such as smartphones, tab devices, other portable mobile devices comprise computing capabilities. Further, it offers academic services free from time, place, and supports on-the-go learning and context-aware learning (Grant, 2019). ML provides better options for learners with busy lifestyles. Further, it provides learners, a secure learning environment in pandemic situations restricting them to an isolated atmosphere. However, for successful ML, various conditions needs to be satisfied, such as quality of the content, technology awareness, devices capable of learning, secure learning environment (Nagahawatta, Warren, & Yeoh, 2020), robust and reasonable connecting facilities, adequate and satisfactory mobile applications for learning, etc. The usability of a mobile application decides whether it supports adequate and satisfactory learning services to stakeholders. Therefore, usability evaluation is important for any learning system to get maximum yield from it.

System usability

The best usability evaluation factors in previous researches related to usability evaluation are efficiency, effectiveness, learnability, and user satisfaction. Further, it reveals that most usability evaluations are done with the system implementation (Mkpojiogu, Hussain, & Hassan, 2018). In another study, a systematic literature review on the usability of ML applications identified that the highest priority usability attribute is learnability while user satisfaction, usefulness, and ease of use are the next important usability attributes with equal significance. Lab-based quantitative and qualitative research methodologies were selected in the most number of researches (Kumar & Mohite, 2018). In previous studies, usability evaluation of e-learning and learning management system (LMS) can be found. An e-learning system designed to meet someone's requirements was tested for usability using 62 computer science students with a four-dimensional usability questionnaire consists usefulness, ease of use, ease of learning, and satisfaction. The evaluation confirmed the usability of the system in every dimension is satisfactory. Further, it reveals that the usefulness, ease of use, and ease of learning equally impact learner's gratification about the system (Hariyanto, Triyono, & Köhler, 2020). In another study, the user experience-based automated metrics were proposed to assess the e-Learning system usability for educators to utilize the automated systems in academic institutions with satisfaction (Harrati, Bouchrika, Tari, & Ladjailia, 2016). A study was conducted to evaluate the accessibility and usability of the instance of a popular institutional LMS. Questionnaire-based evaluation focus on interface, navigations, and easy-to-use facilities of the system. The study guaranteed the usability of the system while it recommended enhancing the system to adhere to educator requirements for pursuing academic services (Alturki, Aldraiweesh, & Kinshuck, 2016). On the other hand, various usability assessment guidelines and frameworks can be found in previous studies. Prevailing usability issues were identified using the previous usability guidelines. New solutions for those gaps are forwarded by introducing novel usability guidelines. The methods to apply these guidelines to mobile learning applications (MLA)s are also proposed. The quantitative evaluation techniques reveal the 81% confirmation by the participant for success in usability improvement in MLAs with proposed guidelines (Hujainah, et al., 2016). Usability evaluation of MLAs while conducting agile software development methodology is proposed. The evaluation recommends this approach as best suitable for experienced developers to conduct usability assessments in MLAs than field studies (Hussain, Saleh, Taher, Ahmed, & Lammasha, 2015). Research is carried out to evaluate the usability of MLA with 105 academic users. A quantitative survey reveals no question of the academic transactions and navigation of the app, but attractiveness is required to improve (Kuhnel, Seiler, Honal, & Ifenthaler, 2018). Augmented reality and gamification features integrated MLA in an outdoor learning environment was tested for usability. 70 students participated in the evaluation while quantitative and qualitative statistical analysis techniques were employed with system usability scales in the study. Students show eagerness to use the system with more than 70 percent system usability (Pombo & Marques, 2018).

Objectives of the study

The main objective of this study is to evaluate the mobile learning system (MLS) for usability. According to the literature, most studies use quantitative and qualitative based statistical analysis to evaluate the usability of learning systems. There is no evidence of using machine learning-based data mining approaches to evaluate usability in MLSs. To

address this research gap authors proposed a pattern mining-based approach for evaluating the usability of the MLS.

Methodology/materials and methods

Mobile learning application

In this study, we evaluate the usability of the mobile MLA which is developed to utilize ML in Sri Lankan higher education. MLA is developed by customizing the Moodle mobile application (MMA). MMA is a platform-specific native app that has separate versions for android and iOS operating systems. Cordova/PhoneGap mobile application development framework with HTML, PHP, JavaScript, and ionic technologies are used to develop the MMA. Functionalities such as content upload, content creation, chat, notes, forum, quizzes, etc. are implemented using plugins (Dougiamas, 2021) and in this study, authors develop new plugins to implement new functionalities in the Moodle ML environment such as Annotate PDF, Checklist, Hot Question, and Game (Dolawattha, Pramadasa, & Jayaweera, 2019).

System usability scale (SUS)

System usability is done using various methods such as questionnaires, expert evaluation, and automated systems. SUS questionnaires are the extensively used method to examine the usability of a system. In this study positive version of the standard SUS with 5 points Likert scale was used (Lewis, 2018).

Table 1. The system usability scale positive version

Que. No	Question
01	I think that I would like to use the mobile application (MA) frequently
02	I found the MA to be simple
03	I thought the MA easy to use
04	I think that I could use the MA without the support of a technical person
05	I found the various functions in the MA were well-integrated
06	I thought there was a lot of consistency in the MA
07	I would imagine that most people would learn to use the MA very quickly
08	I found the MA very intuitive
09	I felt very confident using the MA
10	I could use the MA without having to learn anything new

Pattern mining algorithms

In this study authors used two popular pattern mining algorithms to evaluate the usability of MLS.

Apriori Algorithm: Latin term "Apriori" means "from what comes before". In this algorithm, Bottom-up and breadth-first search strategies are considered. Agarwal and Srikant (1994) coined the Apriori algorithm based on frequent pattern mining for generating associate rules. Min_supp, Min_conf, Frequent itemsets, Apriori Property, Join Operation, Join Step, and Prune Step are the main terms associate with the Apriori algorithm (Suresh & Ramanjaneyulu, 2013).

Frequent Pattern (FP) Growth Algorithm: Another most prevailing pattern mining algorithm used in data mining and FP-tree is used to store frequent patterns. Calculating each database item's support count by scanning, deleting irregular patterns, and order remains are the main steps in this algorithm. Then frequent patterns are generated using FP-tree (Pei & Han, 2000). The efficiency of the algorithm is high as it scans the database only twice. It doesn't generate a candidate set and not suitable for mining patterns in online databases (Nasreen, Azam, Shehzad, Naeem, & Ghazanfar, 2014).

Definition for support threshold in pattern mining: The support of an itemset I is defined as the fraction of the transactions in the database $T=\{T_1, \dots, T_n\}$ that contain I as a subset (Pei & Han, 2000).

Methodology

In this study, 100 learners study in the faculty of Social Sciences were participated. First, they were allowed to do academic activities such as access academic content, take quizzes, submit assignments, access forums, access chatting, and collaborative learning. Finally, they were asked to respond to the usability questionnaire. The questionnaire responses are based on the 5 points Likert scale. Likert scale values are 1 for strongly disagree, 2 for disagree, 3 for neutral, 4 for agree, and 5 for strongly agree. Then few preprocessing steps were done on questionnaire responses and converted to a dataset suitable for mining patterns and discover the information about the system usability. When creating the dataset, each question (Q1 to Q10) can be taken as an attribute in each transaction whose response Likert scale value greater than or equal to 4. Therefore, dataset items are the question numbers whose response value is equal to 4 or 5 (see Figure 1). Finally, the dataset was evaluated for the usability of the MLA with Apriori and FP-Growth algorithms.
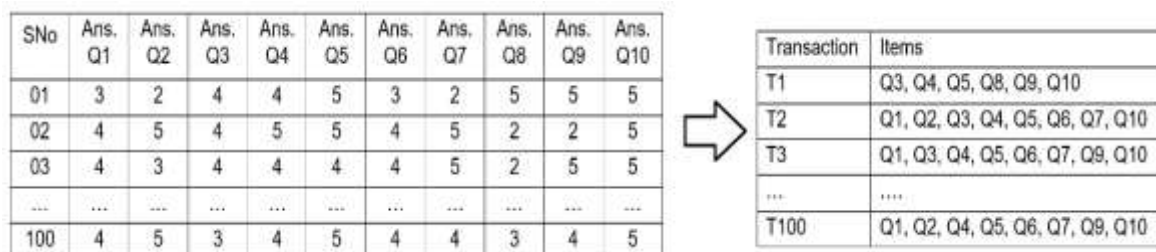
Figure 1. Dataset creation from questionnaire responses

Results and Discussion

Results of Apriori algorithm: The Apriori algorithm was implemented using Python language and web-based Jupiter notebook environment. In this study, the Apriori model was built using the parameters such as min_support=0.5, min_confidence=0.0, min_lift=0.0 to control the association rules. These parameters were selected to have the popularity of a itemset is atleast 50%. Under these conditions, 175 association rules were generated and 12 best rules were selected for describing the usability of the MLA. When selecting these rules, items sets with maximum number of attributes were considered. Also authors limited the itemset with atleaset 5 items to represent atleast harlf attributes of a user response marked as 'agree' or 'strongly agree'.

Table 2*. Apriori algorithm results*

Rule No	Item set	Support
150	'Q1', 'Q4', 'Q5', 'Q6', 'Q7',	90%
154	'Q1', 'Q5', 'Q6', 'Q7', 'Q9',	87%
155	'Q4', 'Q5', 'Q6', 'Q7', 'Q10',	53%
163	'Q3', 'Q4', 'Q5', 'Q7', 'Q9',	51%
165	'Q3', 'Q5', 'Q6', 'Q7', 'Q9',	50%
166	'Q4', 'Q5', 'Q6', 'Q7', 'Q9',	94%
167	'Q1', 'Q3', 'Q4', 'Q5', 'Q6', 'Q7',	53%
171	'Q1', 'Q3', 'Q5', 'Q6', 'Q7', 'Q9',	50%
172	'Q1', 'Q4', 'Q5', 'Q6', 'Q7', 'Q9',	87%
173	'Q4', 'Q5', 'Q6', 'Q7', 'Q9', 'Q10',	50%
174	'Q3', 'Q4', 'Q5', 'Q6', 'Q7', 'Q9',	50%
175	'Q1', 'Q3', 'Q4', 'Q5', 'Q6' ,'Q7', 'Q9',	50%

According to the above results, rule no 175 ensures 50% learner-responses marked as 'Agree' or 'Strongly agree' for 7 out of 10 usability questions in the questionnaire. Also, rule no 172 secures 87% learner-responses marked as 'Agree' or 'Strongly Agree' for 6 out of 10 questions in the questionnaire. Rule no 166 secures 94% learner-responses marked as 'Agree' or 'Strongly Agree' for 5 out of 10 questions in the questionnaire. Therefore, as per the definition of support threshold in pattern mining, the most number of respondents responded to the questionnaire as at least 'Agree'. Hence according to the Apriori algorithm, it can be predicted that the proposed MLA is useable.

Results of FP-Growth algorithm: The FP-Growth algorithm implemented using the same technologies and environment with the dataset. Three types of best patterns were selected using the results of FP-Growth algorithm implementation.

Table 3*. FP-Growth algorithm results*

Pattern description	Min. Support	Min. Confidence	Number of Patterns
7-itemset (7 feature items patterns)	50%	50%	8
6-itemset (6 feature items patterns)	86%	50%	7
5-itemset (5 feature items patterns)	93%	50%	6

According to the FP-Growth algorithm pattern mining results, there are eight patterns with 'Agree' or 'Strongly Agree' responses for seven questionnaire items in 50% learner-responses. Also, there are seven patterns with 'Agree' or 'Strongly Agree' responses for six questionnaire items in 80% learner-responses. There are six patterns with 'Agree' or 'Strongly Agree' responses for five questionnaire items in 93% learner-responses. Therefore, as per the definition of support threshold in pattern mining, it can be assumed that the most of respondents marked the questionnaire items as at least 'Agree'. Hence the study grantees the MLA as usable.

Conclusion

The usability of a mobile learning system is very important for users to pursue academic activities as a learning medium. In this study usability of the mobile learning system was

evaluated through well-established pattern mining algorithms such as Apriori and FP-Growth. Exactly 100 learners participated in the usability questionnaire after allowing them to use the system for an adequate time. According to the results, the Apriori pattern mining algorithm secured 94% system usability while the FP-Growth algorithm granted 93% system usability for the mobile learning system. On the other hand, the study proves the ability to use pattern mining approaches for assessing the usability of learning systems effectively.

References

Ali, A., Alrasheedi, M., Ouda, A., & Capretz, L. F. (2014). A study of the interface usability issues of mobile learning applications for smart phones from the users perspective. *International Journal on Integrating Technology in Education (IJITE), 3*(4), 1-16.

Alturki, U. T., Aldraiweesh, A., & Kinshuck. (2016). Evaluating the usability and accessibility of LMS "Blackboard" at King Saud University. *Contemporary Issues in Education Research (CIER), 9*(1), 33-44.

Dolawattha, D., Pramadasa, H. S., & Jayaweera, P. M. (2019). The Impact Model: Teachers' Mobile Learning Adoption in Higher Education. *International Journal of Education and Development using Information and Communication Technology, 15*, 71-88.

Dougiamas, M. (2021, 06 14). *Moodle Mobile Customization - Moodle Docs*. Retrieved 06 14, 2021, from MoodleDocs: https://docs.moodle.org/dev/Moodle_Mobile_Customization

Grant, M. M. (2019). Difficulties in defining mobile learning: Analysis, design characteristics, and implications. *Educational Technology Research & Development, 67*, 361–388.

Hariyanto, D., Triyono, M. B., & Köhler, T. (2020). Usability evaluation of personalized adaptive e-learning system using USE questionnaire. *Knowledge Management & E-Learning, 12*(1), 85–105.

Harrati, N., Bouchrika, I., Tari, A., & Ladjailia, A. (2016). Exploring user satisfaction for e-learning systems via usage-based metrics and system usability scale analysis. *Computers in Human Behavior, 61* , 463-471.

Hujainah, F., Dahlan, H., Al-Haimi, B., Hujainah, A., Al-Bashiri, H., & Abdulgabber, M. A. (2016). New usability guidelines with implementation ways of mobile learning application based on mobile learning usability attributes. *Indian Journal of Science and Technology, 9*(37), 1-10.

Hussain, A., Saleh, A., Taher, A., Ahmed, I., & Lammasha, M. (2015). Usability evaluation method for mobile learning application using agile: A systematic review. *Jurnal Teknologi, 77*(5), 51–56.

Kuhnel, M., Seiler, L., Honal, A., & Ifenthaler, D. (2018). Mobile learning analytics in higher education: usability testing and evaluation of an app prototype. *Interactive Technology and Smart Education, 15*(4), 332-347.

Kumar, B. A., & Mohite, P. (2018). Usability of mobile learning applications: a systematic literature review. *Journal of Computers in Education, 5*(1), 1-17.

Lewis, J. R. (2018). The System Usability Scale: Past, Present, and Future. *International Journal of Human–Computer Interaction, 34*(7), 577-590.

Mkpojiogu, E. O., Hussain, A., & Hassan, F. (2018). A systematic review of usability quality attributes for the evaluation of mobile learning applications for children. *AIP Conference Proceedings 2016.* AIP Publishing LLC.

Nagahawatta, R., Warren, M., & Yeoh, W. (2020). A Study of Cyber Security Issues in Sri Lanka. *International Journal of Cyber Warfare and Terrorism*, 59-72.

Nasreen, S., Azam, M. A., Shehzad, K., Naeem, U., & Ghazanfar, M. A. (2014). Frequent Pattern Mining Algorithms for Finding Associated Frequent Patterns for Data Streams: A Survey. *The 5th International Conference on Emerging Ubiquitous Systems and Pervasive Networks (EUSPN-2014), 37*, pp. 109 – 116.

Pei, J., & Han, J. (2000). Mining Frequent patterns without candidate generation. *SIGMOD'00 Proceedings of the 2000 ACM SIGMOD international conference on Management of data.* New York, NY, USA,.

Pombo, L., & Marques, M. M. (2018). The EduPARK Mobile Augmented Reality Game: Learning Value and Usability. *International Association for Development of the Information Society*.

Suresh, J., & Ramanjaneyulu, T. (2013). Mining Frequent Itemsets Using Apriori Algorithm. *Int. J. Comput. Trends Technol, 4*, 760-764.

Conference Paper No: PF-06

A hybrid model for wind speed prediction in Anuradhapura, Sri Lanka

K. M. Lenora[1*], S. P. Abeysundara[2] and K. Perera[3]

[1]Postgraduate Institute of Science, University of Peradeniya, Sri Lanka
[2]Department of Statistics and Computer Science, Faculty of Science, University of Peradeniya, Sri Lanka
[3]Department of Engineering Mathematics, Faculty of Engineering, University of Peradeniya, Sri Lanka
kushanilenora092@gmail.com*

Abstract

Wind energy plays a major role in a sustainable future as a useful, environmentally friendly energy alternative. Wind speed is the most important parameter in the design and implementation of wind energy. This paper aims to define a methodology capable of providing accurate monthly average wind speed predictions in the Anuradhapura region, Sri Lanka. Hybrid forecasting of time series is considered to be a potentially effective alternative compared with the conventional stand-alone forecasting modeling approaches like seasonal autoregressive integrated moving average (SARIMA) and artificial neural network (ANN). In this study, at first, SARIMA and ANN models are used to separately recognize and forecast the linear and nonlinear components of time series, respectively. Then, the study suggests a hybrid approach combining SARIMA and ANN for forecasting wind speed and its forecasting results are compared with the single SARIMA and ANN models. The mean absolute error (MAE), root mean square error (RMSE), and paired sample *t*-test are used as performance measures. Results obtained by a case study show that the SARIMA-ANN hybrid approach is the most suitable for wind speed forecasting. This approach demonstrates the potential to be applied to wind speed forecasting in other regions of the country.

Keywords: Artificial neural networks (ANN), Hybrid approach, Seasonal autoregressive integrated moving average (SARIMA), Wind speed

Introduction

The wind speed affects decisions related to agriculture, aviation and maritime, constructions, urban air pollution management, and many other important domains. Recently, as **a** renewable energy source, wind energy source has received considerable attention worldwide. Moreover, wind energy plays a major role in a sustainable future as a green energy alternative. Accurate forecasting and estimation of wind speed are more important if wind energy is to reach its full potential**.** However, accurate and reliable wind speed forecasts become a challenging task due to its stochastic, nonlinear**,** random, indeterminant, discontinuous, and fluctuating nature (Xu et al., 2017;Duan & Liu, 2019; Aasim et al., 2019).

In general, statistical methods such as auto regressive moving average (ARMA), auto regressive integrated moving average (ARIMA) and seasonal auto regressive integrated moving average (SARIMA) have been extensively utilized for wind speed prediction (Haddad et al., 2020; Grigonytė, 2021;Torres et al., 2005). However, the major limitation of such models is their ability to capture only the linear form of time series data under the normality, linearity and stationary assumptions.

Artificial neural networks (ANNs) overcome the limitation of ARIMA. The major advantages of neural networks are their nonlinear modeling capability and the fewer number of assumptions on data prior to the model building process. In wind speed literature, the ANNs have been used for forecasting for many years with impressive results, which have proven to be the better approach for wind speed forecasting. For instance, (Li & Shi, 2010) investigated three types of typical ANN, namely, adaptive linear element, back propagation, and radial basis function, for wind speed forecasting. According to the compared results of three types of ANN show that even for the same wind dataset, no single ANN model outperforms others universally in terms of all evaluation metrics.

In order to overcome the limitations of each of these models, a hybrid methodology that includes both linear and nonlinear modelling capabilities can be one of the best approaches. Once the pipeline of the model is properly trained these types of models show optimal forecasting performance (Shi et al., 2012). Two hybrid models; ARIMA with ANN and a Kalman filter (KF) were proposed by (Liu et al., 2012). The results are showed that the hybrid models have superior outcomes than the classical ARIMA model. Moreover, (Shi et al., 2012) proposed two hybrid models, namely, ARIMA-ANN and ARIMA-SVM, for wind speed and power forecasting. The study investigated the applicability of the proposed hybrid models based on wind speed and wind power generation, respectively. The results indicated that the hybrid approaches are viable options for forecasting both wind speed and wind power generation time series.

The major objective of the present study is to propose an accurate and efficient forecast model to predict the future behaviors of wind speed. This is achieved by developing SARIMA models, ANNs and hybrid methods to forecast the wind speed. Finally, based on the most accurate and efficient forecast model will be determined using the model validation and the selection criteria.

This paper is organized as follows. Materials and methods section describe the data set and the theoretical background of the time series forecast models. Results and discussion section discuss the significant results of the data analysis. Finally, conclusions section presents the conclusion of the study.

Methodology and methods

In this study, seasonal autoregressive integrated moving average (SARIMA), artificial neural networks (ANNs) and hybrid method have been used in forecasting monthly wind speed. The methodology for analyzing data consists of the following three steps. which are:

Step 1: Modelling of SARIMA using Box-Jenkins procedure.

Step 2: Modelling of ANNs with three types of input variables, which are based on seasonal and non-seasonal lag orders of SARIMA model.

    a. The inputs based on the order of the SARIMA model
    b. The inputs based on the seasonal lag.
    c. The inputs based on the lag 1 and seasonal lags $\pm$ 1

Step 3: Modelling of SARIMA-ANN hybrid models

Finally, the Root Mean Square Error (RMSE), Mean Absolute Error (MAE) and paired sample t-test are used as performance measures to find the suitable model for forecasting wind speed.

SARIMA model

SARIMA was proposed by box and Jenkins in 1976 as an extension of the well-established ARIMA model (Janacek, 2009). It is a most widely used linear time series forecasting method for univariate time series data that contains trends and seasonality. The $SARIMA(p, d, q)(P, D, Q)_S$ model can be written in the general form as follows:

$$\phi_p(B)\Phi_P B^s(1-B)^d(1-B^s)^D Y_t = \theta_q(B)\Theta_Q(B^s)e_t \quad (1)$$

where B is denoted as the backward shift operator, d and D are denoted as the non-seasonal and seasonal orders of difference respectively, ϕ is the non-seasonal AR polynomial of order p, ϕ is the seasonal AR polynomial of order P, ϕ is the regular MA polynomial of order q, Θ is the seasonal MA polynomial of order Q, Y_t is the observed value at time t and e_t is the residual value at time t.

Based on the Box-Jenkins methodology, the SARIMA approach provides the main four steps of identification, estimation, and validation and prediction (Society, 2016).

ANN model

ANN is a nonlinear model which maps a set of input variables through several layers of processing elements or neurons into a set of output variables (Faraway & Chatfield, 1998). Generally, in a time series modelling ANN input consist of previous value of observations while the output is the observation at time t. The following equation illustrate the relationship between the input variables and output variable in a neural network.

$$y_t = \alpha_0 + \sum_{j=1}^{q} \alpha_j\, g\left(\beta_{0j} + \sum_{i=1}^{p} \beta_{ij}\, y_{t-i}\right) \quad (2)$$

where y_t is the output variable, α_0 is the bias of the hidden layer, α_j is the weights of the hidden layer weight, $g(x)$ is the activation function, β_{0j} input bias, β_{ij} is the input weight and y_{t-i} is the lag input variables.

Hybrid (SARIMA-ANN) model

The SARIMA and ANNs both have their own strength to analyze their own pattern data, where SARIMA is suitable for linear pattern while ANNs are suitable for nonlinear pattern. (Zhang, 2003) has developed a hybrid approach that is described under the two phases based on their linear and non-linear behaviors. According to Zhang's hybrid methodology, time series Y_t can be defined as,

$$Y_t = L_t + N_t \quad (3)$$

where Y_t is the time series observation at time t, L_t is the linear component of the time series, N_t is the non-linear component of the time series. The hybrid approach consists of two steps. First, the SARIMA approach is mainly used to analyze the linear component of the time series. Then we assume that the residual from the linear model will contain

only the non-linear behavior of the time series. Next, the ANN-based approach was applied to capture the nonlinear component of the series. The forecasted value of the hybrid model is the sum of the forecasted value of the SARIMA and the ANN models.

Data

The data employed in this study were collected from the Department of Meteorology, Colombo, and represent the monthly average wind speed in Anuradhapura region from January 1995 through December 2019.

Results and discussion

The time series plot of the original observations for the period 1995-2019 is shown in Figure 1. As an initial step of the study, Box-Jenkins procedure is applied to find the suitable SARIMA model for the time series. The results suggested that, $SARIMA\ (1,0,2) \times (1,1,2)_{12}$, with AIC value of 808.319 is the most suitable model for forecasting time series

.
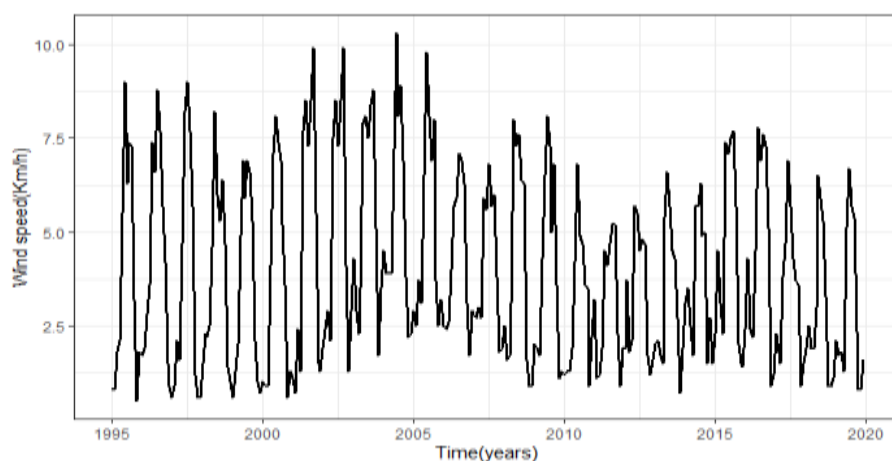
Figure 1. *Time Series plot for Monthly wind speed figures from period 1995-2019*

After selecting the best model, diagnostic checking was carried out. Jarque-Bera test was used to check normality, Ljung-Box test was used to check the autocorrelation and heteroskedasticity ARCH test was used to check for ARCH effect. The Jarque-Bera test results indicated that, the residuals are normally distributed (p-value = 0.124). Ljung–Box test for autocorrelation up to the maximum lag order of 48 was 29.1 at the p-value of 0.36. Test results concluded that the residual has no autocorrelation. Furthermore, the Heteroskedasticity ARCH test results indicated that the model hasn't an ARCH effect (p-value = 0.408)

Next, an ANN with three types of input nodes based on SARIMA and single hidden layer with up to 10 hidden nodes is fitted.

Table 1. *Model accuracy measures for wind speed data*

Models	RMSE	MAE
$SARIMA$ $(1,0,2) \times (1,1,2)_{12}$	0.5894	0.4808
ANN		
All Lags	0.7855	0.5179
Seasonal Lags 12,24	0.5575	0.4630
Lag 1 with seasonal Lag $\pm$ 1	1.4170	1.0733
Hybrid		
All Lags	0.5102	0.4271
Seasonal Lags 12,24	0.4680	0.3481
Lag 1 with seasonal Lag $\pm$ 1	0.5595	0.4900

The fitted model is used to forecast the wind speed using hybrid methodology and the corresponding results are summarized in Table I. According to the error analysis results, the proposed SARIMA-ANN hybrid model is the most suitable model with the lowest RMSE error. Moreover, MAE that the hybrid model is more significant than stand-alone SARIMA and ANN models for the speed forecasting.

In terms of RMSE, the percentage decrements of the hybrid model over the SARIMA and ANN are 20.59% and 16.05%, respectively. In terms of MAE, the percentage decrements of the hybrid model over the SARIMA and ANN are 27.60% and 24.82%, respectively. Thus, the hybrid model is better in wind speed forecasting.

The 12-month forecasted values for the test data of the selected SARIMA, ANN, and SARIMA-ANN hybrid model is represented in Figure 2. The mean absolute percentage error (MAPE) of the SARIMA, ANN and SARIMA-ANN hybrid model are 27.93% ,19.46% and 17.66%, respectively. The paired sample *t*-test (at 5% level of significance) was carried out to validate any significant differences between the actual values and predicted values of each of the models. Results revealed that there is no significant difference between the forecasted and actual values of wind speed for SARIMA-ANN hybrid model (p-value = 0.8625).
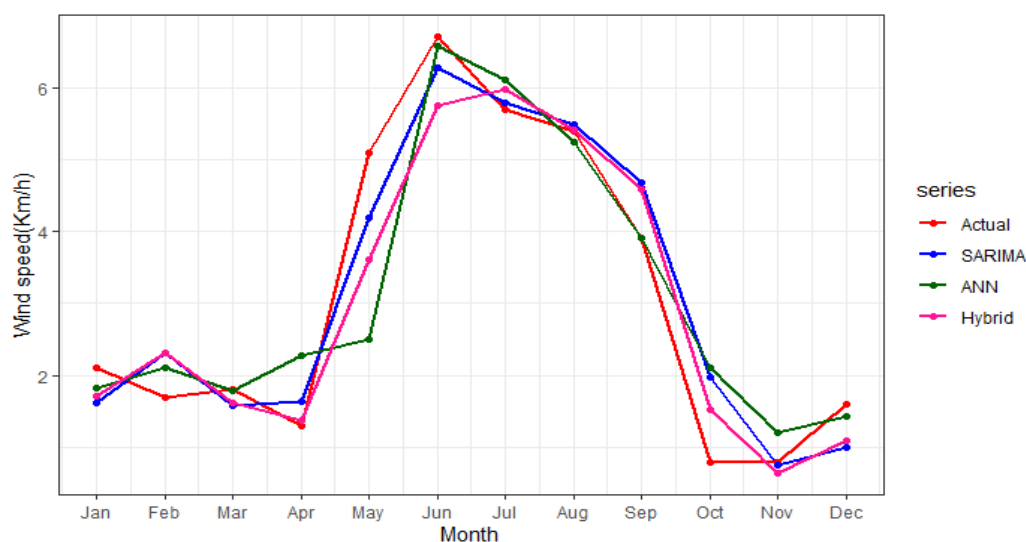
Figure 2. *Actual vs. predicted values for selected SARIMA, ANN, and hybrid model*

Conclusions

The study considered forecasting the wind speed based on three models such as ANN, SARIMA and Hybrid model. A hybrid model comprising ANN and ARIMA is proposed for wind speed forecasting. The mean absolute error (MAE), root mean square error (RMSE), and paired sample *t*-tests are used to compare the performance of all the developed models. Results showed that the SARIMA-ANN hybrid approach is the most suitable for forecasting the wind speed.

References

Aasim, Singh, S. N., & Mohapatra, A. (2019). Repeated wavelet transform based ARIMA model for very short-term wind speed forecasting. *Renewable Energy*, *136*, 758–768. https://doi.org/10.1016/j.renene.2019.01.031

Duan, Z., & Liu, H. (2019). An evolution-dependent multi-objective ensemble model of vanishing moment with adversarial auto-encoder for short-term wind speed forecasting in Xinjiang wind farm, China. *Energy Conversion and Management*, *198*(July), 111914. https://doi.org/10.1016/j.enconman.2019.111914

Faraway, J., & Chatfield, C. (1998). Time series forecasting with neural networks: A comparative study using the airline data. *Journal of the Royal Statistical Society. Series C: Applied Statistics*, *47*(2), 231–250. https://doi.org/10.1111/1467-9876.00109

Grigonytė, E. (2021). *Short-term wind speed forecasting using ARIMA model. July 2016.* https://doi.org/10.6001/energetika.v62i1-2.3313

Haddad, M., Nicod, J., Mainassara, Y. B., Masry, Z. Al, Péra, M., Haddad, M., Nicod, J., Mainassara, Y. B., Rabehasaina, L., & Masry, Z. Al. (2020). *Wind and Solar Forecasting for Renewable Energy System using SARIMA-based Model To cite this version : HAL Id : hal-02867736 Wind and Solar Forecasting for Renewable Energy System using SARIMA-based Model.*

Janacek, G. (2009). Time Series Analysis Forecasting and Control. *Journal of Time Series Analysis*, *2009*(December 2009), 9892. https://doi.org/10.1111/j.1467-

9892.2009.00643.x

Li, G., & Shi, J. (2010). On comparing three artificial neural networks for wind speed forecasting. *Applied Energy*, *87*(7), 2313–2320. https://doi.org/10.1016/j.apenergy.2009.12.013

Liu, H., Tian, H., & Li, Y. (2012). Comparison of two new ARIMA-ANN and ARIMA-Kalman hybrid methods for wind speed prediction. *Applied Energy*, *98*, 415–424. https://doi.org/10.1016/j.apenergy.2012.04.001

Shi, J., Guo, J., & Zheng, S. (2012). Evaluation of hybrid forecasting approaches for wind speed and power generation time series. *Renewable and Sustainable Energy Reviews*, *16*(5), 3471–3480. https://doi.org/10.1016/j.rser.2012.02.044

Society, A. (2016). *American Society for Quality Review Author (s): Beat Kleiner Review by : Beat Kleiner Published by : Taylor & Francis , Ltd . on behalf of American Statistical Association and American Society for Quality Stable URL : http://www.jstor.org/stable/1267710 Accessed : 27-06-2016 04 : 44 UTC Your use of the JSTOR archive indicates your acceptance of the Terms & Conditions of Use , available at*. *19*(3), 343–344.

Torres, J. L., Blas, M. De, Francisco, A. De, & Garcı, A. (2005). *Forecast of hourly average wind speed with ARMA models in Navarre (Spain)*. *79*, 65–77. https://doi.org/10.1016/j.solener.2004.09.013

Xu, Y., Ren, Q., Zheng, Z. J., & He, Y. L. (2017). Evaluation and optimization of melting performance for a latent heat thermal energy storage unit partially filled with porous media. *Applied Energy*, *193*, 84–95. https://doi.org/10.1016/j.apenergy.2017.02.019

Zhang, P. G. (2003). Time series forecasting using a hybrid ARIMA and neural network model. *Neurocomputing*, *50*, 159–175. https://doi.org/10.1016/S0925-2312(01)00702-0

Conference Paper No: SF-01

An enhanced ensemble model for crime occurrence prediction using machine learning

W. S. V. Lakshan[1*], A. T. P. Silva[2] and W. A. C. Weerakoon[1]

[1]Department of Statistics and Computer Science, University of Kelaniya, Sri Lanka
[2]Department of Computational Mathematics, University of Moratuwa, Sri Lanka
lakshanw_ps15070@stu.kln.ac.lk*

Abstract

With the rapid increase of crime, law enforcement departments are struggling to stop crimes and continuously demand automated advanced systems for crime control to provide better protection to the human being in a community. Crime predication plays a vital role in crime control. Crime analysis & prediction can reveal the complexities and hidden patterns in the crime datasets, and it can be used for early decision making. The early researchers attempted to predict the crime using a machine learning model with main factors including time, date and location but overlooked other essential factors. This paper aims to present an enhanced crime prediction algorithm based on ensemble classification technique while identifying several factors that affect the learning model's performance. The correlation of the factors versus the prediction label is analyzed using the Spearman and Pearson techniques to determine the important, influential factors. The prediction model was developed based on Ensemble techniques using the Random forest model with the Voting Classifier. Multiple decision trees had implemented the crime prediction model of this research as the base model and the Logistic Regression and K-Nearest Neighbor algorithm as the sub-models. The final classifier was developed based on using the Graphical User Interface and the REST API methods to predict the possibilities of the crime occurrences at a given specific time in each location. The proposed method can identify the likelihood of a crime in a particular location at a specific time. This helps to implement better strategic and tactical ways to minimize crimes with less risk, as the accuracy of the crime prediction algorithm was 89%.

Keywords: Correlation, Ensemble techniques, Graphical User Interface (GUI), REST API, Voting Classifier.

Introduction

For a better surveillance level of the country, the law enforcement is working as a shield for the citizen's protection by taking defenses against crimes and unlawful acts. Therefore, implementing a suitable crime prediction system by using machine learning tools and data mining techniques is a progressively approachable strategy towards the law enforcement. The criminology is the scientific learning of the crimes and the behaviors and intentions of the criminals. The crime prediction is the practice of forecasting the crime occurrences by analyzing huge dataset with the analyzing techniques. The motivation for implementing an enhanced algorithm to predict the future crime was the knowledge and understanding obtained from the machine learning (ML) techniques. For the crime prediction, searching the supportive information to use and assist in crime prediction problems are possible, but there is no definitive method to predict crimes with the various data (Shamsuddin et al., 2017) and the new technologies make much easier to

identify the crime hotspots where the crimes placed repeatedly over an area by focusing a specific area (Ratnayake, 2015). Data analyzing is crucial to understand the patterns of crime occurrences and several results can be obtained by using the same input factors for the different algorithms (Yuki et al., 2019). The Ensemble model had been resulted better than the other ML models and suitable model selection can be done based on the accuracy, recall and precision (Iqbal et al., 2013). Though there were many effective analyzing tools to identify the common patterns of the crime incidents, but the cost of installation is high (A & Santhosh Baboo, 2011). The Random Forest model has a better accuracy level for the pattern identification of crime types, and it can be modified with more features to predict the future crime occurrences (Alves et al., 2018). According to the facts, the main consideration of each previous research was to predict the future crime occurrences by using an algorithm to identify the patterns or distribution of crime hotspots to determine the future crime occurrences. All the previous studies revealed that the sufficient data set is essential to achieve a better performance by training the model which was implemented for the crime prediction system.

The crime occurrence prediction within concerned area at a specific time frame and identification of the new factors for a better prediction process were the main objectives of the research. The current system has been modified with the user-friendly Graphical User Interface (GUI) and Application programming Interface (API) to improve the performance of the enhanced algorithm. The crime prediction system has been implemented to predict the crime occurrence accurately based on the factors which can be give the predictions under the high measure of potential casualties (Dharmaraju, 2017). Therefore, the null hypothesis (H0) for the current algorithm building was "The crime occurrence could be predicted by the crime prediction system" and the alternative hypothesis (H1) was "The crime occurrence could not be predicted by the crime prediction system". Compared to the previous studies, this is not only a system which was built to predict the future crime occurrences, but very efficient and effective to be promoted easily among the officers of the law enforcement for encouraging the crime investigation and detection process. This study would be turning the old-cultured police stations, recording data and the activities of investigating into the new easy and effective paths which are more suitable for the present-day scenarios with the new technology.

Methodology/materials and methods

The model implementation and the algorithm development for the crime prediction system has been done based on the Python Language as it is an object-oriented scripting language which stimulates code reuse with the modules for data analysis. The Google Colaboratory Notebooks has been used for executing the code on Google`s cloud servers and the Spyder application has been used for training the model with the GUI. The Django and Postman frameworks had been used for building and testing the REST API respectively. The crime data for the model implementation found by "Kaggle" open database, website of "Statistics Canada" and the Census data (2011 and 2016) from the "Census Profile of the Statistics of the Canada" website to get the data related to the Vancouver city as required to the factors. While preprocessing the data, data integration has been performed by combining the data collected from each source, then data cleaning has been performed to remove the missing values and data transformation has been done by labelling such as that number of 'crime types' as 1-11, number of 'neighborhoods' as 1-26 and 'class' of crime occurrence as "if the crime occurred then 1 if not as 0" then split the data into two phases as training phase and testing phase. This large dataset has been summarized into smaller one that contains the information and extract the suitable

features using the Principal Component Analysis. The Pearson Correlation and Spearman`s Ranking are the correlation tests had been performed to test the mutual relationship precisely between each input feature and the 'class' variable. Then the algorithm has been implemented based on the Random Forest classifier with the two sub models called Logistic Regression algorithm and K– Nearest Neighbors (KNN) algorithm which have been chosen based on the accuracy level and the Support Vector Machine model did not result better accuracy. Finally, Max Voting has been chosen as the suitable Ensemble classifier for a better accurate future crime prediction.

The Random Forest, Neural Network and KNN models had been used to predict the 'Crime type' with the other input factors (without the previous 'class' variable). The levels of accuracy were lower than 50% and the correlation coefficients between the 'Crime type' variable and other factors were very small. Through the R&Ds, checked for the possibilities to predict the level of the severity of sending back the offender to the society and found that the current factors were not suitable to use as the inputs. There are new various factors which can affect the level of severity and crime type as shown in the table 1 below, but the data are not available as required.

Table 1. Factors related to both Crime Type Prediction and Severity Level Prediction

Feature Category	Factors for Crime Type Prediction	Factors for Severity Level Prediction
Historical features	Crime type Event Trend	First time or a repeat offence
	Crime Rate of Surrounding Regions	Main offender or an Accessory
	Seasonal Pattern of each crime type	Contribution of the offender
Demographical features	Gender	Gender of the offender
	Age group	
	Income level	Age of the offender
	Number of Residence	
Dynamic features	Diversity of visitors in a location	Committed under Personal stress or Duress
	Visitor Ratio	Committed without intention (or self-defensing purpose)
	Count of unique visitors	Attempted with Destructive/ Vindictive intention
Geographical features	Venue Category distribution	
	Density	
	Reginal Diversity	

Therefore, the prediction system for Crime Occurrence was developed with the GUI by using the "Tkinter package (Tk interface)" and Tk GUI toolkit makes it easier to develop suitable standard Python Interface for the algorithm which is as shown in the figure 1. Using the Django framework implemented the REST API locally. The ".joblib" extension

used to serialize the model and the "python manage.py runserver" command to make server up in the Anaconda prompt and produced a local IP address. Users will be able to access the web GUI of the REST API by using IP address. The "Basic Authentication" facility has been created for the security checking process while accessing the REST API. The postman framework used to test the efficiency. Finally, the Local Endpoint would be ''http://127.0.0.1.8000/api/predict/'' and the default port was 8000 used by the local host.

Figure 1. Graphical User Interface.

Results and Discussion

According to the correlation coefficients as shown in table 2 and table 3, identified the new four (04) factors which can be affected for the crime occurrences.

Table 2. Correlation checking for the Current Features Used in Previous Studies

According to Class	Type	Date	Month	Year	Time	Area
(r)	-0.014	0.005	-0.014	-0.022	-0.086	-0.026
(rs)	0.081	0.066	-0.004	0.029	-0.004	0.032

The above factors were taken as the input variables for the previous research works. Therefore, those factors will be considered for the current model building by concerning the graph of the variable importance of the factors towards the model as shown in the figure 2.

Table 3. Correlation checking for the New Features selected for the Current study.

According to Class	Near to Main Road or Not	Near to Commercial Centre or not	Income status of the House Owner	Population of Area	Knowledge of House Owner
(r)	-0.003	-0.122	0.017	-0.128	0.066
(rs)	-0.086	0.068	-0.001	-0.002	-0.047

The "Income status of the house owner" variable had been removed due to weak relationship (as the values are closer to the 0). Then, checked for the variable importance of the selected variables as follows.
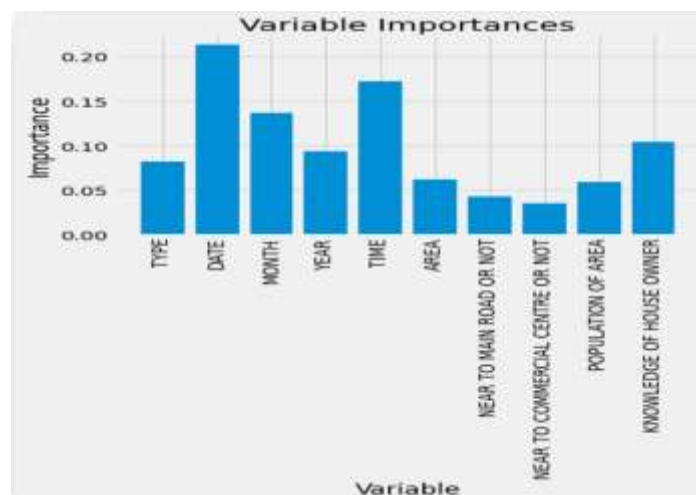
Figure 2. *Graph of the Variable Importance.*

For the base model, the Random Forest algorithm was trained with six test cases by increasing the number of decision trees such as 10, 50, 100, 120, 150 and 200, respectively. The optimum result was obtained as 90% of accuracy with 100 decision trees. Accuracy of the Logistic Regression algorithm and the K – Nearest Neighbor algorithm were obtained as 90% and 87.8% respectively. Each algorithm has been used for the Voting classifier without boosting since the accuracy of each model did not change with Adaptive Boosting technique and resulted in 89.8% of accuracy for the final enhanced Ensemble model. The precision, recall and F1 score obtained as 90.4%, 99.5% and 94.7% for the final model respectively. Then the Ensemble model tested with 06 months of real data and obtained 92% of accuracy predicting 5011 incidents out of 5432 crimes exactly. The response time of the REST API is the time elapsed between sending the JSON Request and the response from REST API was 200 – 250 ms and the outputs obtained through the REST API as follows in the figure 3.
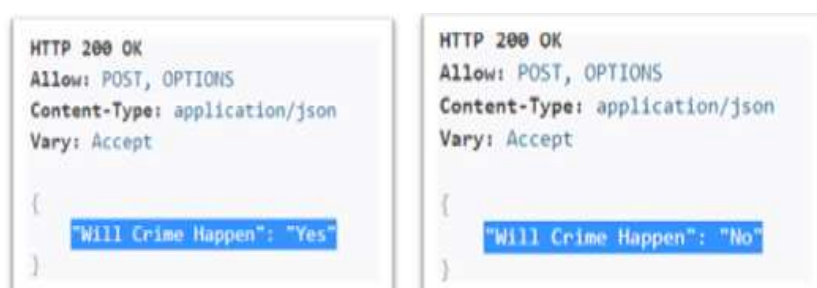
Figure 3. *Possible Outputs from the REST API.*

Incomplete dataset was the main issue and after the data cleaning phase there were less amount of data. Therefore, the results had been less reliable and difficult to identify crime patterns. The use of sensible data is essential as it plays a major role in the crime prediction and not having such data is a limitation to identify many hidden patterns with the increased number of input factors while training the model. Multiple models were implemented to overcome the main drawbacks of the decision tree algorithm such as overfitting and biasness of the trained model. In a Deep Neural Network it needs a lot of resources, data, and computational power for the model training phase. Therefore, Ensemble model has been chosen as it is capable to obtain a higher percentage of accuracy with less data.

Conclusion

The main aim was achieved by implementing an enhanced Ensemble model to predict the occurrence of the crimes with the 89% of accuracy level. The accuracy of the trained model resulted as 92% of accuracy for real time data. Identified new four (04) factors which can be used for the model building for a crime prediction system. The user-friendly GUI and the REST API had been developed for the user interaction and to reduce the cost of hardware implementation. The law enforcement will be able to use the current crime prediction system in multiple locations at the same time concurrently. Therefore, each objective of the study has been achieved. The output of this research will be a benefit for a better performance in the crime detection and analyzing process. For further development, the current model will be enhanced to predict the type of crime and the level of severity by finding the related data. Not only the researchers can be focused on building more reliable models with the collaboration of the law enforcement collecting sensitive data records, but for focusing on other metrics to measure the performance of the algorithm except the accuracy.

Acknowledgment

References

A, M., & Santhosh Baboo, S. (2011). An Enhanced Algorithm to Predict a Future Crime using Data Mining. *International Journal of Computer Applications*, *21*(1), 1–6. https://doi.org/10.5120/2478-3335

Alves, L. G. A., Ribeiro, H. V, & Rodrigues, F. A. (2018). Crime prediction through urban metrics and statistical learning. *Physica A: Statistical Mechanics and Its Applications*, *505*, 435–443. https://doi.org/10.1016/j.physa.2018.03.084

Dharmaraju, G. (2017). Analysis of Crime data using data mining. *International Journal of Engineering, Science and Mathematics*, *6*(8), 1059–1071.

Iqbal, R., Murad, M. A. A., Mustapha, A., Panahy, P. H. S., & Khanahmadliravi, N. (2013). An experimental study of classification algorithms for crime prediction. *Indian Journal of Science and Technology*, *6*(3), 4219–4225. https://doi.org/10.17485/ijst/2013/v6i3/31230

Ratnayake, R. (2015). Distribution Pattern of Urban Crimes in Sri Lanka; with Special Reference to Mirihana Police Division. *International Journal of Multidisciplinary Research and Development*, *2*(8), 441–453.

Shamsuddin, N. H. M., Ali, N. A., & Alwee, R. (2017). An overview on crime prediction methods. *6th ICT International Student Project Conference: Elevating Community Through ICT, ICT-ISPC 2017*, *2017-Janua*(May), 1–5. https://doi.org/10.1109/ICT-ISPC.2017.8075335

Yuki, J. Q., Mahfil Quader Sakib, M., Zamal, Z., Habibullah, K. M., & Das, A. K. (2019). Predicting crime using time and location data. *ACM International Conference Proceeding Series*, *July*, 124–128. https://doi.org/10.1145/3348445.3348483

Conference Paper No: SF-02

Blockchain-based tractability framework for quality assurance in construction projects

A. W. H. P. Alagalla[1], and T. N. Samarakkody[2]

[1]Faculty of Graduate Studies and Research, Sri Lanka Institute of Information Technology, Sri Lanka
[2]Institute of Business Administration, Kandy, Sri Lanka
heshanalagalla@gmail.com*

Abstract

The construction industry has a complex supply chain due to its collaborative working nature. Most of the stakeholders of construction companies are involved in every phase of a project life cycle. Lack of trust among the parties and related quality issues have obstructed the development of the construction industry in Sri Lanka. Project tractability systems powered by blockchain technology have addressed these issues successfully. This design framework that involves with consortium blockchain platform facilitates building trust among stakeholders of the construction company through providing a higher level of transparency and visibility of the quality control process. Real-time data capturing and fraud data avoidance were ensured with the integration of IoT modules to blockchain architecture. Cryptocurrency-based transactions were eliminated from the proposed framework, by considering the legal and technical constraints of the country. Apart from that this research introduces a techniques to develop a new blockchain using transaction selection and node validation by Etherium or Cardano based platforms.

Keywords: Blockchain, Construction Industry, Quality Assurance, Supply chain, Smart Contracts

Introduction

The Construction industry now and again changes with technological development. Quality, time, and cost are significant for the execution of effective undertaking in the construction industry (Aziz, 2013). A higher degree of uncertainty is associate with this industry, as it has a complex supply chain with many partners (Salama & Habis, 2009). Client, Architect, Town planners, Engineers, Surveyors, Contractor, Sub-Contractor, Supplier are ket supply chain partners as identified by (Yanga, et al., 2020; Seng, et al., 2018). This is a flexible industrial sector, where the client involves in the entire project life cycle to assure quality in each phase. Hence, trust among supply chain partners plays a vital role in customer satisfaction of the construction companies (Aziz, 2013).

Blockchain technology

The emergence of blockchain technology has broadened the avenue for quality improvement in the supply chain of many industries (Chen, et al., 2017). The blockchain concept was introduced by Satoshi Nakamoto, in 2008 through a cryptocurrency called "Bitcoin". This is a peer-peer decentralized, electronic currency scheme. Blockchain technology rapidly spread as a secure and encrypted mode of digital transaction (Turk & Klinc, 2017). The distributed ledger is the core concept of the blockchain. There is an ordered chain of blocks and each block incorporates a record of substantial organization movement. These blocks can be identified as encrypted bits of information (Benton &

Radziwill, 2017), which connect with cryptographic hash values. Elimination of middlemen and decentralization ensure the trust of the participant in the blockchain network. The smart contract was introduced by blockchain 2.0, which is an interesting and amazing application (Turk & Klinc, 2017). Business rules and constraints related to two or more parties can convert into smart contracts (Perera, et al., 2020). This provides a higher level of accuracy to any process without the interference of an external application.

Research problem

The use of information technology in the construction industry is relatively less. Though the systems like Business Information Management (BIM) were evolved, still construction companies struggling to adapt to those in an uncertain, complex and, challenging environment (Turk & Klinc, 2017; Epasinghe, et al., 2018). There are new concepts like build and design which are rapidly spread all over the world due to the lower level of risk, less project time and, cost (Ruvinda & Banmunuarachchi, 2020) but the Sri Lankan construction industry failed to hit the higher performance in build and design sector due to the issues in project transparency. A study by (Joseph & Jayasena, 2008) showed that the public sector of Sri Lanka mostly preferred to use Measure and pay methods in construction projects due to the features like accountability and project transparency. Hence the development of trust with effective mechanisms has become a challenge to construction companies.

Research objectives

There is a lengthy supply chain for a construction project. To build a blockchain-based framework all the essential supply chain partners, who are associate with the different stages of the project life cycle should be added to the system. Placement and connection of entities at the appropriate levels through a decentralized system have ensured and enhanced transparency and traceability of the whole business process. Sri Lanka lags behind new technologies like blockchain hence cryptocurrency-based digital transactions do not take place in the country. Therefore this study was conducted with the general objective of development of a quality management system for the construction companies, which facilitates real-time information gathering, assessing the quality standard in and process validation while maintaining the transparency of the quality management system to build trust among the stakeholders.

Blockchain Development and Methodology

Framework definition

There are outer environment parties as well as inner environment parties that should be included in this proposed system. Confidential information and business secrete should not visible to the outer environment. By considering business risks and required functionalities have to select the appropriate network.

Blockchain networks

Description of the Blockchain Network are given in Table 1.

Table 1: Blockchain Network

Blockchain Type	Description
Public Blockchain	This is an open-source network, where no restriction on the network participants. The Authority of the network has decentralized, hence anyone can enter the network and be able to access (read, write and edit) (Alam, 2019). Once the entered data validate through the network, changes or modifications of the entries are restricted through the system (Benton & Radziwill, 2017).
Private blockchain	Private blockchains networks consist of pre-selected participants. Permission of the authorized party of the blockchain is essential to join the network (Perera, et al., 2020). There are different access levels within the network, thus able to differentiate the users who can write, read and edit blockchain. Private networks also use distributed ledgers, but there is less level of decentralization than public networks. This facilitates, pre-define participant, to reach the information, validation, and verification of each transaction that happen among the nodes (Lin & Liao, 2017).
Consortium blockchain	Consortium blockchain can be identified as the most suitable platform for construction projects where many parties work collaboratively. Previous studies by (Zhong, et al., 2020; Perera, et al., 2020; Nanayakkre, et al., 2021) also suggested a consortium blockchain network for the construction industry where the governance of the network always keeps with the construction company. Separate networks can form by looking at the flow of items, network administration will assign to reliable executive-level employees of the company (e.g. project manager, project engineer). The authors proposed to create project-wise consortiums where all the partners of a project will appear within the same consortiums. When creating the communication channel for each consortium, able to assign several governance bodies by considering different levels of partnerships and strategic alliances among the supply chain partners. The reliability of the machine can improve with the sharing governance. The higher degree of transparency reduces the risk of sharing governance among the partners.

Development of the system architecture

The architecture of the proposed Blockchain model illustrates in the Figure 1 and description given in Table 2.

Table 2: Layers in Blockchain Architecture

Layer	Description
Layer 1	Data Input Layer: IoT module has been integrated to boost the performance of quality management. It's supported by different types of sensors such as temperature sensors, to monitor the quality of raw material input and Infrared

|	
	sensors to read the measurements in construction sites. The use of Radio Frequency Identification (RFID) together with Global Positioning System (GPS) technology assure the quantity, quality, and presence of material at the appropriate location. Researchers (Alam, 2019; Chen, et al., 2017) who have done blockchain applications to various industries have integrated IoT modules to gather information as well as to communicate. Project details and policies in ERP and other Information Systems (IS) have also been entered into blockchain through this layer to boost supply chain performance (Hader, et al., 2020). Also (Farouk & Darwish, 2020) has proposed reversed logistic e- supply chain by linking ERP with blockchain technology.
Layer 2	Ledger Layer: Data entered into the blockchain, will be stored as ledgers in the second layer. Quality ledgers of products, quality ledgers of process, and assets ledgers with participants are some of them. Need to keep copies of public ledgers as well as private ledgers for the execution of smart contracts. There are techniques relevant to ledger layers such as encryption algorithm, hash code, and digital signatures which are all fueled by the advanced data structures. These ledgers appear as a linked list of block in this layer, and each block link to the previous list through hash pointers in blockhead as shown in figure.
Layer 3	Contract Layer: This layer is crucial for quality assurance. Acceptance and the rejection of the materials, process, and legal constraints handle through smart contracts, which is hard to handle with any other technology. Approval of legal activities such as tenders, acceptance of orders, and processes such as design and development tackle through the smart contracts by considering client requirements and company policies.
Layer 4	Business Service Layer: Every Application that is running on a blockchain platform is listed under this. There is a wide range of soft wares and decentralized applications which have been introduced to an assessment of quality, procurement processing, Supplier Relationship Management (SRM), Customer Relationship Management (CRM), and smart contract execution.
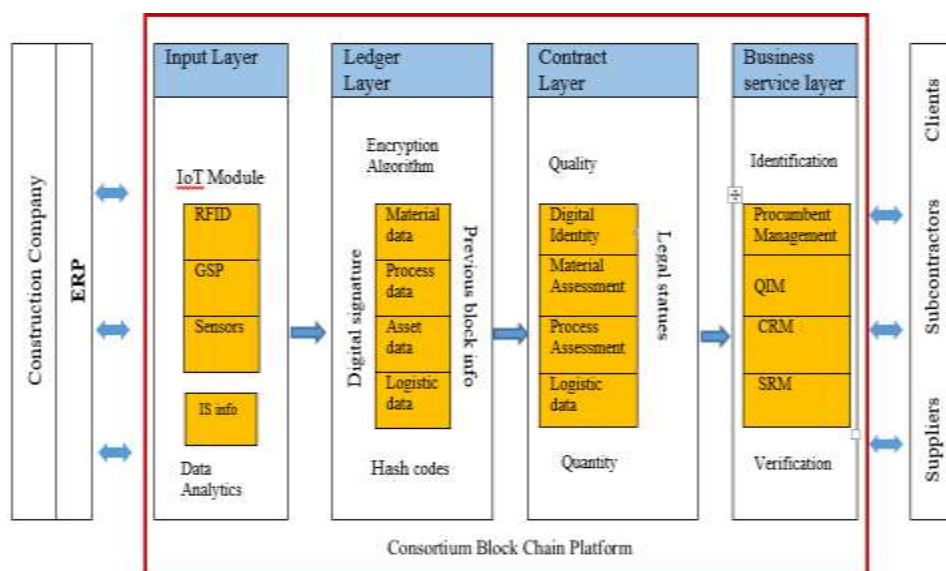
Figure 1: *Architecture of the proposed framework*

Development of business applications

Identification of the appropriate blockchain platform is the first step. Several blockchain platforms were designed for commercial purposes. Different algorithms, consequence mechanisms, and languages are associated with those platforms. By assessing features of blockchain platforms Etherium and Cardano have selected for this proposed framework. As per the studies by (Nanayakkara, et al., 2021; Bahalul Haque & Rahman, 2020) lucrative features of these blockchain platforms were gathered in table 3.

Table 3: Details of Blockchain platforms

Etherium	Cardano
A popular platform	Rising popularity
Uses proof of work technology	Proof of stake technology
High support community	Satisfactory support community
Popular in apps development	Evidence-based and peer-reviewed

Transaction selection

In blockchain development, every function or task that is made through the network is recognized as a transaction (Bahalul Haque & Rahman, 2020). The occurrence of all the transactions will be notified between the peers. Sender's public key and private key are essential to exchange information among peers, and blocks are using to store all types of data.
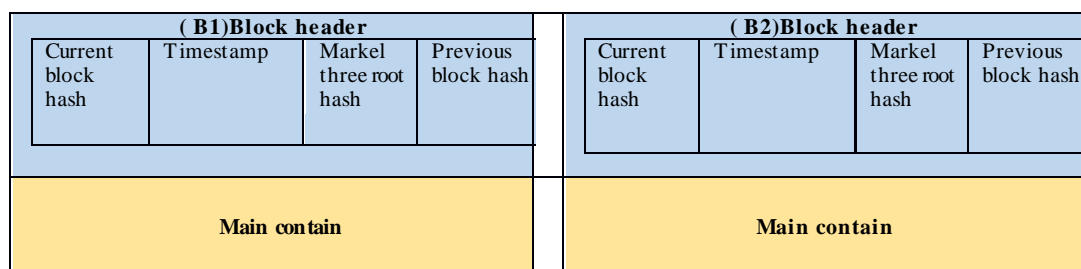
Figure 2: Block Structure

Apart from main data, blocks have timestamps of the transaction, block hash, and market root hash values (Bahalul Haque & Rahman, 2020), as in figure. In this proposed system, the main content will include quality-related data such as quantity, quality certifications of suppliers, and manufacturers' detail. Timestamps assure the time and date that every item adds to the inventory and is released from the inventory. Usually, data that is transferred through the network is encrypted using a hash function (SHA256 or any other), which acts as a unique identifier for each block (Mahmud, et al., 2018). Markel three function is essential to the generation of hash values. This performs the complex mathematical hash calculation, which resulting 64 character codes (Lin & Liao, 2017). This calculation uses all the transactions relevant to a single block.

Node validation

Single change made on data items leads to changes in the hash value. Hence it facilitates checking whether any update has been done on existing information or not (Bahalul Haque & Rahman, 2020). A higher level of quality of all the material in inventories is ensured regardless of the number of suppliers and contractors through this mechanism.

The proposed system should be developed with some priority flags to recognize the necessity of adding the node to the blockchain. When there are nodes with the same priority level, nodes to be validated validate can select by considering their arrival time to the mining pool. Smart contract-based secure mechanism able to use for the miner registration and block validation in this proposed system (Zhang & Lee, 2019). Construction firms handle several projects simultaneously, with different suppliers, subcontractors, and contractors. Consortium blockchain network facilitates provide visibility of selected contracts only to selected parties. Accordingly, miners' registration and validation of critical quality-related information can hand over to authorized parties of the company (Dib, et al., 2018). When the validation is performed, the relevant block will be integrated into the blockchain and notification will be broadcast to every peer in the network. This also provides the transparency of transactions, as every miner receives a copy of information through distributed ledger technology (Zheng, et al., 2017).

Conclusion

Consortium blockchain networks provide a strong background to maintain privacy levels among the participants in a construction project through the use of permissoned and permission-less members in the network. Necessary aspects of ERP outputs are supposed to add to the ledgers, hence participants in the blockchain will access only specific detail of the Authorized project. IoT module enhances the accuracy of the input data relevant to quality assessment by avoiding human errors. Quality measures were empowered through smart contracts, which are validated by the responsible pool of miners (consists of internal and external parties). Smart contract-based miner registration and node validation mechanism have been suggested to use to achieve a higher level of accuracy while maintaining the simplicity of the system. Due to the current legal and technical constraints of the country, cryptocurrency base transactions were avoided from this proposed framework. Future research avenues are there to link cryptocurrency-based digital transactions to boost overall performance in the construction industry.

References

Alam, T., 2019. Blockchain and its Role in the Internet of Things (IoT). *International Journal of Scientific Research in Computer Science, Engineering and Information Technology,* 05(01).
DOI:10.31219/osf.io/cmza5

Aziz, R. F., 2013. Ranking of delay factors in construction projects after the Egyptian revolution. *Alexandria Engineering Journal,* Volume 52, p. 387–406.

Bahalul Haque, A. K. M. & Rahman, M., 2020. Blockchain Technology: Methodology, Application and Security Issues. *IJCSNS International Journal of Computer Science and Network Security,* 20(2).

Benton, C. & Radziwill, N. M., 2017. Quality-and-innovation-with-blockchain-technology. *SQP,* pp. 35-45.

Chen, S., Shi, R. & Ren, Z., 2017. *A Blockchain-based Supply Chain Quality Management Framework*. s.l., Research Gate, pp. 172 -177.

Dib, O. et al., 2018. Consortium Blockchains: Overview, Applications, and Challenges. *International Journal on Advances in Telecommunications,* Volume 11. http://www.iariajournals.org/telecommunications/

Epasinghe, E. A. K., Jayasena, . H. S., Kolugala, N. & Wijewickrama, S., 2018. Open BIM Adoption in Sri Lankan Construction Industry. *FOSS4G Asia 2018 Conference.*

Farouk, M. & Darwish, S. M., 2020. Reverse Logistics Solution in e-Supply Chain Management by Blockchain Technology. *Egyptian Computer Science Journal,* pp. 22-34.

Hader, M., Elmhamedi , A. & Abouabdellah , A., 2020. *Blockchain Integrated ERP For a Better Supply Chain Management.* s.l., IEEE 7th International Conference on Industrial Engineering and Applications (ICIEA).

Joseph, A. L. & Jayasena, H. S., 2008. *Impediments to the Development of Design and Build Procurement System in Sri Lanka.* Salford, UK, School of Build Environment, University of Salford, United Kingdom.

Lin, I. C. & Liao, T. C., 2017. A Survey of Blockchain Security Issues and Challenges. *International Journal of Network Security,* 19(05), p. 653–659.

Mahmud, H., Lu, J. & Xu, Q., 2018. A Blockchain-based Service Provider Validation and Verification Framework for Healthcare Virtual Organization. Journal of science and technology, 2(2).

Nanayakkara, S. et al., 2021. Blockchain and Smart Contracts: A Solution for Payment Issues in Construction Supply Chains. *Informatics.*

Perera, S. et al., 2020. Blockchain Technology: Is it Hype or Real in the Construction Industry?. *Journal of Industrial Information Integration.*

Ruvinda, L. & Banmunuarachchi, H., 2020. *A Study on Design and Build Procurement Methods' Benefits to Clients in Sri Lankan Building Construction Industry.* Colombo, Sri Lanka, Research Gate.

Salama, M. & Habis, A., 2009. Investigating the causes of variation within the construction projects in uae. *com conference,* Volume 25, pp. 949-57.

Seng, L. Y., Riazi, S. R. M., Nawi, M. M. & Ismail, R., 2018. Review of material supply chain management during pre-construction phases in. *International Journal of Supply Chain Management,* 07(01).

Turk, Z. & Klinc, R., 2017. *Potentials of Blockchain Technology for Construction Management.* Croatia, Science Direct, pp. 638-645.

Yanga, R. et al., 2020. Public and private blockchain in construction business process and information integration. *Automation in Construction,* p. 118.

Zhang, S. & Lee, J. H., 2019. Smart Contract-Based Secure Model for MinerRegistration and Block Validation. *IEEE Access- special section on artificial intelligence in cybersecurity,* Volume 7.
Digital Object Identifier 10.1109/ACCESS.2019.2940551

Zheng, Z. et al., 2017. *An Overview of Blockchain Technology: Architecture, Consensus, and Future.* s.l., IEEE 6th International Congress on Big Data.
DOI: 10.1109/BigDataCongress.2017.85

Zhong, B. et al., 2020. Hyperledger fabric-based consortium blockchain for construction quality information management. *Frontiers of Engineering Management,* pp. doi:10.1007/s42524-020-0128-y .

Conference paper No: MF-01

A laboratory study on the effects of fertilizer addition on mobilization, percolation and leaching of calcium ions in soils of Anuradhapura district

Y. Ranaweera and R. C. L. De Silva*

Department of Chemistry, Faculty of Sciences, University of Kelaniya, Sri Lanka.
russel@kln.ac.lk*

Abstract

This study aims to investigate the effect of fertilizer addition to limestone soils around Thirappane, in Anuradhapura District. Groundwater is the primary source of freshwater in this area. There is evidence that the degree of hardness of groundwater in the area has increased over the years, probably as a result of long-term and large-scale application of chemical fertilizer. Our results show that the exchangeable and total calcium ion concentrations in the soil of non-agricultural increases with depth of the soil profile, indicating the existence of calcium deposits beneath the soil profile. Columns (Dimensions ~ 4.00 cm^2 x 100 cm) were filled with soil (up to 60 cm height in each column) from the study area and 0.5% (w/w) of nitrogen fertilizers (Ammonium sulfate and urea) were introduced to the columns to study the effects of fertilizers on properties of soil. Deionized water (100.0 mL) was added by using a dropper from the top of each column and it was allowed to pass through the soil at a rate of 1 mL/minute. The highest effect on the calcareous soil was shown by fertilizer containing ammonium sulfate. After running the columns for 30 days, it was observed that the pH of the leachate in the column introduced with urea, had gradually declined while the calcium ion concentration had gradually increased, whereas the pH of the leachate, in the column introduced with ammonium sulfate fertilizer, showed a rapid decrease and the calcium concentration was very high, compared to the control. Total calcium ion concentration had decreased down the soil sample columns while exchangeable calcium ion concentration increased. The pH value had also decreased down the soil profile. This indicates the dissolution of calcium carbonate in the soil due to the increment of acidity. This highlights that mobilization, percolation, and leaching of calcium ions in the soil change with nitrogen fertilizer application, potentially contributing to increased groundwater hardness.

Keywords: Calcareous soil, pH, Calcium ion, Nitrogenous fertilizers

Introduction

Calcium is the most abundant alkali metal ion in soil. In some soils it occurs as limestone deposits. The North Central province of Sri Lanka which is situated in the dry climatic zone, is known to contain lime deposits and reported to be with the highest prevalence of kidney diseases in the country. A high level of calcium ion concentration (more than 120 mg/L) in water is suspected to be one of the reasons for kidney disease (Dissanayake & Iqbal, 2014). The reason behind the high levels of calcium in water is speculated to be a result of excessive use of fertilizer for cultivation. Continuous use of inorganic nitrogen fertilizers increases the acidity of soil that in turn increases the breakdown of limestone present in the soil. Most of the exchangeable calcium ions leach, mobilize, and percolate into the groundwater through the soil increasing the accumulation of calcium ions in groundwater. This research was aimed at studying the effect of nitrogenous fertilizer on

limestone in soils of the Anuradhapura District and how it affects the percolation, mobilization and leaching of calcium ions in the soil that can contribute to rising groundwater hardness.

In Sri Lanka, most of the paddy lands and croplands, are located in the dry zone where rainfall is seasonal (Jayathileke & Matsueda, 1992). There are two main cultivation seasons per year namely Yala (March to August) and Maha (September to February) where most of the rain is received during Yala (Gunatilaka & Panabokke, 2008). During dry seasons, availability of water in Anuradhapura area is very limited. As a result, during the dry months of the year, people face a serious shortage of water for domestic, agricultural, commercial, and other purposes. Tube wells with a diameter of 150-200 mm and agro-wells with a diameter of 3-5 m have helped to mitigate the shortage to some extent. Groundwater has been the primary source of water for the majority of people in these areas for household needs. This has led to rapid extraction of groundwater resources. According to reports, the shallow groundwater system in the hard rock areas has a continuous aquifer with a single water table in crystalline rocks, in contrast to separate pockets of groundwater, each with a distinct water table (De Silva, 2005) and the quality of drinking water varies from place to place (Dissanayake & Weerasooriya, 1985; Gunatilaka & Panabokke, 2008; Jayathileke & Matsueda, 1992). With time, hardness of this groundwater has become very high and it has been revealed that calcium ions were the main reason for this hardness.

Generally, calcium ions remain adsorbed onto colloidal particles such as clay. These colloidal particles attract cations, especially hydrogen ions due to their surface negativity. The soil contains a reservoir of mobile cations including calcium, which can be exchanged with hydrogen ions thus increasing the soil acidity (Al-aidi et al., 2014; Kroeck, 2011; Rengel, 1992; Narasimhan, 1998).

The acidity of the soil is known to change (Rengel, 1992) with long-term and large-scale use of chemical fertilizer. The increased acidity causes the degradation of limestone mobilizing the calcium ions and as a result, they leach into groundwater. Fertilizers that contain ammonium ions, sulfate ions, and phosphate ions prompt a major effect on the calcareous soil (Al-aidi et al., 2014; Kroeck, 2011; Rengel, 1992; Narasimhan, 1998). In this study, effects from nitrogenous fertilizers were investigated.

Fertilizers containing ammonium salts are used commercially to provide crops with nitrate ions, an important source of nitrogen for plants. Microbial activities have been shown to increase the acidity of the soil when nitrogenous fertilizer such as urea is introduced (Herren,et al., 2020). Furthermore, it has been recorded that many farmers in this area "lime" (add $Ca(OH)_2$) their lands before cultivation. As a result, the calcium concentration in the soil further increases and farmers are reportedly known to overuse fertilizers too. Many studies have revealed that the calcium ion concentration in the topsoil and the calcium ion concentration of groundwater samples in the area to be high (Abeysingha & Gunapala, 2019). However, studies on the effects of fertilizer addition on leaching, percolation, and mobilization of calcium ions in the soil of the area have not been reported.

Methodology/ Materials and methods

All chemicals used were from recognized chemical supplying companies and the purity of each is as given below. Calcium chloride dihydrate (97.0%), Sulphuric acid (96.5% w/v), Hydrochloric acid (35% w/v, density = 1.18 g mL^{-1}), Sodium hydroxide (97%), Hydrogen peroxide (30% w/v), Ammonia solution (25%, density = 0.91 g mL^{-1}) and Ammonium sulphate.

Flame photometer (Jenway PFP7, UK), flame atomic absorption spectrophotometer (FAA-GBC 5000 Savanta model), balance (Kern EW2200 – 2NM), electric oven (Gallencamp), pH meter (Thermo scientific Orian star- MODEL-A211), thermometer, and centrifuge machine (Yider Technology Co.Ltd. Model DSC-200A-1) were used as instruments.

In this study, sampling was conducted in the vicinity of Thirappane town in the Anuradhapura District. A suitable sampling location was chosen in a home garden, where no fertilizer had been applied to the soil. Using an auger screw, five soil samples were collected from each 30 cm depths up to 150 cm, and another soil sample was collected from the surface layer.

All the samples were air-dried and sifted using a 2 mm diameter net sieve and stored in sealed plastic bags in a cool dry place. The surface soil sample was examined for soil characterizations, including pH, calcium ion concentration, cation exchange capacity, moisture content, organic matter content, and texture. The other five samples were examined for pH and calcium ion concentration.

The soil sample collected for the model studies was air-dried for 1 week. Three glass columns (Area is around 4.00 cm^2 and height is around 100 cm) were prepared to model the natural soil structure and to investigate leaching patterns that occur in the soil. Columns were filled with the original soil sample (60 cm in each column). 0.5% (w/w) of the fertilizer (urea and ammonium sulfate) was introduced to the soil from the top of the column. Then fresh deionized water (100.0 mL) was allowed to pass through the soil (1 mL/minute) by maintaining a constant height (5 cm) of the water column over the soil surface. All experiments were duplicated. The blank (control) was prepared as above without using fertilizer.

A fresh portion of deionized water (100.0 mL) was added by using a dropper from the top of each column and the leachate samples were collected. The leachate volumes and the leached calcium ion concentrations were measured. This process was repeated for 30 days. After 30 days the soil in the column was air-dried and was sectioned into slices of 10 cm. Total calcium concentration was determined by using acid digestion method where H_2SO_4 (0.25 M) and HNO_3 (0.5 M) was used in 1:1 ratio and leachable calcium concentration of each section were determined by suspending soil in ammonium acetate solution (pH 7). The total and leachable calcium concentration values of each section were obtained using the flame photometer.

Results and Discussion

Ammonium salts in commercial fertilizer releases ammonium ions to the soil. These ammonium ions are consumed by fungi, and special bacteria (nitrifying bacteria) oxidizing them to nitrate ions, thus releasing hydrogen ions into the environment (Abeysingha & Gunapala, 2019). Calcium ions and other alkaline elements attached to cation exchange sites of soil particles are mobilized due to these hydrogen ions. Furthermore, limestone and other natural calcium compounds begin to decompose due to the acidity of the soil, leaching calcium ions into the soil solution. Concomitantly, these mobile calcium ions will leach/percolate into groundwater through the soil over time, with the rain and irrigated water, contaminating it (Herren et al., 2020; Abeysingha & Gunapala, 2019).

Table 1 shows the variations of total and exchangeable calcium ion concentration with the pH value downwards the soil profile of non-agricultural land in Thirappane, Anuradhapura District.

Table 1. pH and calcium ion concentration with the sample depth in non-agricultural soil in Thirappane, Anuradhapura District.

Sample depth (cm)	Active acidity (pH)	Exchangeable acidity with NH_4OAc (pH)	Exchangeable Ca^{2+} concentration (mg/L)	Total Ca^{2+} concentration (mg/L)
30	6.79	6.6	224	368
60	7.2	6.71	238	336
90	7.24	6.8	240	288
120	7.34	6.71	288	352
150	7.9	7.09	240	448

Total calcium ion concentrations increase with the depth of the non-agricultural soil indicating the existence of the calcium deposits below the soil surface. Furthermore, pH of the soil decrease with the depth of the non-agricultural soil indicating less acidity in the below soil layers.

The highest effect on the calcareous soil was shown by ammonium fertilizers. After running columns for 30 days, it was observed that the pH in the column prepared with urea reduced slowly and the calcium concentration in the resultant leachate samples was gradually increased. The pH of the column prepared with ammonium sulfate fertilizer showed a rapid reduction and the calcium concentration in the resultant leachate samples were comparatively high. The blank/ control showed a lower amount of calcium concentration in the leachate compared to that of the leachates from columns with fertilizers and pH did not change rapidly as in sample columns (Fig. 1).
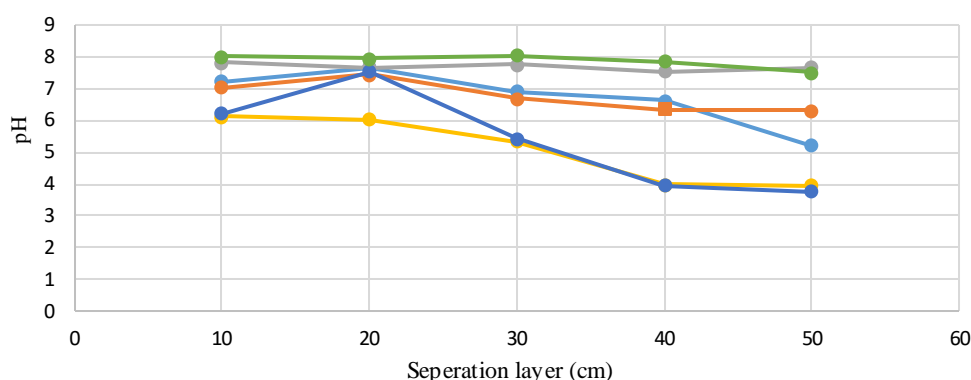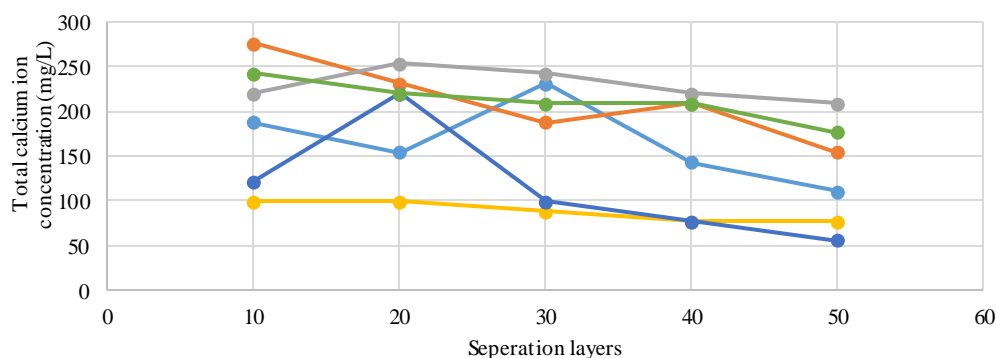
Figure 1. a

Figure 1. b
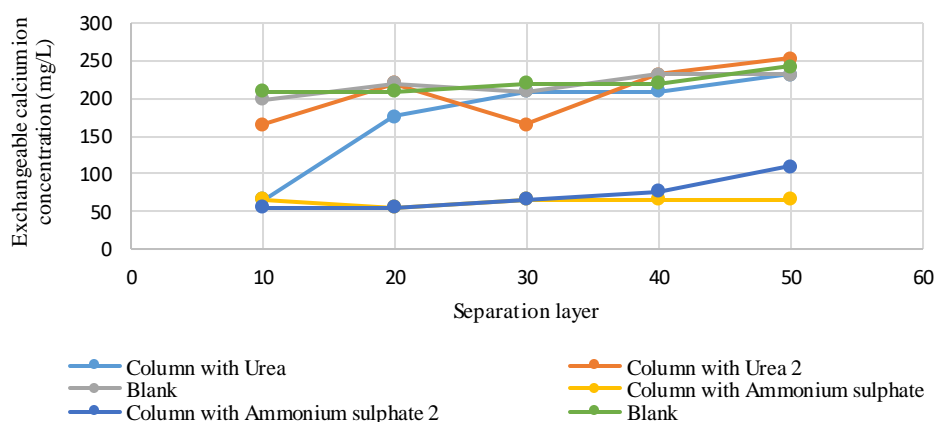
Figure 1. c

Figure 1: Exchangeable and total calcium ion concentration and pH variation down the soil + fertilizer columns.
a) pH variations through the soil column profile.
b) Total calcium ion concentration through the soil column profile
c). Exchangeable calcium ion concentration through the soil column profile.

Total calcium ion concentration was decreased from the top to the bottom of the sample column while exchangeable calcium ion increased in the fertilizer added samples. The pH has also decreased from the top to the bottom through the soil profile. This indicates the dissolution of calcium carbonate in the soil due to the acidification of the soil. Increment of exchangeable calcium ion concentration and the increment of calcium ion

concentration in leachate samples in comparison to blanks shows the leaching effects of the calcium ions through the soil. This indicates the effect of nitrogenous fertilizer addition on mobilization, percolation, and leaching of calcium ions in the soil.

According to the observations, the texture of the content of the column which used ammonium sulfate as fertilizers changed rapidly and the water flowing capability through the soil decreased. Soil particles in the columns were observed to accumulate clay and silt particles around them with time. Therefore, this aggregation block the water flow passages. Also it was observed that there was a higher chance of aggregation when ammonium sulfate is used.

Results of the study show that the exchangeable and total calcium ion concentrations in the soil of non-agricultural land increases downwards within the soil profile, which indicate the existence of calcium deposits l below the soil profile. Free or leachable calcium ion concentration increases from the surface to the bottom in soil indicating movement of calcium ions from surface downwards with percolating water. Results of this study therefore support published observations (Paranagama et al., 2018).

Conclusion

According to the results, more calcium ions have been displaced to the leachates as a direct consequence of the nitrogenous fertilizer addition than in the blank samples. It was also observed that the effects of ammonium sulfate are more swift and strong, while the effects of urea are relatively weaker and slower. It can be concluded that this occurs as a result of direct release of ammonium ions from ammonium sulfate, while urea takes longer time to release ammonium ions. Calcium deposits in the soil degrades as the soil becomes acidic due to addition of fertilizers, and the released calcium ions leach into groundwater, increasing the hardness.

Acknowledgment

References

Abeysingha, N. S., & Gunapala, K. G. M. J. W. (2019). Chemical Retention Function of Thaulla Area of Small Reservoir, A Case Study in Ulankulama Tank, Anuradhapura, Sri Lanka, *Resources and Environment*, 9(3), 49-57. https://doi: 10.5923/j.re.20190903.01.

Al-aidi, M., Al-dhahi, H., & Al-timimi, J. (2014). Effect of nitrogenous fertilizers and agricultural sulfur addition on release of calcium and magnesium in some of iraqi calcareous soils. *International Journal of Agricultural Science and Research* (IJASR), 4 (ISSN(P), 2250-0057; ISSN(E), 2321-0087, 59-64.

Bhuiyan, M.A., Jayasuriya, N., & Paranagama, D.G.A. (2018). Factors associated with Chronic Kidney Disease of unknown aetiology (CKDu) in North Central Province of Sri Lanka: a comparative analysis of drinking water samples. *Appl Water Sci* 8, 151. https://doi.org/10.1007/s13201-018-0792-9

De Silva, C. S. (2002). Sustainable groundwater resource management in the Thirappane tank cascade system. *Journal of the National Science Foundation of Sri Lanka*, *30*(3–4), 97. https://doi.org/10.4038/jnsfsr.v30i3-4.2499

De Silva, R. P. (2005). Limitations of a Soil Water Budgeting Method in Estimating Groundwater Recharge with Particular Reference to the Dry Zone of Sri Lanka. *Journal of the National Science Foundation of Sri Lanka*, *33*(2), 99. https://doi.org/10.4038/jnsfsr.v33i2.2340

Dissanayake, C. B., & Iqbal, M. C. M. (2014). CKDu in Sri Lanka. Science, 344(6187), 981. https://doi.org/10.1126/science.344.6187.981-b

Dissanayake, C., & Weerasooriya, S. (1985). A geochemical classification of groundwater of Sri Lanka. *Journal of the National Science Foundation of Sri Lanka*, *13*(2), 147. https://doi.org/10.4038/jnsfsr.v13i2.8337

Gunatilaka, A., & Panabokke C.R. (2007) Groundwater Conditions in Sri Lanka: a Geomorphic Perspective. National Science Foundation of Sri Lanka. *Journal of the National Science Foundation of Sri Lanka*, *36*(1), 113. https://doi.org/10.4038/jnsfsr.v36i1.140

Herren G.L., Habraken J., Waeyenberge L., Haegeman A., Viaene N., Cougnon M., et al. (2020). Effects of synthetic fertilizer and farm compost on soil nematode community in long-term crop rotation plots: A morphological and metabarcoding approach. *PLoS ONE* 15(3): e0230153. https://doi.org/10.1371/journal.pone.0230153I

Jayathileke, S., & Matsueda, H. (1992). A comparison of the mineralogy of Sri Lanka and a part of east antarctica. *Journal of the National Science Foundation of Sri Lanka*, *20*(2), 271. https://doi.org/10.4038/jnsfsr.v20i2.8082

Kováč, K., Macák, M., & ŠVančárková, M. (2011). The effect of soil conservation tillage on soil moisture dynamics under single cropping and crop rotation. *Plant, Soil and Environment*, *51*(3),124–130. https://doi.org/10.17221/3564-pse

Narasimhan, T. (1998). Quantification and Ground Water Hydrology. *Ground Water*, *36*(1), 1. https://doi.org/10.1111/j.1745-6584.1998.tb01056.x

Rengel, Z. (1992). Modeling magnesium uptake from an acid soil: IV. Depletion of magnesium, calcium, and potassium from soluble and exchangeable phase. *Communications in Soil Science and Plant Analysis*, 23(1–2), 165–174. https://doi.org/10.1080/00103629209368579

Conference Paper No: BF-03

Formulation and quality evaluation of fruit and vegetable-based energy drink

R. M. N. A. Wijewardane[*1], J. A. A. S. Jayaweera[2] and G. A. A. R. Perera[2]

[1]National Institute of Postharvest Management, Research and Development Center, Jayanthi Mawatha, Anuradhapura, Sri Lanka
[2]Department Export Agriculture, Uva Wellassa University, Badulla
nilanthiwijewardana@yahoo.com*

Among specific food products, sports drinks, as well as energy drinks, have become very popular in the last few decades. Although energy drinks currently available are particularly rich with stimulants like caffeine those are very important to the people like athletes, students, and elderly people. The long-term exposure to various components of energy beverages may cause adverse health effects. The present study aims to develop a nutritionally rich natural energy drink formulation using locally available fruits and vegetables without adding stimulants like caffeine. Different combination of energy drink formulations were prepared using different combinations of beetroot, watermelon, pomegranate, orange juices, and king coconut water. Different combinations of energy drink formulations were evaluated based on physicochemical properties, energy content, and organoleptic properties. The best performing formulation was treated with Sodium metabisulphite (SMS) and Sodium Benzoate (SB) with a control (no added preservative) and stored under room temperature (30°C) vs. the refrigerated condition (4±2°C). Data obtained in triplicate (n=3) and the results were analyzed by completely randomized using ANOVA. Mean separation was done using Least Significant Difference (LSD) at $\alpha= 0.05$. The selected best formula contained beetroot (40%), watermelon (20%), pomegranate (30%) and orange (5%) juices, and king coconut water (5%) by volume with 50 ppm of sodium benzoate as a preservative. The content of energy is 54.74 kcal.g^{-1} and 12.37 g of carbohydrate per 100 mL of beverage. Therefore the product can be stored at refrigerated conditions (4±2°C) for a period of two months without deteriorating the quality.

Keywords: Energy drink, nutrition, fruits, vegetables, storage

Conference Paper No: BF-04

Identification of marker compounds and antioxidant activity of *Terminalia chebula Retz.* fruit pericarps used in selected commercial herbal preparations in Sri Lanka

K. P. C. D. Suraweera[1,2], H. M. R. Amarasekara[2], T. M. S. G. Tennakoon[1] and S. R. Wickramarachchi[2*]

[1]Link Natural Products (Pvt) Ltd., Sri Lanka
[2]Department of Chemistry, University of Kelaniya, Sri Lanka
suranga@kln.ac.lk*

Medicinal plants contain phyto-constituents which show pharmacological effects. This study is focused on identification and quantification of marker compounds and determination of the antioxidant activity of *T. chebula* Retz. fruit pericarps used in selected commercial herbal preparations in Sri Lanka. Commercial samples were obtained from Sri Lanka (SL_C) and India (IN_C), separately from three different batches of *T. chebula* stocks from raw material quarantine section at Link Natural Products (Pvt) Ltd. As these commercial samples are a mixture of fruits from wider geographical locations, five samples (SL_A) collected from known locations in Sri Lanka were included for comparison. Methanolic extracts (70 % v/v) were prepared from each sample. Chromatographic profiling was done using thin layer chromatography (TLC) and high-performance liquid chromatography (HPLC). Extracts were assayed for gallic acid content, total tannin content and antioxidant activity. Gallic acid and ellagic acid could be used as marker compounds in quality control of *T. chebula* commercial stocks. All samples had a low IC_{50} value than butylated hydroxytoluene (BHT) standard showing that *T. chebula* fruit pericarps have higher antioxidant activity than BHT. Variations in IC_{50} values were observed within and among SL_A, SL_C and IN_C suggesting that both intrinsic and extrinsic factors may lead to the change in antioxidant potential of the fruits. The mean IC_{50} value of SL_C samples was (6.32 ± 2.09) µg/mL whereas that of IN_C samples was (7.42 ± 0.93) µg/mL suggesting that antioxidant activity was higher in SL_C samples over IN_C samples. A variation in antioxidant activity in SL_A samples was observed, depending on the sampling site.

Keywords: Antioxidants, Gallic acid, Polyphenols, Tannin, *Terminalia chebula*

Conference Paper No: BF-05

An ethnobotanical approach to control *Typha angustifolia*: A case study from Sri Lanka

K. P. K. Madushani[1*], M. D. Amarasinghe[1], R. M. C. S. Ratnayake[1] and D. D.G. L. Dahanayaka[2]

[1]Department of Plant and Molecular Biology, University of Kelaniya, Sri Lanka
[2]Department of Zoology, The Open University of Sri Lanka
2017_madushani@kln.ac.lk*

Typha is a cosmopolitan genus that is infamous globally for having nuisance plant species. In Sri Lanka, *Typha angustifolia* is distributed in both coastal and inland wetlands, including lagoons, paddy fields, and small reservoirs. Pervasive effects of *Typha* include hindrance to fishing activities, navigation, agriculture, human health, and ecosystem functions, especially provision of habitats for wading birds in coastal lagoons. The present study attempted to formulate an ethnobotanical strategy to control the distribution of *Typha* in Embilikala lagoon in Bundala National Park in Hambantota District in Southern Sri Lanka. *T. angustifolia* edible plant parts were tested for antioxidant activity to promote it as a phytonutrient that boosts the overall health of the body. Hexane, methanol, and aqueous extracts of leaf, leaf base, rhizome, and pollen of *Typha* were analyzed with DPPH and ABTS bioassays for the presence of antioxidants. Leaves were tested for their quality as raw material for making paper using the mould and deckle pouring method and couching technique. Methanol was found to be superior to hexane and deionized water as a solvent for both the assays. Leaf base (99.5 ± 5.3 µg/mL) and rhizome (65.3 ± 0.6 µg/mL) of *T. angustifolia* showed higher radical scavenging activity, and in some instances, higher than that of standard butylated hydroxytoluene (BHT) (119.3 ± 4.5 µg/mL), indicating their potential as sources of bioactive compounds that can reduce free radicals. Contents of heavy metals (Arsenic: 0.338 ± 0.040, Cadmium: 0.628 ± 0.146, Chromium: 63.641 ± 1.30, Lead: 15.657 ± 1.70 ppb) in the rhizomes were below the standard permissible level (100.0 ppb). Pulp made with *Typha* leaves alone and a mixture of *Typha* (95%) and wastepaper (5%) were used successfully to produce writable paper. Findings suggest that *T. angustifolia,* which is widely considered as an invasive plant and marginally utilized currently, has a promising potential to be exploited as food and raw material to introduce new livelihoods to rural communities. This ethnobotanical approach may potentially be used to control the distribution of *T. angustifolia* in wetlands where it is found in invasive proportions.

Keywords: Control, Invasive plants, Sri Lanka, *Typha angustifolia*

Conference Paper No: BF-06

Bioactive properties and metabolite profile of an endolichenic fungus, *Hypoxylon lividipigmentum*

W. R. H. Weerasinghe[1], C. D. Shevkar[2], R. S. De Silva[3], R. N. Attanayake[4], G. Weerakoon[5], A. S. Kate[2], K. Kalia[2] and P. A. Paranagama[1*]

[1]Department of Chemistry, University of Kelaniya, Sri Lanka
[2]National Institute of Pharmaceutical Education and Research, India
[3]College of Chemical Sciences, Institute of Chemistry Ceylon, Sri Lanka
[4]Department of Plant and Molecular Biology, University of Kelaniya, Sri Lanka
[5]Department of Life Sciences, The Natural History Museum, United Kingdom
priyani@kln.ac.lk*

Endolichenic fungi (ELF) serve as a novel source of secondary metabolites. *Hypoxylon lividipigmentum* is an ELF isolated from the lichen *Opegrapha medusulina*, collected from mangrove plant *Xylocarpus granatum* from Negombo lagoon, Sri Lanka. The fungus was identified to the species level using morphological and DNA barcoding techniques. Ethyl acetate extract of the fungus was subjected to in vitro assays to determine antioxidant, anti-inflammatory, tyrosinase inhibitory and antibacterial potency. Liquid Chromatography-Mass Spectrometry (LCMS) dereplication was conducted on the crude extract in order to detect the secondary metabolites present. The extract reported a IC_{50} value of 18.34 ± 1.37 μg/ml on par with the positive control BHT, in DPPH radical scavenging assay. It also exhibited moderate anti-inflammatory activity with an IC_{50} value of 81.08 ± 1.05 μg/ml. Tyrosinase inhibitory activity was fairly comparable with an IC_{50} value of 121.20 ± 2.55 μg/ml. Agar well diffusion assay was conducted to determine antibacterial activity against aerobic bacterial species *Escherichia coli*, *Bacillus subtilis*, *Staphylococcus aureus* and the anaerobic bacterial species *Streptococcus mutans*. Suppression of growth was shown only against *B. subtilis*. Five major mass peaks were observed during the study of LCMS profile of the extract. After a thorough dereplication process, two masses could be presumed to be from novel scaffolds. Since none of the mass peaks could be dereplicated within the species or genus level, it could be speculated that the chemical profile of *Hypoxylon lividipigmentum* was previously poorly explored in literature thus making it an interesting organism to study further for novel metabolites.

Keywords: Bioactivity, Endolichenic Fungi, *Hypoxylon lividipigmentum*, LCMS dereplication, Lichens

Conference Paper No: PF-07

Thin film cuprous oxide homojunction photoelectrode for water splitting

F. S. B. Kafi, S. A. A. B. Thejasiri[1], R. P. Wijesundera[*] and W. Siripala

Department of Physics and Electronics, University of Kelaniya, Kelaniya, Sri Lanka
palitha@kln.ac.lk*

Employing cuprous oxide (Cu_2O) photoelectrodes in photoelectrochemical cells to generate hydrogen by water splitting is beneficial. Conventionally, it is limited in practice because of the well-known reasons of its inherent corrosiveness and poor conversion efficiencies. In this study, we have investigated the possibility of improving the efficiency of Cu_2O photoelectrode in the form of p-n homojunction together with sulphidation. Initially, the optimum pH values for the n- and p-Cu_2O thin film deposition baths are determined as 6.1 and 13 for Ti/n-Cu_2O/p-Cu_2O in photoelectrochemical cell configuration. Then, at these pH values the duration of n- and p-Cu_2O thin film deposition is optimized by forming Ti/n-Cu_2O/p-Cu_2O photoelectrode. In this study, we found that at 45 minutes of n-Cu_2O and 50 minutes of p-Cu_2O thin film deposition together with sulphidation forms relatively high efficient Ti/n-Cu_2O/p-Cu_2O photoelectrode resulting Solar-To-Hydrogen (STH) conversion efficiency of 0.9%. In addition, current-voltage characteristic of the best Cu_2O homojunction photoelectrode exhibits more negative shift in onset of photocurrent which indicates that photocurrent generation and transportation have improved by the formation of homojunction and further been enhanced by sulphidation.

Keywords: Cuprous oxide, Electrodeposition, Photoelectrode, p-n junction, Water splitting

Conference Paper No: PF-08

Copula-based drought severity-duration-frequency analysis for Anuradhapura and Puttalam in the dry zone of Sri Lanka

W. R. P. M. S. S. Wijesundara[1*] and K. Perera[2]

[1]Computing Center, Faculty of Engineering, University of Peradeniya, Sri Lanka
[2]Department of Engineering Mathematics, Faculty of Engineering, University of Peradeniya, Sri Lanka
sachinisw1515@gmail.com*

Drought is a severe problem in many areas of Sri Lanka, where rainfall amounts are low and extremely high due to climatic changes. To reduce the negative consequences of droughts, it is important to understand the drought characteristics (drought duration and drought severity) and their associations. Therefore, to build a drought severity-duration-frequency (SDF) relationship, a probabilistic technique is proposed using rainfall data from 1996 to 2018 in the two districts Anuradhapura and Puttalam in the dry zone of Sri Lanka. Drought characteristics were defined using 3-month standardized precipitation index (SPI) and Copulas are employed to derive the joint distribution function. Occurrences of 41 droughts from both stations were identified. The derived SDF relationship is a function of marginal distribution functions of drought characteristics linked by a copula. Log-normal distribution and Gamma distribution were identified as the best marginal distribution to represent drought duration and drought severity, respectively, using AIC, BIC and Kolmogorov-Smirnov test. Gaussian copula and Frank copula were identified as the best among the other five copulas based on AIC, BIC and Cramer-Von Mises statistics. Both Log-normal distribution and Gamma distribution along with the Gaussian copula and Frank copula combined to derive the joint distribution of Anuradhapura and Puttalam, respectively. Joint return periods in terms of recurrence intervals were calculated and derived the SDF curves. According to the derived SDF curves, drought severity in Puttalam is greater than those in Anuradhapura for a given recurrence interval and drought duration.

Keywords: Copula, Drought, Joint distribution, Marginal distributions, SPI

Conference Paper No: PF-09

Fourier method for one dimensional parabolic inverse problem with Dirichlet boundary conditions

H. A. K. Amanda[1*] and W. P. T. Hansameeu[1]

[1]Department of Mathematics, University of Kelaniya, Sri Lanka
kviamahettiarachchi@gmail.com*

The finite difference method, spectral method, and double shifted Lagrange's polynomials have been discussed for the one-dimensional inverse problem of the heat equation with control parameters and the source term in literature. Here, we present, Fourier method for the one-dimensional parabolic inverse problem with Dirichlet boundary conditions. In this study, after analyzing the control parameters, the initial condition and the source term are used to track a temperature distribution at a point in the interval. We validated that desired temperature distribution and measured temperature distribution (or the point evaluation) at an internal point overlap each other for the derived values of control parameters (source term and initial distribution) using the Fourier method. Moreover, we validated the temperature distribution at a point in the domain and tracked the desired harmonic and linear temperature distributions using numerical simulations. Finally, we simplified the above numerical simulations using the COMSOL software and illustrated some figures to the given point.

Keywords: Dirichlet boundary conditions, Fourier method, One dimensional heat equation control, Tracking problem, Point evaluation

Conference Paper No: PF-10

The Holt-Winters' method for forecasting water discharge in Attanagalu Oya

M. L. P. Anuruddhika[1*], L. P. N. D Premarathna[1], K. K. K. R. Perera[1], W. P. T. Hansameenu[1] and
V. P. A. Weerasinghe[2]

[1]Department of Mathematics, University of Kelaniya, Sri Lanka
[2]Department of Zoology and Environmental Management, University of Kelaniya, Sri Lanka
prasadianuruddhika@gmail.com*

Forecasting river water discharge is significant in developing flood and agriculture management plans. Annual flood events damage properties, agricultural field, and infrastructures, etc. can be observed in Attanagalu Oya catchment area in Sri Lanka. Therefore, the aim of this study is to forecast water discharge rates (m^3/s) at the Dunamale gauging station of Attanagalu Oya using Holt-Winter's method. Holt-Winter's method was chosen because of its' ability to model trend and seasonal fluctuations, less data requirements and simplicity. Time series models were fitted using the Holt-Winter's method to daily water discharge rates for the period of 2015 –2019 and water discharge was forecasted for the year 2020. The accuracy of the fitted time series models was tested using root mean squares error (RMSE) and mean absolute error (MAE) values. Results showed that the additive Holt-Winters' method is more appropriate for future forecasting which gave the minimum RMSE and MAE values. Forecasted results will be useful to identify future flood events in advanced to take necessary actions to mitigate damages.

Keywords: Attanagalu Oya, Flood, Holt Winters' Methods, Time Series Analysis, Water Discharge

Conference Paper No: PF-11

Time series modeling and forecasting of total primary energy consumption in Sri Lanka

P. A. D. S. P. Caldera[*], N. N. D. Malshika, S. H. A. S. Nikapitiya, U. S. C. B. Udugedara and N. V. Chandrasekara

Department of Statistics and Computer Science, University of Kelaniya, Sri Lanka
sandunicaldera97@gmail.com*

Primary energy is the energy that is harvested directly from natural resources. Forecasting total primary energy consumption in Sri Lanka is significant as primary energy consumption worldwide is expected to continue increasing. This study aimed to model and forecast total primary energy consumption in Sri Lanka, which has not yet been analysed using Time Series Analysis. For this purpose, the annual data of total primary energy consumption in Sri Lanka from 1960 to 2019 in terawatt-hours was extracted from the world wide web and analysed with Auto-Regressive Integrated Moving-Average (ARIMA) model. The stationary of the series was tested using the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test, Phillips-Perron (PP) test, and Augmented Dickey-Fuller (ADF) test. The study revealed the ARIMA(4,2,1) model as a best-fitting model, which gave the minimum value of Akaike Information Criterion (AIC). Total primary energy consumption from 2008 to 2019 was forecasted using ARIMA(4,2,1) model as it satisfied the model diagnostics, which are ARCH test, autocorrelation function, and normality of residuals. With Mean Absolute Error (MAE) of 5.0283 and Root Mean Squared Error (RMSE) of 5.9216, the results illustrate that ARIMA(4,2,1) model captures the trend in total primary energy consumption accurately. Based on the results, the study suggests ARIMA(4,2,1) is more convenient in determining the trends and the patterns of the future in total primary energy consumption in Sri Lanka.

Keywords: ARIMA model, Energy consumption, Forecasting, Sri Lanka, Time series modeling

Conference Paper No: SF-03

Human in the loop design for intelligent interactive systems: A systematic review

N. Arambepola[*] and L. Munasinghe

Software Engineering Teaching Unit, Faculty of Science, University of Kelaniya, Sri Lanka
nimasha_2019@kln.ac.lk*

It is undeniable that modern computers are incredibly fast and accurate. However, computers cannot 'think' (act intelligently) as humans unless it is trained to learn from the past knowledge. Despite their intelligence, humans are comparatively slow in computational tasks. However, the combination of the computational capacity of computers and human intelligence could produce powerful systems beyond the imagination. This concept is called Human-in-the-Loop (HITL) where both human and machine intelligence support the creation of Machine Learning (ML) models. HITL design is an emerging technology which is used in many domains such as autonomous vehicle technology, health systems and interactive system implementations. In this research, we systematically reviewed past research of HITL systems with the objectives of identifying key benefits and limitations of the HITL design. This systematic review was conducted by analyzing 68 research papers published in top-ranked journals and conferences during the past decade. Moreover, the papers were selected using keyword-based searching and references of the most cited HITL research papers. The PRISMA model was used to exclude irrelevant papers, and keyword-based clustering was used to identify the frequent keywords in the selected papers. Although the HITL design often improves the performance of intelligent interactive systems, there are certain drawbacks of this concept when compared to fully manual or fully automated systems such as making decisions with emotional bias and being unable to take actions when demanded. Thus, we comprehensively discuss the approaches proposed by the recent researchers to overcome some of the issues of the existing HITL designs.

Keywords: Human-in-the-loop design, Human intelligence, Intelligent interactive systems, Machine learning, Keyword-based clustering

Conference Paper No: MF-02

Effect of application process and physical properties of penetrant material to the sensitivity of liquid penetrant inspection

D. S. K. L. Fernando[1*] and M. W. S. Perera[2]

[1]Faculty of Science, University of Peradeniya, Sri Lanka
[2]National Center for Non Destructive Testing, Sri Lanka Atomic Energy Board, Sri Lanka
klf.shelly@gmail.com*

Liquid Penetrant Testing is one of the most popular and widely used NDT method in a wide range of industries such as oil & gas, power generation, aerospace, marine and automotive. It can be used to detect open to surface defects on all non-porous materials. Solvent removable visible dye penetrant testing is employed in this project. Reliability of using dye penetrants that have elapsed their manufacturer-recommended usable time for liquid penetrant testing, is presented in this paper. There are two main parts in this study; comparing the sensitivity of dye penetrants by varying inspection techniques, and comparing the physical properties of penetrant materials. Four color contrast dye penetrant samples, with different chemical aging, were selected to perform the tests. For the first part, penetrant testing was performed on two selected welding discontinuities by varying dwell time and the number of developer layers with the aid of selected dye penetrant samples. For the second part, the density and viscosity of each dye penetrants were measured. According to the results, sensitivity and detectability of solvent removable visible dye penetrant decreases with the chemical aging. However, with increased dwell time and a minimal number of developer layers, it can be used to detect volumetric defects. With chemical aging, density does not change significantly but viscosity can be changed with different thermal and environmental influences.

Keywords: Color contrast dye penetrant, Liquid penetrant testing, Non-destructive testing, Penetrant dwell time, Sensitivity

Conference Paper No: MF-03

Perceived value analysis of motorcycles in Sri Lanka

P. A. L. Chanika[1*], A. M. C. H. Attanayake[1] and M. D. N. Gunaratne[2]

[1]Department of Statistics & Computer Science, University of Kelaniya, Sri Lanka
[2]Agriculture Sector Modernization Project, Sri Lanka
laknichanika1213@gmail.com*

The motorcycle is the vehicle with highest demand in Sri Lanka. Motorcycle usage in Sri Lanka is expanding rapidly over the years primarily due to its affordable price range. Customer perception refers to the customer's opinion of the service/product and evaluates through perceived value analysis. It is important to know the relationship between the price of motorcycles and customer perceived value of motorcycles for decision-makers in the automotive industry. The objectives of this study are to identify the attributes which are most important in formulating the customer perception towards motorcycle prices, identify the relationship between the price and customer perception of the motorcycles and calculate the perceived value for each motorcycle model under consideration. A total of 1117 customers were used to generate data with respect to 21 motorcycle models. Non- probability sampling techniques were applied in the market survey, that gathered data on customer opinion on attributes such as brand, appearance, features, fuel efficiency, resale value, after-sale services, and suitability for road. were identified as the important attributes in formulating the customer perception towards motorcycle prices. Perceived value for each Commuter Standard, Commuter Deluxe, Sports Classic and Sports Premium motorcycle models were calculated by using the weightage of each attribute and rank of motorcycles. According to the Pearson correlation coefficient, there is a positive relationship between the actual price and the perceived value of motorcycles. Therefore, this analysis helps to understand purchasing decisions of customers and industry players can use this information for adjusting their pricing strategies against the market competition.

Keywords: Customer perception, Perceived value analysis, Prices of motorcycles

Conference Paper No: MF-04

Applicability of modified queueing model with encouraged arrivals for economic recession

J. A. S. Dinushan[*] and C. K. Walgampaya

Department of Engineering Mathematics, University of Peradeniya, Sri Lanka
sanoj.j@eng.pdn.ac.lk*

Businesses often offer lucrative deals and discounts so that customers' encouragement to engage with those firms are developed. This kind of arrivals are termed as encouraged arrivals. As a pandemic is overwhelming the world, it could be suggested that, for upbringing of declining businesses, this concept, now, deserves to be taken into account more than ever in the past. In order to describe the encouraged arrival process mathematically, a Markovian queuing model is used and the parameter that represents the arrival rate is modified with percentage increase in the arrival rate of customers. In this paper, we investigate the behavior of measures of performances with and without encouraged arrivals for multi-server finite capacity queuing system. In the analysis it was possible to identify that a significant number of customers compared to the normal arrival process is engaged with the system when it is affiliated with the encouraged arrival process. As well as it shows that customers engage more and more with the system irrespective of the high rates of arrivals and low rates of services. In addition to that under the economic analysis, it was uncovered that the profit increment due to encouraged arrivals is very higher than that due to normal arrivals.

Keywords: COVID-19, Economic Recession, Encouraged Arrivals, Queuing System

With Best Compliments!!!!!!!!!!!!!!!!!!!!!

CHAIRMAN / MANAGING DIRECTOR

With CPSTL Staff

CEYLON PETROLEUM STORAGE TERMINALS LTD.

Oil Installation - Kolonnawa

www.cpstl.lk

TRACKS

BIOLOGICAL SCIENCES

PHYSICAL SCIENCES

SOFTWARE INTENSIVE SYSTEMS

MULTIDISCIPLINARY RESEARCH