

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



**PGIS RESEARCH CONGRESS 2019
PROCEEDINGS**

11 October 2019

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ISBN 978-955-8787-10-6

Published by

Postgraduate Institute of Science (PGIS)

University of Peradeniya

Peradeniya 20400

SRI LANKA

Printed by

Sanduni Offset Printers (Pvt) Ltd,

1/4, Sarasavi Uyana Goodshed Road,

Sarasavi Uyana, Peradeniya 20400,

SRI LANKA

Printed in the Democratic Socialist Republic of Sri Lanka

TABLE OF CONTENTS

Message from the Director, Postgraduate Institute of Science	v
Message from the Congress Chairperson	vii
Message from the Editor-in-Chief.....	ix
Editorial Board	xi
A Brief Biography of Prof. Alan Lyons	xiii
A Brief Biography of Prof. Veranja Karunaratne	xv
List of Abstracts	xvii
 Abstracts	
Abstract of the Keynote Speech.....	1
Abstract of the Plenary Speech	3
Theme-I Earth and Environmental Sciences.....	5
Theme-II ICT, Mathematics and Statistics	31
Theme-III Life Sciences	71
Theme-IV Physical Sciences.....	119
Theme-V Science Education.....	137
PGIS Research Congress Organizing Committee.....	151
Sponsors.....	154
Author Index	155

PGIS Research Congress 2019

Message from the Director, Postgraduate Institute of Science



The Postgraduate Institute of Science (PGIS), University of Peradeniya, which was established in the year 1996, is a National Institute dedicated for Postgraduate Teaching and Research in all scientific and related disciplines which including Biochemistry and Molecular Biology, Biomedical Sciences, Botany, Chemistry, Earth Science, Environmental Science, Physics, Mathematics, Science Education, Statistics & Computer Science and Zoology. Quite remarkably, the PGIS has made an admirable progress during the two decades where she has successfully expanded to the current level of conducting numerous M.Sc., M.Phil. and Ph.D. programs under Eleven Boards of Study, catering to several thousands of postgraduate students drawn from almost all universities of Sri Lanka and many other universities abroad. The teaching staff of the PGIS comprises of distinguished academics and renowned researchers of Sri Lankan universities and other institutes whose dedicated services enabled the production of nationally and internationally recognized budding scientists.

The PGIS further thrives on continuing to produce leaders in the fields of sciences and contributes to the betterment of the society through its R&D activities particularly in the areas of national and international significance. Additionally, the PGIS organizes and conducts national and international symposia and conferences as well as numerous workshops and short courses. The annual research congress (RESCON) is such a main event of the PGIS which provides a platform for postgraduate research students and senior scientists to disseminate their findings, interact and exchange ideas with leading scientists throughout the globe. Born just five years ago, the RESCON has grown continuously into its current high standard, and is evolving every year in succession, to even higher standards. As the current director of the PGIS, I am delighted to extend my fullest support to the organizing committee of the RESCON-2019 who has been working with utmost dedication and devotion to make this event a great success. Past RESCONs were indeed very successful and there is no doubt that RESCON-2019 will also be a great success. RESCON-2019 will demonstrate high standards of research carried out in Sri Lanka, quality of abstracts submitted, and the dedicated services of reviewers and the organizing committee of RESCON-2019. I take this opportunity to express my heartiest appreciation to all those who worked in numerous ways to make RESCON-2019 a great success and I do hereby request your continued support towards even better future RESCONs.

Prof. H.M.T.G.A. Pitawala

Director/Postgraduate Institute of Science

PGIS Research Congress 2019

Message from the Congress Chairperson



The Postgraduate Institute of Science (PGIS), University of Peradeniya, has organized its sixth Annual Research Congress (RESCON 2019), to be held on Friday 11th October 2019. On behalf of the Organizing Committee, it is a great honor and privilege for me to welcome you all to the PGIS RESCON 2019. This is a multi-disciplinary congress that provides excellent opportunities for academicians, scientists, engineers, students and researchers to present their scholarly contributions, share new ideas with stimulating discussions on future research trends and to exchange information on cutting-edge new technologies. We are honoured to have His Excellency Mr. Taranjit Singh Sandhu, High Commissioner of India to Sri Lanka as the Chief Guest, Prof. Upul

B Dissanayake, the Vice Chancellor, University of Peradeniya, as the Guest of Honour, distinguished Professor, Prof. Alan Lyons of the City University of New York, USA, as the Keynote Speaker. An eminent scientist, Prof. Veranja Karunaratne, Senior Professor, Department of Chemistry, University of Peradeniya and the Vice-Chancellor of the SLINTEC Academy is yet another plenary speaker who will be talking on “Fostering a Research Culture in Sri Lanka”.

It is very pleasing to note that around 150 research papers will be presented under 5 key-themes: Earth and Environmental Science, ICT, Mathematics and Statistics, Life Sciences, Physical Sciences and Science Education, in parallel technical sessions. RESCON will bring together a rich diversity of researchers from various universities, research institutions and industries to share ideas and new perspectives in a wide range of topics. Selected papers will be published in a Special issue of the Ceylon Journal of Science published by the University of Peradeniya. A Post-Congress workshop on “Scientific Writing” conducted by Prof. Alan Lyons, has also been organized by the Board of Study in Chemical Sciences in order to help improve scientific writing ability of our postgraduate students.

The success of the congress eventually depends on the collective untiring effort of Prof. H.M.A.T. Pitawala, Director/PGIS, Dr. Nalin Suranjith, Secretary/ PGIS RESCON 2019, Conveners and all members of sub-committees for their valuable advices and luminous suggestions and the contributions of the reviewers thorough and timely reviewing of the papers and proving valuable comments and postgraduate students who have worked with us in planning and organizing the congress. I would like to express my deepest appreciation to all the authors who submitted their outstanding research papers to the RESCON 2019. The Congress could not have organized without the financial support from the Ministry of Science and Technology and all the other generous sponsors. Finally, I wish all the participants a highly stimulating, enlightening, and enjoyable congress.

Prof. A. D. L. Chandani Perera
Chairperson/PGIS RESCON 2019

PGIS Research Congress 2019

Message from the Editor-in-Chief



It is with great pleasure and privilege that I write this congratulating note for the successful bringing up of the Proceedings of the 6th Annual Research Congress of the Postgraduate Institute of Science (RESCON-2019), University of Peradeniya. RESCON provides a forum and platform for the dissemination of scientific knowhow and cutting-edge findings of Sri Lankan researchers working in Universities, Research Institutes and Private Sector Organizations throughout the country. This year, we have received 175 abstracts from almost all universities of Sri Lanka and many research institutions which spanning all geographic horizons of the Island. All the abstracts together with their extended abstracts were thoroughly peer reviewed by eminent academics and researchers, and based on their recommendations, 151 abstracts were accepted for presentation. This year proceedings include all the accepted abstracts together with messages from the Director of the Postgraduate Institute of Science, Professor H.M.T.G.A. Pitawala, the Congress Chairperson, Professor A.D.L.C. Perera, and the Editor-in-Chief of the Proceedings, Professor R.M.G. Rajapakse, and biographies and abstracts of the Keynote Speaker, Professor Alan Lyons of the City University of New York, USA, and the Plenary Speaker, Professor Veranja Karunaratne, Senior Professor of University of Peradeniya and the Vice Chancellor of the SLINTEC Academy.

The successful outcome of the Proceedings is collective efforts of Authors, Reviewers, Members of the Editorial Committee, Editorial Assistant (W.G.D. Chathuranga), Editor-in-Chief, Congress Chairperson and the Staff of the PGIS including the Director, without which this would not have been possible. I am grateful to all those who contributed in numerous ways for bringing up of this booklet which will be a useful guide for researchers throughout the globe. Last but not least, my fondest thanks go to Sanduni Printers for their professional workout of the Proceedings and ATG Intelligent Glove Solutions Lanka Ltd., and Textured Jerseys Lanka Ltd., for generous financial supports.

Professor R.M.G. Rajapakse

Editor-in-Chief/PGIS RESCON 2019

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A Brief Biography of Professor Alan Lyons



Alan Lyons received a B.Sc. in Chemistry from Brown University and Ph.D. in Polymer Chemistry from Polytechnic University (now NYU-Tandon). He was a Distinguished Member of Technical Staff with the research division of Bell Laboratories and a founding member of Bell Labs Ireland. He joined the City University of New York, as a Professor in the Department of Chemistry in 2008. His work is focused on developing multi-functional materials with novel wetting, thermal and catalytic properties. He has authored over 45 publications as well as 38 issued patents. Based on this work, he has co-founded two companies: ARL Designs LLC, which develops advanced coatings for glass and metal; and SingletO2 Therapeutics LLC, which develops device for oral healthcare.

A Brief Biography of Professor Veranja Karunaratne



Professor Veranja Karunaratne graduated with a B.Sc. Chemistry (Special) University of Colombo, Colombo, Sri Lanka (First Class), followed by a Ph.D. in Synthetic Organic Chemistry - University of British Columbia, Vancouver, B.C. Canada. He has carried out research on diverse areas such as Synthetic Chemistry, Bioactive natural Products from endemic plants & lichens, Lichen taxonomy, Nanoscience & Nanotechnology over three decades of research.

He was the former Head, Department of Chemistry, University of Peradeniya, (2005 -2008), Former Chairman, Senior Student Counsellors, University of Peradeniya (1997-2001), Former Science Team Leader, and Associate Director, Sri Lanka Institute of Nanotechnology) (2008 -2016) and currently is a Senior Professor Department of Chemistry, University of Peradeniya and Vice Chancellor, SLINTEC ACADEMY.

He was honoured by the government of France in 2012 with a Chevalier dans l'Ordre des Palmes Académiques (Knight of the Order of Academic Palms). He is an elected Fellow of the National Academy of Sciences and a Fellow of the Royal Society of Chemistry. Professor Karunaratne is a Visiting Professor, University of British Columbia from 2003 to date.

Professor Karunaratne received the National Science Foundation, Special Merit Award for outstanding research, General Research Award by the Sri Lanka Association for Advancement of Science, National Science Foundation Science & Technology Award for Best Innovation Having Commercialization Potential, and Presidential Award for Research and Scientific Publication from 2001-2017.

Professor Karunaratne has supervised 16 PhD and 10 MPhil students. He has published 155 publications in peer reviewed journals (H index: 30) and is the inventor of 53 patents and applications. He has presented 220 archived abstracts at national and international conferences. Ten of his postgraduate students have are employed in the academia in a number of universities in Sri Lanka.

PGIS Research Congress 2019

PROCEEDINGS

List of Abstracts

Keynote Speech	MULTI-FUNCTIONAL SUPERHYDROPHOBIC POLYMER SURFACES <i>Alan Lyons</i>	01
Plenary Speech	FOSTERING A RESEARCH CULTURE IN SRI LANKA <i>Veranja Karunaratne</i>	03

THEME-I Earth and Environmental Sciences

Abstract ID No.	Title and Authors	Page No.
4	SOLAR ENERGY FORECASTING WITH MACHINE LEARNING APPROACHES <i>M.D.S. Hossain</i>	05
8	TOLERANCE OF Cr(VI) AND Cd(II) BY THREE BACTERIAL GENERA ISOLATED FROM A WATER BODY RECEIVING INDUSTRIAL EFFLUENT <i>D.G.N.S. Senevirathne and I.V.N. Rathnayake</i>	06
12	HYDROGEOCHEMICAL CHARACTERISTICS OF GROUNDWATER IN WILGAMUWA REGION: AN AREA WITH HIGH INCIDENCE OF CHRONIC KIDNEY DISEASE WITH UNCERTAIN ETIOLOGY (CKDU) <i>H.P. Amaratunga, S. Balasooriya, S. Diyabalanage and R. Chandrajith</i>	07
15	EFFECTS OF SELECTED WATER QUALITY PARAMETERS ON SEASONAL FLUCTUATIONS OF 2- METHYLISOBORNEOL IN SURFACE WATER BODIES OF SRI LANKA <i>G.S.S. Ganegoda, S.D.M. Chinthaka and P.M. Manage</i>	08
18	TOTAL HARDNESS LEVEL OF GROUNDWATER IN A COASTAL AQUIFER <i>A.H.L.C.M. Athapaththu, D. Wickramasinghe and H. Manthrithilake</i>	09
26	TESTOSTERONE LEVELS IN RELATION TO ANTLER GROWTH IN MALE SAMBAR DEER (RUSA UNICOLOR UNICOLOR) IN HORTON PLAINS NATIONAL PARK, SRI LANKA <i>D.S. Weerasekera, A.N.L. Rathnasekara, H.M.S.S. Herath, D.K.K. Nanayakkara, S.J. Perera and K.B. Ranawana</i>	10
31	ENHANCEMENT OF PHOSPHORUS SOLUBILITY OF EPPAWALA ROCK PHOSPHATE USING MICROBIAL BIOFILMS <i>J.P.H.U. Jayaneththi, G. Seneviratne, H.M.S.P. Madawala and M.G.T.S. Amarasekara</i>	11
53	DRINKING WATER QUALITY AND THE CKDU OCCURRENCE IN WILGAMUWA, SRI LANKA <i>H.P.M. Hewavitharane, N. Nanayakkara, S. Anand, R. Chandrajith, P. Vlahos, S. Schensul, J. Schensul, L. Haider, K.T. Silva, R.M.M.B. Karunaratne and W.M.K.P. Wijerathne</i>	12

THEME-I Earth and Environmental Science

Abstract ID No.	Title and Authors	Page No.
71	SITE SUITABILITY ANALYSIS FOR SOLID WASTE DISPOSAL IN VAVUNIYA DISTRICT, SRI LANKA <i>H. Jayaweera, S. Devaisy, S. Wijeyamohan and A. Nanthakumaran</i>	13
76	MITIGATION OF HIGH TDS WATER WITH ELECTRODIALYSIS REVERSAL METHOD–AN ALTERNATIVE SOLUTION FOR DRY ZONE WATER PROBLEM IN SRI LANKA <i>J.U. Halpegama, P. Rukshagini, B. Tian, A.C. Herath, S.K. Weeragoda, Y. Wei and R. Weerasooriya</i>	14
77	ASSESSING DRINKING WATER QUALITY AMONG CKDU PATIENTS WITH TUBULITIS: A CROSS SECTIONAL STUDY CONDUCTED IN SRI LANKA <i>O.S.S. Premarathne, N. Nanayakkara, R. Chandrajith and H.P.M. Hewavitharane</i>	15
81	VARIATIONS IN WATER QUALITY PARAMETERS IN NEGOMBO LAGOON, SRI LANKA AND ITS IMPACT ON FISH AND SHELLFISH ABUNDANCE <i>R.M.S.W. Rathnayake and D.C.T. Dissanayake</i>	16
86	MORPHOLOGICAL DIVERSITY OF PHYTOLITHS OF SELECTED SRI LANKAN TRADITIONAL RICE LANDRACES <i>W.M.M.T. Thennakoon and M.L.A.M.S. Munasinghe</i>	17
87	SITE SUITABILITY EVALUATION OF BEACHES FOR ECOTOURISM DEVELOPMENT IN THE JAFFNA DISTRICT, SRI LANKA <i>Packiyathan Rajkumar and Chaminda S. Wijesundara</i>	18
90	PHYTOCHEMICAL SCREENING, ANTIFUNGAL AND ANTIBACTERIAL ACTIVITY OF <i>PSIDIUM GUAJAVA</i> LEAF EXTRACT <i>S.K.A.M.R. Samarasinghe, R. Srikanan and A.C. Thavaranjit</i>	19
91	MODIFICATION OF ZEOLITE FOR REMOVAL OF FLUORIDE IN WATER <i>E.M.A.P.B. Ekanayake, W.M.A.T. Bandara, S.V.R. Weerasooriya and I.P.L. Jayarathna</i>	20
99	USE OF POST CONSUMER POLY(ETHYLENE TEREPHTHALATE) BOTTLES AS A SOURCE OF METAL ORGANIC FRAMEWORK SYNTHESIS <i>D.S.D. Weerasinghe and W.S.S. Gunathilake</i>	21
110	FINFISH SPECIES COMPOSITION AND COMMERCIAL FISH PRODUCTION OF BOLGODA NORTH LAKE, SRI LANKA <i>D.M.C.P. Dissanayake and S.M.D.A.U. de Alwis</i>	22
114	PALEO-CLIMATE AND PALEO-ENVIRONMENT VARIABILITY OF SOUTHEASTERN SRI LANKA AS INFERRED BY A PALEO-PROXY RECORD FROM POTTUVIL LAGOON <i>K. Premaratne, Si-Liang Li, N.P. Ratnayake and R. Chandrajith</i>	23
130	ABUNDANCE AND GRAIN MORPHOLOGY OF HEAVY MINERAL ACCUMULATIONS IN SOUTH-WESTERN COAST OF SRI LANKA <i>A.M.G.K. Wijeratne and S.P.K. Malaviarachchi</i>	24

THEME-I Earth and Environmental Science

Abstract ID No.	Title and Authors	Page No.
131	WASTE PEANUT HULL AS A BIOSORBENT TO TREAT RICE MILL WASTEWATER: A COMPARISON WITH THE EFFICIENCY OF GRANULAR ACTIVATED CARBON <i>U.D.T.M. Uduwarage and S. Devaisy</i>	25
141	TOURIST COMPOSITION AND THEIR OPINION ON ECOTOURISM POTENTIALS IN THE JAFFNA DISTRICT, SRI LANKA <i>P. Rajkumar and C. S. Wijesundara</i>	26
143	DEGRADATION OF SUMIFIX REACTIVE RED EXF AND BLUE EXF DYES USING A COBALT TRIMESIC COORDINATION POLYMER <i>H.M.C.B. Wathulanda, H.A.I.R. Perera and C.V. Hettiarachchi</i>	27
154	INFLUENCE OF CANNA INDICA ON BOD ₅ AND COD IN DAIRY WASTEWATER THROUGH CONSTRUCTED HORIZONTAL SUB SURFACE FLOW WETLAND <i>K.G.S. Madhushani and U.D.S.S. Ranasinghe</i>	28
158	IMPACT OF ASSOCIATED ANIONS ON LEAD UPTAKE BY <i>PISTIA STRATIOTES</i> FROM WASTEWATER <i>K.N.M.H.H. Kosgahakumbura, C.V. Hettiarachchi and H.M.S.P. Madawala</i>	29
176	MINERALOGICAL CHARACTERISTICS OF THE ROAD, HOUSEHOLD AND ROCK DUST IN SRI LANKA <i>R.K.D.S. Samaradiwakara, H.M.T.G.A. Pitawala, D.G.G.P. Karunaratne, M.M.M.G.P.G. Mantilaka and C.P. Galagoda</i>	30

THEME-II ICT, Mathematics and Statistics

Abstract ID No.	Title and Authors	Page No.
10	THE DOMINATION NUMBER AND NON-SPLIT DOMINATION NUMBER OF ROACH GRAPH <i>K.G.M.U. Wickramasinghe and K.K.K.R. Perera</i>	31
11	SPATIAL AND CLUSTER ANALYSIS OF DENGUE TRANSMISSION IN WESTERN PROVINCE <i>G.A.P. Kethmi and L.P.N. D. Premarathna</i>	32
29	AN ATTENTION BASED CONVOLUTIONAL NEURAL NETWORK FOR LANDMARK RECOGNITION IN ASIAN REGION <i>S. Perera and A. Ramanan</i>	33
30	k-FACTORS OF k-FACTORIZATION OF $K_{(2,2,2,\dots,2)}$ WITH n-PARTITE SETS FOR $k=1,2$ AND $n \geq 2$ <i>M.D.M.C.P. Weeraratna, D.M.T.B. Dissanayake, D.G.S.D. Dehigama, K.D.E. Dhananjaya and A.A.I. Perera</i>	34
33	MEAN SQUARE ERROR COMPARISON OF ALMOST UNBIASED RIDGE ESTIMATOR AND MODIFIED ALMOST UNBIASED RIDGE ESTIMATOR IN LOGISTIC REGRESSION <i>N. Varathan and P. Wijekoon</i>	35
34	STABILITY ANALYSIS OF SRI LANKAN TEA EXPORT MARKETS USING MARKOV CHAIN APPROACH <i>S. Kayathiri and A. Laheetharan</i>	36
35	ANALYTICAL APPROACH TO THE CAMASSA HOLM-NONLINEAR SCHRODINGER EQUATION USING LAPLACE DECOMPOSITION METHOD <i>R. Thushanthani, K. Himalini and T. Mathanaranjan</i>	37
36	PRIME LABELING OF ROACH GRAPH <i>D.G.S.D. Dehigama, D.M.T.B. Dissanayake, M.D.M.C.P. Weeraratna, K.D.E. Dhananjaya and A.A.I. Perera</i>	38
44	AN ASYMMETRIC CRYPTOSYSTEM BASED ON MULTIPLICATIVE TRAPDOOR KNAPSACK AND MULTI-PRIME RSA <i>A.P. Madushani and P.G.R.S. Ranasinghe</i>	39
46	ACTION RECOGNITION IN VIDEOS USING CONVOLUTIONAL AND SPATIAL-TEMPORAL INTEREST POINT FEATURES <i>T. Tharmini and A. Ramanan</i>	40
48	AN IMPROVED METHOD TO FIND AN INITIAL FEASIBLE SOLUTION TO A TRANSPORTATION PROBLEM <i>N.G.S.A. Nawarathne and Z.A.M.S. Juman</i>	41
55	A LOSSY GRAYSCALE IMAGE COMPRESSION BASED ON DELAUNAY TRIANGULATION <i>T.M.V.D. Gunasekara and A. Ramanan</i>	42
56	A MODEL TO PREDICT DEPRESSION OF UNDERGRADUATES IN FACULTY OF DENTAL SCIENCE, UNIVERSITY OF PERADENIYA <i>W.A.L.S. Boyagoda, M.K.D.C.K. Chandrasiri, H.M.K.B. Wijerathna, L.S. Nawarathna and T.P. Gamagedara</i>	43

THEME-II ICT, Mathematics and Statistics

Abstract ID No.	Title and Authors	Page No.
61	PHONE USAGE PATTERN ANALYSIS TOWARDS SERVICE ENHANCEMENT <i>Y. Jerom and T. Kartheeswaran</i>	44
62	ANALYSIS OF MEDICAL SENSOR DATA TOWARDS HEALTH DISORDER IDENTIFICATION <i>S. Meruja and E.Y.A. Charles</i>	45
65	CONSTRUCTION OF MAGIC SQUARES OF ORDERS q^n , WHERE q IS ODD AND $n \in \mathbb{N}$ <i>W.V. Nishadi and A.G.C. Perera</i>	46
66	CONSTRUCTING STRONGLY REGULAR GRAPHS FROM SKEW-HADAMARD MATRICES <i>D.M.T.B. Dissanayake, M.D.M.C.P. Weerathna, D.G.S.D. Dehigama and A.C.G. Perera</i>	47
73	RESTRICTED LEAST ANGLE REGRESSION ALGORITHM FOR LASSO <i>M. Kayanan and P. Wijekoon</i>	48
74	THE BEST- FIT PROBABILITY DISTRIBUTION AND RETURN LEVELS FOR ANNUAL MAXIMUM MONTHLY RAINFALL <i>P.A.D.A.N. Appuhamy, L.G.De Silva and E.M.P.Ekanayake</i>	49
75	A SURVIVAL ANALYSIS ON DENGUE PATIENTS IN KALUTARA DISTRICT <i>T. C.D. De Silva, N. Satkunanathan and M.B.A. Ghouse</i>	50
89	A NOVEL APPROACH OF VOICE RECOGNITION USING MFCC AND GMM, SPEECH RECOGNITION AND TEXT RECOGNITION TO ASSIST FOR EMAIL COMMUNICATION FOR VISUALLY IMPAIRED PEOPLE <i>K. Senthuja and S. Mahesan</i>	51
98	A BAYESIAN LINEAR REGRESSION MODEL FOR METHOD COMPARISON DATA WITH HOMOSCEDASTIC MEASUREMENTS <i>S.M.M. Lakmali, L.S. Nawarathna and P. Wijekoon</i>	52
102	ARTIFICIAL NEURAL NETWORK BASED APPROACH FOR SPEECH EMOTIONS RECOGNITION OF SINHALA LANGUAGE <i>N. Dharmabandu and S. Thirukumaran</i>	53
105	IMPACT OF CROSSOVER OPERATORS ON THE GENETIC ALGORITHM TO SOLVE CAPACITATED VEHICLE ROUTING PROBLEM <i>M.K.D.D. Sandaruwan, D.M. Samarathunga and W.B. Daundasekara</i>	54
107	DEEP LEARNING APPROACH TO DETECT PLAGIARISM IN SINHALA TEXT <i>K.A.T. Chathurani and E.Y.A. Charles</i>	55
115	3D FACE RECONSTRUCTION USING SINGLE IMAGE <i>A.M.D. Bandara and R. Siyambalapitiya</i>	56
116	MAXIMIZING THE PRODUCTION TIME USING A MIXED INTEGER NON-LINEAR MATHEMATICAL MODEL <i>A.A.D.R.G. Amarasinghe, D.M. Geekiyanage, S.W.S. Sasna, A.S. Nakandala, H.D.S.I. Madusanka, P.H.S.A. Gunawardane and T.H.K.R. De Silva</i>	57

THEME-II ICT, Mathematics and Statistics

Abstract ID No.	Title and Authors	Page No.
117	SPLITTING ALGORITHM FOR ATTAINING THE NEAR OPTIMAL UPPER BOUND ON THE MINIMAL TOTAL COST TO THE SMALL SIZED TPVDS <i>Z.A.M.S. Juman, M.I.M. Waseem and N. Hamna</i>	58
122	A NOVEL APPROCH IN SOLVING FUZZY TRANSPORTATION PROBLEMS USING MODIFIED ANT COLONY ALGORITHM <i>E.M.U.S.B. Ekanayake and W.B. Daundasekara</i>	59
132	OPTIMAL ROUTING OF SOLID WASTE COLLECTION TRACTORS: A CASE STUDY AT KURUNEGALA MUNICIPAL COUNCIL <i>R.D.S.S. Rambandara, R.A.R. Prabodanie, E.A.C.P. Karunaratne and R.D.D. Rajapaksha</i>	60
134	REDUCING 'UNIT COST PER MINUTE' IN A GARMENTS MANUFACTURING PROCESS USING GOAL PROGRAMMING TECHNIQUES <i>D.S.O. De Silva, H.M.K.B. Wijerathna, A.Y. De Costa, K.M.E.N. Bandara, A.S.M.C.D. Abhayawickrame, W.A.L.S. Boyagoda and T.H.K.R. De Silva</i>	61
140	PARALLELIZING ACTIVE CONTOUR MODEL FOR OBJECT SEGMENTATION <i>B. Saranya and S. Suthakar</i>	62
144	A NEW FIVE PARAMETER GENERALIZED LINDLEY DISTRIBUTION <i>R. Tharshan and P. Wijekoon</i>	63
157	BATSMEN PERFORMANCE ANALYSIS IN THE GAME OF CRICKET USING ARTIFICIAL NEURAL NETWORKS <i>D.T. Jayasekara and R. Siyambalapitiya</i>	64
160	A MODEL TO DETECT MALFUNCTIONS OF AN AUTOMOBILE ENGINE AND TO RECOMMEND ACTIONS USING GAS EMISSION DATA <i>W.M.L.N. Wanninayake, R.D. Nawarathna and S.R. Kodituwakku</i>	65
165	STOCHASTIC MODELING OF POPULATION INTERACTION WITH ALLEE EFFECTS AND STOCKING <i>S.P.D.S.S.K Karunaratna, T.M.M. De Silva and R.A.C.S. Ranawaka</i>	66
167	ESTIMATION OF THE AGE-STRUCTURED FEMALE POPULATION OF SRI LANKA USING LESLIE MATRIX <i>G.K.S. Hansika, D.M.N.K. Dissanayaka and T.H.K.R. De Silva</i>	67
172	IMPORTANCE OF INTEGRATING APPEARANCE AND MOTION FEATURES TO CLASSIFY DYNAMIC PATTERNS USING DEEP LEARNING <i>S.P. Kasthuri Arachchi, W.G.C.W. Kumara and Timothy K. Shih</i>	68
173	IDENTIFICATION OF DRUG-RELATED PERSONAL EXPERIENCE SOCIAL MEDIA CONTENT USING A DEEP LEARNING MODEL <i>S.T. Jarashanth and R.D. Nawarathna</i>	69
174	OPTIMAL LAND ALLOCATION FOR PADDY CULTIVATION IN SRI LANKA <i>S.R.T. Kulasekara and D.M. Samarathunga</i>	70

THEME-III**Life Sciences**

Abstract ID No.	Title and Authors	Page No.
05	EVALUATION OF MAIZE HYBRIDS TOWARDS A SUPERIOR HYBRID OPTION <i>H.M. Weerasooriya, W.N. Wickremasinghe and W.M. Ranjala Kumari</i>	71
06	VALIDATION OF TRIPLEX POLYMERASE CHAIN REACTION BASED METHOD FOR MOLECULAR IDENTIFICATION OF YELLOWFIN, BIGEYE AND SKIPJACK FRESH TUNA SAMPLES <i>S.N.H. Ariyaratne and W.W.P. Rodrigo</i>	72
07	HELMINTHIASIS OF DOGS IN PERADENIYA UNIVERSITY PREMISES: A POTENTIAL PUBLIC HEALTH PROBLEM <i>C. S. Sepalage, P. K. Perera and R. S. Rajakaruna</i>	73
13	ANTIBACTERIAL ACTIVITY OF COTTON FABRIC MODIFIED WITH COPPER-DOPED ZnO/CHITOSAN HYBRID NANOCOMPOSITE AGAINST SELECTED MEDICALLY IMPORTANT BACTERIA <i>A.M.A.E. Dilrukshi, N. M. Adassooriya and A. C. A. Jayasundera</i>	74
17	MORPHOLOGICAL AND MOLECULAR CHARACTERIZATION OF PIPER LONGUM L. POPULATIONS FOUND IN DIFFERENT DISTRICTS OF SRI LANKA <i>H. Sukumaran, W.W.P. Rodrigo and R.M. Dharmadasa</i>	75
19	ANTIBACTERIAL ACTIVITY OF <i>ARISTEA ECKLONII</i> AND <i>PROSOPIS JULIFLORA</i> AGAINST MULTIDRUG-RESISTANT ACINETOBACTER SPP AND METHICILLIN-RESISTANT <i>STAPHYLOCOCCUS AUREUS</i> <i>K. Dilakshana, N.C. Bandara, A. Ekanayake, L.V.C. Liyanapathirana, D.S.A. Wijesundara and B.M.R. Bandara</i>	76
20	PROBIOTIC POTENTIAL OF BACTERIAL ENDOPHYTES ISOLATED FROM LEAVES OF <i>MURRAYA KOENIGII</i> L. <i>A.C. Bandara, C.L. Abayasekara, A.M. Karunaratne and G.J. Panagoda</i>	77
21	INSECTICIDAL ACTIVITY OF SEVEN INVASIVE ALIEN PLANTS AGAINST APHIDS (<i>MYZUS PERSICAE</i>) <i>V.G.A.U. Samarasinghe, K.M.D.W. Prabath Nishantha, N.C. Bandara, J.W. Damunupola, D.S.A. Wijesundara, and B.M.R. Bandara</i>	78
22	APHIDICIDAL, ANTIOXIDANT AND CYTOTOXIC PROPERTIES OF FOUR INVASIVE ALIEN PLANTS <i>J.H.P.K. Jayamaha, M.P.C.K. Marasinghe, N.C. Bandara, K.M.D.W. Prabath Nishantha, D.S.A. Wijesundara and B.M.R. Bandara</i>	79
25	OPTIMIZATION OF A PROTOCOL FOR THE EXTRACTION OF DNA FROM HUMAN BLOOD FOR THE ISOLATION AND EXPRESSION OF THE HUMAN GENE CTSK, IN BACTERIAL EXPRESSION SYSTEM, <i>ESCHERICHIA COLI</i> <i>H. Madubashetha, Y. Dissanayake, L. Piyasiri, S. Wickramasinghe, N. De Silva, L. Warnakula and R. Cooray</i>	80
32	ISOLATION OF GENE CANDIDATES FOR SEMI-DWARFISM FROM PROSO MILLET (<i>PANICUM MILLACEUM</i>) <i>P.G.S.M. Chandresene and H.A.C.K. Aryarathne</i>	81
37	PHYSIOLOGICAL AND GENETIC CHARACTERIZATION OF RHIZOBIAL POPULATIONS INHABITING <i>GLIRICIDIA SEPIUMIN</i> SELECTED LOCATIONS OF POLONNARUWA DISTRICT, SRI LANKA <i>S.M.N.S. Samarakoon and R.G.S.C. Rajapakse</i>	82

THEME-III**Life Sciences**

Abstract ID No.	Title and Authors	Page No.
38	OPTIMIZATION OF DNA EXTRACTION AND PCR PROTOCOLS FOR THE TROPICAL FRUIT TREE SPECIES, <i>ELAEOCARPUS SERRATUS</i> (WERALU) AND <i>ELAEOCARPUS GANITRUS</i> (NIL WERALU) <i>W.G.A.S. Sumanarathne and S.D.S.S. Sooriyapathirana</i>	83
39	RESISTANCE TO PARASITISM IN COMMON HOURGLASS TREE FROG, <i>POLYPEDATES CRUCIGER</i> TOWARDS TREMATODE INFECTIONS: ARE EARLY TADPOLE STAGES MORE VULNERABLE TO CERCARIAE? <i>N.U.K. Pathirana, M. Meegaskumbura and R.S. Rajakaruna</i>	84
40	ASSESSMENT OF BOD, COD AND METAL CONTENT IN WASTEWATER IN DAIRY AND MEAT PROCESSING INDUSTRY IN SRI LANKA <i>R.D.J. Sanjeevani, R.A.U.J. Marapana and A. Cooray</i>	85
42	PREVALENCE OF <i>HELICOBACTER PYLORI</i> IN THE ORAL CAVITIES OF A GROUP OF SRI LANKAN DENTAL STUDENTS WITH CLINICAL EXPOSURE <i>M.A.D.K.S. Mallikaarachchi, J.A.M.S. Jayatilake and R.G.S.C. Rajapakse</i>	86
43	INVESTIGATION OF INHIBITORY EFFECTS OF <i>AZADIRACHTA INDICA</i> (KOHOMBA) BARK AND LEAVES, <i>MIMOSA PUDICA</i> (NIDIKUMBA) AND <i>TERMINALIA CATAPPA</i> (KOTTAMBA) ON GLYCATION AND GLYCATION INDUCED CROSS-LINKING <i>O. Dheerasekera and H. K. I. Perera</i>	87
47	TREE AND SHRUB DIVERSITY AND ABUNDANCE ALONG AN ELEVATION GRADIENT OF AMBOKKA MOUNTAIN RANGE, SRI LANKA <i>M.P.T. Wijewickrama, H.M.S.B. Herath, D.S.A. Wijesundara and H.M.S.P. Madawala</i>	88
49	A PRELIMINARY PHYLOGENY OF BALLINI JUMPING SPIDERS IN SRI LANKA (ARANEAE: SALTICIDAE) <i>D.P. Boppearachchi, N. Kanesharatnam, N. Athukorala and S.P. Benjamin</i>	89
54	EVALUATION OF NUTRITIONAL QUALITY OF <i>ULVA FASCIATA</i> AND <i>GRACILARIA EDULIS</i> SEAWEEDS COLLECTED FROM SRI LANKA <i>M.M Jayakody, M.P.G Vanniarachchy and I. Wijesekera</i>	90
58	DNA ISOLATION AND AMPLIFICATION FROM DRIED BARK OF CINNAMON <i>M.A.L.M. Peiris and W.R.P. Wijesinghe</i>	91
59	DETERMINATION OF CHANGES OCCUR IN CHEMICAL PROPERTIES OF PALM OLEIN DURING DEEP FAT FRYING WITH INCORPORATION OF DIFFERENT DIETARY ANTIOXIDANT SOURCES <i>U.S. Wijewardhana, U.G.S.A. Gunathilaka and S.B. Navaratne</i>	92
80	EMBRYONIC DEVELOPMENT IN THE GOLDEN CARP (<i>CYPRINUS CARPIO</i>) UNDER LABORATORY CONDITIONS <i>K.G.D.D. Thilakarathne, P.H.T. Lakkana, G.N. Hirimuthugoda and S. Kumburegama</i>	93
88	REAL TIME PCR-BASED METHOD FOR DETECTION OF VIABLE STAPHYLOCOCCUS AUREUS IN DAIRY PRODUCTS IN SRI LANKA <i>V.K. Siriwardena, T.N. Kapuruge, A.M.M.H. Athapaththu and W.A.J.S. Perera</i>	94

THEME-III**Life Sciences**

Abstract ID No.	Title and Authors	Page No.
92	REAL TIME PCR-BASED METHOD FOR DETECTION OF VIABLE <i>SALMONELLA</i> SPP. IN MEAT PRODUCTS IN SRI LANKA <i>T. D. Senarathna, T.N. Kapuruge, A.M.M.H. Athapaththu and W.A.J.S. Perera</i>	95
93	ANTICARIOGENIC EFFECTS OF DIFFERENT SOLVENT EXTRACTS OF A TRADITIONAL SRI LANKAN HERBAL MIXTURE (DAHAT WATTIYA) USED TO PROTECT ORAL HEALTH - AN IN VITRO STUDY <i>G.R.A.I. Rathnayaka, B.G.T.L. Nandasena, J.A.M.S. Jayatilake and M.P. Paranagama</i>	96
95	VALIDATION OF A REAL TIME PCR (RT-PCR) BASED METHOD FOR IDENTIFICATION OF GENETICALLY MODIFIED (GM) BAKED BAKERY PRODUCTS <i>K.S. Sayakkara, A.M.M.H. Athapaththu and W.T.G.S.L. Withana</i>	97
96	<i>ERAGROSTIS TEF</i> (TEFF), AS A BRIDGING SPECIES TO IDENTIFY BLAST DISEASE RESISTANCE GENES IN UNDERUTILIZED CEREAL CROPS <i>G.K.S.N. Gajanayake and H.A.C.K. Ariyaratna</i>	98
97	TOWARDS ECO-FRIENDLY AGRICULTURE ON MARS: A PRELIMINARY STUDY WITH LETTUCE <i>Chasika Prematunga, Nimeshi Wijekoon, Gamini Seneviratne and Udeni Jayalal</i>	99
103	EVALUATION OF CONSERVATION STATUS OF GENUS <i>SALACIA</i> (CELASTRACEAE) IN SRI LANKA <i>W.I.N.S. Senevirathne, P.L. Hettiarachchi, D.M.D. Yakandawala and A. Attanayake</i>	100
104	ANALYSIS OF GENETIC DIVERSITY AND ANTAGONISTIC ACTIVITY OF DIVERSE <i>TRICHODERMA</i> ISOLATES IN SRI LANKA <i>D.W.G.A.S. Alukumbura and M.P.C.S. Dhanapala</i>	101
119	BIOFILM BIOFERTILIZER MEDIATED RESTORATION OF NITROGEN FIXERS IN THE SOIL-PLANT SYSTEM IN PADDY CULTIVATION <i>S.W. Meepegamage, G. Seneviratne and R.G.S.C. Rajapakse</i>	102
124	DETERMINATION OF SEED DORMANCY AND GERMINATION BEHAVIOUR OF 25 PLANT SPECIES FROM TROPICAL LOWLAND RAINFORESTS IN SRI LANKA <i>B.R.C.P. Samarasinghe, K.M.G.G. Jayasuriya, A.M.T.A. Gunaratne and S.M.C. Senanayaka</i>	103
126	DOES BIOFILM BIOFERTILIZER WORK IN LARGE SCALE RICE CULTIVATION UNDER FARMERS' FIELD CONDITIONS? <i>A.T.D. Rathmathilaka and G. Seneviratne</i>	104
129	BIOFILM BIOFERTILIZER: A PROMISING ECO-FRIENDLY ALTERNATIVE TO FUTURISTIC MARTIAN AGRICULTURE <i>S. Gunarathne and G. Seneviratne</i>	105
133	OPPORTUNISTIC CANNIBALISM BY TADPOLES OF COMMON HOUR-GLASS TREE FROG, <i>POLYPEDATES CRUCIGER</i> <i>W.G.D. Chathuranga, Kalpa Kariyawasam, R.S. Rajakaruna and W.A.P.P. de Silva</i>	106

THEME-III**Life Sciences**

Abstract ID No.	Title and Authors	Page No.
136	ANTIMICROBIAL, BRINE SHRIMP LETHALITY, ANTIOXIDANT AND ANTI-INFLAMMATORY ACTIVITIES OF ALKALOIDS OF <i>HOLARRHENA MITIS</i> (VAHL) R.BR. <i>A.T. Jayaweera, W.G.D. Wickramasingha, D.N. Karunaratne, J.M.S. Jayasinghe and V. Karunaratne</i>	107
137	CLINICO-LABORATORY PROFILES AND COMPARISON OF NS1 AND VIRAL RNA DETECTION IN A SELECTED GROUP OF DENGUE SUSPECTED PATIENTS <i>S.D.K Wijesuriya, M. Abeywardena, F. Noordeen and W.A.S.S Wickrama</i>	108
139	LARVICIDAL ACTIVITY OF SYNTHESIZED ZINC OXIDE NANOPARTICLES AGAINST MOSQUITO VECTORS <i>U.M.T.M. Gunathilaka, W.A.P.P. de Silva and R.M.G. Rajapakse</i>	109
142	ISSR PCR BASED GENETIC DIVERSITY OF <i>STAPHYLOCOCCUS AUREUS</i> AND <i>ESCHERICHIA COLI</i> FROM BOVINE SUBCLINICAL MASTITIS MILK IN SRI LANKA <i>P.P. Jayasekara, I.S.B. Athapaththu, W.M.R.R. Wijethunga, G.A. Gunawardana, G.A.D. Chandana and R. Wimalagunaratne</i>	110
148	COMPARISON OF SUSPECTED AND LABORATORY CONFIRMED CASES OF BOVINE AND CAPRINE BRUCELLOSIS AND THE DISEASE DISTRIBUTION PATTERN IN SRI LANKA <i>G.I.S. Perera, P.S. Fernando, S.K. Yatigammana, K.M.S.G. Weerasooriya, M.A.R. Priyantha, S.M.T.S. Manchanayake and M.I. Wijemuni</i>	111
149	ISOLATION AND CHARACTERIZATION OF DIESEL-UTILIZING BACTERIA FROM PETROLEUM CONTAMINATED SITES <i>K.M.A Karunathilaka and P. Samaraweera</i>	112
151	PRELIMINARY PHARMACOGNOSTIC EVALUATION AND IN-VITRO ANTICANDIDAL ACTIVITY OF YOUNG LEAVES OF COMMON BETEL TYPES IN SRI LANKA <i>W.G.M. Lakmali, S.N.P. Athukorala, G. J. Panagoda, C. L. Abayasekara, J.A.M.S. Jayathilaka, P.S. Rajapaksha and R.D. Jayasinghe</i>	113
152	DEVELOPMENT AND CHARACTERIZATION OF POLYSACCHARIDE NANOPARTICLES FOR TARGETED DRUG DELIVERY <i>M.F.F. Reesha, D.N. Karunaratne, A.D.L.C. Perera, V. Karunaratne and J.M.S. Jayasinghe</i>	114
153	CALLUSING AND SHOOT PROLIFERATION OF <i>RAUVOLFIA SERPENTINA</i> <i>H.N.T.M. Kumarasiri, K.K.H.H.Sasanthika and P.L. Hettiarachchi</i>	115
156	<i>IN VITRO</i> PROPAGATION OF <i>HYLOCEREUS UNDATUS</i> (DRAGON FRUIT) <i>M.A.N.F Zumaira, P.L.T. Nirath and P.L Hettiarachchi</i>	116
168	EFFECT OF FLUORIDE RICH WATER ON KIDNEY AND LIVER AND DISTILLED WATER FOR DAMAGE MITIGATION <i>W.T.R. Perera, J.G.S. Ranasinghe, N. Alles and R. Waduge</i>	117
171	SCREENING ANTI-BACTERIAL ACTIVITY OF ENDOLICHENIC FUNGI COLLECTED FROM NEGOMBO LAGOON, SRI LANKA <i>W.R.H. Weerasinghe, R.N. Attanayake, G. Weerakoon and P.A. Paranagama</i>	118

THEME-IV Physical Sciences

Abstract ID No.	Title and Authors	Page No.
16	SURFACE PLASMON RESONANCE EFFECT OF Au NANOPARTICLES ON THE EFFICIENCY OF CdS QUANTUM DOT- SENSITIZED SOLAR CELLS <i>T. Jaseetharan, M.A.K.L. Dissanayake and G.K.R. Senadeera</i>	119
23	ALIEN INVASIVE PLANT <i>PROSOPIS JULIFLORA</i> : ALKALOID-MONTMORILLONITE NANOCOMPOSITES AND ANTIOXIDANT AND CYTOTOXIC PROPERTIES <i>N.D.J.L. Ananda, N.C. Bandara, D.S.A. Wijesundara and B.M.R. Bandara</i>	120
24	MEDICINAL PLANT <i>HOLARRHENA ANTIDYSENTERICA</i> : ANTIOXIDANT ACTIVITY AND ALAKALOID-MONTMORILLONITE NANOCOMPOSITES <i>G.D.N. Gunawardana, N.C. Bandara and B.M.R. Bandara</i>	121
27	REMOVAL OF EXCESS ZINC AND ALUMINIUM PRESENT IN BIOLOGICAL TREATMENT PLANT SLUDGE OF WASTEWATER TREATMENT PLANTS OF NATURAL RUBBER GLOVE DIPPING INDUSTRIES USING CHELATING AGENTS AT DIFFERENT pH VALES <i>A.S.S. Mendis, S. Walpolage and R.M.G. Rajapakse</i>	122
45	ALKALOID-MONTMORILLONITE NANOCOMPOSITES OF <i>ZANTHOXYLUM TETRASPERMUM</i> : ANTIOXIDANT AND CYTOTOXIC PROPERTIES OF EXTRACTS AND COMPOSITES/RELEASED ALKALOIDS <i>S. Thilakarathne, N.C. Bandara, C.L. Abayasekara and B.M.R. Bandara</i>	123
60	NANOHYBRID BASED ZERO-VALENT COPPER NANOPARTICLES IMPREGNATED ACTIVATED CARBON FOR ANTIMICROBIAL APPLICATIONS <i>C.B. Wijetunga, R.G.S.C. Rajapakse, M. N. S. Kottegoda, G. Priyadarshane and A.D. L.C. Perera</i>	124
64	MODIFICATION OF THE BANDGAP OF STRONTIUM TITANATE TO HARVEST VISIBLE LIGHT <i>M.C.M. Rajapaksha and J. Bandara</i>	125
67	CONSTRUCTION OF CARBON DIOXIDE MONITOR AND ACQUISITION OF DATA IN SOME SELECTED PLACES <i>R.P.N.R. Rajapakse and P.W.S.K. Bandaranayake</i>	126
70	LOW COST HYDROGEN PRODUCTION USING SOLAR ENERGY <i>E.M.A.S. Edirisooriya and P.W.S.K. Bandaranayake</i>	127
78	ENCAPSULATION OF NITROGEN FERTILIZER UREA IN POROUS CALCIUM CARBONATE NANOPARTICLES <i>S.P. Dumuweera, K.A.A. Ruparathna and R.M.G. Rajapakse</i>	128
84	STUDY OF SCIENCE BEHIND BISSOKOTUWA IN ANCIENT LAKES IN SRI LANKA <i>D.C. Maddumage and B.M.K. Pemasiri</i>	129
85	COMPARISON OF THE CATALYTIC ACTIVITY OF COBALT AND NICKEL BASED POLYOXOMETALATES FOR WATER REDUCTION <i>M.P.G.D.L. Premarathna and M.Y.U. Ganehenege</i>	130
101	THE EFFECT OF CORE ARCHITECTURE ON THE LOADING CAPACITY OF DENDRIMERS <i>K.M.W.K. Kulathunga, N.P.N.R. Kumarachchi and R.J.K.U. Ranatunga</i>	131

THEME-IV Physical Sciences

Abstract ID No.	Title and Authors	Page No.
109	MIXING VEGETABLE OILS WITH LUBRICANT OIL FOR AUTOMOBILES AS A COST REDUCTION METHOD <i>W.H.P. Kumari and L.R.A.K. Bandara</i>	132
111	DETERMINATION OF THERMAL NEUTRON FLUX AND THERMAL TO EPITHERMAL NEUTRON FLUX RATIO OF THE Am-Be NEUTRON SOURCE <i>W.W.S. Poornima, V. Sivakumar, C.P. Jayalath and T.P. Ranawaka</i>	133
112	REMOVAL OF Cd ²⁺ FROM DRINKING WATER USING MgO NANOPARTICLES AND DESIGNING A WATER FILTER <i>B.A.A.R. Balasooriya, R.M.G. Rajapakse and A.S.S. Mendis</i>	134
113	DOSIMETRY ON ¹³¹ I TREATMENT AT THE NUCLEAR MEDICINE UNIT OF UNIVERSITY OF PERADENIYA <i>M.F. Shirooza, D.K.K. Nanayakkara, J.A.C.P. Jayalath and V. Sivakumar</i>	135
121	A NEW APPROACH TO DETERMINE THE DEAD TIME OF A GEIGER MÜLLER COUNTER <i>M.F.M. Hijas and C.P. Jayalath</i>	136
127	ELECTROSPUN POLY (VINYL ALCOHOL) NANOFIBER MATS LOADED WITH <i>TERMINALIA CHEBULA</i> FRUIT EXTRACT–PREPARATION, CHARACTERIZATION AND ANTIMICROBIAL ACTIVITY <i>J. Janeni, N.M. Adasooriya, S. Perera, R.G.S.C. Rajapakse, P.V.T. Weerasinghe, U.G.N.S. Udapitiya and M.A.D.K.S. Mallikaarachchi</i>	137
145	ACTIVATED CARBON BASED COMPOSITE ELECTRODES SUITABLE FOR SUPERCAPACITORS <i>P.W.S.K. Bandaranayake and M. Rabindran</i>	138
162	PRESSURE DEPENDENCE OF ELECTRICAL CONDUCTIVITY OF CARBON POLYMER COMPOSITES <i>P.W.S.K. Bandaranayake and S.M.T.K. Labutale</i>	139
169	DEVELOPMENT OF ELECTROSPUN PVdF-HFP/PEO BLEND POLYMER MEMBRANE ELECTROLYTE FOR DYE SENSITIZED SOLAR CELLS <i>J.M.K.W. Kumari, M.A.K.L. Dissanayake, G.K.R. Senadeera and C.A. Thotawatthage</i>	140

THEME-V Science Education

Abstract ID No.	Title and Authors	Page No.
02	EXPLORATION OF EXISTING STATUS OF THE SCHOOL BASED ASSESSMENT SYSTEM IN G.C.E. ADVANCED LEVEL CHEMISTRY <i>G.G.P.S. Perera, W.M.A.T. Bandara and T.M.S.S.K. Yatigammana Ekanayake</i>	141
57	A CASE STUDY OF STUDENT-CENTRED CHEMICAL LABORATORY ACTIVITIES FOR GRADE 11 STUDENTS' CHEMISTRY LEARNING IN VAVUNIYA DISTRICT <i>T. Sakeetharan, A.D.L.C. Perera and T.M.S.S.K. Yatigammana Ekanayake</i>	142
100	FACTORS AFFECTING STUDENTS' LOWER ENROLMENT IN G.C.E. ADVANCED LEVEL SCIENCE STREAM: A CASE STUDY IN KULIYAPITIYA EDUCATION ZONE <i>L.M. Hettige and T.M.S.S.K. Yatigammana Ekanayake</i>	143
125	GUIDING THREE SELECTED STUDENTS OF GRADE SIX TO SOLVE STATEMENTS BASED MATHEMATICAL PROBLEMS <i>H.D.K.D. Hathurusinghe and W.D. Chandrasena</i>	144
128	APPLICATION OF A COMPUTER ASSISTED LEARNING MATERIAL IN A SELECTED TOPIC OF G.C.E. ADVANCED LEVEL PHYSICS: A CASE STUDY IN GIRIULLA ZONE <i>J.D.U.K. Jayasinghe and W.D. Chandrasena</i>	145
146	SCIENCE PERFORMANCE OF INDIGENOUS STUDENTS AND THEIR NON-INDIGENOUS COUNTERPARTS IN MAHIYANGANAYA EDUCATION ZONE IN SRI LANKA <i>A.M.R.S. Bandara and T.M.S.S.K. Yatigammana Ekanayake</i>	146
147	EFFECTIVENESS OF TEACHING ALIPHATIC HYDROCARBONS IN G.C.E. (A/L) CHEMISTRY THROUGH COMPUTER ASSISTED LEARNING TOOLS <i>A.D.N. Karunadasa and R.J.K.U. Ranatunga</i>	147
161	USE OF A PRACTICAL COMPONENT TO IMPROVE STUDENTS' BASIC SCIENCE PROCESS SKILLS <i>G.G.H.M.H.S. Bandara and P.R.K.A. Vitharana</i>	148
163	TEACHERS' VIEWS ON TEACHING-LEARNING PROCESS OF G.C.E. (A/L) BIOSYSTEMS TECHNOLOGY IN KANDY DISTRICT <i>J.M.C.N. Jayasundara and P.R.K.A. Vitharana</i>	149
177	LEARNING SCIENCE IN BILINGUAL MODE: TRENDS AND ISSUES IN MONARAGALA DISTRICT <i>G.R.S.P. Kumara and T.M.S.S.K. Yatigammana Ekanayake</i>	150

Key note Speech

Multi-Functional Superhydrophobic Polymer Surfaces

Alan Lyons

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Low surface energy polymers are especially well-suited to form superhydrophobic surfaces because they can be easily processed into a wide range of useful forms using techniques ranging from lamination to 3D printing. Additional functionality can be achieved by further modifying the surface structure and/or incorporating catalytically active particles. In this presentation, I will discuss different approaches to increasing the functionality of superhydrophobic surfaces for specific applications.

In one approach, nanoscale topography is formed in the surface of a fluoropolymer using a novel lamination-peeling mechanism (Figure 1). The nanoscale roughness, low refractive index, and hierarchical topography combine to impart anti-reflective properties, reducing reflections from solar photovoltaic cover glass by more than 75%. These superhydrophobic surfaces also exhibit anti-soiling and self-cleaning properties in the presence of liquid water owing to the high mobility of the solid-liquid-vapor triple contact line. For heat transfer applications, coalescence-induced jumping condensation can occur on these chemically stable surfaces, even at large values of sub-cooling ($\Delta T > 70$ K).

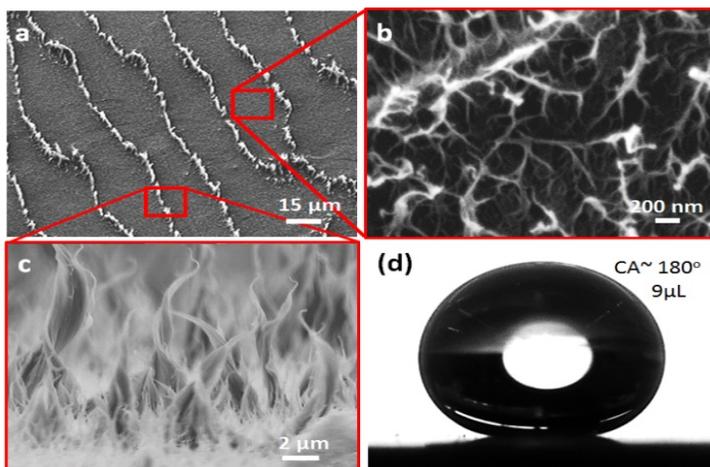


Figure 1: Superhydrophobic surface made by lamination-peeling showing hierarchical topography: a) overview showing microscale ridges between nanoscale fibrils, b) nanoscale fibrils, c) cross-sectional view of microscale ridges, d) water droplet poised on the surface.

In a second approach, photo-catalytic particles are partially embedded into a surface created by 3D printing an array of polydimethylsiloxane posts, thereby enabling the generation of reactive oxygen species that can oxidize organic compounds. When sensitizers for singlet oxygen are incorporated, the reactive gas can diffuse across the plastron and efficiently kill microbes while preventing direct contact of the sensitizer with biofluids. By controlling the topography, stable superhydrophobic properties are achieved even with hydrophilic particles. Complete biofilm inactivation (>5 log killing) of *Porphyromonas gingivalis*, a bacterium implicated in periodontal disease, is achieved using a superhydrophobic singlet oxygen delivery device.

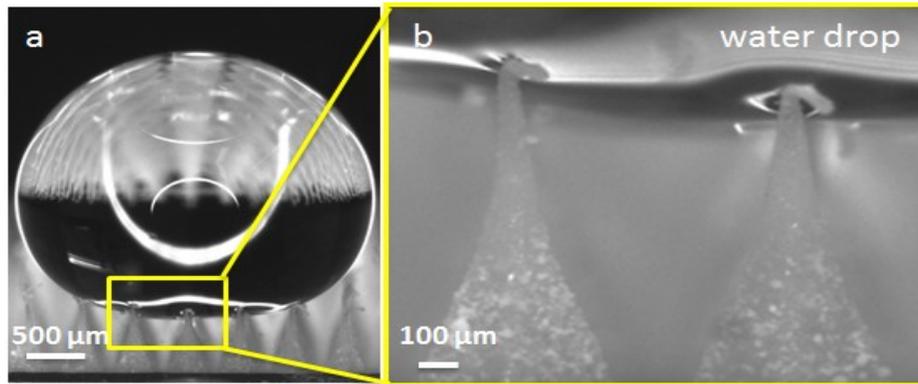


Figure 2: Superhydrophobic surface made by 3D printing a PDMS pre-polymer followed by coating with TiO₂ nanoparticles: a) Optical micrograph of a water droplet poised on the surface, b) High magnification view of the solid-liquid-air interfaces showing how the droplet surface conforms to the surface hierarchical structure.

Plenary Speech

Fostering a research culture in Sri Lanka

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According to a definition given by the **Royal Society**, “*research culture encompasses the behaviors, values, expectations, attitudes and norms of our research communities. It influences researchers’ career paths and determines the way research is conducted and communicated*”. Although all younger academics work among their colleagues in the same Department, in similar roles, your career paths will turn out to be very different from each other in the next two decades or so. These differences arise in spite of the fact that careers are seemingly mapped out from day one: from PhD to Professorship. However, your passion and propensity for research will determine your trajectory of success. **Organisation for Economic Co-operation and Development** defines Research and experimental development as “*creative work undertaken on a systematic basis in order to increase the stock of knowledge including knowledge of man, culture and society and to use this stock of knowledge to device new applications*”.

Ever since our brain sizes emerged as the largest in the animal kingdom some 500,000 years ago, we have been engaged in research. Research allowed us to survive the life in the cave, move into an agricultural society and to the industrial revolution. Research is Fundamental to how University education works; research is what makes the academic staff intellectual; it ought to become the fundamental support of our teaching; it should be the basis of the support of our society. Research Culture is the structure that gives that behavior significance and allows us to understand, appreciate and evaluate the research activity. That cultural structure based around a behavior of staff and students allows us to transfer that knowledge (gained through this systematic process) to our students and to society. We transfer that knowledge in today’s setting, not yesterday’s, along with the ability to analyze the evidence in the context of tomorrow. That structure is the culture we must strive to build through continuous development. We cannot afford to stop researching and learning or we run the risk that our teaching will suffer and loose its relevance in the context of tomorrow. This cannot be achieved quickly or easily. It is going to be as slow as the decline would be if we do nothing.

Although many of us are fond of saying as academics in Sri Lanka, our primary duty is teaching, it is worth remembering that if you are not a knowledge creator you cannot be an effective knowledge disseminator. But we also know that the life of the teacher-scholar can be demanding. Expecting faculty to be successful teachers and contributing researchers, while working hard to keep these two connected, is asking for a lot. Requesting that they simultaneously serve the university community and the country at large, adds to the challenge. Difficulties notwithstanding, the teacher-scholar must have a love of learning, and a passion for seeking and articulating the research finding as best they can. They must also possess a commitment to serve institutions through long and distinguished careers and introducing and mentoring young people to the lifelong pursuit of being a teacher-scholar.

SOLAR ENERGY FORECASTING WITH MACHINE LEARNING APPROACHES

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Climate is changing day-by-day. The strength of energy is fluctuating according to the climate change because energy is measured by environmental elements such as wind, temperature and humidity. Since energy crisis is also increasing nowadays, electric utility companies must forecast accurate strength of energy so that energy and the consumption of fossil fuels can be balanced. This is the goal of our work. For this purpose three different machine learning approaches, such as XGBoost, Random Forest and Linear Regression, were compared for solar energy prediction, where XGBoost and Random Forest are non-linear algorithms and the Linear Regression is a linear algorithm. It is found that XGBoost performs better than other approaches for solar energy prediction. XGBoost gives a root mean squared error (RMSE) of 480.53 ± 7.65 as compared to 487.68 ± 13.43 and 774.60 ± 6.82 by Random Forest and Linear Regression, respectively.

Keywords: Linear regression, Random forest, Solar energy, XGBoost

TOLERANCE OF Cr(VI) AND Cd(II) BY THREE BACTERIAL GENERA ISOLATED FROM A WATER BODY RECEIVING INDUSTRIAL EFFLUENT

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Assessment of microbial heavy metal tolerance is of significance to the field of environmental biotechnology, especially in remediation of metal-contaminated sites. Three bacterial species viz. *Bacillus* spp., *Micrococcus* spp., and *Staphylococcus* spp. were isolated from a wastewater stream, and their tolerance to different environmentally permissible concentrations of both Cr(VI) ($K_2Cr_2O_7$) and Cd^{2+} [$Cd(NO_3)_2$] (0.025, 0.050, 0.100, 0.150, and 0.200 mg L⁻¹) into inland surface water was assessed based on optical density change as a proxy for growth reduction in modified Tris-minimal medium. Dose-response analysis revealed that at 96 hour exposure, the tolerance for both Cr(VI) and Cd^{2+} followed the order: *Bacillus* spp. > *Micrococcus* spp > *Staphylococcus* spp. Of the three isolates, *Bacillus* spp. was the most tolerant organism for the two heavy metal ions tested, which showed EC₅₀ values greater than 0.200 mg L⁻¹, therefore could tolerate even higher concentrations. The EC₅₀ values exhibited by *Micrococcus* spp. were 0.123 and 0.101 mg/L, while those of *Staphylococcus* spp. were 0.069 and 0.070 mg L⁻¹ for Cr(VI) and Cd^{2+} , respectively. These data suggested that from the two metal ions, *Micrococcus* spp. tolerated Cr(VI) better while *Staphylococcus* spp. showed similar tolerance levels for both. However, the tolerance for Cr(VI) was gradually increased by 96 hours, indicating the acquisition of resistance by all organisms to Cr(VI) with prolonged exposure, whereas the tolerance for Cd^{2+} was gradually decreased, implying the acquisition of sensitivity by the isolates except *Bacillus* spp. to Cd^{2+} with prolonged exposure. The results indicated the importance of the three bacterial species as potential candidates for bioremediation purposes with regard to heavy metal toxicity.

Keywords: Bacteria, Cd^{2+} , Cr(VI), EC₅₀, Tolerance

HYDROGEOCHEMICAL CHARACTERISTICS OF GROUNDWATER IN WILGAMUWA REGION: AN AREA WITH HIGH INCIDENCE OF CHRONIC KIDNEY DISEASE WITH UNCERTAIN ETIOLOGY (CKDU)

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Chronic Kidney Disease of unknown etiology (CKDu) is one of the most controversial health issues that is scattered in certain geographical areas of the dry zone of Sri Lanka. The aim of this study is to determine the involvement of possible hydrogeochemical factors rooting under this issue. The study was focused on Wilgamuwa region in the Matale administrative district which is well-known to be a CKDu hot spot. Sixty-five (65) groundwater samples each from areas with high prevalence of CKDu and non-prevalence were analyzed for major and trace element constituents and water isotope ($\delta^{18}\text{O}$ and $\delta^2\text{H}$) composition. In both CKDu affected and non-CKDu samples, trace element concentrations existed within the WHO permissible limits. In general, the mean concentrations of Na^+ , Mg^{2+} , Ca^{2+} , EC, hardness, alkalinity, NO_3^- and SO_4^{2-} were higher in the CKDu samples than those of in the non-CKDu samples. However, 76% of the CKDu and 46% of non-CKDu samples showed high fluoride levels which exceeded the WHO limit of 0.5 mg L^{-1} . In consideration of the CKDu samples, the correlation coefficient is significant among EC, hardness, alkalinity and Mg^{2+} whereas pH, EC and Na^+ showed the same in non-CKDu samples.

This work is supported by the National Research Council (NRC), Sri Lanka –TO14-05.

Keywords: Chronic Kidney Disease of unknown etiology (CKDu), Wilgamuwa, Hydrogeochemical characteristics

EFFECTS OF SELECTED WATER QUALITY PARAMETERS ON SEASONAL FLUCTUATIONS OF 2- METHYLISOBORNEOL IN SURFACE WATER BODIES OF SRI LANKA

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2-MIB (2- Methylisoborneol) is one of the major T&O causing compounds and have been an extensive issue in worldwide water sector causing drinking water aesthetically unacceptable leading to consumer rejection. This compound is prevailing in some Sri Lankan raw water bodies where water is taken for treatment purposes by National Water Supply and Drainage Board. Present study was aimed to find seasonal variation of 2-MIB in selected Sri Lankan water bodies with respect to some physico-chemical aspects. 2-MIB levels in 17 water bodies were analyzed by Solid Phase Micro-extraction coupled with Gas Chromatography-Mass Spectrometry. 2-MIB varied between 5.3 ± 0.94 to 139.4 ± 0.21 ng L⁻¹ throughout dry season and from 4.4 ± 0.78 to 73.8 ± 0.65 ng L⁻¹ during wet season. In dry season, the highest level of 2-MIB was recorded in Kondawatuwana tank (139.4 ± 0.21 ng L⁻¹), while the lowest was detected in Ridiyagama tank (5.3 ± 0.94). During wet season, the highest level was recorded in Jayanthi tank (73.8 ± 0.65 ng L⁻¹), where the lowest detected in Beira lake (4.4 ± 0.78 ng L⁻¹). *Anabaena* sp., *Microcystis* sp., *Cylindrospermopsis* sp., *Oscillatoria* sp., *Cyclotella* sp. *Volvox* sp., *Gloeocystis* sp., and *Uroglenopsis* sp. are the major taste and odour forming cyanobacteria recorded from the reservoirs during the study. Total cyanobacteria cell density varied between $102,560 \pm 2.28$ cells ml⁻¹ (Thuruwila tank) to 3649 ± 0.34 cells ml⁻¹ (Ridiyagama tank) in Dry season whereas from 98235 ± 4.73 (Beire lake) cells ml⁻¹ to 135 ± 3.11 cells ml⁻¹ (Kanthale tank) during wet season. The Pearson's correlation coefficient analysis revealed a significantly strong positive correlation between 2-MIB level and the total phosphorus concentration ($r = 0.870$, ($p < 0.05$), water pH ($r = 0.822$ ($p < 0.05$)) and the Electrical Conductivity level ($r = 0.671$, ($p < 0.05$)). Further, it was found that cyanobacteria cell density ($r = 0.725$, ($p < 0.05$)) had a significant positive correlation with 2-MIB level in water bodies. Hence, it is clear that there is a significant effect from water quality parameters such as total phosphorus, pH, electrical conductivity and cyanobacteria cell density towards 2-MIB level. Therefore, when taking necessary steps to control 2-MIB levels in reservoirs it is wise to set attention on the physicochemical parameters as well.

Financial assistance from National Science Foundation grant (NSF/RG/2016/EB/04) is acknowledged.

Keywords: 2-MIB, SPME, GC/MS, Physico-chemical parameters, Seasonal variation, Cyanobacteria

TOTAL HARDNESS LEVEL OF GROUNDWATER IN A COASTAL AQUIFER

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Groundwater is a major source of fresh water available for human consumption. Total hardness or the occurrence of calcium and magnesium ions in water affects water quality making water undesirable to use for domestic and industrial purposes. This study focuses on investigating total hardness levels in groundwater in and around selected rapidly expanding coastal towns selected in the Western Province of Sri Lanka. The data on total hardness levels in groundwater in Katana, Negombo, Wattala and Ja-Ela were obtained from the Water Resource Board and analyzed. The data include analyses from 57 boreholes collected during the period of 2014-2016. Spatial variation of data was mapped using GIS, and water quality was interpolated using *Topo to Raster* interpolation technique of Arc Map 10.5 version. Risk levels were defined based on Sri Lankan Standards for drinking water for total hardness level ($250 \text{ mg l}^{-1} \text{ CaCO}_3$) and four categories were defined ranging from very low ($< 50 \text{ mg l}^{-1}$) to very high ($> 600 \text{ mg l}^{-1}$). Wattala and the region south of the Negombo lagoon (Kapunagoda, Dandugama, Ammbalammulla) were identified as high risk areas due to very high total hardness values and its prevalence throughout the study period. The total hardness occasionally ranged from 4 mg l^{-1} to 3125 mg l^{-1} indicating extremely high levels. The results indicate the possibility of saltwater intrusion as a result of overexploitation of groundwater and sea level rise. The findings of this study warn of water stress in some areas which pose challenges in achieving water security goals.

Keywords: Geographic Information System, Groundwater, Risk mapping, Total hardness

TESTOSTERONE LEVELS IN RELATION TO ANTLER GROWTH IN MALE SAMBAR DEER (*RUSA UNICOLOR UNICOLOR*) IN HORTON PLAINS NATIONAL PARK, SRI LANKA

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A study was carried out to determine the testosterone concentrations in the different phases of the antler growth cycle in male sambar deer (*Rusa unicolor*), using faecal samples. Sambar deer inhabiting the Horton Plains National Park (HPNP), Sri Lanka, were used in the study. Based on antler appearance, antler growth cycle of sambar was categorized into seven phases; Cast (C), Growing single spike (GS), Growing into a Y as first tine appears (GIY), Growing Velvet begins to harden as third tine appears (GVT), Growth completed - velvet shedding begins (VS), Hard antler (HA), Casting (CT) based on phenotypic observations. Faecal samples from 10 male sambar deer in each of the different phases of the antler growth cycle were collected, within half an hour of voidance. Faecal testosterone level was determined using radioimmunoassay (RIA). Faeces of sambar deer in C phase had the lowest mean testosterone concentration of $05.52 \pm 0.84 \text{ ng g}^{-1}$. The study also reveals a declination of the testosterone concentration ($06.80 \pm 0.120 \text{ ng g}^{-1}$) in GS phase. In the GVT phase, the mean testosterone concentration was $09.50 \pm 2.01 \text{ ng g}^{-1}$, while in the VS phase the mean testosterone concentration increased to $14 \pm 0.189 \text{ ng g}^{-1}$. Hard antler phase (HA) had the highest mean testosterone concentration of $18.52 \pm 0.187 \text{ ng g}^{-1}$.

Keywords: Antler cycle, Horton Plains, Sambar deer, Testosterone

**ENHANCEMENT OF PHOSPHORUS SOLUBILITY OF EPPAWALA ROCK
PHOSPHATE USING MICROBIAL BIOFILMS**

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Biofilms are complex multi-cellular communities of microbes, some having the potential to biosolubilize certain nutrients in the substrate. National Institute of Fundamental Studies (NIFS) has developed four biofilm formulations (BF1, BF2, BF3 and BF4) with the potential of solubilizing phosphorus (P) in Eppawala Rock Phosphate (ERP) leading to promising results in preliminary studies. Thus, this study was designed to further evaluate the efficacy of these biofilm formulations in solubilizing ERP. An experiment was conducted under laboratory conditions in a Completely Randomized Design (CRD) with three replicates. The five treatments tested include the four biofilm formulations sprayed separately (1.7 L of biofilms per 100 kg of ERP) on to trays containing a thin layer of autoclaved ERP and without biofilms (control). Data were statistically analyzed using analysis of variance (ANOVA), followed by mean separation using Tukey's HSD test. The biofilm treated and un-treated ERP were analyzed for available P, water soluble P and microbial biomass C and P fractions in two weekly intervals up to three months. Microbes in each treatment were cultured and fungal colony morphologies were observed monthly throughout the experimental period. Results revealed that BF3 released significantly higher cumulative available P (279.9 mg kg⁻¹), water soluble P (16.07 mg kg⁻¹), biomass P (212.9 mg kg⁻¹) together with the highest microbial biomass (13.77 mg g⁻¹) than the other biofilm formulations. Furthermore, BF3 was dominated by *Penicillium*, *Aspergillus* and *Mucor spp.* All treatments, except the control, showed acidic pH (pH<6) as biofilms produce organic acids when solubilizing P. Overall, it can be concluded that the BF3 is the most efficient biofilm formulation in solubilizing P in ERP. Further studies are recommended to evaluate the effectiveness of BF3 under field conditions in enhancing the solubilization of ERP.

Keywords: Biofilms, Biosolubilization of phosphorous, Eppawala rock phosphate

**DRINKING WATER QUALITY AND THE CKDU OCCURRENCE IN
WILGAMUWA, SRI LANKA**

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Chronic kidney disease of unknown aetiology (CKDu) is similar to the CKD that causes irreversible renal failure and eventually the death. Although the exact causative factors are unknown, drinking water is considered as one of the factors that contribute to CKDu occurrence. The main objective of this study was to systematically investigate the quality of the water consumed by CKDu patients in Wilgamuwa. The study sample consisted of 302 male and female patients with moderate CKDu. Information on drinking water sources was collected through an interviewer administered questionnaire. Water samples were collected from various drinking water sources used by CKDu patients. Majority of CKDu patients (~ 97%) used water from dug wells for drinking and cooking purposes. The remaining 3% used other water sources which is in the order of public water supply > tube wells > tank water. All types of drinking water were near-neutral (pH ranges from 4.91 to 7.83). Water consumed by more than half of the CKDu patients was less in ionic strength with electrical conductivity <250 $\mu\text{S cm}^{-1}$. Majority of CKDu patients (84%) consumed moderate to hard water, and the hardness values were above the threshold levels for human consumption according to WHO guidelines. Only 31% of CKDu patients consumed water with high fluoride (i.e. >1 mg F L⁻¹). Phosphate concentration varied greatly from 0.44 mg PO₄³⁻ L⁻¹ to 9.9 mg PO₄³⁻ L⁻¹. Aluminum and trace metals concentrations were below the WHO recommended values. Overall, the quality of the drinking water consumed by CKDu patients is within the WHO acceptable levels. This indicates that possible ingestion of trace metals through drinking water is minimal. Long term consumption of hard water rich in phosphate may link to the occurrence of CKDu.

Key words: Chronic Kidney Disease, Hardness, Trace elements

SITE SUITABILITY ANALYSIS FOR SOLID WASTE DISPOSAL IN VAVUNIYA DISTRICT, SRI LANKA

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Open dumping of Solid Waste (SW) has become a challenging issue in Sri Lanka and causes environmental pollution and public nuisance. Vavuniya District is no exception, and mixtures of all types of SW collected within the Urban Council limits are collectively emptied in Pampaimadu which is 10 km away from Vavuniya town. The partial burning of SW in the dump site aggravates air pollution and nuisance which was reported by the residents living proximity to the dump site. As an alternative measure, construction of sanitary landfill would be an appreciable option considering environmental safety. However, finding a suitable site for a sanitary landfill is the challenge for the district as environmental, demographic and social factors have to be considered. The aim of this study is to identify suitable sites for municipal SW disposal for Vavuniya District considering all the relevant environmental and social factors using Geographic Information Systems (GIS) techniques. In this context, factors such as; surface water bodies, land use pattern and transport network were considered for the GIS analysis which was performed on ArcMap version 10. Appropriate functions, such as buffering, rasterizing and reclassification, were performed to obtain the final output. The analysis was based on Multi-Criteria Analysis in combination with Weighted Overlay Analysis to identify and categorize the suitable areas for SW disposal site. The results revealed, 0.2% (3.96 km²) of the total area of the District is highly suitable; 35.6% (665.8 km²) is moderately suitable; 62.8% (1175.6 km²) is less suitable and 1.4% (26.0 km²) is unsuitable as a SW disposal site based on the sizes of bufferzones considering the degree of environmental safety. In addition, topographic elevation and groundwater table data must be considered along with the field validation for the selection of best possible site as well as to make sure the feasibility.

Keywords: GIS, MCA, Open Dumping, Sanitary landfill, Solidwaste

MITIGATION OF HIGH TDS WATER WITH ELECTRODIALYSIS REVERSAL METHOD – AN ALTERNATIVE SOLUTION FOR DRY ZONE WATER PROBLEM IN SRI LANKA

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High TDS groundwater sources are ubiquitous in the dry zone. However, the WHO or other regulatory agencies, do not list TDS as a primary drinking water standard; hence, its regulation is not mandatory. The mitigation of TDS in water is commonly carried out by Reverse Osmosis and nanotechnology treatment methods. However, groundwater in the dry zone rarely exceeds TDS > 5000 mg/L which renders that direct importation of RO methods are not suitable. In this research, based on the source water quality, EDR performance was optimized. However, the parameter optimization to a given water source remains as a challenge. JR-EDR laboratory equipment was used in this study. The EDR cell was constructed using Ti-RuO₂ electrodes and Tingrum JCM – II + JAM – II intra phase ion exchange membrane. EDR operation was performed on water collected from a tube well at the Faculty of Applied Sciences, Rajarata University of Sri Lanka. Tube well rock hole is with 6 inches in diameter, 10.25 to 40.00 m in depth and 4.03 m below ground level for the static water level. The heterogeneous aquifer is composed of quartz (38.56 %), albite (16.73%), orthoclase (8.1%), anerite (1.51%), and muscovite (2.84%). To reduce turbidity, sand and activated carbon filters were used before EDR treatment. The input current was varied from 0.5 - 3.0 A, and the flow rate adjusted to 5.25 mL min⁻¹. According to the results obtained, 40 W power was recommended for its highest performance. It was found that 23.07% current efficiency, 53.33 kWh m⁻³ energy consumption, 87.3% system desalination efficiency calculated based on conductivity measurement, 57.98% treated water recovery, 88.57% removal of TDS and 56.23% of water rejection. The composition of the treated and concentrates are pH 6.4, 7.5 EC 90, 1050 TDS 40, 510 respectively. The results show that a thorough assessment of source water quality and parameter optimizations are essential for efficient use of EDR technology to the villages of Sri Lanka.

Financial assistance from National Research Council (Grant No: NRC-TO-16-015) is acknowledged.

Keywords: Current efficiency, Electrodialysis, Energy consumption, Water quality

ASSESSING DRINKING WATER QUALITY AMONG CKDU PATIENTS WITH TUBULITIS: A CROSS SECTIONAL STUDY CONDUCTED IN SRI LANKA

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Symptomatic Chronic Kidney Disease of uncertain etiology (CKDu) with tubulitis is a recently described clinical entity. Drinking water is often considered to be a major source of nephrotoxic contaminants that cause CKDu. The present study was aimed to assess the drinking water quality among CKDu patients with tubulitis. Forty six biopsy confirmed CKDu patients with tubulitis from Girandurukotte, Wilgamuwa and Kandy renal clinics were recruited from May 2017 to October 2018. Water samples were collected from each patients' current drinking water source at home and at the work place (most of the time at the field). A 73% of patients have been using these water sources for past three years while 27% of patients have been using more than three years. The present study showed that most of the patients (52%) use Protected Dug Well (PDW) water for drinking at home while 11% of patients use Reverse Osmosis (RO) water. About 22%, 9% and 4% of patients use public water supply (PWS) sources, tube well (TW) water, and spring water (SW), respectively. According to the present study the median Fluoride concentration in PDW is 0.529 mg/l. The RO water has relatively less median Fluoride level (0.054 mg/l) when compared with other drinking water sources. The PDWs have the median of 1.871 mg/l concentration of NO₃⁻ while TW, PWS, Surface water and RO water has 1.863 mg/l, 1.619 mg/l, 1.151 mg/l, 0.726 mg/l, 0.296 mg/l of NO₃⁻, respectively. Most of the CKDu patients with tubulitis studied consume dug well water. Fluoride, nitrate including anion levels and Cd, Pb including other heavy metals are below the WHO recommended values for drinking water. It is recommended that analysis of biological fluids (urine and blood) for nephrotoxic heavy metals and disease markers, histochemical analysis of kidney tissues and food and other environmental sample analysis for heavy metals and pesticide residues are also needed to be carried out in order to identify the possible aetiology of the CKDu with tubulitis.

Financial assistance from National Science Foundation Research Grant (Grant No: RPHS/2016/CKDu/06 is acknowledged.

Keywords: Chronic Kidney Disease, Tubulitis, Nephrotoxic

**VARIATIONS IN WATER QUALITY PARAMETERS IN NEGOMBO LAGOON,
SRI LANKA AND ITS IMPACT ON FISH AND SHELLFISH ABUNDANCE**

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Negombo lagoon (7° 6' - 7° 12'N, 79° 49' - 79° 53'E) is one of the most productive lagoon located in Sri Lanka. This study aims to evaluate the variations in water quality parameters and their impact on the fish and shellfish abundance in the Negombo lagoon. Three major sites located approximately at 5 km distance from each other, *i.e.*, Kadolkele, Dungalpitiya, and Kepungoda, were selected. Fish and shellfish sampling was done once a month from January to December 2018 using a seine net with 50 mm stretch mesh size. The sampling area was set at 250 m² and triplicate samplings were done. Salinity and surface water temperature were measured *in-situ*. Water samples were collected to determine Dissolved Oxygen (DO), pH, Nitrate-N and Orthophosphate. The Generalized Additive Model (GAM) was used to examine the relationships between the site variables and the abundance of fish and shellfish. Temperature and pH variation were not significant within the three sites although salinity, DO, Nitrate-N and Orthophosphate variations were significant. Highest salinity was recorded in Kadolkele site (21.3±8.6 ppt) while lowest in Kepungoda (13.7±7.86 ppt). Although Kadolkele has been reported as a highly productive mangrove habitat, this study proved that there is very low abundance of finfish and shellfish due to very low DO (~3.14 mg L⁻¹) and high Orthophosphate levels (~1.02 mg dm⁻³) (low compared to the level required for fish and aquatic life). PCA analysis indicated that water quality of the lagoon could have a profound effect from Orthophosphate, salinity and pH. According to GAM, Orthophosphate has the highest influence on the density of fish and shellfish. Multiple predictor fits depict that combination of four predictors; Orthophosphate, DO, Nitrate-N and salinity have a significant effect on the density of fish and shellfish in Negombo lagoon. Detailed and continuous assessment will be useful in the future to manage and conserve the fish and shellfish resources in Negombo lagoon.

Keywords: Fish, Shellfish, GAM, Negombo Lagoon, Water quality

MORPHOLOGICAL DIVERSITY OF PHYTOLITHS OF SELECTED SRI LANKAN TRADITIONAL RICE LANDRACES

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Rice (*Oryza sativa*; Family Poaceae) absorbs Silica (Si) in the form of monosilicic acid from the soil through Si transporters present in roots thus forming amorphous Si accumulations known as phytoliths. Phytoliths have diverse morphotypes. The major objective of this study is to determine the different phytolith morphotypes in selected 13 traditional rice varieties and two improved rice cultivars namely, Bg370 and Bg374 and to compare the morphological variations of phytoliths of selected traditional varieties and improved rice varieties. Dry ashing method was used for the extraction of phytoliths from dried rice leaves of selected rice varieties. Different phytolith morphotypes were observed under B350 OPTIKA microscope. The highest and the lowest phytolith contents were observed in Bg374 and Bg370 varieties which are lodging resistant and lodging sensitive respectively whereas other selected varieties were distributed between them thus showing a relationship with lodging parameter with phytolith content. The dimensions of selected morphotypes (rectangular, bulliform and bilobate shapes) were measured for the statistical analysis. The highest and the lowest length to breadth ratio of rectangular shape was observed in Kahawanu and Suwandal varieties respectively while the largest and the smallest bulliform shapes were observed in Suwandal and Suduru Samba varieties. The highest and the lowest length to breadth ratio of bilobate shape were observed in Sulai and Herath Banda varieties. Other varieties were distributed among these varieties. However, the dimensions of these morphotypes do not show any considerable variation among traditional rice varieties. Scanning Electron Microscopic analysis and molecular studies must be conducted to determine the 3-dimensional structure and the genetic basis of the formation of different phytolith morphotypes respectively.

Keywords: Bilobate, Bulliform, Morphotypes, Phytoliths, Rice

**SITE SUITABILITY EVALUATION OF BEACHES FOR ECOTOURISM
DEVELOPMENT IN THE JAFFNA DISTRICT, SRI LANKA**

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Jaffna District has a number of important beaches which are suitable for promotion of ecotourism. These include Casuarina, Chatty, Delft, Senthankulam, Kankesanthurai, Akkarai, Thumpalai and Manatkadu. The objective of the present study was to identify and prioritize the potential ecotourism beach sites by using a Geographic Information System (GIS). GIS, together with Multi Criteria Decision Method and Criteria Ranking Method, were used for analysis. Seven criteria *viz.* facilities, ecotourism resource base, tourist preferences, proximity to residential areas, proximity to accommodation, distance from roads, and scenic beauty were used to evaluate suitability of beach sites of Jaffna District. Those factors were selected according to expert opinion. GIS plays a key role in ecotourism planning. The methodology used in this study helps in identification of best suitable beach sites based on their current condition by using multi criteria. The study revealed that Casuarina is a high potential area and Chatty and Akkarai beaches are moderate potential sites based on their basic facilities. Based on the multi criteria analysis, Chatty, Casuarina and Kankesanthurai beaches are high potential sites. Delft, Senthankulam and Thumpalai represent moderate potential status. Akkarai and Manatkadu showed low status. The potential sites were derived based on the status of the six criteria. Basic facilities for all beaches have not been developed. Traditional fishing villages and fishing activities are associated with all beaches and there are potential areas for water sports and sea food. The study also revealed that these beaches are much less polluted and crowded compared to beaches in other parts of Sri Lanka. These areas have not yet been promoted for ecotourism. Hence these beaches, with their natural resources, offer good opportunities for ecotourism rather than mass tourism. Local Government bodies should give more attention on ecotourism based beach development.

Keywords: Beach based ecotourism, Casuarina beach, Chatty, Jaffna

**PHYTOCHEMICAL SCREENING, ANTIFUNGAL AND ANTIBACTERIAL
ACTIVITY OF *PSIDIUM GUAJAVA* LEAF EXTRACT**

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Plants are capable of synthesizing various chemical compounds that support defend against attack from an immense diversity of predators such as fungi, bacteria, insects and herbivorous mammals. Although some of these chemical compounds are toxic to plant predators, they seem to be effective drugs for human diseases. *Psidium guajava* is an important medicinal plant of the family Myrtaceae. Extracts of leaves of *Psidium guajava* from dry zone and wet zone of Sri Lanka were obtained through Soxhlet extraction method using hexane, acetone and methanol as the solvents. Antifungal assay, antibacterial assay and preliminary phytochemical analysis were carried out for all these three extracts. The antifungal bioassay was performed by Agar well diffusion method with a concentration of 500 mg/L of the leaf extracts against the fungi *Aspergillus* sp., *Fusarium* sp., *Penicillium* sp., *Rhizopus* sp. and *Trichoderma* sp. Methanol and acetone leaf extracts of *P. guajava* from both the dry and the wet zones displayed high degree of antifungal activity (mean diameter) against *Aspergillus* sp.(20.75 mm, 18.50 mm, 23.00 mm and 20.25 mm) and *Trichoderma* sp.(16.25 mm, 20.25 mm, 20.25 mm and 22.50 mm). An antibacterial bioassay was performed by agar well diffusion method with the concentration of 500 mg/L of the leaf extract against the bacteria *Acinetobacter* sp., *Bacillus* sp., *Escherichia coli*, *Pseudomonas* sp., and *Staphylococcus* sp. Methanol and acetone wet zone leaf extracts of *P. guajava* revealed high degree of antibacterial activity (mean diameter) against *Bacillus* sp.(26.00 mm, 27.00 mm) and *Acinetobacter* sp.(20.00 mm, 23.00 mm). The phytochemical analysis revealed that the leaves of *P. guajava* contain secondary metabolites alkaloids, flavonoids, saponins, tannins, coumarins and cardiac glycosides which are the bioactive compounds that play a major role in antimicrobial activities.

Keywords: Agar well diffusion method, Antibacterial activity, Antifungal activity, Phytochemical analysis, *Psidium guajava*

MODIFICATION OF ZEOLITE FOR REMOVAL OF FLUORIDE IN WATER

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High amount of fluoride in drinking water causes too many health issues worldwide including Sri Lanka. For removal of fluoride ions different methods are available. Out of these, adsorptive methods are prominent due to relatively low cost and simplicity of generation. Zeolite is a high crystalline pores material which is modified with $\text{FeCl}_2 \cdot 4\text{H}_2\text{O}$ in order to adsorb fluoride. Solid state ion exchange process was used to impregnate the Fe species into the zeolite. Characterization of Fe-zeolite was done, before and after the fluoride adsorption, by Fourier transformation infrared spectroscopy, scanning electron microscopy, and energy dispersive spectrometry and X-ray diffraction. Langmuir and Freundlich isotherm models were used to study the fluoride adsorption behavior. Kinetic studies were done to study the order of the adsorption reaction. Characterization results concluded that Fe species undergo an ion exchange process with acidic hydrogen present in zeolite by compensating negative charge of the framework. SEM and EDX data also indicated the presence of Fe in modified samples. Adsorption of fluoride on to Fe-zeolite was observed with respect to the contact time, adsorbent dosage and initial fluoride concentration. As the dosage of Fe-zeolite, initial fluoride concentration and contact time increases, the adsorption also increased. Therefore, optimum value of 20 g L^{-1} dosage and 10 mg L^{-1} of initial fluoride was selected. An efficient fluoride adsorption (about 74% of the initial fluoride) was observed within 60 minutes by 20 g L^{-1} of Fe-zeolite. Fe-zeolite was proved to be an effective fluoride adsorbent since pure zeolite does not cause a significant adsorption. The Langmuir adsorption isotherm was the best fit, and kinetic studies showed that the reaction is more compatible with pseudo second-order model. Findings of this study could be applied in developing low cost water purification filters using modified zeolites.

Keywords: Adsorption, Fluoride, Isotherm, Kinetics, Zeolite

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

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Poly(ethylene terephthalate) (PET) has a wide range of applications due to its distinct properties. Thus the global PET consumption has increased dramatically over the past years. This has resulted in a significant problem to the environment due to the impacts of post-consumer PET on both human and nature. Out of many post consumer PET remediation methods, depolymerization by hydrolysis can be considered as one of the efficient methods. Acid hydrolysis of post-consumer PET in to its 1,4-benzenedicarboxylic acid (BDC) monomer, and the use of BDC as a precursor to synthesize Metal Organic Frameworks (MOFs) is reported in this work. BDC was isolated by acid hydrolysis of four different types of used PET bottles by using H₂SO₄. De-colourization was done with charcoal for the coloured samples. Isolated products were characterized by Fourier transform Infrared (FTIR) spectroscopy and for all the samples, around 75% yield was obtained. Two MOFs, Zn(BDC) and Cu(BDC) were synthesized by reacting Zn²⁺, Cu²⁺ with isolated BDC using simple non-solvothermal method. This method was further applied in two distinct routes as direct synthesis and interfacial synthesis methods. The MOFs were characterized by using Powdered X Ray Diffraction (PXRD) and Scanning Electron Microscopy (SEM). PXRD analysis revealed, Bragg diffraction peaks with higher intensities at 9.04°, 21.02°, 25.87°, 32.70° for Zn(BDC) and 8.96°, 17.96° 26.19° for Cu(BDC). Scanning Electron Microscopy studies revealed Zn(BDC) has a cubic shaped crystal morphology while Cu(BDC) has a cluster morphology with irregular shaped flakes. Particle size of each MOF varied with the method of synthesis. Particles obtained for each MOF by direct synthesis were smaller than that obtained by the interfacial method. Porosity of external surface of Cu(BDC) was higher than in Zn(BDC). This study indicates that the BDC isolated by acid hydrolysis of post consumer PET products can be successfully used as a precursor, in synthesis of Zn(BDC) and Cu(BDC).

Keywords: Acid Hydrolysis, Metal Organic Framework, Poly(ethylene terephthalate)

FINFISH SPECIES COMPOSITION AND COMMERCIAL FISH PRODUCTION OF BOLGODA NORTH LAKE, SRI LANKA

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Bolgoda Lake (6° 40'-49' N; 70° 54'-58' E) located in the western province is a shallow brackish water body. It has two major basins; North and South Lakes. The present study was done in the North Lake which is the main commercial fishing area where fishery is reported to be declining. Sampling was carried out twice a month from January to December 2018 in three major fish landing sites; Diggala, Indigahathotupola and Kithalanduwa. Species composition, water pollution and daily fish catch in each landing site were recorded. A total 28 species consisting of 13 inhabiting freshwater, brackish and sea water; 2 exclusively freshwater, 2 exclusively marine, 1 exclusively brackish, 4 marine-brackish and 6 freshwater-brackish were recorded. The highest number of fish species was recorded from Diggala (26), the lowest from Kithalanduwa (11) and 17 from Indigahathotupola. The average Monthly Total Production (MTP) of the North Lake was 715.31 (\pm 53.16 Kg). Highest MTP was recorded from Diggala fish landing site which had lowest amount of water pollution. The major species contributing to the monthly fishery production of the North Lake was *Etroplus suratensis* from Diggala and Kithalanduwa, *Oreochromis niloticus* from Indigahathotupola. Compared with previous studies (MTP of North Lake in; 1992 was 2500 Kg, 1996 was 4583.33 Kg and in 2014 was 848.28 Kg) a decline in fish catches is observed. Pearson co-relation analysis between water pollution sources and MTP at each landing site shows a strong negative relationship. Statistically significant spatial variation of finfish composition and MTP was recorded between studied fish landing sites ($p < 0.05$). The main factor attributed to the decline of finfish was identified as pollution. In addition tidal fluctuations due to harbour development activities and invasive floating plants such as *salvinia* sp. and *Ipomea* sp. may contribute towards the decline of finfish catches in the Lake.

Keywords: Bolgoda north lake, Finfish, Monthly total production, Species composition

**PALEO-CLIMATE AND PALEO-ENVIRONMENT VARIABILITY OF
SOUTHEASTERN SRI LANKA AS INFERRED BY A PALEO-PROXY RECORD
FROM POTTUVIL LAGOON**

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In order to trace the paleo-monsoon variability and paleo-environment changes occurred during the Holocene in the north-eastern region of Sri Lanka, a high-resolution paleo-proxy record was obtained from a sediment core retrieved from the Pottuvil lagoon. Since lagoon formations of the Island are attributed to Holocene epoch, sedimentary sequences of lagoons represent the paleo-environment and climate status that existed at least for ten thousand years. The selected lagoon is located directly in the path of the winter monsoon track of Sri Lanka and the region is sheltered from summer monsoon influence thus depicting the winter monsoon variability. A 5.1 m sediment core was obtained from the lagoon and granulometric properties, contents of major and trace elements, total organic carbon (TOC) and total nitrogen (TN) were determined in sub-sections selected at 5 cm intervals. Based on elemental ratios of K-Al, Mg-Al and K-Rb, and grain size distribution, three distinct phases of enhanced monsoon activities were identified at 0-25, 130-190 and 370-425 cm depths. Intermittent weak monsoon phases were also observed at 25-70, 190-250 and 425-450 cm depths. This was further supported by Al-normalized Fe and Mg values while ratios of K-Al and Mg-Al were showed a strong negative correlation with Fe-Al and Mn-Al ratios. However, Rb-Sr ratio of the sediment sequence was increased during wet intervals and decreased during dry or weak monsoon phases. However, paleo-productivity signals were not consistent as inferred by TOC and TN signatures, probably due to intense degradation or poor preservation of organic matter in lagoon sediments. Pulses recorded in sulfur and Sr/Al, Rb/Sr proxies at 70-130 and 190-250 cm depths suggested a certain degree of marine influence that was also observed at 25-70, 310-370, 425-450 and 485-500 cm depths. This may be possible episodes of Holocene transgression of sea level in the eastern coast of the island. However, ¹⁴C age records are required to confirm the ages of the different events.

Financial assistance from National Science Foundation of Sri Lanka (Grant No: NSF/SCH/2018/06) is acknowledged.

Keywords: Holocene, Lagoon sediments, Monsoon variability, South-east coast

ABUNDANCE AND GRAIN MORPHOLOGY OF HEAVY MINERAL ACCUMULATIONS IN SOUTH-WESTERN COAST OF SRI LANKA

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Heavy minerals, which have higher densities (specific gravity >2.8) and economic value than those of silicates, dictate the exploration potential of a deposit. North-east coast of Sri Lanka (from Arisimalai to Pulmuddai) is rich in heavy minerals, and currently being exploited while south-western coast is barely exploited due to the lack of information on the deposits. Objectives of this study are to estimate the abundance and determine the exploration potential of heavy minerals from Kalutara to Hambantota. Augured sediments were analysed using several methods. Dry sieve analysis where 250 g of sample was mechanically sieved (model JIS Z 8801). Most were medium sized grains (500 to 180 µm) with highest frequency at 300 µm. Coarser and finer sand content was small while Silt/clay were negligible. Wet sieving was followed by density separation using sodium polytungstate (Na₆[H₂W₁₂O₄₀]). Heavy minerals showed high concentrations near surface and varied with the depth, ranging from 86.48% to 36.85% by weight. Hambantota and Tangalle had higher yields for garnet (>50%), and ilmenite (~15%) by weight. Prepared grain mounts were observed through a stereo microscope to calculate modal percentages. Highest values were obtained from Hambantota (garnet 35.77%, opaque (ilmenite + magnetite) 35.01%) and Beruwala (monazite 42.22%, zircon 10.37%). Garnet, monazite and zircon showed localised abundances, while ilmenite was moderately spread area-wide. Majority of the grains were sub-angular to sub-rounded indicating a nearby source while rounded Beruwala sand indicated a distant source. Accordingly, these minerals have derived from nearby sources (except for Beruwala) and their content varies with location and depth. Ocean current sediment supply and source of deposits are being further studied. According to weight and modal percentages, ilmenite has an exploration potential within the whole study area, while garnet, monazite and zircon are found localised. However, exploitation will depend on the environmental factors which should be investigated further.

Financial assistance from the Ministry of Science, Technology and Research (Grant No: MTR/TRD/AGR/3/2/20) is acknowledged.

Keywords: Coastal sand, Heavy minerals, Sediment, Sediment morphology

WASTE PEANUT HULL AS A BIOSORBENT TO TREAT RICE MILL WASTEWATER: A COMPARISON WITH THE EFFICIENCY OF GRANULAR ACTIVATED CARBON

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The objective of this study was to evaluate the performance of waste Peanuthull as a biosorbent in treating ricemill wastewater. The performance of the peanuthull was compared under similar conditions with coal based Granular Activated Carbon (GAC) which is a well-known adsorbent for organic pollutants. The adsorbents were carefully washed, dried, grinded and sieved to obtain uniform particle size <1 mm. Batch adsorption studies were conducted for peanuthull and GAC for varying doses (0 - 6 g/L) and contact times (0 - 300 min) to determine the optimum dosage of adsorbents and contact time with wastewater respectively at pH 8.0±0.25 and at temperature 28±2⁰C. The performance efficiencies of the adsorbents were tested based on the removal (%) of Nitrates, Phosphates, five days-Biological Oxygen Demand (BOD₅) and Chemical Oxygen Demand (COD) from wastewater which was collected from a ricemill located in Vavuniya. Three replicates were carried out for each test. The optimum removal of organics and nutrients were observed with Peanuthull at the dose of 4 g/L, in which the removal efficiency of BOD₅, COD, nitrate and phosphate were 65, 70, 67 and 24% respectively. In comparison with GAC, the optimum removals were noticed at the dose of 1 g/L in which the removal efficiency of BOD₅, COD, nitrate and phosphate were 90, 75, 56 and 24% respectively. According to contact time of adsorbent with wastewater, the peanuthull attained optimum removal at 120 mins whilst the GAC attained the optimum removal at 45 mins in which the optimum doses of peanuthull and GAC were maintained at 4 g/L and 1 g/L respectively. Based on t-test, the performance of peanuthull was similar to GAC in terms of COD, nitrate and phosphate (p-value > 0.05) reduction from ricemill wastewater. Since the adsorbent was prepared from waste Peanuthull and no chemicals are required, this can be used as a cost-effective option and environmentally friendly biosorbent to treat ricemill wastewater.

Keywords: Adsorbent, Biosorbents, Peanuthull, Ricemill, GAC, Wastewater

**TOURIST COMPOSITION AND THEIR OPINION ON ECOTOURISM
POTENTIALS IN THE JAFFNA DISTRICT, SRI LANKA**

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The purpose of this study was to analyze tourist composition and their perceptions on potential of ecotourism, especially ecotourism activities and infrastructure facilities of Jaffna District. For the identification of tourist composition, data were collected for the past two years, as secondary data from Department of Archeology and Central Cultural Fund which have daily records of tourist's arrivals. In addition, primary data were collected by using semi-structured questionnaires from 160 tourists representing foreign (54) and local (106), based on convenience sampling. The preferences on ecotourism were recorded from the selected tourists. The questions, related to tourist's opinions on the Eco activities and infrastructure facilities were based on the Likert scales. The study reveals that 69736 tourists came to Jaffna in 2017 and increased up to 145,602 by 2018. Out of this, international tourists were 5751 in 2017 and increased up to 12,244 in 2018. A high number of international tourists (over 1000) arrived in Jaffna from June to October in 2018. High numbers of local tourists visited Jaffna from August to December (over 8000) in 2018. Among them, 172 tourists arrived to Jaffna per day in 2017 and it was 329 in 2018. Data gathered from questionnaires revealed that 76% of tourists preferred nature, culture tourism and ecotourism. A 77% of tourists accepted that Jaffna District has ecotourism potentials. According to tourists' opinions, basic infrastructure facilities are at a moderate level and tourists are not satisfied with facilities such drinking water, waste management, etc. In addition, safety measures, signs boards, road symbols, conservation efforts, promotion activities, and ecotourism activities are not at satisfactory levels. Tourists satisfied (75%) on the availability of traditional products and food. We conclude that tourist arrivals are increasing in the district, therefore, ecotourism infrastructure facilities and promotional activities should be further developed.

Keywords: Ecotourism, Jaffna District, Tourist compositions, Tourist opinion, Tourism infrastructure

**DEGRADATION OF SUMIFIX REACTIVE RED EXF AND BLUE EXF DYES
USING A COBALT TRIMESIC COORDINATION POLYMER**

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Textile industry is one of the largest industries releasing a large volume of waste effluents to the environment. The contamination of water bodies may damage the entire eco-system. The present study aimed to mitigate the dye effluent contamination from the industrial dye waste water sources. Red EXF and Blue EXF reactive compounds are two famous dyes, which are widely used in textile industry worldwide. Sri Lankan textile industries release a large volume of these dye effluents to the environment. This research study was based on removal of reactive Red EXF and Blue EXF reactive dye effluents using a cobalt trimesic coordination polymer, combined with hydrogen peroxide. In the present study, removal of 10 mg L⁻¹ SUMIFIX SUPRA Red EXF and SUMIFIX SUPRA Blue EXF were investigated under LED, CFL light irradiation and dark conditions by changing the photocatalytic dosages. A combination of cobalt trimesic coordination polymer with hydrogen peroxide was used to efficiently degrade the above two dyes. A photo-Fenton process has taken place in the degradation process involving Co (II)-Co(III) redox couple and OH[•] radicals. Red EXF dye degradation was most efficient under ambient conditions and observed 85.08 %, 82.05 % and 83.33 % degradation under CFL, LED irradiation and dark conditions for 3 , 3 and 24 hours of exposure, respectively. Blue EXF dye showed 90.89 %, 87.06 % and 95.21 % degradation under the similar conditions. The optimum dye degradation values were observed at pH 6.5-7.5 range.

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

Keywords: Dyes, Fenton process, Photocatalyst, Reactive, Textile dyes

INFLUENCE OF *CANNA INDICA* ON BOD₅ AND COD IN DAIRY WASTEWATER THROUGH CONSTRUCTED HORIZONTAL SUB SURFACE FLOW WETLAND

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Wastewater discharged from industrial operations contains high concentrations of organic and inorganic substances causing environmental pollution. The treatment of wastewater using constructed wetlands is one of the suitable treatment systems. Among the different types of constructed wetlands, horizontal sub surface flow constructed wetlands are most widely used and become low impact alternatives to more conventional wastewater treatment processes. This study was undertaken to determine the influence of *Canna indica* planted in horizontal subsurface flow constructed wetland on BOD₅ (Biological Oxygen Demand) and COD (Chemical Oxygen Demand) when dairy wastewater was filtered through it. 15 L of raw water was fed into each treatment once in five days and the samples were collected in 3 days of hydraulic retention time from each treatment unit and control unit where no plants were planted. The laboratory tests were conducted to determine the BOD₅ and COD. The data on the inlet of raw water and outlets of treated water were analyzed using Paired-t test by SPSS 25.0 at $\alpha = 0.05$ and confident interval (CI) = 95%. Results revealed that there was a significant difference between the inlet and outlet of each *Canna indica* unit ($P = 0.0030$) and control unit ($P = 0.0000$) in BOD₅. The highest reduction efficiency of BOD₅ in the control unit and *Canna indica* unit was observed as 40.46% and 91.69% respectively. Further, there was a significant difference between the inlet and outlet of *Canna indica* unit ($P = 0.0240$) and control unit ($P = 0.0150$) in COD. The highest reduction efficiencies of COD observed in the control unit and *Canna indica* unit was 90.39% and 93.87% respectively. Hence, we conclude that constructed horizontal sub-surface flow wetlands through phytoremediation may be an effective green technology for the treatment of dairy wastewater.

Keywords: BOD₅, *Canna indica*, COD, Constructed horizontal sub surface flow wetlands

IMPACT OF ASSOCIATED ANIONS ON LEAD UPTAKE BY *PISTIA STRATIOTES* FROM WASTEWATER

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Heavy metal contamination of aquatic ecosystems is a critical issue due to industrialisation. Among many methods, phytoremediation is a cost-effective and efficient green technology to mitigate this problem. *Pistia stratiotes*, being a floating aquatic hyperaccumulator, was examined for its potential of removing Pb (II) from wastewater and impacts of its counter anion. The impact of the counter ion in the cation uptake has not been examined previously. Plants of *P. stratiotes* of similar growth stage were grown in plastic basins containing 3.0 L of solutions with Pb (II) maintaining at 10 mg L⁻¹ using different lead salts viz., chloride, nitrate, acetate, fluoride and arsenate. *P. Stratiotes* were grown in distilled water as controls. Solutions collected on the 1st, 2nd, 3rd, 5th, 10th days were analyzed for cation and anion concentrations using Atomic Emission Spectroscopy and Ion Chromatography, respectively. The average Pb (II) removal per unit mass of the plant after 10 days of exposure to Pb (II) solutions of chlorides, nitrates, acetates, fluorides and arsenates were 0.954, 1.036, 1.228, 0.637 and 0.637 mg g⁻¹ respectively. Being the relatively more effective Pb(II) salts, acetate and nitrate concentrations were increased up to 10, 15, 20 mg L⁻¹ by adding Na(C₂H₃O₂) or NaNO₃ while maintaining Pb(II) concentration at 10 mg L⁻¹ to evaluate the anionic effect on Pb (II) removal by *P. stratiotes*. The average Pb (II) removal per unit weight of the plant were recorded as 1.335, 1.412 and 1.215 mg g⁻¹ for acetates and 0.885, 1.051 and 1.293 mg g⁻¹ for nitrates respectively. The highest Pb (II) removal was recorded at 15 mg L⁻¹ of acetate and 20 mg L⁻¹ of nitrates. Among the counter anions, the most effective uptake of Pb(II) was with acetate. The results indicate that the Pb (II) removal of *P.Stratiotes* is influenced by the concentration and the type of the anion associated with Pb (II).

Financial assistance from University of Peradeniya (Grant No: URG/ 2017/51/S) is acknowledged.

Keywords: Associated anion, Heavy metals, Hyperaccumulators, Phytoremediation, Wastewater

MINERALOGICAL CHARACTERISTICS OF THE ROAD, HOUSEHOLD AND ROCK DUST IN SRI LANKA

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Air pollution is one of the most serious problems facing humanity and other life forms on our planet today. Air pollution has been increased with the increasing of populations, urbanization, industrialization and transport activities. Present study is focused on the road and household dust as well as quarry dust of Sri Lanka. Eighteen road dust samples and thirteen household dust samples were collected in the Kandy and Colombo municipal areas and fifteen quarry dust samples were collected within Kandy district in order to study mineralogical and morphological characteristics of them. X-ray diffraction, scanning electron microscopic and fourier-transform infrared spectroscopic analyses were carried out. There are no significant differences in the mineralogical compositions of the road and household dust. Most of the fibrous particles of road and household dust samples are micro-scale plastic and textile materials. All the studied particles show a higher degree of angularity. Mineralogical compositions of road and household dust samples indicate that they have originated from the surrounding soil. The composition of quarry dust is comparable to that of their parent rocks. However, the quarry dust is predominated with secondary minerals such as chlorite, gibbsite and goethite and some other clay minerals which can not be found in partilly weathered rocks. The formation of such secondary minerals has been triggered due to the tropical environmental condition prevailed in the country. The present study revealed that climatic conditions affect highly on the human-caused environmental changes of the country.

Financial assistance from National Research Council (Grant No: AB 19-004) is acknowledged.

Keywords: Household dust, Road dust, Rock dust

**THE DOMINATION NUMBER AND NON-SPLIT DOMINATION
NUMBER OF ROACH GRAPH**

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Given a graph $G = (V, E)$, a set $D \subset G$ is said to be a dominating set, if every vertex not in D is adjacent to a vertex in D . The domination number of G denoted by $\gamma(G)$, is the minimum cardinality of a dominating set. A dominating set D is a non-split dominating set if the induced subgraph $\langle V - D \rangle$ is connected. The non-split domination number $\gamma_{ns}(G)$ is the minimum cardinality of a non-split dominating set. C. Sujatha et.al. (2019) have analyzed the domination parameters corresponding to non-split domination number of a graph and obtained several results on these parameters. They found bounds for $\gamma_{ns}(G)$ and exact values for $\gamma_{ns}(G)$ for some standard graphs. Further, graph theoretic properties of domination numbers of jump graphs, $\gamma(J(G))$ and their exact values for some standard graphs have been studied by V.B. Maralabhavi et.al (2013). The relationship between $\gamma(J(G))$ with other parameters is also investigated by them. In this study, we reviewed the properties of domination number and non-split domination number of a graph and then obtained the results related to the special graph called “roach graph” denoted by $R_{(2n,2k)}$. Roach graph which resembles a cockroach having $2n + 2k$ vertices, where $2n$ vertices belong to the body and $2k$ vertices belong to its two antennas in head. This graph has been recently studied from several perspectives by very few authors. Due to the lack of results derived for the domination number of a roach graph, our focus is to obtain a general equation for the non-split domination number of a roach graph by considering the two main cases, $n = 1$ and $n > 1$. Furthermore, a conjecture for the domination number of a roach graph has been stated.

Keywords: Domination number, Non-split domination number, Roach graph

SPATIAL AND CLUSTER ANALYSIS OF DENGUE TRANSMISSION IN WESTERN PROVINCE

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Dengue fever is a mosquito-borne viral disease caused by the dengue virus. It is transmitted to humans through the bite of infected *Aedes mosquitoes*, mostly *Aedes aegypti*. Dengue has become a rapidly growing and spreading endemic during past three decades. Sri Lanka experienced the most number of deaths due to dengue virus during the year 2017. Western province has been reported as the highest number of dengue incidences during the period 2013-2017. To implement a better and efficient prevention program, areas and time intervals of the year that require more focus should be identified. The aim of this research is to find correlation between dengue incidences and environmental factors, analyse the distribution of dengue virus spatially and to identify meaningful clusters with the climatic factors that affecting dengue in Western province. *Spear-man's Rank correlation coefficient* was used to calculate correlation between number of dengue incidences and environmental factors which are discrete data and continuous variables respectively. *Agglomerative hierarchical clustering* method is used and *Ward's method* is used as the linkage method. This study shows that rainfall and humidity have negative correlation with number of dengue incidences while temperature has a positive correlation. This analysis exhibits that the Colombo district as the highest dengue dense and Kalutara district as the least dengue dense area in the Western province. Another important conclusion made using the cluster analysis is, during the period of first peak of monsoon season of the year, there is an increase in spread of dengue virus in Western province.

Keywords: Correlation, Cluster analysis, Dengue, Environmental factors, Spatial analysis

**AN ATTENTION BASED CONVOLUTIONAL NEURAL NETWORK FOR
LANDMARK RECOGNITION IN ASIAN REGION**

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Image retrieval is a fundamental problem in computer vision especially important for querying images which accounts for a large portion of what people like to photograph. Moreover, tourists often travel to various countries and take tons of selfies and/or groupies including several landmarks for posting on social network sites. They only realise a month later when looking at those photos wandering where they were standing in front of. In this regard, landmark recognition greatly helps people to better understand and organise their photo collections with the introduction of deep convolutional neural network that is used for image processing. In this study we consider 30 classes of landmarks that are located in 30 different countries in Asia. Images are collected from the famous Kaggle competition, the Google Landmark Recognition Challenge. This study proposes a CNN model based on the VGG-11 by adding an attention branch that combines predicted *conv5* and fine grained features to gate or magnify the *conv5* features to improve the precision of landmark classification. We utilise the $14 \times 14 \times 512$ predicted feature map of *conv5* to max pool the features in to $1 \times 1 \times 512$ and thereafter the features are reconstructed through upsampling to $14 \times 14 \times 1024$, thus producing dense feature map of size $14 \times 14 \times (512 + 1024)$. The training set used in our experiment contains 35 images per landmark and the testing set contains 15 images per landmark. Images that were not landmarks at all in the given dataset were excluded. The proposed method shows 94% of classification accuracy by contributing the CNN to yield attentive image features.

Keywords: Convolution neural network, Deep learning, Kaggle competition, Landmark recognition

**k -FACTORS OF k -FACTORIZATION OF $K_{2,2,2,\dots,2}$ WITH n -PARTITE SETS FOR
 $k = 1, 2$ AND $n \geq 2$**

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A factor of a graph G is a spanning sub-graph of G which is not totally disconnected and a graph factorization of G is a partition of edges of G into disjoint factors. Factorization is one of the most active research areas in Graph Theory. The notion of factorization was introduced by Kirkman in 1847 and a result on a factorization of 1-factor (factors of degree one) was obtained by Reiss in 1859. Most of the research work on factorization is on complete graphs and complete bipartite graphs. In this work, complete k - partite graphs are considered. A *complete k -partite graph* is a simple k -partite graph in which each vertex in one partite set is adjacent to all the vertices in the other partite sets. In this research, complete multipartite graphs $K_{2,2,2,\dots,2}$ with n partite sets were used and 1-factor and 2-factor of their factorizations for different values of n have been constructed. It has been

shown that 1-factor for 1-factorization can be obtained by the formula $\frac{{}^{2n}C_2 - n}{n} = 2(n-1)$

for $n \geq 2$ and is proved by giving a combinatorial proof. Moreover, when n is even, 2-factors for 2-factorization of a complete multipartite graph have been obtained using the tournament scheduling technique by considering n partite sets as n teams. Labeling partite sets as a_1, a_2, \dots, a_n , one 2-factor can be obtained as $a_1a_2, a_3a_4, \dots, a_{n-1}a_n$. So, $(n-1)$ such 2-factor are constructed, which is a 2-factorization of $K_{2,2,2,\dots,2}$. Future work is to construct factorization of the complete multipartie graph with n partite sets of the form $K_{2^r, 2^r, 2^r, \dots, 2^r}$ for integers $r, n \geq 2$.

Key words: Factorization, Tournament scheduling technique

MEAN SQUARE ERROR COMPARISON OF ALMOST UNBIASED RIDGE ESTIMATOR AND MODIFIED ALMOST UNBIASED RIDGE ESTIMATOR IN LOGISTIC REGRESSION

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Multicollinearity severely affects the variance of the estimates of the parameters in the logistic regression model. As a result, one may not obtain efficient estimates for the unknown parameters. Several alternative estimators namely, Logistic ridge estimator, Principal component logistic estimator, Logistic Liu estimator, Liu-type logistic estimator, Almost unbiased ridge logistic estimator, and Almost unbiased logistic Liu estimator, have been proposed in the literature to handle the problem of multicollinearity in the logistic regression. This study has been focused on proposing a new parameter estimator for the logistic regression model when multicollinearity presents. The proposed estimator was called Modified almost unbiased ridge logistic estimator, and the performance of this estimator was theoretically compared with the existing Almost unbiased ridge logistic estimator in the mean square error sense. Further, the condition for superiority of the proposed estimator over the Almost unbiased ridge logistic estimator was derived, and a real data application was used to illustrate the theoretical findings. Results revealed that the proposed estimator has smaller estimated mean square error than the Almost unbiased ridge logistic estimator when high multicollinearity exists among the explanatory variables.

Keywords: Almost unbiased ridge logistic estimator, Logistic regression, Logistic ridge estimator, Mean square error, Multicollinearity

**STABILITY ANALYSIS OF SRI LANKAN TEA EXPORT MARKETS USING
MARKOV CHAIN APPROACH**

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Among plantation crops, tea has been playing a significant role in the agrarian economy as it adds substantially to the GDP of the country. Stability analysis of tea export market by the economic community in any country serves several purposes viz business forecast for wise decisions; the assessment of the growth of the economy; and, the future design of tea plantations. Contribution of the tea production within the agriculture sector leads a dominant role in providing employment opportunities in Sri Lankan economy. The aggregate data of tea export from Sri Lanka to various countries is collected from the Sri Lanka Tea Board and the Central bank reports for the period covers from 2009 to 2017. The objective of the study is to analyze the dynamic changes of tea export volume from Sri Lanka to tea markets in different countries employing the Markov chain model. The aggregate data from Markov chain models explain that the present observed proportion of one country is stochastically related to recent past observed proportion of the countries including itself. The transition probabilities are estimated using the non-linear programming technique under the minimization of mean absolute deviation method. In addition, the steady state probabilities and mean recurrence times have been obtained. The results have shown Syria and Iraq as the stable destinations for Sri Lankan tea exports. The other traditional importing countries such as Russia, Turkey and Iran have recorded low retention probabilities, indicating unstable export share to these markets. The long run stable probabilities revealed that Sri Lanka retains the trade partnership with traditional importing countries except Syria.

Keywords: Aggregate data, Markov chain, Mean recurrence time, Tea export, Transition probability

ANALYTICAL APPROACH TO THE CAMASSA HOLM-NONLINEAR SCHRÖDINGER EQUATION USING LAPLACE DECOMPOSITION METHOD

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The Camassa Holm-Nonlinear Schrödinger (CH-NLS) equation has the following form:

$$i m_t + u_{xx} + 2\sigma m \left(|u|^2 - a^2 |u_x|^2 \right) = 0, \quad m = u - a^2 u_{xx}$$

where $u(x,t)$ is a complex field, $\sigma = \pm 1$ pertains to focusing or defocusing nonlinearity, a is a constant and subscripts denote partial derivatives. Clearly, for $a = 0$ the above model reduces to the cubic nonlinear Schrödinger (NLS) equation. The above equation was recently derived by A. Arnaudon when developing a theory of a deformation of hierarchies of integrable systems. Exact solutions of most of the nonlinear Schrödinger equations cannot be found easily. Therefore, analytical and numerical methods have been used in the literature. Some of the analytical methods for solving nonlinear problems include the Adomian decomposition method, Variational iteration method and Homotopy analysis method. In this study, we use the Laplace decomposition method to construct the approximate analytical solutions of the CH-NLS equation. The Laplace decomposition method is a combined form of the Adomian decomposition method and Laplace transformation. By using the above method, we found the approximate analytical solution for CH-NLS equation in the series form. For a specific choice of parameter, our approximate solution is reduced to the exact solution of nonlinear cubic Schrödinger equation. The obtained solution is compared graphically and numerically with the exact solution to verify the accuracy of the method. The computations show that the described method is easy to apply, and it needs smaller size of computation as compared to the aforementioned existing methods. Further, the solutions are derived in a series form which shows the effectiveness of the method for solving a wide variety of nonlinear Schrödinger equations.

Keywords: Camassa Holm Nonlinear Schrödinger equation, Adomian decomposition method, Laplace Transformation.

PRIME LABELING OF ROACH GRAPH

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Study of relatively prime numbers is a flourishing research area in graph theory. Prime labeling has applications in graph labeling which can be applied in computer network and coding theory. Our work is focused on the prime labeling of Roach graph. Roach graph is a graph in the shape of a crockroach having $2n + 2k$ vertices and is denoted by $R_{2(n,k)}$. $2n$ and $2k$ are the vertices in the head (antennas) and body respectively, where n and k are positive integers such that $n \geq 1$ and $k \geq 2$. There are two separate paths with $n + k$ vertices, where the opposing k vertices in each path are joined as a ladder. Since the Roach Graph represents a grid structure of a ladder shape, it can be used to model as a computer network structure or as a part of it. A prime labeling of a simple graph $G = G(V, E)$, where V and E denote the set of vertices and edges respectively, is a labeling of vertices of G with distinct integers from the set $\{1, 2, \dots, n\}$ in such a way that the labels of any two adjacent vertices are relatively prime. In this work, conditions for prime labeling of $R_{2(n,k)}$, have been proved using two theorems; $R_{2(n,k)}$ has a prime labeling if $n + k + 1$ is prime and $R_{2(n,k)}$ has a cyclic prime labeling if $2(n + k) + 1$ is prime. These results were illustrated for some selected values of n and k . Furthermore, two methods for the labeling of the Roach graphs were introduced and it can be seen that if both $n + k + 1$ and $2(n + k) + 1$ are primes, then $R_{2(n,k)}$ has a prime labeling according to the methods given by the theorems.

Keywords: Prime labeling, Roach graph

**AN ASYMMETRIC CRYPTOSYSTEM BASED ON MULTIPLICATIVE
TRAPDOOR KNAPSACK AND MULTI-PRIME RSA**

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The discovery of the asymmetric or public-key cryptosystem in 1976 by Diffie and Hellman is considered as a renaissance in cryptography. One of its celebrated members is the RSA cryptosystem which was invented by Rivest, Shamir, and Adleman in 1977. It was based on the idea that, even though it is easier to choose two large distinct prime numbers and multiply them together to get a modulus, factoring the modulus is much more difficult. One of the variants of the RSA scheme is the multi-prime RSA which differs from its predecessor in that the modulus being a product of more than two distinct primes. In 1978, Merkle and Hellman developed an algorithm based on a well-known NP-problem called the knapsack or subset sum problem. Our algorithm is based on multiplicative trapdoor knapsack together with a non-superincreasing knapsack that uses multi-prime RSA algorithm for higher security and is designed under the three basic steps: key generation, encryption, and decryption. The key generation is presented in three steps: first generating an additive knapsack sequence via a multiplicative trapdoor knapsack sequence and then creating the public trapdoor knapsack sequence, followed by selecting the necessary components for the multi-prime RSA algorithm. The ciphertext is obtained as a finite sum of products of the plaintext (in binary form) and the public knapsack components are raised to a power as in RSA. The security of our algorithm depends on the security of all three associated cryptosystems.

Keywords: Additive knapsack, Multiplicative trapdoor knapsack, Multi-prime RSA

ACTION RECOGNITION IN VIDEOS USING CONVOLUTIONAL AND SPATIAL-TEMPORAL INTEREST POINT FEATURES

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Usually human action recognition is based on complex handcrafted structures such as local features. Previous work in action recognition shows that the space-time interest points (STIP) provide better performance when compared to other local features. STIP detects local structures in space-time. Recently, convolutional neural network (CNN)-based features reveal better performance in object classification. This paper improves capturing spatial-temporal variation in human actions from videos using the STIP and convolutional features. The temporal variation is captured using a model that aims to express sub actions from a complex action, in a video build on top of the output of the last layer (i.e., *FC7* features) in CNN. Given a video, *FC7* features are computed for each frame which is then mapped into a short binary code using local sensitive hashing method. Key-frames are selected across the time space by tracking changes in each bit of the binary codes in a given video. A subset of key-frames (i.e., a snippet) is constructed using a fixed-sized window which is applied to the initial set of key-frames by striding the window with a constant factor. CNN flow is computed by differencing the last key-frame and the first key-frame of a snippet. A vector representation is computed by stacking the CNN flows of each snippet. In the final step, all the videos are represented as bag-of-features (BoF) of temporal words. On the other hand, space-time interest points are searched in the video and feature descriptors are computed. These descriptors are also represented as BoF. Action-specific codebooks are constructed using K-means for BoF representation. The concatenated feature vector is classified by a linear one-versus-all SVM. The proposed framework is evaluated on the KTH videos using the provided training and testing sets. Test results show that the concatenation of CNN flow and STIP feature performs better in action recognition that yields a recognition rate of 94%.

Keywords: Action recognition, Convolutional features, CNN flow, Space-time interest points

**AN IMPROVED METHOD TO FIND AN INITIAL FEASIBLE SOLUTION TO A
TRANSPORTATION PROBLEM**

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Transportation Problem (TP) is a special type of minimum cost flow problem. The key objective of the TP is to minimize the total cost of transporting products from origins to destinations subject to the respective supply and demand requirements. Due to the special structure of this problem, the transportation algorithm is preferred to solve it. The transportation algorithm consists of two major steps: 1) Finding an Initial Feasible Solution (IFS) to TP and 2) Examining the optimality of this IFS. A better IFS generates lesser number of iterations to obtain the Minimal Total Cost Solution (MTCS). Recently, Juman and Hoque Method (2015) and Efficient Alternative Method for Juman and Hoque Method were introduced to find a better IFS to TP. In this paper, the existing Efficient Alternative Method is improved to get a better IFS to a TP. A comparative study on a set of benchmark instances illustrates that the new improved method provides better solutions compared to the existing Efficient Alternative Method.

Keywords: Efficient alternative method, Initial feasible solution, Minimal total cost solution, Transportation algorithm, Transportation problem.

A LOSSY GRAYSCALE IMAGE COMPRESSION BASED ON DELAUNAY TRIANGULATION

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The need for compressed images continues to increase due to the increasing quality and quantity of images around the digitised world. Compression techniques that exist for images are improving continuously. On the other hand, digital image transmission through the Internet is becoming the main reason that causes Internet traffic. Due to those reasons there is still a demand for novel image compression techniques that are lossless and provides better compression rate. Though lossless compression techniques are preferred, lossy compression techniques have a good demand owing to the fact that the web pages and other network related content providers consider producing visibly equivalent images to the end user. In this work, we outline a compression technique that is lossy but provides an improved compression rate using Delaunay triangulation which produces visibly equivalent images. The initial lattice for the Delaunay triangulation is constructed on the edges that are detected by the Canny algorithm. Thereafter, a split-and-merge technique is used to perform triangular lattice on the image and encode each triangle along with the intensity value that covers the region. The triangulation process that continues until the convergence of having homogeneous area, may end up with triangles consisting less number of pixels which in turn will hinder the compression rate. The construction of such smaller triangles is controlled using a predefined threshold during the conformity with homogeneity of triangles. The storage requirement for a triangular element is to store seven values: Vertices of the triangle and the mean intensity of the triangular region. The results show favourable statistics, in terms of *PSNR* but this depends on the nature of the image.

Keywords: Delaunay Triangulation, Image Compression, Lossy Compression, Thumbnails

A MODEL TO PREDICT DEPRESSION OF UNDERGRADUATES IN FACULTY OF DENTAL SCIENCE, UNIVERSITY OF PERADENIYA

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Depression is a treatable common medical illness which is negatively affected in various aspects such as the way of think, feel and act. Moreover, due to the stressful academic schedules, university undergraduates face depression during their academic duration which will be a major reason for their physical and mental health problems and poor academic performances. By identifying depression before it comes to its final stages, it can be cured through consulting programs. Therefore, the main objective of this research is to build a statistical model using classification techniques for identifying whether a particular student has depression or not. Besides the effect of demographic factors, biological factors, psychosocial factors and economic factors associated with depression were observed using the Peradeniya Depression Scale (PDS). The students scored more than 10 were categorized into the depressed group and the rest is to the non-depressed group. The associations between the depression level with the other variables were identified using the Pearson Chi-square correlation test. Further, statistical models were developed to classify depressed and nondepressed students using Naïve Bayes, Neural networks, Support Vector Machines (SVM), K-Nearest Neighbors (KNN), Random Forest and Bagging CART methods. In order to select the best model, several accuracy measures namely model accuracy, misclassification rate, specificity, sensitivity and F1 statistic were used. The outcome of this study proposes a classification-based approach to predict depression. The Support vector machine (SVM) method performed well when compared with the other methods with the highest accuracy, sensitivity and precision.

Keywords: Bagging CART algorithm, Depression, K-Nearest Neighbors, Naïve Bayes, Peradeniya Depression Scale, Random Forest, Support Vector Machines.

PHONE USAGE PATTERN ANALYSIS TOWARDS SERVICE ENHANCEMENT

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Telecommunication service providers serve their customers through a set of predefined service plans. Eventhough the customers have varying needs; they have to select a service plan out of the available options. In many cases, the available service plans are not suitable for all. Telecommunication service providers record the metadata of communications of their customers for billing and other reporting purposes. These records are known as Call Details Records (CDR), which contains several details including the caller phone number, destination number, starting time of call and duration. This research work proposes a method to create a phone usage profile for a group of similar customers using CDR records. These profiles can be utilized to develop suitable service plans to cater the varying needs of customers. The CDR records is used to extract features and needed information. The feature extraction is performed in a way to represent the usage pattern of each customer. Customers with similar usage pattern can be identified by clustering the extracted usage patterns. Individual user profiles can be generalized for a group of customers having similar usage patterns by summarizing the patterns in each cluster. The *Nodobo* mobile phone usage dataset was used to analyse the effectiveness of the proposed method. *Nodobo* data set contains data gathered during a study of the mobile phone usage of 27 high-school students from September 2010 to February 2011. The dataset includes 13035 calls, 83542 messages, 5292103 presences records, and other related data. The CDR records for a particular phone number on a particular date were filtered out, the number of calls made in every six-hour period throughout the day and the duration of the total calls were extracted to verify the proposed approach. This was performed for all the days and the average usage in the same six-hour periods were computed. In this way, a usage profile was created for each customer phone numbers individually. More features such as; number of repeating phone numbers in each interval, highest and lowest call duration can also be extracted to make the profile of each customer more accurate. Clustering these extracted features using Self Organizing Map (SOM) resulted in four clusters with adequate number of records in each cluster. Manual analysis on the records of the formed clusters revealed a high correlation of usage patterns in each cluster. Cluster 1 records shows a higher amount of activity in each time duration. Therefore, they need at any time a large volume of plans. Likewise, the cluster 3 has a less amount of activity and does not need a large volume of plans. Therefore, some simple plans also needed. Whereas, the other two clusters show similar behavior which can be interpreted with the assistance of a service providers and perhaps we can find more details and clusters. Here, each cluster represents a generalized customer profile which can be used to create service plans to suit the customers need. Furthermore, with the cluster details, a classifier can be built to predict the appropriate service plan for a new customer.

Keywords: CDR, Phone usage, Service plan, SOM

ANALYSIS OF MEDICAL SENSOR DATA TOWARDS HEALTH DISORDER IDENTIFICATION

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Medical sensors play a vital role in monitoring the health condition of a patient. Medical sensors generate a huge amount of data with the potential for early detection of disorders. This study focuses on analysing methods suitable for detection of health disorders using medical sensor data, particularly the data from Photo-plethysmograph (PPG). Photo-plethysmography quantifies the volumetric change of the heart by measuring the light transmission or reflection on arteries. This study has used PPG-BP dataset containing features namely, Systolic Blood Pressure, Diastolic Blood Pressure, Heart Rate, Age, Sex and Body Mass Index (BMI) which were collected from 219 persons. Systolic blood pressure, diastolic blood pressure, and heart rate were calculated from the PPG recordings. The dataset contains data for normal persons as well as for persons with disorders. Listed disorders in the dataset are namely; hypertension, diabetes, cerebral infarction, and cerebrovascular disease. This study analysed various pre-processing approaches to handle issues arising in medical datasets, especially the imbalance of data items. The study analysed the effect of under-sampling and duplicating data records to overcome the issue of imbalanced data. In addition, the study analysed the performance of three popular machine learning methods, namely; K Nearest Neighbor (KNN), Support Vector Machine (SVM), and Naïve Bayes classifiers. As the standard practice, 70% of the dataset was used to train the models and 30% was used for testing. Further N-fold cross-validation was used to evaluate the performance of the models. By performing under-sampling and duplicating data records, the study found that the KNN provides the highest accuracy for identifying Diabetes (84.21%), Cerebral infarction (100%), and Cerebrovascular disease (90.48%) than other models for different K. Even though SVM is considered as a superior classifier it has achieved the highest accuracy only for identifying Hypertension (98.41%). It should be noted that the accuracy improvement was observed to be large in comparison with the accuracy obtained with the imbalanced data. Further, this study confirms that medical sensor-based data can be effectively utilized to identify potential disorders.

Keywords: Health monitoring, Machine learning, Medical sensor data, PPG signal

CONSTRUCTION OF MAGIC SQUARES OF ORDERS q^n , WHERE q IS ODD
AND $n \in \mathbb{N}$

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The name “*Magic Square*” was inspired by the ancient Chinese literature where it was named as the *Lo Shu square*. For centuries, math enthusiasts and mathematicians alike have found the recreation mathematical topic of magic squares in nature to be an interesting and entertaining subject such as rhythm in music and very popular puzzle Soduku. In this work, magic squares of odd orders have been constructed using the properties of Latin squares. A *Latin square* is an $n \times n$ array filled with n different symbols, each occurring exactly once in each row and exactly once in each column. A *natural magic square* of order n is a square array of numbers consisting of distinct positive integers $1, 2, 3, \dots, n^2$ arranged such that each cell contains a different integer and the sum of the integers in each row, column, and diagonal is always the same number known as the *magic constant*. The magic constant of a normal magic square with numbers depends only on n and equals to $\frac{n(n^2+1)}{2}$. A line of a magic square is any row, any column or either of the two main diagonals of the square. If n odd, then middle cell is $\frac{(n^2+1)}{2}$. For the magic squares of odd orders, reduced Latin square is used by formulating the cyclic shifting method with the entries $(1, 2, \dots, n), (n+1, n+2, \dots, 2n), \dots, (n(n-1), \dots, n^2)$. This work has been generalized for magic square of order q^n , when q is odd and $n \in \mathbb{N}$, by using the mathematical formula $x \equiv y \pmod{q^n}: y = 1, 2, \dots, q^n$. As future work, we are planning to automate this work so that magic squares of higher order can be constructed easily.

Keywords: Cyclic shifting, Latin squares, Magic squares, Reduced latin squares

CONSTRUCTING STRONGLY REGULAR GRAPHS FROM SKEW-HADAMARD MATRICES

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Construction of strongly regular graphs using Hadamard matrices is well known. Since less attention is made on skew-Hadamard matrices, we have focused our research on skew-Hadamard matrices to construct strongly regular graphs which have many applications in computer networks, telecommunication, data structures and to solve many real world problems. A skew-Hadamard matrix is a $n \times n$ matrix H with entries ± 1 such that $HH^T = H^T H = nI_n$ and $H + H^T = 2I_n$. Yamada and Williamson has constructed Skew-Hadamard matrix of order n for some n values which are multiples of 4 such that $n - 1$ is a prime. In our work, a new algorithm is proposed and it can be used to construct strongly regular graphs from skew-Hadamard matrices. A k -regular graph on v nodes is *strongly k -regular* if there exist positive integers k, λ and μ such that every vertex has k neighbours, every adjacent pair of vertices has λ common neighbours and every non-adjacent pair has μ common neighbours and is denoted by $SRG(v, k, \lambda, \mu)$. The proposed method is based on matrix manipulations and is similar to the construction given by Jayathilaka A.A.C.A. et al., where they considered Hadamard matrices. In this work, two strongly regular graphs have been constructed by using skew-Hadamard matrices of order 2 and 4. By considering columns of these skew-Hadamard matrices, adjacency matrix of the corresponding strongly regular graphs have been constructed. Further, corresponding strongly regular graphs, $SRG(4,4,0,2)$ and $SRG(16,11,4,6)$, have been obtained using a Java programme. Considering skew-Hadamard matrices of higher order, larger strongly regular graphs can be obtained and those can be used as networks with several nodes.

Keywords: Hadamard matrices, Skew-Hadamard matrices, Strongly regular graphs

RESTRICTED LEAST ANGLE REGRESSION ALGORITHM FOR LASSO

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Least Absolute Shrinkage and Selection Operator (LASSO) method has been used for variable selection in the linear regression model when multicollinearity exists among the predictor variables. A popular algorithm to find LASSO solutions is known as the Least Angle Regression (LARS) algorithm. Researchers have shown that the estimation of regression parameters is improved when adding prior information to the model, which can be in the form of exact linear restrictions or stochastic linear restrictions. In this study, we modify the LARS algorithm by incorporating stochastic linear restrictions to improve the LASSO solutions. Further, we compared the performance of restricted LARS algorithm with the existing algorithm in Root Mean Square Error (RMSE) and Mean Absolute Prediction Error (MAPE) criteria using a Monte Carlo simulation study and a real-world example. The comparisons revealed that restricted LARS algorithm for LASSO shows better performance when prior information of regression coefficients is available.

Keywords: Least angle regression, LASSO, Root mean square error, Stochastic linear restrictions

THE BEST- FIT PROBABILITY DISTRIBUTION AND RETURN LEVELS FOR ANNUAL MAXIMUM MONTHLY RAINFALL

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Extreme rainfall conditions can have a severe impact on a country like Sri-Lanka which has an agriculture based economy. Due to surge in extreme weather incidents, Sri-Lanka like many other countries has been experiencing negative consequences, for instance, floods over the recent decades. Developing a reliable model that could accurately predict extreme rainfall events is an emerging topic of research. Therefore, the objectives of this study are to find the best fitted probability distributions for annual maximum monthly rainfall data of Yala and Maha seasons separately in Anuradhapura district and thereby estimate return levels at various return periods. The total rainfall received over each month during the 60 year period (1958-2018) in Anuradhapura district were collected from the Department of Meteorology. Several probability distributions have been tested for both seasons and the parameters were estimated through the method of moments and L-moment. The Chi-square and Anderson-Darling Goodness of Fit tests were conducted to find the best fitted distribution. The two fitted distributions from respective tests were used to simulate data and the corresponding Mean Square Errors (MSE) were calculated to determine the best. The estimates of return levels at different periods were derived based on the best distribution. The study revealed that, of the two fitted distributions for Yala season namely, the Generalized Extreme Value (MSE=114.46) and the Frechet (MSE=151.87), the former distribution was the best. On the other hand, for Maha season, among the Gamma (MSE=143.83) and the Johnson SU (MSE=212.96), the Gamma distribution was the best. Further, the estimated maximum monthly rainfall for 2, 3, 4, and 5-year return periods for each season were accurate enough(nearly 80%) to provide vital information to adjust cultivators' decision on cropping strategies and intensities and to enable precautionary actions to reduce the risk of damage caused by extreme rainfalls.

Keywords: Extreme event, Rainfall, Return level

A SURVIVAL ANALYSIS ON DENGUE PATIENTS IN KALUTARA DISTRICT

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Dengue is one of the most important vector borne diseases which spread in epidemic proportion in many countries including Sri Lanka. The survival of dengue patients is influenced directly or indirectly by demographic and clinical characteristics factors. This motivated us to explore the influential factors on survival of dengue patients. For this study, demographical data such as age, locality, gender and ethnicity and clinical data such as platelet count, white blood cell count, packed cell volume, initially treated place, admission mode, liver enlargement, severity of dengue (dengue fever-DF or dengue hemorrhagic fever-DHF), number of days spent at home before admission to the hospital from onset date were treated as covariates. Time to recover from dengue was treated as the response variable. Data of 214 dengue patients from Kalutara district during the period January 2015 to March 2017 were obtained from the Epidemiology Unit of Ministry of Health. Kaplan Meier estimator was used to estimate the survival curve from censored and uncensored data without the assumption of an underlying probability distribution and log rank test was used to compare the survival curves among groups within each risk factors. Cox proportional hazard model was used to create a model that describes the relationship between the survival time of dengue patients and covariates. This study showed that the severity of dengue, liver enlargement and the number of days spent at home before admission to the hospital from the onset were significantly associated with the time to recover from dengue. Moreover, DHF patients, patients with liver enlargement and patients with late admission to the hospital were found to have more time to recover from dengue compared to DF patients, patients without liver enlargement and patients who get admitted early to the hospital, respectively.

Keywords: Cox proportional hazard model, Kaplan-Meier estimation, Log-rank test, Time to recover from dengue

**A NOVEL APPROACH OF VOICE RECOGNITION USING MFCC AND GMM,
SPEECH RECOGNITION AND TEXT RECOGNITION TO ASSIST FOR EMAIL
COMMUNICATION FOR VISUALLY IMPAIRED PEOPLE**

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Nowadays, Human-computer interaction plays a prominent role in the day to day life. However, it has become a challenging task for visually impaired people to get involved with computers in their day-to-day activities because of limited accessibility to the input mechanism. I propose speech-to-text, text-to-speech, and voice recognition technique access for blind people to interact with Email communication. Voice recognition helps to recognize the voice of a specific person from the audio recording as voice is different from each other than the fingerprint where Speech recognition helps to disregard the language and meaning to detect by the person behind the speech. The proposed model is based on the classification of MFCC coefficients obtained from speech signals with GMM for voice recognition. The proposed method is evaluated using VoxForge Dataset; containing the 340 voices of 34 speakers and obtained the result with 100% success.

Keywords: Gaussian Mixture Method (GMM), Mel Frequency Cepstral Coefficient (MFCC), Speech recognition, Text recognition, Voice recognition

**A BAYESIAN LINEAR REGRESSION MODEL FOR METHOD COMPARISON
DATA WITH HOMOSCEDASTIC MEASUREMENTS**

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Method comparison can be considered as an essential and a colossal area of clinical science. In simply a method comparison can be explained as the studies performed to compare a new method with the existing standard reference method to check whether the existing method can be replaced by a new method. If two methods agree sufficiently well, we may prefer the cheaper or the less invasive method and they can be used interchangeably. When considering the real situations, the method may be a medical device, clinical observer or instrument which is used to measure the continuous response. In this study, we propose a Bayesian Linear Regression model to deal with homoscedastic method comparison data. Then we compared the performance of the proposed model with the existing models, namely Mixed Effect Model, Deming and Passing Boblok model. In the Bayesian model, past experiences are used as prior data to get a key idea about the result. Those data also used to build the posterior distributions which are used to draw inferences about the data. The proposed methodology is then used to analyze the Cardiac ejection fraction (%) data that consists of radionuclide ventriculography (RV) and impedance cardiography (IC). Shapiro-Wilk normality test and QQ plot were used to test the normality of the dataset. The best model was selected using the model with the minimum value of the Mean Absolute Percentage Error (MAPE), Sum of Squares Error (SSE) and Mean Squares Error (MSE) values. After selecting the best model, Interclass Correlation Coefficient (ICC), Mean Square Deviation (MSD), Concordance Correlation Coefficient (CCC) and Total Deviation Index (TDI) were used to evaluate the agreement between two methods. The Bayesian model has the minimum error values compared to other models, and the limit of agreement lies between the range of (-1.2815, 2.4858). Further MSD and TDI values are relatively low while CCC value is near to one. The results showed that the Bayesian model is the best model with 99% accuracy. The selected best model is then used to measure the agreement of two methods, and it is observed that the two methods have a good agreement. Therefore, the two methods RV and IC can be used interchangeably.

Keywords: Agreement, Bayesian regression, Homoscedastic, Method comparison

**ARTIFICIAL NEURAL NETWORK BASED APPROACH FOR SPEECH
EMOTIONS RECOGNITION OF SINHALA LANGUAGE**

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The Sinhala language suffers from the lack of appropriate emotional speech database for research into speech emotion recognition. In this paper, we represent our efforts to develop an emotional speech database, as it would facilitate future research on speech emotion recognition in the Sinhala Language. The database is planned to be built with 250 speech corpora of five emotions happiness, anger, neutral, sadness and fear containing 50 speech corpora per each emotion. The input data has been analyzed in three categories, namely training, validation and testing. 100 samples were selected to split for the processes. Target data is a 5 x 100 matrix indicating the state of emotion for the sentences. Then the paper uses an Artificial Neural Network approach to represent a classification analysis and recognition of emotional speech using the short-term and mid-term features of speech signals. The key features include time domain and frequency domain features such as speech rate, energy, entropy of energy, MFCCs, etc. The important key features are used to distinguish the emotions such as happy and sadness or angry and sadness. 35 Features have been extracted from speech signals which are related to the statistics of energy, pitch, etc. The classification results of the trained and validated network are represented in confusion matrices for performance analysis. The results show that the ANN used as a classifier is a feasible technique and the selected features are robust and effective by predicting overall accuracy of 91.65% and 86.5% for Short term and Mid-term proceedings respectively. As well as with compare to the preliminary researches we infer that there is an association between the language and the emotions.

Keywords: Artificial neural network, Mid-term features, Short-term features, Speech emotion recognition

IMPACT OF CROSSOVER OPERATORS ON THE GENETIC ALGORITHM TO SOLVE CAPACITATED VEHICLE ROUTING PROBLEM

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The Capacitated Vehicle Routing Problem (CVRP) is a special variant of the vehicle routing problem which has been extensively addressed in the literature. Because of the NP-Hardness, excessive time is required to find the exact solution to CVRP. Therefore, meta-heuristics are generally applied to solve this type of problems. Among the popular meta-heuristics, Genetic Algorithm (GA) is prominent in solving CVRP. The GA consists of 3 genetic operations: Selection, Crossover and Mutation. The convergence of GA is highly affected by the crossover operation. Various techniques have been introduced to perform the crossover operation. In this research, a statistical comparison was conducted for 10 crossovers of GA with regard to optimal solutions and CPU time consumed to solve CVRP. The comparison was conducted under 3 categories according to the problem size: Small (nodes<40), Medium (40≤nodes< 70) and Large (nodes≥70). The one-way ANOVA was used for comparison of crossovers by keeping other factors (permutation chromosome encoding, 100 population size, tournament selection (size 4), swap mutation (probability 0.4), 0.1 elitism rate and 5000 maximum generations) fixed. Tukey's method was applied for the significant cases to perform the pairwise comparisons. All these statistical tests are performed with 0.05 significance level. According to the results of the small category, significantly better optimal solutions were provided by the Ordered and HGreX Heuristic crossovers, but HGreX consumed considerably higher CPU time. Therefore, the Ordered crossover is more suitable for solving small CVRP. To solve the medium and large categories of CVRP, the HGreX Heuristic crossover is recommended as it reaches to better optimal solutions by consuming moderate CPU time. It was observed that the best-known solutions of P-n22-k8, E-n30-k3 and P-n55-k15 benchmarks were improved by 14, 25 and 39 units respectively.

Keywords: Crossover operation, CVRP, Genetic algorithm

DEEP LEARNING APPROACH TO DETECT PLAGIARISM IN SINHALA TEXT

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This work focuses on developing a deep learning approach for plagiarism detection in Sinhala documents. In this proposed method, words are represented as word vectors, a row of real numbers where each point captures a dimension of the word's meaning. The quality of word vector representation depends on the quality of the training corpus. Publicly available UCSC_Sinhala_News corpus is used to build a Word2Vec word embedding model. Using the built word2vec model, vectors for the words in a source sentence and target sentence are computed. In order to represent a sentence, the word vectors for each word in that sentence are combined using a simple aggregation method. To compare the similarity of two sentences, cosine similarity and soft-cosine similarity metrics are used. Sentences in a target document are compared with sentences in the source document and similarity scores are given to sentence pairs. The sentence pairs with the highest similarity scores are considered as plagiarized. To improve the efficiency of the model Natural Language Processing techniques have been applied to the text in the pre-processing stage. Since there is no existing text corpus for plagiarism detection in Sinhala, a corpus was developed as part of this research work. 50 documents were randomly selected from the UCSC_Sinhala_News corpus, and those were plagiarised by a selected group of students. Plagiarising included changing the word order and replacing words with similar words. The plagiarized text has been rechecked by Sinhala language experts and the sentences were tagged as similar or not similar. The proposed model was found to be capable of detecting direct and sophisticated copying such as replacing the words with their synonyms as well as changing the order of words in sentences. Work is still needed to construct a large and well structured Sinhala plagiarism detection dataset such that the proposed model can be evaluated accurately and the performance of similar work can be compared.

Keywords: Deep Learning, Plagiarism, Sinhala, Word vector

3D FACE RECONSTRUCTION USING SINGLE IMAGE

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3D character is frequently used in electronic games, virtual simulation, animation and many other fields. Virtual character is the medium where users interact with the virtual environment. Creating a realistic 3D character with the same features with the user's face and appearance has a positive effect in improving the users' experience. There are several methods to construct 3D faces. In one of the most commonly used methods, initially the first two images (sagittal and coronal views) are added together. Secondly the result is aligned and specific feature points are selected. In the final step the character specifications are adjusted. Creating a new character is another method to construct 3D faces. But this method is considered to be difficult for the users. In our research we propose a method where a 3D face can be constructed by inserting only a frontal image. In this method we use distances of face landmarks to reconstruct the 3D face and input single frontal image to get the 3D face as the output. Initially we acquire the images and then we process the captured images. Next the face is recognized and the landmarks are detected afterwards. The extracted feature points are used to calculate the distances. Finally the artificial neural network predicts the missing distances and then the 3D face is modelled. In our research we used HOG+SVM and CNN based methods. HOG+SVM is quite fast but does not work with odd angles. CNN based method works with odd angles, but it is relatively slow and also the input image should be a frontal image. The accuracy of our neural network was 48.6%. To obtain a better accuracy, we need to should fine-tune the parameters of the network such as number of hidden layers, learning rate and activation function. Furthermore, the dataset should be enhanced with more data.

Keywords: 3D face construction, 3D face construction single image, 3D face reconstruction, 3D face reconstruction single image

MAXIMIZING THE PRODUCTION TIME USING A MIXED INTEGER NON-LINEAR MATHEMATICAL MODEL

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This study is based on a production problem face by a leading rope manufacturing company in Sri Lanka. Due to the shortage of the total production, the company does not have a required supply to meet the demand. Hence, the purpose of this study is to reduce the gap between demand and supply using the available limited resources. The company uses three main machines to produce 16 types of ropes with different diameters. During the production, each machine needs change over time for different types of ropes. In order to increase the total production, the production time needs to be optimized. Therefore, increasing the production time by controlling the resetting frequency is considered in this study. Here, we develop a Mixed Integer Non-Linear Programming (MINLP) Problem to improve the production time. We define Maximization of total production hours as the objective with active capacity constraints. The objective was achieved by optimizing machine reset frequency. Microsoft Excel and LINGO software were used to solve and analyze our formulated MINLP. The optimal solution to the model shows that the company's supply can be increased by optimizing the machine reset frequency and the machine production time for each type of rope. Further, we propose a new work schedule for the company in order to increase the production.

Keywords: Branch and bound method, Generalized reduced gradient (GRG), Mixed integer non-linear programming (MINLP), Production planning and scheduling

SPLITTING ALGORITHM FOR ATTAINING THE NEAR OPTIMAL UPPER BOUND ON THE MINIMAL TOTAL COST TO THE SMALL SIZED TPVDS

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A transportation problem is a linear programming problem based on a network structure consisting of a finite number of supply and demand nodes. In practical situations, due to the change of economy, the number of choices of supplies and demands within their respective ranges increases rapidly as the number of suppliers and number of buyers increase. This study investigates the transportation problem (TP) when the demand and supply quantities vary. In general, lower bound of the transportation problem with varying demands and supplies (TPVDS) can be found by methodologically. But the determination of exact upper bound becomes an NP-hard problem. In literature, there are three approaches, namely Liu's (2003), Juman and Hoque (2014) and Xie, et al.(2017)'s, available to find near optimal upper bound on the minimal cost to TPVDS. However, all of these methods have failed to obtain the correct upper bound solutions. In this study we have developed an alternative solution technique known as splitting algorithm to find the near optimal upper bound to small sized TPVDS problems which is better than certain existing techniques in literature. Also, JAVA computational program for this splitting algorithm is developed.

Keywords: NP-hard problem, Splitting algorithm, Transportation problem with varying demands and supplies

**A NOVEL APPROCH IN SOLVING FUZZY TRANSPORTATION PROBLEMS
USING MODIFIED ANT COLONY ALGORITHM**

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The Transportation problem, which has a wide range of applications, is one of the most attractive problems in the field of Operations Research. In this research, we propose a different technique to solve a fuzzy transportation problem with the use of modified Ant Colony Optimization Algorithm. Also, in this research, we introduce a transportation problem with triangular and trapezoidal fuzzy values for supplies and demands of the sources and destinations, such that the total cost of transportation is minimized. The fuzzy numbers have been applied in many fields such as operation research, management science and control theory. In this new approach, fuzzy quantities are transformed into crisp quantities using Yager's Ranking Method. Ranking of fuzzy numbers plays an important role in decision making, optimization and forecasting. The Ant Colony Optimization Algorithm has been known as a good alternative technique in solving fuzzy transportation problems. The main aim of this research is to propose a new approach for the ranking of generalized fuzzy numbers and several modifications to the ant colony algorithm. Also, the proposed approach is easy to apply and capable of finding the optimal solution for both the balanced and unbalanced fuzzy transportation problems.

Keywords: Transportation problem and ant colony optimization algorithm, Triangular and trapezoidal fuzzy numbers, Yager's ranking technique

OPTIMAL ROUTING OF SOLID WASTE COLLECTION TRACTORS: A CASE STUDY AT KURUNEGALA MUNICIPAL COUNCIL

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Municipal Solid Waste (MSW) has become a burden for many emerging cities around the world. Proper management of MSW is essential for securing environmental and public health. A significant portion of MSW management cost is associated with collection and transportation. This research focused on improving the efficiency of MSW management through optimal service point assignment and routing of waste collection tractors so as to minimize the cost of collection and transportation. We considered the Kurunegala Municipal Council area which consists of twelve municipal council wards as a case study. The tractor assignment and routing optimization problem was formulated as a capacitated arc routing problem considering the road segments by which the service points are located as arcs to be traversed. Due to computational difficulties that arise in handling the sub-tour elimination issue, we first applied the model to a portion of the city council area consisting of three council wards currently served by three tractors. We estimated the number of household along each road segment using online GIS tools and waste generation from the household using published data. Information on wards, tractors and service details were obtained from the municipal council. The optimization model was developed using PuLP modeling language in SolverStudio. The results indicate that if the optimal routing and assignment strategy was applied, only two tractors would be sufficient to serve the area. Further, there is an 18.27% reduction of travelling distance for waste collection. This in return minimizes the fuel cost for waste transportation and also the disturbance to traffic and emissions caused by slow moving waste collection tractors. Generally, we observed that travelling in cyclic paths reduces the total distance to be toured. Therefore this study recommends the application of an optimal tractor routing policy to improve the efficiency of MSW management at urban council level.

Keywords: Capacitated arc routing problem, Collection, Municipal solid waste, Solver studio, Transportation

**REDUCING ‘UNIT COST PER MINUTE’ IN A GARMENTS MANUFACTURING
PROCESS USING GOAL PROGRAMMING TECHNIQUES**

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Industry can use operations research techniques in various situations in order to optimize the use of available resources. The purpose of this project is to find a method to reduce the ‘Unit Cost per Minute’ of a leading manufacturer in garment sector, while maintaining the direct and indirect employee ratio closer to 1:1. Here the ‘Unit Cost per Minute’ is defined as the sum of indirect employee cost per minute and the direct employee cost per minute. According to the required standards of the respective garment factory, its ‘Unit Cost per Minute’ should be set at \$0.40. But, at the moment the unit cost is at \$0.60 per minute. Since, the higher ‘Unit Cost per Minute’ affects the total factory cost (*i.e.* the total cost occurs in a minute in the factory) more than the ratio between direct and indirect employees, it is required to give priority to reduce the ‘Unit Cost per Minute’ and maintain it at \$0.40. Therefore, in this study the preemptive goal programming technique has been used to formulate this problem with two goals. The most prioritized goal was to get the Unit Cost per Minute closer to \$0.40 while being less than the current value \$0.60. The least prioritized goal was to reduce the direct to indirect employees’ ratio closer to 1:1 as much as possible. When solving the model using LINGO software both goals could not be achieved. But, with the solution obtained from proposed model, ‘Unit Cost per Minute’ was reduced by \$0.03 and reached the direct indirect employee ratio to 1:1.02.

Keywords: Direct indirect ratio, Preemptive goal programming, Unit cost per minute

PARALLELIZING ACTIVE CONTOUR MODEL FOR OBJECT SEGMENTATION

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Active contour model, a framework in computer vision, is being used as a technique for the segmentation of objects in images. In the traditional methods, an algorithm namely 'Snake' has been applied for representing object contours. The serial processing method takes substantial time for processing. The main intention of this project is to speed up the performance of active contour process by parallelizing it. As in the serial method, the energy minimizing technique is being used in this method. The initially drawn contour is divided into independent sub-contours, and each sub-contour converges simultaneously in parallel. In order to get closed sub-contours, the divider lines were also used as the straightline segments of the sub-contours. Even though the divider lines are used to form closed contours, the points on the divider lines are kept unchanged while the sub-contour points are being shifted. The final contour is obtained by combining results of all converged sub-contours. As a result, a substantial improvement in the performance is obtained. According to the size of objects in the image, the contour will be divided into more sub-contours, and hence the number of simultaneous processes will be increased. It can also be performed with concave objects in future.

Keywords: Active contour, Convergence, Parallelize

A NEW FIVE PARAMETER GENERALIZED LINDLEY DISTRIBUTION

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Several continuous distributions with one or more parameter(s) bounded to 0 and ∞ have been developed in the literature for modeling lifetime data, which are available especially in the fields of biomedical science, engineering, and actuarial science. Among all, the modification or generalization of a new class of the *Lindley* distribution has been considered recently due to the less complexity of their mathematical forms, shapes and failure rate criteria. In this paper, a new five-parameter family of generalized Lindley distribution, namely a five-parameter generalized Lindley distribution (FPGLD) including location parameter, is introduced by accommodating several existing lifetime distributions, namely *Lindley*, *Shanker*, *Quasi Lindley* (QL), *Two-parameter Lindley* (TPL). The FPGLD is based on a two-component mixture of exponential and gamma distribution with different mixing proportions. The new distribution shows more flexibility over other common lifetime distributions, especially when considering shapes and failure rate criteria. The important statistical properties that include the density and distribution functions, moments and related measures, hazard and mean residual life functions of FPGLD are examined. In the estimation and inferential part of the proposed distribution, the maximum likelihood estimation (MLE) method is used, and the distribution is fitted to two real-data sets in order to test the goodness of fit. Then the goodness of fit of the new distribution is compared with that of Lindley, QL, TPL, and Shanker distributions, and found that the FPGLD provides a better fit with compared to the other distributions.

Keywords: Generalized Lindley distribution, Lindley distribution, Quasi Lindley distribution, Shanker distribution, Two-parameter Lindley distribution

**BATSMEN PERFORMANCE ANALYSIS IN THE GAME OF CRICKET USING
ARTIFICIAL NEURAL NETWORKS**

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Cricket is the second famous game in the world according to the fan base. Other countries use new technologies and methods in selecting their international cricket teams. Therefore need of using new technologies when selecting batsmen for the national cricket team in Sri Lanka is essential. Also there is a need to use new techniques to select players for each cricket match. New techniques help to analyze the data correctly and efficiently. Most of the algorithms which are currently in use focus on player performance such as averages, strike rates and the basic statistics records. In our research we looked into the above mentioned performance measures in different approaches, such as how much does the player performance impact on in each game other than the player's overall records, how players are performing against opponent players playing conditions, playing country and type of the tournament. In our work we use an artificial neural network (ANN) to analyze batsmen performance. Initially two data sets were generated from the acquired data set. They were labeled according to bowlers bowling arm and bowling type. Next an ANN was build and it was trained by changing the activation function and the optimizers. Afterwards the optimal network was selected and finally analyses of players were done. From the selected network we can find the weaknesses of our players and propose the kind of bowlers they need to practice more. Also our system can predict the type of bowlers needed for the team according to the opponent. The proposed method helps to identify the weaknesses in the players and inform them to improve their batting according to their weaknesses. In our results the accuracy values were low. The accuracy can be improved by having more data, data fields, features, and inputs.

Keywords: Artificial Neural Networks, Cricket, Player performance

A MODEL TO DETECT MALFUNCTIONS OF AN AUTOMOBILE ENGINE AND TO RECOMMEND ACTIONS USING GAS EMISSION DATA

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Gas Emission Test centers obtain gas emission data from vehicles and perform tests to check whether emission levels exceed the current limits published by the Government of Sri Lanka. Objectives of emission testing are to reduce air pollution by minimizing the harmful gases released from vehicles and to use it as a requirement for issuing Vehicle Revenue License. Also, if a vehicle fails the emission test, Test Center identifies engine malfunctions and prescribes the corrective actions manually. In this study, we develop a model that automates the determination of the pass/fail status, fault prediction and corrective actions prescription using machine learning techniques. A large dataset containing gas emission data obtained from a local Gas Emission Test Center was used to build the model. The dataset includes features such as Hydrocarbon level, Carbon monoxide level, Carbon dioxide level, etc. Dataset was preprocessed and most suitable feature set was selected. Potential recommendations were represented in a binary matrix in order to apply the collaborative filtering technique. After testing with several standard classification techniques such as logistic regression, linear discriminant analysis, support vector machine, naïve Bayes, and a few others, the decision tree classifier was selected to build the classification model to predict the pass/fail status and the engine malfunctions. Further, 10-fold cross validation was performed to avoid the overfitting and underfitting of the model. Corrective action prescriptions are generated using collaborative filtering which is based on cosine similarity, Jaccard's similarity, and Pearson similarity. The applicability of the two models was verified using a test dataset. The classification model performed with a 96% accuracy while the recommendation model performed with a 90% accuracy. Overall the proposed models will benefit the Gas Emission Test Center to automatically identify the engine malfunctions and to provide the most appropriate corrective actions much more efficiently and effectively.

Keywords: Classification, Collaborative filtering, Emission testing

STOCHASTIC MODELING OF POPULATION INTERACTION WITH ALLEE EFFECTS AND STOCKING

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We propose models of continuous-time Markov chain (CTMC) and Ito stochastic differential equations (SDE) of population interactions based on a deterministic system. The deterministic system is built upon the classical Lotka-Volterra competition system by incorporating Allee effects and stocking into one of the two populations. The Allee effect, referring to the reduced fitness in population growth at low population densities or sizes, was first observed by Allee. When a population is in danger of extinction, constant levels of the external population are added to the resident population in order to conserve the endangered population. In the literature, several discrete-time mathematical models have been proposed to study the effects of external stocking. In this work, we use ordinary differential equations to model population interaction. Demographic stochasticity is invoked for modelling CTMC and SDE. The SDE model is based on the CTMC. As these two stochastic models are time homogeneous, the transition probabilities are time independent. The Euler-Maruyama numerical method is applied to approximate the Ito stochastic differential model and observe that the theoretical results established in the deterministic setting valid in the stochastic models due to random effects of the birth and death process imbedded in the populations. Using our numerical simulations, we conclude that the coexistence of both competing populations under stocking is more robust as compared to the dynamical consequence of no stocking. Persistence occurs in the stochastic models when the populations are extinct in the deterministic setting. Therefore, stochastic modeling with stocking can alter competition outcomes significantly and has a profound effect on population interaction.

Keywords: Allee Effect, Coexistence, Demographic stochasticity, Stocking

ESTIMATION OF THE AGE-STRUCTURED FEMALE POPULATION OF SRI LANKA USING LESLIE MATRIX

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The Leslie matrix is a discrete-time, age-structured model for population growth which is used extensively in population ecology. It can be used to determine how population is affected by characteristics such as survival and fertility rates. Generally, Leslie matrix is applied to population of organisms over a period of time and the population is divided into groups based on age. We use a Leslie matrix model to predict the age structured female population of Sri Lanka. For our study, we considered mid-year female population and live female births in Sri Lanka from 1997 to 2012. According to available data, Sri Lankan female population is divided into 16 age groups as 0-4, 5-9, 10-14, 15-19, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59, 60-64, 65-69, 70-75, 75 and above (75+) and in this study the Leslie matrix is used to predict the population size in each age group. The survival probabilities and fertilities were calculated for the periods 1997-2002, 2002-2007 and 2007-2012, and the averages of those values were used in our model to calculate the Leslie matrix. Using the constructed Leslie matrix, we predict the age structured female population of Sri Lanka for the years 2002, 2007, 2012, 2017 and 2022. In this study, all simulations were performed using the Microsoft Office Excel. The results of the simulations were compared with the recorded female population in Sri Lanka. For most of the data points, our predicted data were a little more than the recorded numbers. Yet, the distribution had the correct trend for the distributions. From these results, it is apparent that over the years total female population increases. Further, over the years more variations and fluctuations can be seen at the younger age groups than in older age groups. Also, this model can be used to identify the number of dependents in coming years.

Keywords: Age-structured population models, Discrete-time models, Leslie matrix

**IMPORTANCE OF INTEGRATING APPEARANCE AND MOTION FEATURES
TO CLASSIFY DYNAMIC PATTERNS USING DEEP LEARNING**

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Deep Learning has perceived a series of remarkable successes in video pattern classification. Among successful artificial neural networks, Convolutional Neural Networks(CNN) have verified superiority in modeling high-level visual concepts, while Long Short-term Memory(LSTM) units have shown great talents when modeling temporal dynamic motions in video-based pattern classifications. However, because of the inherent complexity of spatial and temporal feature extraction, it is crucial to understand and classify the patterns of videos. Therefore, a proper deep learning model should be able to consider both static appearances in single frames and temporal relation between consecutive frames to achieve significant classification accuracy. To clarify the importance of integrating both appearance and motion features, we propose two general deep learning architectures, which are a combination of both CNN and LSTM networks. Consequently, to validate the proposed classification models, we use our firework video dataset, which consists of eight types of fireworks with 1000 video clips. The propose single-stream model, *Single-CNNLSTM* only considers the RGB videos for appearance stream while the two-stream model, *Dual-CNNLSTM* considers both RGB and optical flow videos for appearance and motion streams, to classify the firework types. We implement the models based on the Keras neural-net library with TensorFlow backend and perform experiments fine-tuning the convolution layers and essential model parameters. Besides, to integrate the standalone RGB and optical flow streams, we apply a late fusion technique, which probabilistically combines the classification results. The experimental results demonstrated the *Dual-CNNLSTM* model that fuses both RGB and optical flow features significantly outperform with the training and testing accuracy of 78.04%, and 76.31%, compared to the *Single-CNNLSTM* model, which achieve the accuracies of 70.57% and 43.31%. Therefore, it is needed to integrate appearance and motion features while classifying the dynamic motion patterns.

The Consortium is funded by the Ministry of Science and Technology, Taiwan (ROC) (MOST 108-2634-F-008-002).

Keywords: Convolution neural network, Deep learning, Dynamic motion patterns, Fireworks video classification, Long short-term memory

IDENTIFICATION OF DRUG-RELATED PERSONAL EXPERIENCE SOCIAL MEDIA CONTENT USING A DEEP LEARNING MODEL

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The ongoing increase in self-disclosing personal health-related information on social media captivates health authorities to mine them for public health monitoring and surveillance. A proper assessment of this data requires distinguishing personal mentions over others. The intrinsic characteristics of social media data, including misspellings, non-medical and creative phrases, and informal vocabulary impose additional challenges. Applications of identifying personal health-related information include discovering unreported detrimental effects of drugs and drug abuse. Our objective is to develop a deep learning model that identifies mentions of drug-related personal experiences. We choose Bidirectional Gated Recurrent Unit (BiGRU) as our core classifier, which learns features for each word by utilizing its preceding and succeeding words. The model includes character- and word-level embedding and applies an attention mechanism to refine and meaningfully select the important features from both. Hence, the model gives an enhanced representation for each word, including out-of-vocabulary words. Limitations of BiGRU include inefficacy in capturing local context of a word and identifying the most influential words. The model utilizes a convolutional layer for capturing the n-grams, whereas it incorporates an attention mechanism that weighs more the informative words. We test the model on a Twitter dataset on tweets about personal medication intake, published by Social Media Mining for Health shared task. We design the experimental study as a 3-class classification problem, where classes 1, 2 and 3 represent personal medication intake, possible medication intake, and non-intake, respectively. Our model achieves a micro-averaged F1 score of 0.75 for the classes 1 and 2, which is 8.7% better than the current state-of-the-art model for the same dataset. Experiments reveal that each component of the model contributes to the overall performance. Our study confronts the challenges associated with the said task and presents a model that could be applicable to problems with similar domains.

Financial assistance from University Research Grant (Grant No: URG/2016/82/S) is acknowledged.

Keywords: Bidirectional GRU, Character-level embedding, Deep learning, Personal experience mentions, Social media mining

OPTIMAL LAND ALLOCATION FOR PADDY CULTIVATION IN SRI LANKA

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Paddy cultivation is one of the main Agricultural productions in Sri Lanka. This study is carried out to find optimal land allocation for paddy cultivation using optimization techniques. This land allocation is for all the districts in Sri Lanka including *Mahaweli 'H'* region. Both *Yala* and *Maha* seasons under Irrigation and Rain fed conditions are considered in this study. Two models are used to allocate the optimal land amount under two techniques; Preemptive goal model and linear model with Fuzzy constrains. Lingo Solver is used to solve the models and the data was collected from the 'AgStat' annual magazine 2017. The goals of the preemptive goal model according to their priorities are to maximize the yield while minimizing the cost. Tolerance based Fuzzy technique is used for constraints of the second model to quantify the linear problem with the objective of cost minimization. According to the results, North, North-central and Eastern provinces are the most suitable areas to paddy cultivation during the year. *Hambanthota*, and some districts in upcountry region are selected to cultivate paddy during *Yala* season and the areas affected by the North-East monsoon is selected to cultivate in *Maha* season. *Mahaweli 'H'* region is always used to cultivate under irrigation water regime. As a conclusion, rather than cultivating paddy all among the country to outcome the annual paddy requirement, we can assign some suitable crops for other areas that has not been recommended for paddy cultivation.

Keywords: Irrigation, Land allocation, *Maha*, Optimization techniques, Paddy cultivation, Rain fed, *Yala*,

EVALUATION OF MAIZE HYBRIDS TOWARDS A SUPERIOR HYBRID OPTION

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Maize (*Zea mays* L.) is the second most cultivated crop in the world and the second most important cereal after rice in Sri Lanka. As such, there is a great need for developing superior hybrid maize variety with high productivity for commercial use in Sri Lanka. This study is conducted with 37 hybrid maize varieties to identify high yielders with superior performance. The study used factor analysis based on principal components method of secondary data on several response variables (Y's) and a related set of supplementary variables (X's). Since the first two factors (F1, F2) alone explained 69% of the variability in Y's, a 2-D plot of standardized 'simple factor scores' of varimax-rotated F1 and F2 of Y's was used to find groups of superior varieties. No formal analysis was possible for comparing varieties within groups due to insufficient replications. This simple but statistically sound approach helped identify variety groups reasonably well since the identified members in each group were verified for better performance based on newly created indices, Y and X where values close to 1 showing superior performance. It is found that higher maize yield can be obtained when 'Days to 50% flowering -tasseling', 'Days to 50% flowering- silking', Plant height, Height to upper most ear, Tassel length, Root lodging plant, and Stalk lodging plant, are higher on average. But when number of tasseled branches increase, the yield decreases. Variety 18 (P9/2450Q), 23(NK9/2450Q) and 37 (Jet 999) proved to be superior. Variety 3(11/203), 36(Pacific 339), 16(P7/2450Q), 29(23/NK4) and 17(P8/2450Q) were close competitors and can be considered as relatively superior. Variety 21(NK4/2450Q), 34(MI Maize H 01) and 32(11/P4) can be classified as moderately superior, and all the other varieties as normal. This study provides important but preliminary evidence based only on one season and further experimentation is advised for confirmatory evidence.

Financial assistance from the Department of Statistics, University of Colombo (M.Sc. Project: 2015/APST/38) is acknowledged.

Keywords: Classification of maize, High yielding maize, Hybrid maize, Superior maize varieties

**VALIDATION OF TRIPLEX POLYMERASE CHAIN REACTION BASED
METHOD FOR MOLECULAR IDENTIFICATION OF YELLOWFIN, BIGEYE
AND SKIPJACK FRESH TUNA SAMPLES**

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Tuna industry is an iconic industry which aids in feeding the growing population worldwide that has been developing since the hunting era. Tuna is a great source of income to Sri Lanka and other tuna exporting countries. Yellowfin (*Thunnus albacores*), Bigeye (*Thunnus obesus*) and Skipjack (*Katsuwonus pelamis*) are most commonly available types of tuna species in Sri Lanka which have a high trade value contributing to the national economy of the country as a good exporting source. Once the external features of these tuna are no longer available, the identification of tuna becomes challenging, ultimately causing the consumers to be unassured with the tuna product, hence a validated procedure should be followed to reassure the consumers regarding the identity of tuna types. Therefore, the objective of this study is to validate triplex Polymerase Chain Reaction (PCR) based method for the molecular identification of Yellowfin, Bigeye, and Skipjack tuna to resolve this issue. The samples of authenticated tuna were taken from National aquatic resources research and development agency and DNA was extracted which was followed by a spot gel, fish specific PCR and a triplex PCR to confirm the primer specificity and to confirm the presence of DNA to carry out further steps involved in method validation. The repeatability of the overall samples was more than 80% where one of the validation parameters was successfully achieved and the recovery (sensitivity) was detected as 5 mg (2.5%), which concludes that less than 5 mg will not be detected by the triplex PCR. The results of reproducibility indicated equal band lengths which subsequently prove the procedure was free from errors. Since the necessary parameters for validation are effectively achieved, the triplex PCR based method for molecular identification of Yellowfin, Bigeye, and Skipjack tuna can be validated.

Financial assistance from Treasury grant from Sri Lanka Treasury (Grant No: TG 16/131) is acknowledged.

Keywords: Method validation, Recovery, Repeatability, Reproducibility, Triplex PCR

HELMINTHIASIS OF DOGS IN PERADENIYA UNIVERSITY PREMISES: A POTENTIAL PUBLIC HEALTH PROBLEM

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A sizable population of stray dogs are wandering in the premises of the University of Peradeniya and they ramble and defecate inside faculty buildings and student hostels. A cross-sectional, coprological survey was carried to assess the canine helminthiasis in the Peradeniya University. Fresh fecal samples were collected from stray and owned dogs in the Peradeniya University premises from March to June 2018 and were analyzed using modified Sheather's sucrose flotation technique. Sixty dogs were sampled (25 owned, 35 stray), of which 76.6% was infected with one or more enteric helminths with a higher prevalence in stray dogs (88.6%) than owned dogs (60.0%; Chi square test $\chi^2=22.134$; $p<0.0001$). Seven helminths were recorded: *Capilaria* (3.3%), *Dipylidium* (3.3%), *Ancylostoma* (73.3%), *Spirocerca* (26.7%), *Strongyloides* (10.0%), *Toxocara* (26.7%) and *Trichuris* (5.0%) with 55% of mixed infections. *Ancylostoma* were the most prevalent infection with the highest intensity. There was no difference in the prevalence of *Ancylostoma* infection between stray (46.7%), and owned dogs (60.0%, $\chi^2= 3.39$; $p=0.6539$) but the intensity of infection was significantly higher in owned dogs than that of the strays (Mann-Whitney U test, $U=190.5$; $p=0.041$). Intensity in stray dogs was 71.6 Eggs per Gram (EPG) (range of 1–546 EPG) and in owned dogs it was 155.2 EPG (range 2–755 EPG). Similar prevalence infection among the two groups with high intensity in owned dogs could be due to development of antihelminthic resistance and also owned dogs being mostly pedigreed, often highly inbred and therefore become less robust to infections. Puppies had higher intensity of *Ancylostoma* than adults but there was no difference between males and females. *Ancylostoma* and *Toxocara* are zoonotic infections with a potential of humans acquiring the infections when there is close contacts with dogs. Stray dogs may act as reservoirs of these diseases for owned dogs as well as for humans.

Financial assistance from the University Research Grant (Grant No: URG/2016/88/S) is acknowledged.

Keywords: Dogs, Enteric parasites, Helminthes, Protozoans

ANTIBACTERIAL ACTIVITY OF COTTON FABRIC MODIFIED WITH COPPER-DOPED ZnO/CHITOSAN HYBRID NANOCOMPOSITE AGAINST SELECTED MEDICALLY IMPORTANT BACTERIA

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The textile industry is one of the major consumer goods industries, in which a larger quarter depends on hygiene related antimicrobial textiles. As textiles can provide a suitable substrate for growth of microorganisms, it can generate unpleasant odors. This can indeed lead to serious health problems such as skin infections. With the revolution of nanotechnology, during past few decades, textile researchers are giving a significant attention to develop nano-engineered functional textiles such as antimicrobial fabrics. In this study, Cu-doped ZnO (Cu:ZnO) was used for the textile surface modifications as inorganic nano-structured agents possess improved antimicrobial activity on textiles. Copper was used as the dopant into ZnO as it can change the microstructure and the optical properties of the ZnO system leading to enhanced antimicrobial activity. In addition, chitosan (CS) was used as the binding agent that could bind the antimicrobial agent to the cotton fabrics. Cu:ZnONPs were prepared by co-precipitation method and cotton fabric was soaked in nano-dispersion and chitosan solution separately. Nanostructured materials were loaded on the fabric *via* sonochemical method followed by dry curing. Chemically synthesized nanoparticles were characterized by Powder X-ray diffraction (PXRD), Scanning Electron Microscopy (SEM), and Energy Dispersive X-ray spectroscopy (EDX) for their structural, functional and morphological analysis. The mean sizes of ZnO and Cu:ZnONPs were ≈ 50 nm and ≈ 65 nm, respectively. The antimicrobial activities of ZnO and Cu:ZnONPs/chitosan hybrid nanocomposites were investigated against two gram negative bacterial species *Pseudomonas aeruginosa* and *Escherichia coli* and gram positive bacterium *Staphylococcus aureus*. The observed results indicate that Cu:ZnO/CS/cotton sample has improved antibacterial activity compared to both ZnO/CS/cotton and CS/cotton samples against *P. aeruginosa*, and for *E. coli* the activity follows the order of ZnO/CS < Cu:ZnO/CS. However, *S. aureus* showed a different trend of ZnO/CS > Cu:ZnO/CS.

Keyword: Antimicrobial activity, Chitosan, Copper-doped-zinc oxide, Hybrid nanocomposite, Cotton fabric

MORPHOLOGICAL AND MOLECULAR CHARACTERIZATION OF *PIPER LONGUM* L. POPULATIONS FOUND IN DIFFERENT DISTRICTS OF SRI LANKA

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Piper longum L. is one of the important medicinal plant species used to cure many ailments. Eventhough, Sri Lanka has morphologically different *P. longum* populations, all are considered as single species. Therefore, the main objective of this research was to characterize *Piper longum* populations found in different districts of Sri Lanka using morphological and molecular methods. To resolve the confusions in identifying *P. longum* populations, morphological features of plants were observed and recorded and constructed dendogram using IBM SPSS Statistics software. DNA was extracted for seven poplations of *Piper longum* by CTAB method. Chloroplast tRNA gene was amplified to check whether any impurities or PCR inhibitors present in DNA samples. The *rbcL* and *matK* chloroplast genes were used for the molecular characterization. PCR products were sequenced, analyzed by BioEdit sequence alignment software and constructed a phylogenetic tree using the neighbor-joining method in MEGA 5 software. PCR with Chloroplast specific primers was shown 571 bp product which confirmed that the samples did not contain any PCR inhibitors. Expected band sizes of 650 bp and 850 bp were achieved for *rbcL* and *matK* after altering annealing temperatures to 55 °C and 51 °C respectively. Dendogram prepared with morphological data was highly compatible with phylogenetic trees constructed with molecular data, where two clusters were identified. However, no differences were observed within clusters when considering molecular data. Therefore, results concluded that the tested *P. longum* populations in Sri Lanka can be separated into two clusters based on morphological and molecular data.

Financial assistance from Treasury grant from Sri Lanka Treasury (Grant No: TG 16/132) is acknowledged.

Keywords: Morphological characterization, Molecular characterization, *Piper longum*, *rbcL*, *matK*

ANTIBACTERIAL ACTIVITY OF *ARISTEA ECKLONII* AND *PROSOPIS JULIFLORA* AGAINST MULTIDRUG-RESISTANT *ACINETOBACTER* SPP AND METHICILLIN-RESISTANT *STAPHYLOCOCCUS AUREUS*

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Emergence of multi-drug resistant (MDR) bacteria is a major health problem of global concern. This has rendered the antibiotics currently in use ineffective, and the World Health Organization recommends expediting the discovery and development of new antimicrobials. Plants are a potential source of new antibacterials. In a continuing study on screening of alien invasive plants for their antibacterial properties, the present investigation focuses on determining the minimum inhibitory concentration (MIC) of *Aristea ecklonii* Baker and *Prosopis juliflora* (Sw.) DC. extracts against clinical isolates of MDR bacteria: *Acinetobacter* spp. (three strains) and methicillin-resistant *Staphylococcus aureus* (MRSA, two strains) and three ATCC control bacteria: *S. aureus* ATCC 25923 (normal control), *S. aureus* ATCC 29213 (MIC control) and *E. coli* ATCC 25922 using disc diffusion assay and agar dilution assay. Powdered dry plant parts of *A. ecklonii* (aerial part and root) and *P. juliflora* (leaf, stem-bark and root-bark) were separately extracted into methanol: dichloromethane (1:1) at room temperature using a bottle extractor. The extracts were initially screened for antibacterial activity against a single strain each of MDR *Acinetobacter* spp. and MRSA using disc diffusion assay. The stem-bark and root-bark extracts of *P. juliflora* and the root extract of *A. ecklonii* displayed zones of inhibition against both MDR bacteria; however, the leaf extracts of the plants inhibited only MRSA. In the agar dilution assay, the MIC values for stem-bark and root-bark extracts of *P. juliflora* were 0.1 mg ml⁻¹ against both strains of MRSA and 1 mg ml⁻¹ against the three strains of MDR *Acinetobacter* spp.; the leaf extract had higher MIC values. The MIC values for aerial-part and root extracts of *A. ecklonii* were 1 mg ml⁻¹ against the three strains of MDR *Acinetobacter* spp. and one strain of MRSA; the other strain of MRSA had a lower MIC for the root extract of *A. ecklonii* (MIC 0.1 mg ml⁻¹). The root of *A. ecklonii* and stem-bark and root-bark of *P. juliflora* appeared to contain highly potent antibacterial metabolites with a potential to be developed as formulations to effectively combat MDR bacteria.

SLCARP is acknowledged for partial financial support (Research Grant No: NARP/16/UP/PGIS/01).

Keywords: Antibacterial, *Aristea ecklonii*, Multidrug resistance, *Prosopis juliflora*

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

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

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

INSECTICIDAL ACTIVITY OF SEVEN INVASIVE ALIEN PLANTS AGAINST APHIDS (*MYZUS PERSICAE*)

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Aphids, *Myzus persicae* (Sulzer) (Homoptera: Aphididae), infest vegetables and ornamental plants leading to reduction in yields of crops. Further, aphids vector plant viruses and assist fungal growth. Control of aphids by synthetic pesticides causes problems on the environment and public health. Plant-based pesticides are biodegradable and considered to have minimal impact on public health and beneficial insects. Production of pesticides based on invasive alien plants (IAPs) provides a strategic solution to manage the uncontrolled distribution of IAPs. In this study, 57 extracts prepared from plant parts of seven common IAPs—*Mimosa pigra*, *Ageritina riparia*, *Dillenia suffruticosa*, *Ulex europaeus*, *Aristea ecklonii*, *Miconia calvescens* and *Cestrum aurantiacum*—were screened for aphidicidal activity. Each dried ground plant material was extracted sequentially into n-hexane, dichloromethane and methanol using an ultrasonicator. Aphidicidal activity was determined in triplicate using Potter's spray tower method. One-day-old aphids (10) were placed on a cabbage leaf and sprayed with an emulsion (4 g dm⁻³) of the extract and mortality was observed at 24 and 48 h after introduction (HAI); the positive control was a commercial synthetic insecticide which had 50% w/w sulfoxaflor as the active ingredient. At 24 HAI, methanol extracts of *A. riparia* (leaf), *A. ecklonii* (leaf), *M. pigra* (root-bark) and *U. europaeus* (aerial-part) and the dichloromethane extract of *U. europaeus* (aerial-part) displayed moderate aphidicidal activity (37-50% mortality); the positive control (4 g dm⁻³) caused 97% mortality. At 48 HAI, 22 extracts showed considerable insecticidal activity (50-93% mortality); significant aphidicidal activity (93% mortality) was observed for hexane extract of *A. riparia* (leaf), methanol extract of *M. calvescens* (stem-bark) and dichloromethane extract of *U. europeaus* (aerial-part). The extracts prepared from *A. riparia* leaf, *A. ecklonii* leaf, *M. calvescens* stem-bark and *U. europeaus* aerial-part appear to contain potent aphidicidal phytochemicals from which eco-friendly plant-based aphidicidal formulations may be developed.

Financial assistance from SLCARP (Grant No: NARP/16/UP/PGIS/01) is acknowledged.

Keywords: Aphids, Insecticidal, Invasive plants

**APHIDICIDAL, ANTIOXIDANT AND CYTOTOXIC PROPERTIES OF
FOUR INVASIVE ALIEN PLANTS**

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Invasive alien plants (IAPs) cause damage to biodiversity, natural ecosystems and commercial plantations. Value addition to IAPs through discovery of their bioactivities will help manage their uncontrolled distribution. We screened 12 extracts prepared from plant parts—leaf, root and stem/stem-bark—of the four IAPs, *Sphagneticola trilobata*, *Austroeupeatorium inulifolium*, *Prosopis juliflora* and *Alstonia macrophylla*, for aphidicidal, antioxidant and cytotoxic properties. Each powdered dried plant part was extracted into 50% methanol in dichloromethane using a bottle extractor. The extracts were evaluated for aphidicidal activity by Potter's spray tower method using aphids (*Myzus persicae*) reared on cabbage leaf, antioxidant activity using 1,1-diphenyl-2-picrylhydrazyl (DPPH) and ferric reducing antioxidant power (FRAP), total phenolic content (TPC) using Folin-Ciocalteu reagent and cytotoxicity using brine shrimp lethality assay. Leaf extract of *S. trilobata* was non-toxic ($LC_{50} > 2000 \text{ mg dm}^{-3}$) and displayed the highest aphidicidal activity (77% mortality after 48 h) and strong antioxidant properties (DPPH, $IC_{50} 48 \text{ mg dm}^{-3}$; FRAP, $Fe^{2+} 2.73 \text{ mmol g}^{-1}$). Stem-bark extract of *S. trilobata* was also non-toxic ($LC_{50} > 2000 \text{ mg dm}^{-3}$) but displayed only moderate aphidicidal (57% mortality) and antioxidant (DPPH, $IC_{50} 160 \text{ mg dm}^{-3}$; FRAP, $Fe^{2+} 0.74 \text{ mmol g}^{-1}$) properties. Root and stem extracts of *P. juliflora* showed strong antioxidant properties (DPPH, $IC_{50} 20$ and 17 , respectively; FRAP, $Fe^{2+} 2.6$ and 0.8 mmol g^{-1} , respectively) and contained high TPC (4.0 and $2.6 \text{ mmol of gallic acid equivalents g}^{-1}$, respectively); however, *P. juliflora* extracts displayed low aphidicidal activity (37-47% mortality) and moderate to negligible toxicity ($LC_{50} 169-1449 \text{ mg dm}^{-3}$). Leaf and stem extracts of *A. macrophylla* had low to moderate aphidicidal (40-60% mortality), negligible antioxidant (DPPH, $IC_{50} 220-318 \text{ mg dm}^{-3}$) and low toxic ($LC_{50} 199-767 \text{ mg dm}^{-3}$) properties. All *A. inulifolium* extracts were non-toxic ($LC_{50} > 2000 \text{ mg dm}^{-3}$) and had negligible antioxidant (DPPH, $IC_{50} > 287 \text{ mg dm}^{-3}$) and aphidicidal (23-47% mortality) properties. Most potent aphidicidal, antioxidant and toxic properties were shown by leaf extracts of *S. trilobata*, root and stem extracts of *P. juliflora* and leaf extract of *P. juliflora*, respectively.

SLCARP is acknowledged for partial financial support (Research Grant No: NARP/16/UP/PGIS/01).

Key words: Aphidicidal, Antioxidant, Cytotoxic, Invasive alien plants

OPTIMIZATION OF A PROTOCOL FOR THE EXTRACTION OF DNA FROM HUMAN BLOOD FOR THE ISOLATION AND EXPRESSION OF THE HUMAN GENE *CTSK*, IN BACTERIAL EXPRESSION SYSTEM, *ESCHERICHIA COLI*

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Cathepsin K, encoded by human gene *CtsK* is a major enzyme involved in bone remodeling. Having identified the physiological importance of it, a study was built to investigate the feasibility of *in vitro* expression of *CtsK* gene in bacterial expression system. The objective of the first part of the study was to optimize a protocol for extraction of DNA from human blood. Extraction of DNA is a stringent step since the quantity and the purity of the extracted DNA determines the efficiency and the accuracy of other downstream process such as PCR, restriction enzyme digestion and molecular cloning. DNA was extracted from 04 human blood samples at first stage, obtained by volunteers having obtained ethical clearance, with the use of FlexiGene[®] DNA extraction kit by QIAGEN[®] which has been proven through previous literature to be a highly efficient commercial kit available for the extraction of quality DNA with relatively high yield. Although the protocol provided with this kit was followed unchanged, spectrophotometric absorbency results revealed that the DNA extracted did not have sufficient purity required for molecular cloning as it especially consisted of organic compound contamination, thus reducing the quality. Accordingly, as modifications to the original protocol, volume and number of times of ethanol added to wash away and remove the organic compounds was increased and airdry time to remove all ethanol was increased. With the above modifications, the A_{260}/A_{230} ratio improved drastically from 1.4 to 2.2 (ideal value been 1.8-2.2). In addition, the protein digestion to remove all the protein contamination happened optimally, the $A_{260}/280$ ratio was detected to be 1.73 (ideal value been 1.8). The concentration of the DNA was also increased by increasing the volume of isopropanol added to better pellet out DNA. Accordingly, the optimized protocol for extraction of DNA was developed by modifying the original protocol.

Financial assistance from the Section of Genetics at the Institute for Research and Development in Health and Social Care is acknowledged.

Keywords: Cathepsin K, *CtsK*, DNA Extraction, Expression, Human

ISOLATION OF GENE CANDIDATES FOR SEMI-DWARFISM FROM PROSO MILLET (*PANICUM MILIACEUM*)

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Crop diversification is an urgent need for food and nutritional security. Improvement of crop architecture and thereby crop performance can enhance commercialization potential of minor crops. This study initiates pre-breeding activities by identifying genes and alleles associated with semi-dwarfism in Proso millet (*Panicum miliaceum*). Cereal and grass homologs of the GA-sensitive *sd-1* dwarfing gene were retrieved from the Phytozome database (<https://phytozome.jgi.doe.gov/pz/portal.html>) using the rice wild type (Genbank accession no: AY114310) and the semi-dwarf mutant *sd-1* (Genbank accession no: AAP21386) sequences as the queries. Fifteen cereal homologs were retrieved representing a wide diversity of cereals. Codon based alignment of the 15 sequences identified 34 Gblocks in cDNA resulting in 11 Gblocks in proteins. Heterologous PCR primers were designed targeting the conserved regions of the alignment. By PCR manipulation an economic assay was developed for to enable amplifying the whole gene from Proso millet. Whereby, seven heterologous primers and five different primer combinations were designed that amplified five overlapping fragments spanning the whole gene. DNA was extracted from both wild and semi-dwarf mutant Proso millet by CTAB method. A 394 bp fragment was amplified from both standard and semi-dwarf mutant Proso millet. Further optimization of the PCR and sequencing of the amplified products will enable studying the *sd-1* gene homologs in Proso millet.

Keywords: Comparative genomics, Proso millet, Semi dwarfism

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

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Gliricidia sepium (Jacq.) Walp. is a widely distributed legume that provides a great host range of Rhizobia which is known to fix atmospheric Nitrogen. However, the physiological characterization of stress tolerant Rhizobial strains in *G. sepium* is poorly studied in Sri Lanka. This study focused on the physiological and genetic characterization of stress tolerant Rhizobial strains which were isolated from the root nodules of *G. sepium* in seven selected locations (*Moragaswewa, Jayanthipura, Bakamuna, Aralaganwila, Monarathanna, Sinhapura, and Madirigiriya*) of Polonnaruwa district, Sri Lanka. The 35 isolated Rhizobial strains were subjected to different edaphic conditions (pH, temperature, salinity, and drought) while 15 selected strains were subjected to combined edaphic conditions to mimic the natural soil conditions in Polonnaruwa district which belongs to the Dry Zone of Sri Lanka. The growth of isolates was adversely affected by acidic pH (pH 3 and 4), while most strains exhibited tolerance to alkaline pH (7<9) and extreme drought conditions (3.0% and 4.0% polyethylene glycol 8000 concentration). All rhizobial strains except the strains from *Sinhapura* were moderately tolerant to extreme salt concentrations and they showed a higher tolerance at 1.5 % and 2.0 % sodium chloride concentrations while the natural soil salinity level varied from 7.0×10^{-2} to 0.300 dsm^{-1} . Some strains in *Bakamuna, Moragaswewa, and Aralaganwila* showed better survival in 25 °C to 45 °C temperature range. At combined edaphic conditions, 14 strains showed relatively higher survival except for the *Moragaswewa* strain. The 15 rhizobial strains showed high genetic diversity in the Enterobacterial Repetitive Intergenic Consensus profile as they belonged to 10 clusters at the 65% similarity level. Furthermore, these stress tolerant rhizobial strains can be used for further studies in cross inoculating crop legumes to reduce the usage of chemical nitrogen fertilizers.

Keywords: Biological nitrogen fixation, Cross-inoculation, Drought tolerance, Salinity tolerance, Temperature tolerance

OPTIMIZATION OF DNA EXTRACTION AND PCR PROTOCOLS FOR THE TROPICAL FRUIT TREE SPECIES, *ELAEOCARPUS SERRATUS* (WERALU) AND *ELAEOCARPUS GANITRUS* (NIL WERALU)

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Genus *Elaeocarpus* L. belongs to family Elaeocarpaceae. The members of *Elaeocarpus* are popular because of their medicinal and industrial potentials. *E. ganitrus* and *E. serratus* are especially preferred by the locals of the Indo-Malaysian region since they bear fruits with edible mesocarps. Though there are ample studies conducted on morphology and phytochemistry of *Elaeocarpus*, studies on the genetic diversity are insufficient. Thus a study was carried out to develop a quick and reliable method of DNA extraction from *E. ganitrus* and *E. serratus* and optimize a PCR protocol for DNA marker genotyping. For the DNA extraction, basic and modified CTAB methods were used. In the modified CTAB method; PVP, β -mercaptoethanol and NaCl were added and the modified purification steps were also applied. For the optimization of PCR, spermidine and 4% Bovine Serum Albumin were used as additives in addition to the other regular ingredients. The experiments were conducted in triplicate. The highest purity of *E. ganitrus* DNA samples was obtained as indicated by the spectrometry for the modified CTAB method when applying with PVP. However, for *E. serratus*, basic CTAB method gave the highest purity. For *E. ganitrus*, basic CTAB extraction followed by phenol: chloroform: isoamyl alcohol purification yielded the highest genomic DNA band intensity on the 1 % agarose gel. However, for *E. serratus*, modified CTAB (with PVP and 1.5 μ l β -mercaptoethanol) followed by two consecutive purifications using chloroform: isoamyl alcohol resulted in the highest genomic band intensity. The highest PCR band intensities were observed for both *E. ganitrus* and *E. serratus* when both spermidine and 4 % Bovine Serum Albumin were added to the master mix and the genomic DNA obtained using the two methods optimized in the present study.

Keywords: Bovine serum albumin, CTAB, DNA extraction from tropical trees, Polyvinylpyrrolidone (PVP), Spermidine

RESISTANCE TO PARASITISM IN COMMON HOURGLASS TREE FROG, *POLYPEDATES CRUCIGER* TOWARDS TREMATODE INFECTIONS: ARE EARLY TADPOLE STAGES MORE VULNERABLE TO CERCARIAE?

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Resistance and tolerance are two defence strategies used by hosts against parasitism to maximize their fitness. Resistance lessens the parasite burden and tolerance avoids or resists parasite load, or reduces the damage caused by parasites at a given level of burden. Here, we tested the development-dependent resistance of *Polypedates cruciger* (common hourglass tree frog) tadpoles to furcocercous cercariae by exposing the tadpoles to cercariae at three developmental (Gosner) stages: 27, 28/29 and 30/31. Tadpoles at different ages were exposed to the cercariae under laboratory conditions and the number of cercariae penetrated the tadpoles during a limited time period was determined. The cercariae were collected from the freshwater snail, *Mieniplotia scabra*. Each tadpole was placed in a specimen cup containing water and was exposed to 10 cercariae over a period of one hour. The number of cercariae penetrated, number of cysts formed inside the tadpole body and the disappearance of the cysts for first five consecutive days were recorded. A significantly smaller number of cercariae penetrated into older tadpoles (Gosner stage 30/31days) compared to those of the younger ones (Gosner stage 27; ANOVA, $F= 13.27$, $p < 0.001$). Moreover, a higher number of younger tadpoles died upon exposure to cercariae compared to older ones (Linear mixed effect model, $F= 18.18$, $p = 0.001$). The number of cysts inside the tadpole body decreased from day one to day five. The results suggest that tadpoles in later development stage show a higher resistance towards cercariae penetration by avoiding the penetration of cercariae as well as by destroying the cysts formed inside the body. Physical factors as increased thickness of the skin and improved immunological responses of the older tadpoles may have acted as barriers towards cercariae penetration, and destroy the cysts.

Financial assistance from the National Science Foundation Sri Lanka (Grant No: RG/2014/EB/02) is acknowledged.

Keywords: Cercariae, Furcocercous, Resistance, Survival, Tadpoles

ASSESSMENT OF BOD, COD AND METALS CONTENT IN WASTEWATER IN DAIRY AND MEAT PROCESSING INDUSTRY IN SRI LANKA

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Industrial wastewater entering into water bodies poses a major risk of environmental pollution. Untreated wastewater from food industries pollutes water bodies due to its high Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). The main objective of this study was to characterize the physical and chemical parameters (BOD, COD and metals) of wastewater from dairy and meat processing industries. Samples of wastewater were collected in triplicate from five dairy and meat companies at different days. For analyses, standard methods of American Public Health Association were followed. BOD and COD of wastewater respectively were in the ranges of 111.33±5.51 - 1303.30±12.70 mg l⁻¹ and 1616.70±57.70 - 6400.00±229.00 mg l⁻¹ in dairy industry and 134.33±2.31 - 1206.70±58.60 mg l⁻¹ and 3017.00±231.00 - 12720.00±0.01 mg l⁻¹ in the meat industry. Contents of Pb, Fe, Zn, K, Ca and Mg were varied between 9.10±0.23-778.41±2.49 µ l⁻¹, 3.29±0.01-7.89±0.13 mg l⁻¹, 1.35±0.05-10.58±0.49 mg l⁻¹, 0.18±0.01 - 15.21±0.03 mg l⁻¹, 140.68±0.20 -165.62±9.71 mg l⁻¹ and 4.31±0.18 - 19.94±0.41 mg l⁻¹ respectively. Cu wasn't detected. All mean values of BOD, COD and metals contents of wastewater in dairy and meat industries were significantly different (p<0.05) from each other. The study also showed that wastewater from meat industry showed a higher BOD and COD compared to that of dairy industry. All the properties analyzed for this study do not show any linear relationship and the relationship may be a complex nonlinear. According to the tolerance limits that laid by Central Environmental Authority, maximum BOD, COD and metal contents of wastewater respectively were 30 mg l⁻¹, 250 mg l⁻¹ and 0.1-3 mg l⁻¹. The dairy and meat effluent contains nearly 50 times excess BOD, COD and metals than the limits of environmental regulation (p value<0.05), therefore suitable treatment process and dilution process is required before discharging to the environment.

Keywords: Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Dairy and Meat processing, Wastewater

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

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Helicobacter pylori infection is a leading cause for gastric adenocarcinoma, chronic gastritis, and gastric ulcers. The major transmission mode of *H. pylori* is from person to person, through oral-oral route. Aerosol and droplets of body fluids contaminated with *H. pylori* facilitates further dissemination of the bacterium. Dental health care workers seem to have a higher risk of infection by *H. pylori* mainly due to their frequent exposure to aerosolized dental plaque and saliva of their patients. Hence, the present study was carried out to determine the incidence of *H. pylori* in the oral cavities of a group of Sri Lankan Dental students with clinical exposure and to compare it with a control group of age-gender matched non-clinical University students. Oral-biofilm samples were collected from 38 Dental students (test group) and 33 non-clinical University students (control group). Total DNA was extracted from the oral-biofilm samples after lysis with NaOH. The absorbance values of the lysates at 260nm and 280 nm were measured to determine the DNA concentrations and purity. Presence of *H. pylori* DNA in the lysates was detected by PCR amplification of the *16S rRNA* gene of *H. pylori* using JW22 and JW23 primer pair. Results were confirmed using a repeat PCR which amplified the *Urease* gene of *H. pylori* using HPU1 and HPU2 primer pair. Collected data were statistically analyzed by a Chi-Square Test using Minitab14 software. Of the 71 individuals examined, 11 (28.95%) Dental students and 3 (9.09%) non-dental students were detected positive for *H. pylori*. Accordingly, prevalence of *H. pylori* in oral-biofilms of Dental students was significantly higher than that of age-gender matched non-clinical University students ($p < 0.05$). An Odds ratio of 4.07 indicated that Dental students are more than four times as likely to harbor *H. pylori* in their oral-biofilm than non-clinical students at a 95% Confidence Level. Since Dental students appear to be more susceptible for infection by *H. pylori* inhabiting their patients' oral cavities, there may be an occupational risk of *H. pylori* infection among Dental health care workers. Hence, proper infection control practices are recommended during dental treatments.

Keywords: Dental plaque, PCR amplification, Occupational risk, Oral biofilm

INVESTIGATION OF INHIBITORY EFFECTS OF *AZADIRACHTA INDICA* (KOHOMBA) BARK AND LEAVES, *MIMOSA PUDICA* (NIDIKUMBA) AND *TERMINALIA CATAPPA* (KOTTAMBA) ON GLYCATION AND GLYCATION INDUCED CROSS-LINKING

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Glycation is a non-enzymatic process that affects mainly the long lived body proteins like collagen, a key skin constituent. Through glycation, Advanced Glycation End-products (AGEs) are formed that makes intermolecular Cross-Linking between proteins, affecting its structure and functions. AGE facilitated modifications target Collagen due to its size, composition and half-life. This study aims to investigate the inhibitory effects of *Azadirachta indica* (AI) bark and leaf, *Mimosa pudica* (MP) and *Terminalia catappa* (TC) on Glycation and Glycation induced cross-linking. Methanol extracts of AI, MP and TC were used. Bovine serum albumin (BSA) and lysozyme were incubated with 0.5 M fructose for 21 days at 37°C and pH 7.4, in the presence of concentrations of AI, MP and TC (0.01 - 1 mg/mL) of extracts along with appropriate controls. Aminoguanidine (1mg/ml) was the standard inhibitor used. Both BSA and Lysozyme aliquots were analyzed using native polyacrylamide gel electrophoresis (PAGE) and sodium dodecyl polyacrylamide gel electrophoresis (SDS-PAGE) respectively. NBT Assay was performed using aliquots collected from incubations of first 7 days. Amount of fructosamine formed in the presence of extracts at 0.1 mg/mL were compared with the negative control. Migration towards the anode was increased in Glycated BSA while Lysozyme cross-linking was observed with high band intensity. At 0.5 mg/ml AI, MP and TC all showed high glycation inhibitory effects while at 0.05mg/ml only MP showed glycation inhibition. Strong cross-linking inhibitory effects were demonstrated by plants at 0.25mg/ml but only MP and TC at remained effective at 0.1mg/ml. Percentage fructosamine formation was lower in AI bark (35%) and TC (38%) whereas MP (72%) and AI leaf (78%) were higher. In conclusion, methanol extract of AI bark and leaf, MP and TC showed strong *in vitro* inhibitory effects on glycation and glycation induced protein cross-linking, indicating the value of further studies.

Keywords: *Azadirachta indica*, *Mimosa pudica*, *Terminalia catappa* glycation and cross-linking

TREE AND SHRUB DIVERSITY AND ABUNDANCE ALONG AN ELEVATION GRADIENT OF AMBOKKA MOUNTAIN RANGE, SRI LANKA

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Ambokka Mountain Range (AMR), margined by Central and North-Western provinces, is separated from the Central Massif of Sri Lanka. The southern part of the AMR is in the wet zone while the northern part facing the intermediate zone. The present study assessed the tree and shrub (above 2 m in height) diversity and abundance along an elevation gradient in one of the peaks in the AMR. Five random 100 m² quadrats placed each at four elevation classes viz., 450-500, 550-600, 650-700 and > 800 m were used to enumerate the vegetation, totaling 20 quadrats. All individuals belonging to more than 2 m in height including epiphytes were enumerated. The diversity and evenness indices were calculated. Mean abundance and species richness along different elevation classes were compared using ANOVA. The survey was recorded a total of 123 species including 74 trees, 20 shrubs, 24 lianas and 5 epiphytes. Of them, 21% were endemics, 66% natives and 6% exotics. Of them, 17% identified as nationally threatened and 11% as near-threatened. Anacardiaceae, Euphorbiaceae, Clusiaceae and Rutaceae were the most dominant families in all elevation classes. Species that are uncommon to the particular floristic region viz., *Garcinia hermonii* and *Symplocos elegans* var. *hirsuta* (a threatened endemic) were also recorded. Diversity and evenness indices showed a decreasing trend from lower to upper elevation. The mean abundance (40.6, 28.8, 28.4 and 22.4) and richness (17.4, 15.0, 12.6 and 11.0) also showed decreasing trends from lower to upper elevations. The Correspondence Analysis indicated elevational differences in floristic compositions. The lower elevation classes were dominated by species common to intermediate zone forests while the upper elevation forests were dominated by typical sub-montane forest species. This preliminary study highlights the conservation value of the AMR that harbor a unique floral assemblage.

Financial assistance from the Biodiversity Secretariate, Ministry of Mahaweli Development and Environment, Sri Lanka is acknowledged.

Keywords: Ambokka, Elevation, Species composition, Sri Lanka

A PRELIMINARY PHYLOGENY OF BALLINI JUMPING SPIDERS IN SRI LANKA (ARANEAE: SALTICIDAE)

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Jumping spiders (Salticidae) is the largest family of spiders with 6139 species worldwide placed in 640 genera and 30 tribes. Members of the tribe Ballini have unusual, varied body forms that resembling beetles or ants. *Ballus* is a genus currently with nine species distributed worldwide, with four species recorded from Asia. Of them, *Ballus segmentatus* and *B.sellatus* are morphologically very similar to the European *Ballus* spp and difficult to identify without expert observation. The Type specimen of *B. segmentatus* is a male, whereas *B. sellatus* is a female, and both have been recorded from Sri Lanka about 127 years ago. Type localities of these two species are identical, thus these two species names may refer to the two sexes of the same species. Hence, the objective of this study was to infer the phylogeny of Ballini in Sri Lanka using a multi-locus molecular phylogeny of species collected from the island. Field sampling was conducted in 60 localities in 16 districts of Sri Lanka. Beating vegetation and hand collection were used for collection. Seventy three specimens were preserved in 70% and 100% ethanol. DNA was extracted from two legs of each specimen. Partial fragments of nuclear Histone 3(H3), 28S r DNA (28s) and mitochondrial gene, cytochrome c oxidase subunit I (COI) were amplified. Ten in-group and seven out-group taxa were included in the final analysis. A maximum-likelihood (ML) tree was inferred with RaxML. The analysis of the combined data set (2330 bp) indicated the presence of only one species of *Ballus* in samples collected from montane and sub-montane forests in Central Highlands of Sri Lanka. A species not closely related to the European *Ballus* spp, but more closely related to the African spider genus *Peplometus*. Thus, the preliminary analysis suggests that *B.segmentatus* of Sri Lanka should be transferred to the genus *Peplometus*.

Financial assistance from National Research Council (Grant No: 17-027) is acknowledged.

Keywords: *Ballus segmentatus*, Molecular, *Peplometus*, Salticidae

EVALUATION OF NUTRITIONAL QUALITY OF *ULVA FASCIATA* AND *GRACILARIA EDULIS* SEAWEEDS COLLECTED FROM SRI LANKA

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Seaweeds are an under-utilized marine resource abundant in Sri Lanka which has a potential to be utilized in the food industry. The use of ocean farms to cultivate seaweeds and to popularize among Sri Lankans would be an option since cultivation of seaweeds requires no fresh water, chemical fertilizer or land. In the present study, proximate and element content analysis was carried out for *Ulva fasciata* and *Gracilaria edulis* obtained from Mirissa, ((5°56'53.74" N and 80°27'17.71" E)) and Kalpitiya, Sri Lanka ((8°15'40.8"N and 79°46'33.9"E). The moisture content (%), total fat content (%), protein content (%) and ash content (%) were determined according to the AOAC procedures. The elemental composition of *Ulva fasciata*, and *Gracilaria edulis* were determined by X-ray fluorescence elemental analysis. For *Ulva fasciata*, the parameters of proximate analysis were 18.4 ± 1.05 , 0.26 ± 0.02 , 19.68 ± 0.04 and 13.82 ± 0.72 and for *Gracilaria edulis* 12.61 ± 0.43 , 0.33 ± 0.02 , 5.64 ± 0.28 and 8.51 ± 0.17 , respectively. Total carbohydrate content (%) was analyzed according to the Dubois method and recorded for *Ulva fasciata* as 8.66 ± 0.54 and for *Gracilaria edulis* as 26.06 ± 1.35 . The results recorded high levels (ppm) of calcium, potassium and certain trace elements in both seaweed species. Thus, seaweeds would be a good alternative for land-based cultivated vegetables in Sri Lanka.

Keywords: *Gracilaria edulis*, Minerals, Proximate, *Ulva fasciata*

DNA ISOLATION AND AMPLIFICATION FROM DRIED BARK OF CINNAMON

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Cinnamomum zeylanicum, also known as true cinnamon, is one of Sri Lanka's premier exports. However, the cinnamon industry faces a major threat due to the severe competition and adulteration with inferior quality substitutes like Chinese cinnamon. Quills and powder of the cinnamon dried bark are two major products that are exported. It is also recommended to produce more value-added products to increase export earnings. Whether it is cinnamon quills, powder or value-added products, the application of morphological or chemical methods to detect adulterants have their limitations. However, molecular techniques can distinguish any plant material including processed samples or genetically close species. However, DNA isolation from dried bark is extremely difficult due to the scarcity of DNA containing cells and the presence of polysaccharides and polyphenolic compounds. We successfully developed a protocol to extract DNA from commercially available dried cinnamon bark, powder and a value-added product (cinnamon mixed coriander tea). The CTAB method was adapted with desirable modifications to extract and amplify the required DNA regions. Our results show that the *rbcL* region is more suitable than that of *psbA-trnH* in developing the assays to detect adulterants for the above samples. To the best of our knowledge this is the first report that the PCR amenable DNA was extracted from cinnamon powder and a value-added product. The DNA concentrations of both the samples obtained from 1 g of starting material exceeded 100 ng μ L⁻¹ with an OD 260/280 of 1.9. Our assays worked well on both dried bark and the processed cinnamon products purchased from the market. Therefore, this method can be used as an initial step to authenticate true cinnamon using molecular techniques.

Financial assistance from World Bank (Grant No: AHEAD/RA3/ICE/PDN/SCI/ACTION5) is acknowledged.

Keywords: Adulteration, Authentication, *Cinnamomum*, DNA, Dried bark

DETERMINATION OF CHANGES OCCUR IN CHEMICAL PROPERTIES OF PALM OIL DURING DEEP FAT FRYING WITH INCORPORATION OF DIFFERENT DIETARY ANTIOXIDANT SOURCES

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Deep-frying is a cooking process, in which food is immersed in hot oil (150 °C- 190 °) that leads to various chemical changes in oil such as oxidation, polymerization and hydrolysis. To minimize the changes in oil, antioxidants have been often incorporated. The objective of the study was to incorporate dietary sources of antioxidants into palm olein to monitor the chemical changes during deep-frying. Garlic, cinnamon and black cumin are commonly used spices with high antioxidant vigor and they were added to palm olein before frying at a rate of 2% w/v. Vitamin E was used as the control. Cassava chips were deep-fried for 8 minutes in the same oil for three consecutive frying cycles over a time span of three days. Samples were drawn after each frying cycle and peroxide value (PV), free fatty acid (FFA), conjugated dienes (CD) and conjugated trienes (CT) were measured. Results revealed that the addition of natural antioxidant sources to palm olein before frying reduces the formation of peroxides, free fatty acids, conjugated dienes and conjugated trienes against the control. Garlic showed the highest potential as a dietary antioxidant source compared with the control which significantly (<0.05) reduced the peroxide value from 37.33 ± 4.692 to 13.86 ± 1.710 meq/kg, FFA value from 0.684 ± 0.09 to 0.286 ± 0.02 (% oleic) and CD and CT from 0.301 ± 0.02 to 0.242 ± 0.05 Lcm⁻¹g⁻¹, 0.097 ± 0.009 to 0.069 ± 0.003 Lcm⁻¹g⁻¹ at the end of the third frying cycle, respectively. Thus, garlic has the highest potential to be used as a dietary source of antioxidant in suppressing oil oxidation during deep-frying.

Keywords: Deep-frying, Natural antioxidants, Palm olein

**EMBRYONIC DEVELOPMENT IN THE GOLDEN CARP (*CYPRINUS CARPIO*)
UNDER LABORATORY CONDITIONS**

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The golden carp, *Cyprinus carpio* is a popular ornamental fish as well as a favorite food fish in many countries. The present study focused on documenting the early and later embryonic development of the golden carp as a representative of Family Cyprinidae. Different stages during embryogenesis were observed and photographed under a Zeiss Primo Star microscope. Various embryonic length measurements including body, bones and fin measurements were taken to study larval development. The average diameter of the fertilized eggs was 1.8 ± 0.05 mm. These eggs were translucent and pale yellow in color. Cleavage division started approximately 1 hour post fertilization (hpf). Early embryonic stages consisting of cleavage, blastula and gastrula stages were observed at 1.00, 2.45 and 5.15 hpf. The next series of embryonic stages characterized as segmentation is observed by 10.15 hpf. By 26 hpf the embryos had the maximum number of somites, which was 24. In these embryos the tail was completely separated from the yolk and the heart, pigmented blood cells, digestive tract, pectoral fin, otic placode and eyes were well developed. Heart contractions and blood circulation was also observed during this time. Golden carp embryos hatched approximately 36 hpf. The average length of this initial hatched larva was 3.35 ± 0.05 mm. This larva is sessile and has a closed mouth, vestigial pectoral fins, distinct head, distinct notochord and blood capillaries on yolk sac. By 2 days post fertilization (dpf), the larvae were able to swim freely. Pigmentation of the eye occurred after 3 dpf. By 4 dpf, the swim bladder of the larvae started to form. Between 5 and 6 dpf, the fin folds of the larvae developed. During this period, larvae were fed with boiled chicken egg yolk. By 7 dpf, the caudal fins with visible rays were observed and by 9 dpf, the posterior end of the notochord started to bend dorsally. Between 17 and 20 dpf, the dorsal and anal fin rays differentiated. The pectoral fin started to originate by 23 dpf. The first signs of scales on the anterior part of the body of the larvae were observed by day 24 post fertilization. During larval development, the larvae showed a positive allometric growth for all body length measurements. The transformation of the larvae into juveniles takes place at 32 dpf. Overall, the progress of embryonic development of golden carp is similar to that of zebrafish (*Danio rerio*), which is one of the main model fish species also belonging to Family Cyprinidae. Early embryogenesis and segmentation periods in both these species take approximately 8 and 10 hours respectively.

Key words: *Cyprinus carpio*, Golden carp, Embryo, Embryogenesis, Larval development

**REAL TIME PCR-BASED METHOD FOR DETECTION OF VIABLE
STAPHYLOCOCCUS AUREUS IN DAIRY PRODUCTS IN SRI LANKA**

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Staphylococcus aureus is an opportunistic, Gram-positive and facultative anaerobe, and presence of 10⁵ or more *S. aureus* colony forming units (CFU/g⁻¹) leads to production of toxins, which can cause food poisoning and other diseases to consumers. Milk is a food matrix widely contaminated with *S. aureus*. Therefore, rapid detection of this pathogen in dairy products is crucial in the food and beverage industry. The aim of this project was to validate a rapid pre-enrichment incorporated Real time-PCR method for detection of viable *S. aureus* in dairy products available in Sri Lanka. The main objectives were to assess the repeatability and recovery of the developed method, with the aim of adopting the tested method into local laboratories. Artificially contaminated dairy samples were subjected to an 18 hour pre enrichment followed by to a two-step DNA extraction using DNeasy® Mericon® Food kit. DNA from both extractions was subjected to real time PCR using mericon *S. aureus* kit to confirm the presence and the viability of the spiked cells. This method was assessed for its repeatability by repeating the procedure 10 times, which achieved 95% repeatability. A preliminary study to see the sensitivity of the method without pre enrichment was also performed to assess its suitability for quantification. The recovery was quantified based on colony forming units from a ten-fold serial dilution of a pure *S. aureus* culture enumerated on selective Baird Parker media, and its corresponding cycle threshold values of amplified DNA from rt-PCR. Based on this method, the average limit of detection of the rt-PCR without a prior enrichment was 4-5 x 10¹ CFU/ml. Our results highlighted the suitability of the rt-PCR method for qualitative detection of *S. aureus* in dairy products and its high potential for quantification. With further validation this method can be adopted as a rapid pathogen detection test in local laboratories.

Financial assistance from Sri Lanka Treasury (Grant No: 16/132) is acknowledged.

Keywords: Pre enrichment, rt-PCR, *S. aureus*, Validation

**REAL TIME PCR-BASED METHOD FOR DETECTION OF VIABLE
SALMONELLA SPP. IN MEAT PRODUCTS IN SRI LANKA**

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Salmonella is an important food-borne pathogen and a major health burden in developing countries. Culture-based methods are still the gold standard of *Salmonella* detection in Sri Lanka. To ensure the quality of market food products and consumer safety, it is absolutely necessary to introduce a rapid *Salmonella* detection technique. Therefore, this study aimed to validate a real time PCR (rt-PCR) technique for rapid detection of *Salmonella* spp. in meat products by assessing its repeatability and recovery, while confirming the viability of *Salmonella* cells. Repeatability was performed using 10 replicates of artificially contaminated chicken ham samples under same conditions. Protocol was incorporated with an 18 hour pre enrichment step in Buffered Peptone Water to eliminate the carryover of dead cells. Each sample was subjected to DNA extraction using the Qiagen DNeasy® Mericon® Food kit, before and after pre enrichment. DNA isolated from both extractions were then subjected to real time PCR using the Mericon® *Salmonella* rt-PCR kit. Presence of viable *Salmonella* cells were determined by analysing quantitative changes in target DNA of pre and post enriched samples, using Cycle Threshold (CT) values. A repeatability of 95% was achieved and all 10 arrays of samples exemplified viability. Recovery of rt-PCR without pre enrichment was assessed using a ten-fold serial dilution of *Salmonella* cells which were subjected to DNA extraction and rt-PCR and were simultaneously enumerated on XLD agar. Based on colony forming units (CFU) and CT values, the sensitivity of the test procedure without pre enrichment was determined as 13.5×10^0 ($\sim 10^1$) CFU/ml. These outcomes signified that the pre enrichment incorporated rt-PCR is expedient and suitable for routine analysis of pathogenic bacteria in Sri Lankan food products due to its rapidity, high specificity and sensitivity.

Financial assistance from Sri Lanka Treasury (Grant No: 16/132) is acknowledged.

Keywords: Pre-enrichment, Repeatability, Recovery, rt-PCR, Viability

ANTICARIOGENIC EFFECTS OF DIFFERENT SOLVENT EXTRACTS OF A TRADITIONAL SRI LANKAN HERBAL MIXTURE (DAHAT WATTIYA) USED TO PROTECT ORAL HEALTH - AN IN VITRO STUDY

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Herbal medicines have been used for the treatment and prevention of dental caries since ancient times. One such polyherbal mixture is the Sri Lankan ‘dahat wattiya’. This polyherbal mixture consists of leaves of betel (*Piper betle*), nuts of arecanut (*Areca catechu*), flower buds of clove (*Syzygium aromaticum*), fruits of cardamom (*Elettaria cardamomum*), seeds and mace of nutmeg (*Myristica fragrans*), seeds of coriander (*Coriandrum sativum*) and rhizomes of java galangal / inguru piyali (*Kaempferia galanga*). Even though it is claimed to have anticariogenic effects in Sri Lankan folklore, there is no scientific evidence for this claim. The objective of this study was to analyze the inhibitory effects of this mixture against the major cariogenic pathogen *Streptococcus mutans* (ATCC 700610) using agar well diffusion assay and MBC using micro broth dilution assay. Its ethyl acetate, methanol, hexane and water extracts at a concentration of 100 mg/ml showed zones of inhibition with diameters of 17.5±0.71 mm, 16.0±1.41 mm, 15.5±0.71 mm and 15±0 mm respectively. The dose dependent *S. mutans* inhibitory zones at 100, 50, and 25 mg/ml of the ethyl acetate extract were 15.67±1.53 mm, 14.33±1.15 mm and 13.67±0.58 mm respectively, while that of chlorhexidine (positive control) was 17.83±0.29 mm and 10% DMSO (negative control) was 0 mm. Using broth micro dilution assay, the ethyl acetate extract of this herbal mixture was found to have a MBC of 250 µg ml⁻¹. These findings provide first scientific evidence for the anticariogenic effects of this herbal mixture. Therefore, this herbal mixture may have the potential to be developed into an anticariogenic gel or a chewing gum. Further studies are in progress to analyze the effect of this extract on expression of virulent genes in *S. mutans* and their biofilm formation.

Financial assistance from Peradeniya University Research Grant (Grant No: RG/AF 2013/17D) is acknowledged.

Keywords: Dental caries, Herbal mixture, *S. mutans*, Sri Lankan ‘dahat wattiya’

VALIDATION OF A REAL TIME PCR (RT-PCR) BASED METHOD FOR IDENTIFICATION OF GENETICALLY MODIFIED (GM) BAKED BAKERY PRODUCTS

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Currently, the term “Genetically Modified Organisms (GMO)” has become highly controversial topic among global population. The genome of GMOs has been altered in a laboratory, in order to obtain a desired trait. However, due to lack of laboratory facilities and less consumer concern about GMOs, the presence of GM foods in Sri Lankan market is currently ambiguous. Therefore, a validated GMO detection method should be available in order to promote GM food labeling among industries. Among the food industry, bakery industry is one of the iconic industries in Sri Lanka. Hence, this study aims to validate a Real Time PCR (RT-PCR) based method for detection of CaMV 35S promoter of GMO in baked bakery products. Validation has few main criteria and this study is mainly engrossed into repeatability and recovery. Previously tested non-GMO and GMO reference samples containing baked bakery matrix were used for this study. The DNA extraction and RT-PCR were performed using QIAGEN DNeasy Mericon food kit and QIAGEN Mericon Screen 35S Kit, respectively. Repeatability was tested by extracting DNA from the GM positive reference sample 10 times and subjecting them to RT-PCR detection. In recovery step DNA extraction and RT-PCR was performed to 0%, 0.1%, 0.2%, 0.5%, 1%, 2%, 5%, 10%, 20% and 100% reference GMO standards which were prepared by mixing the GM and Non-GM reference samples. In summary, overall repeatability was 90% and sensitivity was 10%. The reasons for lower sensitivity could be due to poor homogenization conditions and less sensitivity of the RT-PCR kit. However, these results indicate that overall procedure of sample preparation, DNA extraction and RT-PCR can be confidently used in laboratories for detection of GMO in baked bakery products.

Financial assistance from Government treasury (Grant No: TG 16/132) is acknowledged.

Keywords: Baked bakery products, CaMV 35S, GMO, RT-PCR, Validation

ERAGROSTIS TEF (TEFF), AS A BRIDGING SPECIES TO IDENTIFY BLAST DISEASE RESISTANCE GENES IN UNDERUTILIZED CEREAL CROPS

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Pyricularia grisea (*Magnaporthe grisea*) causes blast disease in many cereal crops. Total of twenty three (23) blast disease resistance Quantitative Trait Loci (QTLs) are characterized in rice. Teff (*Eragrostis tef*), sub family Chloridoideae, a close relative of underutilized cereals such as *Panicum miliaceum* (Proso millet), *Setaria italica* (Foxtail millet) and *Sorghum bicolor* (Sorghum). Thus, Teff can be used as a bridging between Rice and other cereal crops in the gene discovery in related species by comparative genomics. Nine Rice QTLs were used in a BLAST search in Rice Genome Browser (<https://rice.plantbiology.msu.edu>) to identify rice resistance genes (RGs). Transcribed rice RGs were used to query Comparative Genomics Platform (<https://genomevolution.org/coge/CoGeBlast.pl>) to identify Teff Resistance Gene Analogs (RGAs). The Teff RGAs were used in BLAST search of CoGe for, Proso millet, Foxtail millet and Sorghum. The Rice QTLs: *Pb 1*, *Pi b*, *Pi 37*, *Pish j*, *Pi 5*, *Pi 9*, *Pi 64*, *Pid 3* and *Piz* identified altogether 18 rice RGs. Clusters of multiple RGs were identified in *Pb 1*, *Pid 3* and *Piz* QTLs. Potential RGAs were identified on Teff chromosomes: 1A, 2A, 2B, 3A, 5A, 6B, 9A. The Teff RGAs identified 6, 13 and 8 orthologs from Proso millet, Foxtail millet and Sorghum, respectively thus showing the effectiveness of Teff in gene identification from related cereals. Proso millet RGAs were distributed in chromosomes 17 and 18. In Foxtail millet RGAs were identified in scaffolds 3, 6, 7 and 8, whereas Sorghum orthologs were found on chromosomes 5, 7, 8, and 9. Downstream processing and isolation of the putative blast resistant RGAs enable use of them in crop improvement of these underutilized cereals.

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

Keywords: Blast disease, Comparative genomics, *Magnaporthe*, RGAs

TOWARDS ECO-FRIENDLY AGRICULTURE ON MARS: A PRELIMINARY STUDY WITH LETTUCE

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With the population pressure, exploitation of Earth's resources has resulted in irreversible damage to our planet, thus prompting to search for an alternative home. The space colonization is the only solution for the issue. Next to the Earth, Mars has the basic requirements for life, though they are in minimal supply. Among others, food supply is a prerequisite for the space colonization. Unlike our planet, food production in an eco-friendly manner is very important, if we are to save at least the next planet we will colonize. Chemical inputs in modern agriculture are the major culprit in many environmental problems. At present, good agricultural practices like the use of biofertilizers minimize the chemicals without lowering crop yields. Among biofertilizers, biofilm biofertilizers (BFBFs) have shown the potential in large scale safe application. Objective of this study was to investigate how to minimize the usage of chemical fertilizers (CF) in futuristic Martian agriculture. Eight different treatments with BFBF and reduced CF rates (up to 50%) were applied to a Martian soil simulant (serpentine soil) in order to determine its effect on plant growth. Each treatment consisted of 3 replicates in a CRD. Lettuce was used as the test plant. After 46 days, plants started to die. However, some parameters of the simulant soil were improved. Compared to the initial soil simulant, both BFBF and CF treated simulant showed significant improvements in moisture, labile carbon, nitrate and non-diazotrophs and a decrease in extractable nickel. Thus, the BFBF may improve the Martian soil conditions for at least subsequent plant growth. However, further studies are needed to investigate this in real Martian soil and environmental conditions.

Keywords: BFBF, Eco-friendly agriculture, Mars, Martian soil, Simulant

**EVALUATION OF CONSERVATION STATUS OF GENUS *SALACIA*
(CELASTRACEAE) IN SRI LANKA**

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The genus *Salacia* comprises of five species in Sri Lanka, *S. acummatissima*, *S. chinensis*, *S. diandra*, *S. oblonga* and *S. reticulata* and it is well known for its therapeutic properties. Mature plants are harvested to prepare various medicines. In order to conserve this genus, it is vital to record existing populations and their abundance. An island wide eco-geographical survey was carried out from January 2016 to December 2018 for all recorded *Salacia* species in different climatic zones in the country. Locations were recorded using Global Positioning System. Visual estimate of the population size, ecological condition and possible causes of threats were recorded for the subpopulations. Potential distribution maps for each species were developed using ArcGIS 10.4 and the extent of occurrence (EOO) and the area of occupancy (AOO) were calculated using a 2 x 2 km² grid on the map. Conservation status of each of the five *Salacia* species was evaluated following IUCN guidelines, Criteria B (2017). Among 82 distinct populations recorded in the study, 84% were new records for the genus. According to the conservation categories based on the National Red List 2012, *S. acummatissima*, Endangered (EN) and *S. chinensis* Near Threatened (NT) remained the same while *S. oblonga* and *S. reticulata* were downgraded from Endangered (EN) to Near-threatened (NT). *S. diandra* was upgraded from Endangered (EN) to Critically Endangered (CR). Moreover, the conservation of *S. acummatissima* and *S. diandra* are critical because they are restricted to undisturbed forests in the wet zone. The only threat observed for *S. chinensis*, *S. oblonga* and *S. reticulata* is the over exploitation for medicinal purposes. Upgrading the conservation status of *S. diandra* and downgrading the conservation status of *S. oblonga* and *S. reticulata* could be considered as an important outcome of the present study permitting sustainable utilization of different species of *Salacia*.

Financial assistance from Rajarata University of Sri Lanka Research grant (Grant No: RJT/RP+HPC/2013/APP/R/01) is acknowledged.

Keywords: Conservation status, Red data, *Salacia*

ANALYSIS OF GENETIC DIVERSITY AND ANTAGONISTIC ACTIVITY OF DIVERSE *TRICHODERMA* ISOLATES IN SRI LANKA

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Trichoderma is the most used biocontrol agent in the world. It is an avirulent fungus which lives as a symbiotic microbe with plants. Due to various beneficial abilities, many studies are available based on *Trichoderma* spp. However, there are few studies concerning genetic diversity and the antagonistic efficacy of *Trichoderma* isolates exist in Sri Lanka. This study focused on the analysis of genetic differences and potential mycoparasitic activity of *Trichoderma* isolates from seven districts of Sri Lanka. The soil samples were collected and *Trichoderma* spp. were isolated in PDA medium. Colony characteristics and the microscopic features were used to identify the *Trichoderma* strains. The fungal genomic DNA was extracted according to the CTAB-fungal DNA extraction protocol and an internal transcribed spacer region of the genomic DNA was amplified using *ITS1* and *ITS4* primers, followed by the analysis of DNA polymorphism. The antagonistic activity of all *Trichoderma* isolates was investigated by dual culture assay. Data were subjected to normality testing and the LS means of radial growth was calculated by applying PROC GLM in the statistical package SAS 9.4. The PCR amplified product using *ITS1* and *ITS4* primers show a DNA polymorphism within *Trichoderma* isolates. According to the dual culture assay, all *Trichoderma* isolates significantly inhibited the radial growth of the test pathogen (in the range of 46% to 66% of inhibition), though not significantly differed between the *Trichoderma* isolates ($p < 0.05$). Similarly, percentage inhibition of test pathogen by various *Trichoderma* isolates was not significantly different. This study can be further extended by investigating the antagonistic activity against various plant pathogenic microorganisms. The fungal DNA can be amplified using different markers and the amplified DNA can be sequenced to identify the different species and their phylogenetic relationships.

Keywords: Dual culture assay, Fungal DNA, *ITS*, Inhibition, Radial growth

BIOFILM BIOFERTILIZER MEDIATED RESTORATION OF NITROGEN FIXERS IN THE SOIL-PLANT SYSTEM IN PADDY CULTIVATION

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Soil microbes and fauna living in the soil-plant system contribute to ecosystem sustainability through signalling in complex network interactions. Chemical nitrogen (N) fertilizers applied to agroecosystems suppress the action of soil microbes, particularly N₂ fixers (diazotrophs), thus leading to produce N-poor soil microbial communities with low biomass. Microbial biofertilizers increase diversity and abundance of soil microbes by introducing beneficial microbes which are depleted in agroecosystems. Among microbial biofertilizers, biofilm biofertilizer (BFBF) can reinstate lost microbial diversity in degraded soils and possibly in plants. Thus, the present study focused on evaluating the effect of BFBF on recovering abundance of plant endophytic and soil diazotrophs in conventional agriculture using rice as the test plant. A field experiment was conducted with four treatments *viz*: 100% CF DOA recommendation (DCF), NIFS CF recommendation for BFBF practice (NCF), NIFS CF recommendation for BFBF practice + BFBF (NCF + BFBF), and the control (without CF and BFBF), each having three replicates. Soil and plant samples were collected from all four treatments and microbes were isolated and grown in N free Combine Carbon Media (CCM) prescribed for growing diazotrophs. Microbial counts were taken and analyzed using Minitab statistical package. According to the results, soil and plant endophytic diazotroph abundances of NCF + BFBF were significantly higher than that of DCF, NCF and the control ($P < 0.05$). This may be due to the dormancy breaking of microbial seeds after BFBF application. Further, diazotroph abundance of NCF was significantly higher than that of DCF. This is because the dosage of N used in NCF is lower than that of DCF, and hence suppression of diazotrophs in the NCF is less. The study concludes that application of BFBF together with a reduced dosage of N fertilizers can restore lost diazotrophs abundance in the soil-plant system of conventional rice cultivation.

Keywords: Biofilm biofertilizer, Chemical fertilizer, Diazotrophs, Rice

**DETERMINATION OF SEED DORMANCY AND GERMINATION BEHAVIOUR
OF 25 PLANT SPECIES FROM TROPICAL LOWLAND RAINFORESTS IN
SRI LANKA**

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Seed germination behavior has been investigated only for a limited number of Sri Lankan rainforest species. Knowledge on seed germination of native rainforest species is important for their effective conservation. The research was conducted to determine the seed dormancy and germination behavior of 25 haphazardly selected ecologically important plant species from lowland rainforests in Sri Lanka. Seed germination tests were conducted using 4 replicates at 25 °C. Embryo: seed ratio was evaluated. Signs of imbibition of germinating seeds were monitored. Time taken from radicle emergence to shoot emergence was recorded. Germination data were analysed with the moods median test. Time taken for shoot emergence and embryo development data were analysed with one-way ANOVA procedure. Among the 25 species, fresh seeds of *Elaeocarpus subvilosus* and *Glochidion sp.* have germinated only with 500 ppm GA₃ indicating presence of physiological dormancy. Embryos of *Hortonia angustifolia* and *Horsfieldia iryaghedi* seeds developed prior to radicle emergence indicating the presence of morphological dormancy. It was confirmed that embryos of 16 species do not developed within the seed. Seeds of the 21 species germinated on distilled water, (*Bhesa ceylanica*, *Bridelia moonii*, *Gaertnera vaginans*, *Semecarpus walkeri*, *Dipterocarpus zeylanicus*, *Freycinetia walkeri*, *Mangifera zeylanica*, *Palaquim thwaitesii*, *Timoneus jambosella*, *Syzigium sp.*, *Exacum trinervium*, *Pericopsis mooniana*, *Artocarpus nobilis*, *Melastoma malabathricum*, *Sonerila sp.*, *Urophyllum ceylanicum*, *Nepenthes distillatoria*, *Fagraea ceilanica*, *Mesua ferrea*, *Ophiorrhiza mungos* and *Schizostigma hirsutum*) were categorized as non-dormant. A substantial delay between radicle and shoot emergence indicated the epicotyl dormancy in *B. ceylanica*, *E. subvilosus* and *G. vaginans* seeds. Our study revealed that most tropical rain forest species in Sri Lanka produce seeds with no dormancy while dormant seed producing species are less prominent.

Financial assistance from National Research Council (Grant No: 17-095) is acknowledged.

Keywords: Conservation, Non-dormant, Physiological dormancy

DOES BIOFILM BIOFERTILIZER WORK IN LARGE SCALE RICE CULTIVATION UNDER FARMERS' FIELD CONDITIONS?

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Sustenance of soil fertility is adversely affected by the excessive use of chemical fertilizers (CFs) mainly in rice cultivation of Sri Lanka. Therefore, the use of organic and biofertilizers together with CFs are being promoted. Amongst, Biofilm Biofertilizer (BFBF) has shown a promising potential to cut down CFs up to 50% in small scale rice cultivation. However, there is no published research on the effect of BFBF application in farmers' fields at a larger scale. Thus, present study investigates the effect of BFBF on soil fertility, plant growth and grain yield of rice grown at large scale farmer fields. The study was carried out in Ampara district, a major rice growing area in Sri Lanka. Eighteen random farmers' fields spreading over 200,000 acres were selected from different locations in the district. Two uniform paddy fields (whole *liyaddas*) were applied CF alone and BFBF + 50% CF separately. Rhizosphere soil and plant samples were collected randomly from three hills from each paddy field at flowering, and were analyzed for soil pH, moisture, total C, N, P and plant parameters. Grain yields were recorded at harvest. Results of the two treatments were compared using two sample t-test in R software. There were significant increases in soil moisture (the increase by 27%), total C (63%), N (69%) & P (86%), plant hill circumference (46%), number of tillers per plant (29%), leaf chlorophyll content (38%), total dry weight (98%), thousand grain weight (18%) and total grain yield (26%) ($p < 0.05$) in the BFBF + 50% CF practice over the CF alone practice. Therefore, it can be concluded that the BFBF application together with a reduced dosage of CFs improves the soil quality, plant growth and grain yield under large scale rice cultivation in the dry zone of the country.

Keywords: Biofertilizer, Biofilm biofertilizer, Chemical fertilizer, Paddy, Rice

BIOFILM BIOFERTILIZER: A PROMISING ECO-FRIENDLY ALTERNATIVE TO FUTURISTIC MARTIAN AGRICULTURE

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Human colonization on Mars has been planned as close as 2031. Here, a big question among other things is how we cultivate our food crops on Mars while saving its environment. Martian soils have limitations for plant growth due to high levels of heavy metals, lack of beneficial microbes and deficiency in some macronutrients. Though chemical fertilizer (CF) may be a necessity for plant growth, it is important to investigate methods which use a minimum amount of CF, if Mars is to be kept with limited pollution due to crop production. Here, biofilm biofertilizers (BFBFs) can play a major role in eco-friendly Martian agriculture. This preliminary study assesses plant growth with the application of BFBF using a serpentine soil, which is used widely as a Martian soil simulant in the world. Lettuce was used as the test plant. A pot experiment was carried out with two BFBF dilutions in sterile distilled water; 1:100 and 1:300, BFBF:water (v/v), and the control (sterile distilled water). Seed germination percentage and seedling length were measured after four weeks. Soil microbial biomass was determined using MicroResp tool kit. Total soil bacterial plate count was also taken. Soil microbial respiration did not differ among treatments. Total soil bacterial count of the 1:300 dilution was significantly higher than that of the control by 6%, the initial serpentine soil by 12% and the 1:100 dilution by 20% ($P < 0.05$). Thus, the 1:300 dilution seems to be an optimal concentration of BFBF for the soil bacterial growth. Increasing trends of both seed germination and seedling length were also observed at 1:300 dilution. The study concludes that BFBF can increase the microbial action in Martian simulant soil, which is a prerequisite for healthy plant growth. More studies including plant heavy metal uptake are needed to evaluate this further.

Keywords: Serpentine soil, Biofilm biofertilizer, Plant growth, Soil microbes

**OPPORTUNISTIC CANNIBALISM BY TADPOLES OF COMMON HOUR-
GLASS TREE FROG, *POLYPEDATES CRUCIGER***

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Tadpoles are primarily herbivorous or detritivorous in nature but some are known to show cannibalism under circumstances. To determine the conditions that shape the cannibalistic decision over other food sources, we examined the cannibalism by tadpoles of the common hourglass tree frog, *Polypedates cruciger* (Rhacophoridae) under two conditions 1) food limitation and 2) overcrowding. First, 20 tadpoles each were separated and given three feeding regimes: Satiation (100% body weight), Sufficient (10% body weight according to literature and the preliminary studies), and Scarce (1% body weight). The effect of overcrowding was studied by raising tadpoles at three densities having 10 (Low), 20 (Medium), and 30 (High) individuals per tank (30 cm ×15 cm ×15 cm) providing only sufficient amounts of food. Both experiments were replicated three times. All the tadpoles (Gosner stage 23) were placed in glass tanks containing 2 L of dechlorinated water and were fed with Kangkung (*Ipomoea aquatica*) daily. Cannibalism was recorded daily and body mass and snout-to-vent length were measured weekly for 30 days. When the tadpoles were fed to satiation, showed significantly low level of cannibalism (1.7%) compared to Sufficient (85.0%) and Scarce (93.3%) feeding regimes (One-way ANOVA, $F=1387.50$, $p=0.0001$). Significant variations in the level of cannibalism was also observed in three density treatments (Low = 80.0%, Medium = 84.4%, High 91.7%; $F=12.58$, $p=0.007$). In both experiments, an exponential increase in the cannibalism level was shown from the second to the third week of the experiment when the tadpoles were at Gosner stage 24. The growth of the tadpoles in the scarce food regime was higher but there was no difference in the tadpoles in the three density treatments. Tadpoles of *P. cruciger* showed opportunistic cannibalism as they fed on their own siblings as a response to reducing food or increasing density conditions under availability of sufficient levels of food, which is the most frequent natural condition in ephemeral water bodies. This study provides the first empirical evidence of cannibalistic behavior by an amphibian species in Sri Lanka.

Financial assistance from National Research Council Sri Lanka (Grant No: 16-059) is acknowledged.

Keywords: Conspecific predation, Density, Food limitation, *Polypedates*

ANTIMICROBIAL, BRINE SHRIMP LETHALITY, ANTIOXIDANT AND ANTI-INFLAMMATORY ACTIVITIES OF ALKALOIDS OF *HOLARRHENA MITIS* (VAHL) R.BR.

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Secondary metabolites synthesized by natural sources consist of structural diversity providing infinite opportunities for new drug discovery. Sri Lanka is a rich source of medicinally valuable endemic plants, however very few of them have been investigated scientifically. *Holarrhena mitis* is one such endemic plant which is used in Ayurvedic medicine for dysentery. Antimicrobial, antioxidant, and anti-inflammatory activities and brine shrimp lethality have been reported for *H. mitis* and phytochemical screening revealed that alkaloids are the main constituents present in this plant. However, the biological potential of these alkaloids have not been tested. Therefore, the purpose of this research was to evaluate the antimicrobial, antioxidant and anti-inflammatory activities and brine shrimp lethality of the alkaloid fraction of *H. mitis*. Alkaloids were separated from methanol extracts of bark of *H. mitis* and tested for antibacterial activity against *Staphylococcus aureus*, *Escherichia coli* using agar dilution assay, antifungal activity against *Candida* sp. using agar well diffusion assay, antioxidant activity by DPPH assay, anti-inflammatory activity by heat induced hemolysis and cytotoxicity using brine shrimp lethality assay. Tests were done in triplicates. The yield of alkaloids in bark extract of *H. mitis* was comparatively high (52.84%) and they showed significant antibacterial activity (MIC: 5 mg mL⁻¹) and antifungal activity against the *Candida* sp. The antioxidant power (IC₅₀: 399.0 µg mL⁻¹) was moderate while the inhibition of haemolysis percentage (5.02%) was insignificant. Further, alkaloids of *H. mitis* showed no cytotoxicity for brine shrimp lethality assay (LC₅₀=1410.11 µg mL⁻¹). These results revealed that alkaloids of *H. mitis* contribute highly to the antimicrobial activity and moderately to the antioxidant activity of the plant.

Financial assistance from Medical Research Institute (Grant No: 25/2013) is acknowledged.

Keywords: Alkaloids, Antimicrobial activity, Antioxidant, Anti-inflammatory, *Holarrhena mitis*

CLINICO-LABORATORY PROFILES AND COMPARISON OF NS1 AND VIRAL RNA DETECTION IN A SELECTED GROUP OF DENGUE SUSPECTED PATIENTS

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Antigen and viral RNA detection methods are available for confirming the dengue viral (DENV) infection during the early phase of the disease. This study was aimed to investigate the clinical and laboratory profiles in 200 dengue suspected patients. A total of 50 out of 200 patients' blood samples were selected to compare the efficiency of DENV RNA detection with NS1 detection. Epidemiological data and clinical profiles of dengue suspected patients aged between 18 to 70 years admitted to the District General Hospital, Matale with fever days 2 to 5 were analysed. Efficiency of DENV RNA detection by loop-mediated isothermal amplification (LAMP) with NS1 detection by immune chromatography (ICT) assay (SD Bioline, Korea) were assessed using 50 selected samples. Of the 200 clinically suspected dengue patients, 44.5% had dengue fever (DF) while 14.5% had dengue haemorrhagic fever (DHF). Mainly females (56.5%) were affected by dengue in the study sample. The average day of presentation for DF and DHF were 4.8 and 4.6, respectively. Individuals between 18 to 27 years were commonly affected by DF and DHF. The test indices such as sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of DENV RNA detection by LAMP with NS1 detection were 50%, 100%, 100% and 61%, respectively. The highest positivity for NS1 (67%) was noted in day 3 of the presentation. The highest positivity for DENV RNA by LAMP (50%) was in day 2 and 3 of the presentation. NS1 detection by ICT assay and DENV RNA detection by LAMP showed a moderate concordance. DENV RNA detection by LAMP is a rapid molecular method to diagnose DENV infection with 100% specificity and PPV. Further studies using a large sample will be of use to confirm the efficiency of LAMP when compared to the NS1 detection.

Keywords: Clinical, Dengue, Laboratory profiles, LAMP, NS1

LARVICIDAL ACTIVITY OF SYNTHESIZED ZINC OXIDE NANOPARTICLES AGAINST MOSQUITO VECTORS

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Slow degradation and controlled release of active ingredients of nanoparticles have been effectively used in controlling many agricultural pests and mosquito vectors. In this study, the lethal effect of chemically synthesized different morphologies of ZnO nanoparticles against the larvae of *Aedes albopictus* and *Anopheles* sp. mosquitoes was investigated. Four different morphologies of ZnO nanoparticles [star (S), plate (P), cubical (C), and needle shape (N)] were prepared by co-precipitation and hydrothermal chemical methods. Presence of ZnO nanoparticles were confirmed by XRD, SEM, XRF and EDX methods. The average sizes of the ZnO nanoparticles determined by dynamic light scattering were 20.2 nm, 27.0 nm, 24.9 nm and 45.8 nm, respectively, for S, P, C and N shapes. Larval bioassays were conducted for 2nd instar larvae of *Aedes albopictus* and *Anopheles* sp. under laboratory conditions (25±2 °C and 84%±2 R.H) for 0, 25, 50, 75, 100 mg l⁻¹ concentrations. Three replicates were done exposing ten larvae for each and every concentration. Mortality was reported for 24 h intervals up to 14 days. Results revealed the time-dependent toxicity against larvae of *Aedes albopictus* (LD₅₀ 38.71, 74.92, 55.52, 47.16 mg l⁻¹) and *Anopheles* sp. (LD₅₀ 7.74, 15.58, 14.27, 12.32 mg l⁻¹) after 10 days of exposure to S, P, C and N nanoparticles. The highest mortality was observed for star-shape particles [*Aedes albopictus* (38.71 mg l⁻¹) and *Anopheles* sp. (7.74 mg l⁻¹)] while the lowest mortality was resulted for plate-like particles [*Aedes albopictus* (74.92 mg l⁻¹) and *Anopheles* sp. (15.58 mg l⁻¹)]. A delayed deployment was observed in the exposed mosquito larvae [*Aedes albopictus* (10-17 days) and *Anopheles* sp. (12-19 days)] when compared to that under control conditions [*Aedes albopictus* (8-10 days) and *Anopheles* sp. (10-12 days)]. This study provides important information on recommending ZnO nanoparticles as mosquito larvicide to which resistance cannot be developed.

Keywords: Co-precipitation method, Hydrothermal method, Larvicidal activity, Zinc oxide nanoparticles

ISSR PCR BASED GENETIC DIVERSITY OF *STAPHYLOCOCCUS AUREUS* AND *ESCHERICHIA COLI* FROM BOVINE SUBCLINICAL MASTITIS MILK IN SRI LANKA

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Mastitis, inflammation of udder is one of the most costly dairy diseases worldwide with two forms namely, clinical and subclinical (SCM). For healthy herds and quality milk, mastitis prevention and control is essential. Though conventional techniques can identify aetiologic agents, detecting genetic variations is essential in control programs to demonstrate strain origin and transmission. As such data are not available within Sri Lanka, a preliminary study was designed to determine the genetic diversity of dairy mastitis causative pathogens by Inter Simple Sequence Repeat (ISSR) PCR. Fifty apparently healthy cows from 20 farms in Matara district were screened for SCM using “California mastitis test”. Fifteen infected cows were identified and their milk samples were cultured. Isolated bacteria were identified by standard methods. Bacterial genomic DNA was extracted using a commercial kit. PCR products obtained with ISSR-P02 primer (5'-GAG AGA GAG AGA GAG AGA C-3') were visualized on 2% agarose gel. Individual ISSR amplicons analysis and phylogenetic tree generation were performed using “GelAnalyzer 2010” and “PyElph”. Ten *Staphylococcus aureus* and five *Escherichia coli* were identified. Identical ISSR PCR profiles of bacteria were not detected. Twenty four ISSR loci were detected for *S. aureus* and PCR fragment sizes ranged from 414 to 6940 bp. Twenty ISSR loci were detected for *E. coli* with PCR fragment sizes ranging from 413 to 2293 bp. Four main clusters of *S. aureus* and three clusters of *E. coli* were produced by phylogenetic trees as per single linkage clustering method. Distinct strains were responsible for each SCM case and farm to farm contamination seemed to be minimal though few affected farms were located within 3 km distance. Biosafety practices should be improved in each farm accordingly to reduce mastitis incidence. ISSR PCR and phylogenetic analysis are valuable tools to detect bacterial genotypes for successful mastitis control program implementation.

Financial assistance from Department of Animal Production and Health is acknowledged.

Keywords: Mastitis, Milk, ISSR PCR, Sri Lanka

COMPARISON OF SUSPECTED AND LABORATORY CONFIRMED CASES OF BOVINE AND CAPRINE BRUCELLOSIS AND THE DISEASE DISTRIBUTION PATTERN IN SRI LANKA

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Brucellosis is an infectious disease of bacterial origin affecting multiple animal species and humans in the world. The disease is endemic in Sri Lanka with a higher prevalence observed in cattle and buffaloes (bovines) and believed to be present in goats (caprines). It is considered as an economically important disease since it causes abortions/stillbirths, birth of weak offspring and infertility in animals. A descriptive retrospective study was undertaken to determine the true positivity of brucellosis in bovines and caprines in Sri Lanka and to understand the disease distribution pattern in the country. Data was obtained from the relevant laboratory entries and diagnostic reports at the national reference diagnostic laboratory for brucellosis at the Veterinary Research Institute, Peradeniya. The study period was 5 years from 2011 to 2015, and samples from clinical suspects of brucellosis (with abortion/stillbirth, birth of weak offspring, infertility) were subjected to Rose Bengal test and complement fixation test or bacterial isolation. During the period, only 14% of the laboratory submitted bovine samples revealed positivity for brucellosis. None of the disease suspected goats were positive for the disease upon testing. The highest laboratory positivity percentage of bovine brucellosis was detected in the dry zone (23%), in contrast to the intermediate zone (10%) and the wet zone (5%). Positivity rates of bovine brucellosis were highest in Hambantota, Monaragala, Vavuniya and Batticaloa districts and Southern, Northern, Eastern and North-Central provinces of Sri Lanka respectively. Since 86% of bovine and 100% of caprine clinical suspects were negative for brucellosis upon testing, the study highlights the importance of laboratory diagnosis of brucellosis compared to clinical diagnosis. It is also recommended to investigate such cases further to explore the actual aetiology, since many other infections and conditions can mimic brucellosis in animals clinically.

Keywords: Abortion, Brucellosis, Bovine, Caprine, Distribution

**ISOLATION AND CHARACTERIZATION OF DIESEL-UTILIZING BACTERIA
FROM PETROLEUM CONTAMINATED SITES**

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Petroleum degrading bacteria are now being used as agents for remediating petroleum contaminants. The indigenous microbial populations in petroleum contaminated sites hold the key to improving bioremediation strategies since the microbes surviving in such locations may have adapted to consume oil. This study mainly focused on the identification of efficient petroleum degrading bacteria from petroleum contaminated soils. Diesel is chosen as the petroleum source since it is a complex mixture containing a range of linear and aromatic compounds, and therefore, bacteria which have different degrading abilities could be isolated. Diesel degrading bacteria were isolated from petroleum contaminated soil samples collected from five selected locations. The soil samples were inoculated into Bushnell-Haas (BH) broth supplemented with diesel. After seven days in culture, BH-diesel spread plates were used to isolate potential diesel degraders. The isolates were subjected to turbidity measurements and BH-plate assay to estimate the growth of individual bacteria on diesel. The consortium cultures, designed from dominant degraders were subjected to turbidity measurements to determine the growth on diesel. A total of seventeen potential isolates capable of degrading diesel were selected based on morphological differences (colour, colony size, shape and smoothness), of which five isolates (C1, A2, N6, C3, K3) were identified as dominant degraders by turbidity measurements and BH-plate assay. Based on morphological and biochemical tests, isolates C1, K3, C3 and N6 appear to belong to the genera *Klebsiella*, *Micrococcus*, *Enterobacter* and *Bacillus* respectively while the highest degrader A2 is yet to be identified. Out of eleven bacterial consortia tested, six consortia were proven more effective in degrading diesel compared to individual cultures. Further studies are needed to determine the quantity of diesel degraded by the isolates and the interactions within the bacterial consortia.

Keywords: Bacterial consortia, BH-plate assay, Biodegradation, Petroleum contamination

PRELIMINARY PHARMACOGNOSTIC EVALUATION AND *IN-VITRO* ANTI-CANDIDAL ACTIVITY OF YOUNG LEAVES OF COMMON BETEL TYPES IN SRI LANKA

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Piper betle is an evergreen, semi-woody climber which belongs to the family Piperaceae. The plant has secondary metabolites which show various pharmacological properties. The objectives of the study were to compare the morphological, anatomical and phytochemical characteristics and to evaluate the anti-candidal activity of young leaves of common betel types in Sri Lanka; *Maneru*, *Ratadalu*, *Narammali*, *SuduNagawalli* and *KahaNagawalli*. *Piper betle* samples were collected from the Intercropping and Betel Research Station at Narammala from February to May 2019. Using the second leaf from the apical bud, morphological and selected anatomical characteristics were compared. Phytochemical screening of the crude ethanolic extract was performed using thin layer chromatography. *In-vitro* anti-candidal activity was investigated against standard cultures of *Candida albicans*, *Candida glabrata*, *Candida krusei*, *Candida parapsilosis* and *Candida tropicalis* by agar well diffusion assay. MICs of active extracts were determined for each *Candida* species using standard methods. Variation among betel types in leaf shape, base, odor, apex, margin, length to width ratio was marginal. *Kaha Nagawalli* consisted of a higher number of epidermal hairs on both upper and lower leaf surface. Anomocytic stomatal arrangement, vein islet number, vein termination and stomatal index were similar for all types. Oil bodies were observed in the lower surface of *Kaha Nagawalli* while the other types possessd oil bodies in both lower and upper leaf surfaces. *KahaNagawalli* contained oil bodies in the midrib in addition to the epidermis. All betel types revealed two flavonoids, two tannins, one phenolic compound, two terpenoids and three alkaloids, while *Ratadalu* showed three terpenoids, respectively. All betel types showed significant anti-candidal activity from which *Ratadalu* was the most significant having a MIC of 6.4 mg/mL. Therefore, *Ratadalu* was selected for further studies.

Financial assistance from AHEAD-ICE grant (Grant No: AHEAD/RA3/ICE/PDN/SCI) is acknowledged.

Keywords: Betel types, *In-vitro* anti-candidal activity, *Piper betle*, Pharmacognostic evaluation

DEVELOPMENT AND CHARACTERIZATION OF POLYSACCHARIDE NANOPARTICLES FOR TARGETED DRUG DELIVERY

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Utilization of natural polysaccharides in nanoformulations has become very prominent as drug carriers due to their biocompatibility, biodegradability and nontoxicity. Among them, alginate and chitosan nanoparticles are widely used in pharmaceutical industry for controlled release of drugs. In this study, carrageenan (CR) which is an anionic polymer extracted from red sea weeds is used for the formulation of nanoparticles as a controlled-release drug delivery system. Curcumin, a polyphenolic compound derived from rhizomes of *curcuma longa* which is commonly known as turmeric, which having antioxidant, anti-inflammatory, anticarcinogenic and antimicrobial properties was used as the drug. CR nanoparticle preparation was performed by the method of ionotropic gelation using CaCl₂ as the cross-linking agent. These nanoparticles were synthesized by varying the CR: CaCl₂ mass ratio, CR and CaCl₂ concentration and solution pH to obtain the optimum formulation. Particle sizes in the range of 240-310 nm were obtained at low concentrations of CR and high concentrations of CaCl₂. For the preparation of curcumin encapsulated nanoparticles, curcumin was added to the carrageenan solution prior to addition of CaCl₂ while stirring. The nanoparticles were characterized by particle size analyzer and Fourier Transform Infrared spectroscopy (FTIR). The particle sizes of blank nanoparticles and curcumin loaded nanoparticles were 247.9 nm and 307.0 nm respectively. Peak corresponding to galactose-4-sulphate linkage at 884 cm⁻¹ shifted to 833 cm⁻¹ and 3,6-anhydrogalactose bond at 956 cm⁻¹ shifted to 917 cm⁻¹. Peak shifts were observed from 1132 cm⁻¹ to 1073 cm⁻¹ and from 1297 cm⁻¹ to 1230 cm⁻¹ for glycosidic bond and sulphate group respectively. Appearance of new IR bands at 1428 cm⁻¹ and 1637 cm⁻¹, which are characteristic for curcumin, indicate that the curcumin is encapsulated inside the CR nanoparticles successfully and the entrapment efficiency was achieved upto 95.9%.

Financial assistance from Accelerating Higher Education Expansion and Development (AHEAD) Innovation Commercialization Enhancement (ICE) (Grant No: AHEAD/RA3/ICE/PDN/SCI/OVAA /03) is acknowledged.

Keywords: Carrageenan, Curcumin, Ionotropic gelation, Nanoparticles

CALLUSING AND SHOOT PROLIFERATION OF *RAUVOLFIA SERPENTINA*

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Rauvolfia serpentina, a native to Indian subcontinent and East Asia, is an important medicinal plant of family Apocynaceae. It is commonly known as “Ekaweriya”, and is known to contain many phyto-chemicals including therapeutically valuable alkaloids. This plant is useful in treatments for hypertension, cardiovascular diseases, breast cancer, mental diseases, anxiety, depression, migraine and headaches. Current conservation status of this plant is ‘endangered’ and it is probably due to limited cultivation and over exploitation by local people and pharmaceutical industries. To satisfy the commercial demand of the life-supporting alkaloid production and for conservation of this valuable plant, it is very much important to develop an *in vitro* regeneration system for *R. serpentina* in Sri Lanka. Shoot tips, nodal segments and leaf explants were successfully made contaminants free by treating with Tween 20 for five minutes followed by 50% Clorox for two minutes. In the present study, mercuric chloride and antifungal agents were not used for surface sterilization as reported by previous workers. These were cultured on Murashige and Skoog (MS) medium supplemented with varying concentrations of Benzylaminopurine (BAP) and 2,4 – dichlorophenoxyacetic acid (2,4 D). Cultures were stored at 25 °C under three variable photoperiods. Callus induction was observed within 5-7 days in all three types of explants under all three photoperiods but was greater when exposed to light (1200 -1400 lux) for 24 hours. Irregular cell masses were obtained from both leaf and nodal segment explants. Shoot proliferation was observed when the shoot tip was used as the explant. The highest percentage (80%) of callus induction was found in MS medium supplemented with BAP 1.5 mg L⁻¹ and 2, 4 D 0.125 mg L⁻¹. These calli and shoots were transferred to half MS medium supplemented with varying ratios of BAP and 2,4 D and are kept in the culture room for plantlet regeneration. The present study has revealed more economical ways (with respect to time and chemicals used) of obtaining calli and shoots of *R. serpentina*.

Keywords: Callusing, Micro propagation, *Rauvolfia serpentina*, Shoot system, Tissue culture

IN VITRO PROPAGATION OF *HYLOCEREUS UNDATUS* (DRAGON FRUIT)

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Dragon fruit (*Hylocereus undatus*) is a climbing vine in the family Cactaceae. Its demand is increasing due to its health benefits and therapeutic values. Stem cuttings are used as propagules since the viability of seeds is low. *In vitro* propagation provides an avenue to obtain many identical plantlets with desired characters especially through callus culture. The present study examined the potential for plantlet regeneration via callus culture using greenhouse grown mother plants (instead of *in vitro* propagated seedlings as reported by previous researchers) to obtain shoot buds and stem explants. Surface sterilization was achieved by washing with running water for 30- 40 minutes followed by rinsing with 70% ethanol for 5 minutes and double sterilization using 50% Clorox with 1 ml of tween 20 for 30 minutes and 10% Clorox for 5 minutes. The cuticle and epidermis of explants were removed before introducing to half strength Murashige and Skoog (MS) medium with four varying combinations of growth regulators. Cultures were stored at 25 °C under three photoperiods: 24 hours light (1200 - 1400 lux), 12 hours light (1200 - 1400 lux) and 24 hours dark until callus formation / plantlet regeneration occurs. Calli were obtained from stem explants in half MS medium supplemented with 5.0 mg L⁻¹ 6 – benzylaminopurine (BAP) and 5.0 mg L⁻¹ 2,4–dichlorophenoxyacetic acid (2,4–D). No significant difference was observed in callus initiation under the three photoperiods used, but the rate of callus growth was greater under 24 h light. Contaminations were high in bud explants. Plantlet regeneration process is still in progress. It can be concluded that callus initiation is possible in *Hylocereus undatus*, using stem explants, within a week at 25 °C using half MS medium supplemented with 5.0 mg L⁻¹ BAP and 5.0 mg L⁻¹ 2,4–D. Surface sterilization was successful (without HgCl₂), when cuticle and epidermis of explants were removed prior to inoculation.

Keywords: Callus mediated regeneration, Dragon fruit, MS medium

**EFFECT OF FLUORIDE RICH WATER ON KIDNEY AND LIVER AND
DISTILLED WATER FOR DAMAGE MITIGATION**

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Hard water and high fluoride levels in drinking water are considered to be related to the prevalence of Chronic Kidney Disease of unknown etiology (CKDu) in Sri Lanka. As such, its confirmation has become an important issue in controlling CKDu. In order to do so, control and test water samples were collected from Kandy and Mihinthale regions, respectively. Twenty-four male rats were randomly divided into 8 groups and water samples were introduced as daily water supply: N1 and N2 groups received normal water for 60 and 90 days and T1 and T2 groups received test water for 60 and 90 days respectively. N3 and T3 groups received normal and test water for 60 days and followed with distilled water for additional 60 days. Similarly, the N4 and T4 groups received normal and test water for 90 days and followed with distilled water for another 90 days. Following treatments, rats were sacrificed. Serum samples were subjected for kidney and liver biochemical tests and kidney and liver were dissected out for histopathological studies. Test water treated groups were associated with the acute tubular injury with were observed for various degrees of tubular epithelial degeneration, integrity of basal membrane and loss of brush border in tubular cells. Test water followed with distilled water treated groups maintained a nearly normal morphology with minimal loss of brush border. Serum creatinine levels in T1 and T2 groups and urea level in T2 group were significantly ($p < 0.05$) increased compared to control groups. These parameters were significantly reduced in T4 groups ($p < 0.05$) compared to T2, after administration of distilled water. Serum AST activity were increased in T4 group ($p < 0.05$) compared to control group with no histopathological changes in liver tissues. Drinking hard water with high fluoride for extended period resulted acute tubular injury with a significant increase in serum levels of creatinine, urea and AST activity. These alterations were minimized by administrating distilled water.

Financial assistance from National Research Council (Grant No: 14-05) is acknowledged.

Keywords: Acute tubular injury, Chronic kidney disease of unknown etiology (CKDu), Distilled water, Fluoride, Water hardness

**SCREENING ANTI-BACTERIAL ACTIVITY OF ENDOLICHENIC FUNGI
COLLECTED FROM NEGOMBO LAGOON, SRI LANKA**

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From the ancient past, natural products have been in use to fulfill a variety of human needs, from sustenance to pharmaceutical necessities. With the discovery of Endolichenic fungi (ELF) as a novel source with prominent bioactivities in recent years, a new trend has been created to explore more about these fascinating organisms, which live inside the lichen thallus asymptotically. ELF isolated from the lichens collected from mangrove plants in Negombo lagoon's Kadol kale area (Latitude: 7°11'50.28" Longitude: 79°50'42") were identified using molecular techniques and were subjected to anti-bacterial assay. Ethyl acetate crude extracts of 18 identified endolichenic fungal strains were obtained and their anti-bacterial activities were tested against aerobic bacterial species *Escherichia coli*, *Bacillus subtilis* and *Staphylococcus aureus*. The assay was carried out using agar well diffusion method using 100 µl of the extracts (5 mg/ml) with Azithromycin as the positive control. The inhibition zone diameters (in cm) against *E. coli* were 1.2 for *Phanerochaete chrysosporium*, 1.2 for *Xylaria feejeensis*, 0.9 for *Gelasinospora seminuda*, 0.9 for *Chaetomium globosum* and 1.5 for *Curvularia lunata* while Azithromycin as the positive control showed a diameter of 2.1. The inhibition zone diameters against *B. subtilis* were 1.0 for *Cochliobolus* sp., 1.0 for *P. chrysosporium*, 1.8 for *X. feejeensis*, 1.7 for *G. seminuda*, 1.2 for *C. globosum*, 1.5 for *Hypoxyylon lividipigmentum*, 2.0 for (*Penicillium* sp), 2.2 for *C. lunata*, 0.9 for *Lasiodiplodia theobromae* and 2.4 for positive control. The inhibition zone diameters against *S. aureus* were 1.1 for *P. chrysosporium*, 2.2 for *X. feejeensis*, 1.0 for *G. seminuda*, 1.0 for *Chaetomium globosum*, 2.0 for (*Penicillium* sp), 1.8 for *Curvularia lunata* and 2.2 for positive control. Out of the 18 fungal strains, 9 showed significant activity against the tested bacterial species while *Endomelanconiopsis endophytica*, *Neofusicoccum parvum*, *Neofusicoccum oculatum*, *Hypoxyylon anthochroum*, *Cytospora xylocarpi*, *Cerrena* sp., *Schizophyllum commune*, *Daldinia eschscholtzi*, *Nodulisporium* sp. fungal strains did not show any inhibition. Further studies will be conducted to isolate compounds responsible for these inhibitions.

Financial assistance from Ministry of Science, Technology and Research (Grant No: STR/TRD/AGR/03/02/07) is acknowledged.

Keywords: Anti-bacterial activity, Endolichenic fungi, Negombo Lagoon

SURFACE PLASMON RESONANCE EFFECT OF Au NANOPARTICLES ON THE EFFICIENCY OF CdS QUANTUM DOT- SENSITIZED SOLAR CELLS

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Quantum dot-sensitized solar cells are emerging as most promisingly cost-effective, third generation photovoltaic devices. Semiconductor quantum dots have gained more attention for a variety of optoelectronic device fabrications including solar cells, sensors, light emitting diodes, lasers and spectrometers, due to their size-dependent optical absorption and emission, ability of multiple exciton generation and high molar extinction coefficients. In order to enhance the performance of quantum dot solar cells, photoanode can be modified by introducing different TiO₂ nanostructures or by incorporating metallic nanoparticles. In this work, TiO₂ photoanode was sensitized with CdS quantum dots by successive ionic layer adsorption and reaction (SILAR) technique and the number of SILAR cycles were optimized with similar TiO₂ electrodes for best solar cell performance. Au colloidal nanoparticles were synthesized by the citrate reduction method. Solar cells were fabricated by using CdS quantum dot-sensitized TiO₂ photoanodes incorporating Au plasmonic nanoparticles. The best plasmon-enhanced solar cell shows an efficiency of 3.97% with a short-circuit current density of 19.25 mA cm⁻² and open-circuit voltage of 531.3 mV, under the simulated light of 100 mW cm⁻² with AM 1.5 spectral filter. Efficiency and short-circuit photocurrent density have been enhanced by 24.45% and 18.53% respectively. The enhancement in the short-current photocurrent is evidently due to the localized surface plasmon resonance effect by the Au nanoparticles.

Financial assistance from National Science Foundation of Sri Lanka (Grant No: NSF/SCH/2018/04) is gratefully acknowledged.

Keywords: Localized surface plasmon resonance, Multiple exciton generation, Quantum dot-sensitized solar cell

ALIEN INVASIVE PLANT *PROSOPIS JULIFLORA*: ALKALOID-MONTMORILLONITE NANOCOMPOSITES AND ANTIOXIDANT AND CYTOTOXIC PROPERTIES

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Alien invasive plant *Prosopis juliflora* (Sw.) Dc. contains bioactive alkaloids. Alkaloids can be trapped into interlayer nanospaces (1-3 nm) present in cation-exchanged montmorillonite clays. The trapping of alkaloids present in *P. juliflora* extracts, by cation- (H^+ and Al^{3+})-exchanged montmorillonite (MMT) clays, was investigated and the releasing of alkaloids from the composites was studied. Antioxidant properties of extracts were determined using 2,2-diphenyl-1,1-picrylhydrazyl (DPPH) assay and cytotoxic properties of extracts and their clay composites using brine shrimp lethality assay (BSLA). Powdered root-bark, leaf and stem-bark were separately extracted into dichloromethane: methanol (1:1), for 48 h, using a bottle extractor. The alkaloid fractions of leaf, root-bark and stem-bark extracts were isolated by acid base method and their yields were 10.2%, 9.4% and 4.1%, respectively. Each extract was separately stirred with Al^{3+} -MMT and H^+ -MMT clays for 24 h and the clays trapped alkaloids (84-96%) (as determined by the ion-pair formation method) from the extracts to furnish the corresponding alkaloid-clay composites. The clays were characterized by FT-IR and XRD methods. Alkaloid- Al^{3+} -MMT and alkaloid- H^+ -MMT, derived from the root-bark extract, slowly released 98% and 78% of the trapped alkaloids at pH 1.2 (gastric), respectively, during 6 h; the corresponding values at pH 7.4 (intestinal) were 48% and 21%, respectively. In the DPPH assay, the IC_{50} values of leaf, stem-bark and root-bark extracts and the alkaloid fraction of the root-bark extract were 119.7, 23.4, 21.3 and 56.5 $mg\ dm^{-3}$, respectively; the root-bark extract appeared to contain potent non-alkaloid antioxidant principles. In the BSLA, the root-bark extract, Al^{3+} -MMT, H^+ -MMT and the clay composites appeared non-toxic (LC_{50} 7080-2248 $mg\ dm^{-3}$). The moderately toxic (LC_{50} 205 $mg\ dm^{-3}$) alkaloid fraction of the root-bark extract was successfully intercalated directly from the extract into H^+ -MMT and Al^{3+} -MMT clays to furnish non-toxic clay composites, which slowly released trapped alkaloids at gastric and intestinal pH values.

Sri Lanka Council for Agricultural Research Policy (SLCARP) is acknowledged for partial financial support (Research Grant No: NARP/16/UP/PGIS/ 01)

Keywords: Alkaloids, Antioxidant, Cytotoxic, Montmorillonite, *Prosopis juliflora*

MEDICINAL PLANT *HOLARRHENA ANTIDYSENTERICA*: ANTIOXIDANT ACTIVITY AND ALKALOID-MONTMORILLONITE NANOCOMPOSITES

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The medicinal plant *Holarrhena antidysenterica* (L.) Wall. ex A. DC. contains bioactive alkaloids. The present study focuses on the trapping of *H. antidysenterica* stem-bark alkaloids into interlayer nanospaces (1-3 nm) of cation-(H⁺ and Al³⁺)-exchanged montmorillonite (MMT) clays. The powdered stem-bark of *H. antidysenterica* was extracted into hexane and methanol sequentially using Soxhlet method and the alkaloid content in each extract was determined by ion-pair formation method. Antioxidant activity of extracts/fractions was determined by 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay. The methanol extract contained a higher amount of alkaloids (10.7%) than the hexane extract (0.7%) and also showed higher antioxidant potential than the hexane extract in the DPPH-TLC method. The methanol extract had potent antioxidant activity (IC₅₀ 22.2 mg dm⁻³) in the DPPH assay, and it was further separated into alkaloid and non-alkaloid fractions by acid-base method. The alkaloid fraction (IC₅₀ 418.9 mg dm⁻³) displayed less antioxidant activity than the non-alkaloidal low-polar fraction (IC₅₀ 125.1 mg dm⁻³) and the remaining aqueous fraction (IC₅₀ 35.9 mg dm⁻³). The methanol extract was separately stirred with H⁺- and Al³⁺-MMT clays at room temperature for 24 h to obtain the corresponding alkaloid-clay composites, which respectively contained 94% and 100% of the alkaloids initially present in the methanol extract, as estimated by ion-pair method. The supernatants that remained after intercalation of alkaloids into H⁺-MMT and Al³⁺-MMT showed high antioxidant activity (IC₅₀ 51 and 54 mg dm⁻³, respectively). The clays were characterized by FT-IR and XRD techniques. Alkaloid-Al³⁺-MMT and alkaloid-H⁺-MMT released more alkaloids at pH 1.2 (50% and 42%, respectively) than at pH 7.4 (12% and 11%, respectively) during 6 h. Non-alkaloid constituents appeared to contribute to the antioxidant activity of the methanol extract. The alkaloids of *H. antidysenterica* stem-bark can be directly trapped from the extracts into H⁺-MMT and Al³⁺-MMT clays.

Keywords: Alkaloids, Antioxidant, *Holarrhena antidysenterica*, Montmorillonite

REMOVAL OF EXCESS ZINC AND ALUMINIUM PRESENT IN BIOLOGICAL TREATMENT PLANT SLUDGE OF WASTEWATER TREATMENT PLANTS OF NATURAL RUBBER GLOVE DIPPING INDUSTRIES USING CHELATING AGENTS AT DIFFERENT pH VALES

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Glove manufacturing processes use zinc oxide and zinc diethyldicarbamate and pigments containing heavy metals (Cd, Cr, Pb, Ni). The wastewater contains excess Zn (up to 100 ppm) and low concentrations of heavy metals (less than 1 ppm). Wastewater treatment processes use alum. Treatment processes end up in biological treatment plants and metal ions are concentrated in the bacteria sludge (~5000 ppm of Zn, ~50,000 ppm of Al and < 1 ppm of heavy metals). Acid digestion removes them to less than maximum allowable limits. However, large amounts of corrosive acids are required to remove excess Zn and Al. The use of chelating agents, such as hydroxyethylidene diphosphonic acid (HEDP), 2-hydroxyphosphonoacetic acid (HPAA) and ethylenediamine tetraacetic acid (EDTA) at different pH conditions for Zn and Al removal from the sludge of 10000 TSS at 30 °C is described. At pH 1, and optimum treatment time of 2 h, the percentage removal of Zn and Al using HEDP, HPAA and EDTA are (91.67%, 93.84%), (53.28%, 91.25%) and (77.11%, 61.47%), respectively. At low pH, digestion of the sludge followed by removal of metal ions by complexation contributes to higher percentage removal. As pH is increased, percentage removal showed complicated behavior. Between pH 4 and 6, bio-sorption of metal ions by the bacterial sludge dominates showing negative vales for percentage removal. Around neutral and slightly basic pH, precipitation of hydroxides of metal ions on the sludge decreases the percentage removal. At high pH, dissolution of hydroxides again increases the percentage removal. As such, pH of 2 and treatment time of 2 h were used as optimum conditions with HEDP for industrial scale study.

Keywords: Acid digestion, Removal of metal ions, Biological treatment plant sludge, Natural rubber glove dipping industry, Chelating agents

ALKALOID-MONTMORILLONITE NANOCOMPOSITES OF *ZANTHOXYLUM TETRASPERMUM*: ANTIOXIDANT AND CYTOTOXIC PROPERTIES OF EXTRACTS AND COMPOSITES/RELEASED ALKALOIDS

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Montmorillonite (MMT) clay consists of expandable interlayer nanospaces (1-3 nm) in which exogenous molecules like alkaloids can be trapped. The medicinal plant *Zanthoxylum tetraspermum* Wight & Arn. has cytotoxic/anticancer and antioxidant properties and antimicrobial alkaloids. The present study focuses on the formation of alkaloid-MMT composites from stem-bark extracts of *Z. tetraspermum* and Na⁺-exchanged MMT, the releasing of alkaloids from the composites, and the determination of antioxidant and cytotoxic properties of stem-bark extracts and clay composites/released alkaloids. Dried and powdered stem-bark of *Z. tetraspermum* was extracted sequentially into n-hexane, dichloromethane, methanol and water using Soxhlet apparatus. Methanol and water extracts were separately treated with Na⁺-MMT to form clay composites which were characterized by FT-IR, XRD and SEM techniques. The alkaloids of the original extracts and in the supernatants after intercalation were quantified by ion-pair formation method. The contents of alkaloids present in methanol and aqueous extracts were 2.9% and 1.7%, respectively, and Na⁺-MMT trapped 82% and 100% of alkaloids, respectively, to furnish the corresponding composites. Each of the two composites slowly released approximately 30% of the trapped alkaloids at pH 1.2 (gastric) and pH 7.4 (intestinal) after 6 h. The released alkaloids from the clay composites displayed high antioxidant activity (IC₅₀ 10-29 ppm) in the 2,2-diphenyl-1-picrylhydrazyl radical scavenging assay; the methanol and aqueous extracts also displayed high antioxidant activity. In the brine shrimp lethality assay, the aqueous extract was non-toxic (LC₅₀ > 4000 ppm) while the methanol extract was moderately toxic (LC₅₀ 407 ppm); however, the clay composite of methanol extract was non-toxic (LC₅₀ > 4000 ppm). Na⁺-MMT can trap alkaloids from *Z. tetraspermum* extracts to furnish non-toxic alkaloid-MMT composites which can release trapped alkaloids slowly at both gastric and intestinal pH values. The alkaloids contribute to the antioxidant properties of stem-bark extracts.

Keywords: Alkaloids, Antioxidant, Cytotoxic, Montmorillonite, *Zanthoxylum tetraspermum*

**NANOHYBRID BASED ZERO-VALENT COPPER NANOPARTICLES
IMPREGNATED ACTIVATED CARBON FOR ANTIMICROBIAL
APPLICATIONS**

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In the recent past, there had been several scientific attempts to engineer metal particles impregnated-activated carbon hybrids in order to shed light on the synergistic properties arising from both materials. This study focuses on the development of a simple pathway to impregnate zero-valent Cu nanoparticles (NPs) within the graphitic layers of activated carbon derived from coconut coir (ACC). The nanohybrid containing Cu and C was synthesized following a simple one pot approach. Activation of coconut coir and impregnation of Cu NPs were carried under controlled pyrolysis. Dried coir (30 g) was soaked in CuCl₂ (0.1 M, 1 L) for 24 h, filtered, dried at 90 °C, mixed with KOH (1 M, 1 L) and boiled for 1 h. The product was separated and pyrolyzed at 450 °C for 1 h under N₂ gas and the final product was washed with distilled water until the pH of the filtrate reached 7. Powder X-ray diffraction peaks observed at 2θ of 43.33°, 50.43° and 74.06° corresponds to zero-valent Cu NPs. The peaks observed at 932.8 and 952.6 eV in the high resolution X-ray Photoelectron spectrum are attributed to the binding energies of Cu2p_{3/2} and Cu2p_{1/2} of metallic copper respectively. This confirms the formation of a zero-valent Cu NPs impregnated activated carbon nanohybrid. Cu NPs present in C matrix do not undergo further oxidation since they are trapped in nano-cavities which are present in a highly reducing environment. Transmission electron microscopic images indicated that metal particles were spherical in shape with an average diameter less than 5 nm. Antimicrobial activity was evaluated by a qualitative method; zone of inhibition against selected Gram positive (*Staphylococcus aureus*) and Gram negative (*Escherichia coli*) bacteria. Cu impregnated ACC showed higher efficiency in antimicrobial activity against both gram positive and negative bacteria compared to pure ACC. These nanohybrids therefore, have future potential applications in medical, catalytic and water purification fields.

Keywords: Antimicrobial properties, Impregnated activated carbon, Nanohybrids, Zero-valent copper nanoparticles

MODIFICATION OF THE BANDGAP OF STRONTIUM TITANATE TO HARVEST VISIBLE LIGHT

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In order to prevail over the present massive energy problem, the use of solar energy which is considered as clean and renewable can be the best option as it is the most promising alternative energy source. The key challenge in photocatalytic H₂ production is the finding of highly efficient and stable visible light active photocatalyst that can produce H₂ and O₂ under visible light irradiation. Despite their stability, high-bandgap oxides such as TiO₂, SrTiO₃ harvest only the UV region and hence not suitable as visible light active photocatalysts. In this investigation, deeply reduced SrTiO₃ was produced by using the reducing agent NaBH₄. The SrTiO₃ powder and NaBH₄ were mixed in 1:1 ratio and the mixture was sintered at 550 °C for 1 h in a tube furnace under argon saturated environment. After sintering, the sample was allowed to cool down to room temperature and washed thoroughly with distilled water to remove any remaining sodium borohydride. Finally the black-colored SrTiO₃ was dried at 100 °C under ambient conditions. SrTiO₃ photocatalyst was characterized using powder X-Ray Diffraction and FTIR. The photocatalytic experiment was carried out at room temperature and 1 atm pressure with the catalyst (1 mg per 1 ml of distilled H₂O) under the visible light irradiation. The produced hydrogen gas was measured by using Gas chromatography (SHIMADZU MODEL GC-9AM) using the TCD detector with a steel column of 12 feet in length packed with a charcoal column. When the reduced SrTiO₃ was irradiated under visible light at pH 3, the observed hydrogen production rate was 0.486 μl min⁻¹ and under UV irradiation, the hydrogen production rate was roughly two times higher than the visible light irradiation. In conclusion, SrTiO₃ was modified to produce hydrogen from pure water under visible light irradiation.

Keywords: Hydrogen, Photocatalyst, Photocatalytic water splitting, Strontium titanate, Wide band gap

CONSTRUCTION OF CARBON DIOXIDE MONITOR AND ACQUISITION OF DATA IN SOME SELECTED PLACES

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Atmospheric carbon dioxide (CO₂) is not considered as an air pollutant. However, it is responsible for the global climate change. Therefore, the concentration of CO₂ is monitored and recorded worldwide throughout the year. Though the CO₂ produced by human respiration is insignificant in open environments, it can reach harmful levels in closed spaces. It has been medically proven that the high concentration of carbon dioxide in closed environments affects the short term mental condition and human health. The importance of monitoring of carbon dioxide level in closed environments has not yet been established in Sri Lanka. However, in USA a standard for indoor carbon dioxide concentration has been set as 700 ppm. In the present study, we have constructed an electronic device to measure CO₂ concentration accurately using a non-dispersive infrared CO₂ gas sensor. Its function was also extended to simultaneously measure the ambient temperature and the relative humidity. The accuracy of the device was tested using known concentrations with an average error of 1%. The device was used to monitor the concentration of CO₂ in various closed environments such as inside passenger vehicles, laboratories, auditoriums and rooms with air-conditioning etc. Although air conditioners control the temperature and the relative humidity, it can not control the CO₂ level. The results show that the CO₂ concentration in populated places exceed the comfortable limit of 700 ppm. In most closed environments, the CO₂ concentration reached 1000 ppm level in less than 30 minutes. In some cases, the CO₂ concentration increased up to 5000 ppm creating a very uncomfortable and an unhealthy environment. Therefore, the monitoring of the carbon dioxide concentration inside closed environments is important in order to control CO₂ levels before reaching an unhealthy level.

Keywords: Carbon dioxide level, Carbon dioxide monitoring, Closed environment, Indoor air quality

LOW-COST HYDROGEN PRODUCTION USING SOLAR ENERGY

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One of the low cost solar energy conversion methods is the photoelectrochemical (PEC) splitting of water to obtain hydrogen. Hematite ($\alpha\text{-Fe}_2\text{O}_3$) is a promising material as the photoanode of PEC cells, mainly due to its favorable optical band gap of 2.2 eV, chemical stability in oxidative environments, abundance and low cost. In the present study, $\alpha\text{-Fe}_2\text{O}_3$ photoanodes were synthesized by spray pyrolysis technique and their structural and photoelectrochemical characterizations were performed. The influences of Zn, Al and Sn doping were investigated to identify the best dopant ion to improve the efficiency. Thin films were spray deposited on indium tin oxide (ITO) glass substrates by optimizing the preparative parameters to obtain uniform thin films with good adherence to the substrate. The deposited $\alpha\text{-Fe}_2\text{O}_3$ thin films showed the hematite phase with polycrystalline rhombohedral crystal structure and exhibited an *n*-type semiconductivity confirmed by anodic photocurrent generation. Optical analysis depicted the increase of direct band-gap energy with the doping concentration, which is favorable to absorb high intensity blue or green regions of the solar spectrum. The XRD peaks of $\alpha\text{-Fe}_2\text{O}_3$ with 5.0 mol% Zn and increased majority carrier concentration, confirmed the doping of Zn. The photoanode with 5.0 mol% Zn doping in $\alpha\text{-Fe}_2\text{O}_3$ exhibited the highest photocurrent response achieving a solar to hydrogen conversion efficiency of 0.86% in 13 pH NaOH electrolyte solution under 1.5 AM solar illumination. The NaOH solution of pH 13 was verified as the optimum electrolyte by testing solutions varying pH values from 11.5 to 13.5. In addition, the above photoanode demonstrated improved visible-light absorption efficiency as well as high incident photon-to-current efficiency. The tested photoanodes exhibited excellent stability and corrosion resistance in alkaline medium with a maximum hydrogen generation rate of 10 liters $\text{hr}^{-1} \text{m}^{-2}$. The flat-band potentials obtained from Mott-Schottky plots indicated that the photoanode with the highest efficiency has the maximum negative flat band potential. The tested PEC cells also provided the facility to generate oxygen as a useful byproduct.

Keywords: Hematite photoanodes, Hydrogen generation, Photoelectrochemical cell, Water splitting

ENCAPSULATION OF NITROGEN FERTILIZER UREA IN POROUS CALCIUM CARBONATE NANOPARTICLES

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Nitrogen is a critical element for plant growth. Although inorganic nitrogen compound (i.e. NH_4^+ , NO_2^- and NO_3^-) account for less than 5% of the total nitrogen in soil, they are the main form of the element absorbed by most plants. Inorganic and organic fertilizers are applied to maintain the nutritional condition of different cropping systems. For an organic agricultural system, continuous application of manure increases the nitrogen (N), phosphorus (P), potassium (K), calcium (Ca) and magnesium content in soil. Once organic fertilizers are applied to soils and mineralization begins, inorganic nitrogen is released and absorbed by plants. However, the rate of mineralization is controlled by microorganism, soil properties, temperature, and water content etc. Slow or controlled-release technology could successfully resolve these problems and avoid or reduce the loss of fertilizers and environmental pollution. As such, this research was carried out to develop an economical, easily adaptable and scalable method to encapsulate urea in calcium carbonate nanoparticles (CCNP) synthesized using our own dolomitic recourses. Synthesized CCNP are in the nano-range between 20 - 80 nm with average particle size of 38.9 nm in 90% confidence interval. Surface morphology is clarified by SEM images and it shows the porous structure of calcium carbonate nanoparticles. The FTIR spectra of urea encapsulated nanoparticles have all the bands corresponding to CaCO_3 at 3455 cm^{-1} , N-H at 1625 cm^{-1} , C=O at 1677 cm^{-1} and C-N at 1453 cm^{-1} clearly indicating the presence of urea in CCNP. EDAX spectrum clearly shows the presence of the elements Ca, O and N which is derived from CCNP and Urea.

Keywords: Calcium carbonate nanoparticles, Dolomite, Encapsulation, Slow release, Urea

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

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Artificial lakes were designed in Sri Lanka to store water from rain or to detain water from the floods. Method of breaking the lake bund that was used to release water from smaller lakes could not be applied for large lakes because large amount of water flow through the broken bund could cause destruction to the bund and canal banks. A weak point of the lake bund can be broken due to hammer effect when a direct sluice is used to release water. Therefore, ancient engineers introduced a suitable mechanism, called *Bissokotuwa* to large lakes that caused the development of a greater hydraulic civilization in Sri Lanka. This project investigates the kinetic energy (KE) loss and the pressure variation inside the *Bissokotuwa* and compare them with water channeling through a direct sluice with the aid of a scale down physical model constructed using perspex and wood, of *Bissokotuwa* in *Buwewa* lake in *Polonnaruwa*. The behavior of the *Bissokotuwa* was assumed to be unchanged in the scale down model. But there may be some effects on results due to the surface nature of the scale down model compared to a real *Bissokotuwa*. The study indicates that the outlet flow (OF) velocity is less than that of the inlet flow (IF). The pressure head inside the *Bissokotuwa* is less than that of the reservoir head. Percentage of KE loss does not depend on the reservoir head and it is about 43.5% for scale down physical model. Turbulence are observed only inside the *Bissokotuwa* and IF and OF obey *Poiseuille's law* and are laminar. The total head of IF reduces due to this occurrence of turbulence inside the *Bissokotuwa*. The study optimizes square shape to be the most suitable shape for the *Bissokotuwa* to acquire maximum KE loss.

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

**COMPARISON OF THE CATALYTIC ACTIVITY OF COBALT AND NICKEL
BASED POLYOXOMETALATES FOR WATER REDUCTION**

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Hydrogen is an excellent alternative fuel to replace fossil fuels. Water splitting is the best and environmentally friendly method to produce hydrogen. Water reduction catalysts are under extensive study, as they improve the efficiency of hydrogen production by splitting water. Classically, Nobel metals were used as water reduction catalysts but, due to their high cost and heterogeneous nature, alternative catalysts are sought. Among them, polyoxometalates (POMs) are considered as potential catalysts. Most of the original POMs used for water reduction were composed of higher transition metal elements which are comparatively expensive despite of their high efficiency. The development of POMs using earth-abundant-3d transition metals have been attracted the attention of many researches as a viable solution for the production of efficient and inexpensive water reduction catalysts. The main objective of the study reported herein was to compare the catalytic activity of nickel-based POMs (Ni₉-POM) with that of reported cobalt-based POMs (Co₉-POM) for water reduction. In this regard, both Co₉-POM and Ni₉-POM were synthesized and characterized using PXRD, FT-IR, UV-Visible, SEM imaging and EDX data. The 2θ values of the 3 prominent peaks (including the highest peak at 2θ ~10°) of the PXRD pattern for Co₉-POM are consistent with the reported data. The PXRD pattern obtained for Ni₉-POM could not be compared, as it has not been reported. The catalytic activity of both POMs was investigated through cyclic voltammetry (CV) followed by spectroscopy. The results revealed that the catalytic activity of Ni₉-POM is lower than that of reported Co₉-POM. The catalytic efficiency of Co₉-POM was 40% while that of Ni₉-POM was 10%. The turnover number (TON) of Co₉-POM is three times bigger than that of Ni₉-POM. The work reported herein revealed a significant difference in the water reduction efficiency of the POMs, when the electronic structure of the 3d-metal ion of POMs changes from d^7 [Co (II) of Co₉-POM] to d^8 [Ni (II) of Ni₉-POM]. These metal centers are reduced to their + (I) state during the process of CV. This increased catalytic efficiency of Co₉-POM may be due to the easier coordination of water molecules with the reduced Co(I) (d^8) center than that with the reduced Ni(I) (d^8) center of the POMs.

Keywords: Co₉-POM, Ni₉-POM, POMs, Water reduction catalysts, Water splitting

THE EFFECT OF CORE ARCHITECTURE ON THE LOADING CAPACITY OF DENDRIMERS

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Dendrimers are a class of polymeric material which is monodispersed, highly branched and macromolecular. Dendrimers have a well defined three-dimensional structure, with structural parameters such as generation number (G), core functionality (C_f) and core spacer (S_c) length; which can be manipulated to produce the desired structures. One potential application for dendrimers is in pharmaceuticals where the ability to entrap molecules within the dendrimer is utilized. We have used molecular dynamics computer simulations to study the effect of architectural parameters on the entrapment efficiency of dendrimers. Dendrimers with coarse grained structures were studied, varying generation ($G= 4, 5$), core coordination ($C_f= 2, 3, 6$) and core spacer length ($S_c = -(CH_2)_6-$, $-(CH_2)_{12}-$) were simulated at 300 K and 1 atm conditions. The ability for the dendrimer to entrap molecules (loading capacity) was analyzed using a unique solvent system, where dendrimer molecules overloaded with phenol molecules were simulated within a water solvent box. A reservoir of phenol was also kept adjacent to the water to allow saturation of the water with phenol. With time the overloaded phenol diffuses out of the dendrimer, and we extrapolate this behaviour to obtain the equilibrium loading capacity. Loading capacity results show that the loading capacity has increased with the increase of core-spacer length and decreased with the increase of generation number and core coordination. The results may have important implications in the future design and synthesis of novel dendrimers for drug delivery.

Keywords: Core spacer length, Core coordination, Dendrimers, Drug loading, Generation

MIXING VEGETABLE OILS WITH LUBRICANT OIL FOR AUTOMOBILES AS A COST REDUCTION METHOD

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Lubricant oils are used for the engines of automobiles or any other machine to get the best performance and also for the durability and for the protection. When an engine is running, lubricants help to cool down and to reduce the corrosion of its metal components and reduce the friction between the moving parts. Vegetable oils such as olive oil, palm oil and castor oil are used for the lubrication of rough machinery vehicles and bearings and lubrication of delicate instruments like watches, clocks. This study investigates the possibility of blending mineral oil with coconut oil or palm oil at different compositions (% v/v) to the viscosity requirement of commercial lubricant. A blend that meets the viscosity requirement was then chosen for physical and chemical property characterization. The properties evaluated include viscosity, density, specific heat capacity, acid number, flash point and interactions between different types of molecules were characterized using *FTIR* spectroscopy. The viscosity, density and sulfur concentration of 10% palm oil + 90% mineral oil composition are similar to those values of SAE 20, commercially available lubricant oil. For this same composition specific heat capacity, acid number (acidity) and flash point have better values than SAE 20 lubricant oil. However, 30% (v/v) coconut oil + 70% mineral oil composition has the similar values of soot, nitration, water, glycol, diesel and gasoline concentrations as the lubricant oil. For low viscosity lubricant oil required engines, 30% (v/v) palm oil composition can be used. The reduction of the cost for 10% (v/v) palm oil composition and 30% (v/v) palm oil composition are about 85 LKR - 250 LKR per liter respectively. These alternatives can be used as suitable low cost substitutes to lubricant oils in engines of automobiles.

Keywords: Lubricant oil, Oil composition, Viscosity

**DETERMINATION OF THERMAL NEUTRON FLUX AND THERMAL TO
EPITHERMAL NEUTRON FLUX RATIO
OF THE Am-Be NEUTRON SOURCE**

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The Americium Beryllium neutron source with an initial activity of 10 Ci installed in 1991 at the Department of Physics, University of Peradeniya is used for identifying trace elements in a specimen by Neutron Activation Analysis (NAA). During NAA, a specimen with unknown trace elements is irradiated with neutrons and the radiation emitted from the compound nucleus is analyzed using radiation detectors. The success of this analysis depends on the total flux emitted by the neutron source. Hence this study was aimed to determine the thermal and epithermal neutron flux of the Am-Be source after about twenty-seven years of installation. This was the first time that the epithermal flux of the source was measured since the source was considered as a thermal neutron source for the previous studies. The flux of the source was estimated to be 2.43×10^7 neutrons $\text{m}^{-2} \text{s}^{-1}$ in 2016 and 3.74×10^7 neutrons $\text{m}^{-2} \text{s}^{-1}$ in 2014. Since the absorption cross-section of Cd is very low for epithermal neutrons and high for thermal neutrons, Cd difference method is used to separate the thermal and the epithermal fluxes of the source. Using bare and Cd covered Cu foils, it was found that the values for the thermal flux, and f parameter (the ratio between thermal flux and epithermal flux) using bare and Cd covered Cu foils are 2.34×10^7 neutrons $\text{m}^{-2} \text{s}^{-1}$, and 7.34 respectively. It could be deduced that Cd is a better neutron shielding material than Cu. The flux reduction by 1 mm thick Cd shielding was 74.11% while the flux reduction by the same thickness of Cu shielding was 29.64%. From the results obtained it can be concluded that the Am-Be neutron source can be used as a thermal neutron source since the f parameter is high. Knowing these parameters is useful in the planning of sample irradiation for further analysis.

Keywords: Epithermal neutron flux, Foil activation, Neutron activation analysis, Thermal neutron flux

REMOVAL OF Cd²⁺ FROM DRINKING WATER USING MgO NANO PARTICLES AND DESIGNING A WATER FILTER

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Environmental contaminants with heavy metal ions have been a potential threat to humans and animals due to their ability of bio-accumulation. These contaminants are of anthropogenic and/or industrial origins or due to natural disasters. In this study nano magnesium oxide (MgO) was prepared using MgCl₂ (3.074 mol dm⁻³) solution, calcined dolomite and hexadecyltrimethylammonium chloride (CTAT) surfactant to use as heavy metal adsorbent. Prepared nano MgO shows a wire like morphology under scanning electron microscope (SEM) with width less than 200 nm. The X-ray diffraction (XRD) pattern of nano-MgO shows XRD peaks at 2 θ values of 36.94° and 42.89° characteristic of MgO. The MgO nano-wires were used for the removal of Cd²⁺ from aqueous solutions. Over 96% removal of Cd²⁺ was achieved with 6 mg of MgO nano-wires from 1510 ppb Cd²⁺ solution while 100% removal from 675 ppb Cd²⁺ solution.

Keywords: Cd²⁺ removal from water, Heavy metal Adsorption, Magnesium oxide nano-wires, Nano-magnesium oxide

**DOSIMETRY ON ¹³¹I TREATMENT AT THE NUCLEAR MEDICINE UNIT OF
UNIVERSITY OF PERADENIYA**

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In general, thyroid cancer therapy consists of total or near total thyroidectomy followed by radiation treatment by the administration of radioactive Iodine (¹³¹I). Patients receiving radioiodine are potentially a significant source of radiation, emitting γ radiation to the medical personnel, care givers and members of general public. The aims of this study were to measure the radiation dose rate emitted from the ¹³¹I treated outpatients at the Nuclear Medicine Unit (NMU) of the University of Peradeniya, Sri Lanka and to compare the results with the radiation dose rate limits established in other countries. For the study, a total number of 40 post thyroidectomy patients including 7 men and 33 women were partaken. All of them were treated with an average activity of 30 mCi at the NMU to ablate residual thyroid tissues. The dose rate emitted at 1.0 m distance from the neck and abdomen area after 1 hour, 2 hours and 96 hours were measured. The international regulatory body, Nuclear Regulatory Commission (NRC), has imposed regulations to the therapy procedure using ¹³¹I, based on the activity administered. Accordingly, patients administered with a maximum activity of 50 mCi or when the dose rate emitted from the patients is less than 50 $\mu\text{Sv h}^{-1}$, the patient can be discharged from the hospital. However, Sri Lankan regulations follow activity-based limit of 30 mCi as the maximum dose administered for outpatients or the limit for discharging isolated patients from hospital. From this study, the average dose rate of the outpatients at releasing was found to be 50.01 $\mu\text{Sv h}^{-1}$. When compared to dose rate regulations followed by the other countries such as Japan, USA, Australia, China, Pakistan, Oman, and European countries, the obtained dose rate values were moderately high, and hence need some precautionary measures to protect the care givers and the general public. In order to minimize the radiation exposure by these therapy patients, either the patients can be kept in isolation for some time or a collar madeup of a shielding material can be introduced to cover the neck part, at least for few days.

Keywords: ¹³¹I therapy, Nuclear medicine, Radiation exposure, Thyroid cancer

**A NEW APPROACH TO DETERMINE THE DEAD TIME OF A GEIGER
MÜLLER COUNTER**

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Geiger Müller (GM) counter is used in nuclear and radiation industries to detect ionizing radiation. GM counter is a gas filled detector which relies upon avalanche multiplication of ionizing events due to radiation. Due to simplicity, high stability, portability, low cost and ease of operation, GM counters are continued to be used in present time in various nuclear and radiation related fields. However, the true count rate of the ionizing events is lost due to the successive radiation disintegrations which occur during the dead time (DT) of the GM counter. Dead time (DT) is defined as the time interval in which the detector is insensitive to the incoming radiation. Accurate estimation of the DT is vital in determining the radiation field. Two theoretical models were used to study the behaviour of the DT of a GM counter, namely; paralyzable and nonparalyzable models. In this study these models were further developed using the principle of radiation attenuation. Data were collected by attenuating the radiation through Al shields. The variation of count rate with respect to the thickness of the shield was derived. These data were then subjected to the two idealistic models and graphical expressions of the two models were separately obtained for the same set of data. Through graphical analysis, the data points which aligns more close to a straight line was chosen as the best model which is closer to the real system. Further, it was found that for lower radiation count rates both models were closer to the real system. For a GM counter under room temperature working at operating voltage of 840 V, the DT was found as 35.3 ms.

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

ELECTROSPUN POLY (VINYL ALCOHOL) NANOFIBER MATS LOADED WITH *TERMINALIA CHEBULA* FRUIT EXTRACT – PREPARATION, CHARACTERIZATION AND ANTIMICROBIAL ACTIVITY

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Electrospinning is a simple technology to produce nanofibers with unique properties such as high surface-area-to-volume ratio, high porosity, and mechanical flexibility. Antimicrobial electrospun nanofibers are leading towards greater attention due to their wide range of applications in the medical and health care sectors. They are commonly produced by incorporating antimicrobial compounds to the polymer solutions prior to electrospinning or post-functionalization. This study was conducted to investigate the antimicrobial activity of Poly (Vinyl Alcohol) (PVA) electrospun nanofiber mats loaded with *Terminalia Chebula* (TC) fruit extract. PVA nanofiber mats loaded with *T. Chebula* extract (PVA/TC) were successfully fabricated by electrospinning for the first time. *T. Chebula* crude extracts at different loading amounts (1%, 5%, 10% based on the weight of PVA (w/w)) were dissolved in the PVA solutions (10% (w/v) in distilled water) before electrospinning. Accordingly, the prepared solutions were electrospun by using the electrospinning machine under a fixed electric field of 20 kV and with a working distance of 15 cm. The feed rate was adjusted to 0.13 $\mu\text{l s}^{-1}$ and 18 Gauge needles were used. The average diameters of smooth fibers of PVA only and PVA/TC 1% were observed as 245 nm and 215 nm, respectively. The FTIR spectroscopy confirmed the presence of *T. Chebula* extracts in PVA nanofibers by the identification of functional groups in the active compounds. The crystallinity decreased for PVA/TC 1% compared to PVA without TC nanofiber mat. The average zone of inhibitions (ZOI) observed for PVA/TC solutions (1%, 5%, 10%) were 9 mm, 10 mm, and 11.5 mm respectively against gram-positive *Staphylococcus Aureus*. It is clear that the increase of *T. Chebula* concentration strongly inhibits gram-positive *S. Aureus*.

Keywords: Antimicrobial, Electrospinning, Nanofibers, Terminalia Chebula

ACTIVATED CARBON BASED COMPOSITE ELECTRODES SUITABLE FOR SUPERCAPACITORS

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Supercapacitors (SC) are used as high power density energy storage devices in many applications. Supercapacitor electrodes are made from very high specific surface area materials. Using porous electrodes, the effective surface area of the interface can be increased. Thin aluminum foils of thickness 10 μm were used as electrical contacts and slurry of the activated carbon, MnO_2 or mixture of them was deposited on the metal foil either using doctor blade or spraying method. A non-woven Vildon separator was sandwiched between two such electrodes and it was soaked in the liquid electrolytes. SCs with organic solvents have higher decomposition potential up to 2.8 V compared to aqueous electrolytes with a stability limit of 1.23 V, which has also been verified for composite activated carbon electrode materials. Similar or dissimilar electrodes were tested in different aqueous and non-aqueous electrolyte media. All the measurements were carried out at room temperature. The results ranged in the standard levels of the high decomposition potential stability limit for each electrolyte used. Complex impedance was measured from LabPro 991 for the assembled supercapacitors. The straight line of complex impedance plot gives the evidence of non-reacting interfacial activity. The cyclic voltammogrammes verified the chemical stability of the cell within the charge-discharge limits between +1.0 V to -1.0 V in aqueous KOH solution and +3.0 V to -3.0 V in ethylene carbonate and propylene carbonate with LiClO_4 . The maximum capacitance of 1.12 F cm^{-2} was obtained for activated carbon and KOH supercapacitor. Also the investigation showed that the coconut-charcoal based activated carbon can be effectively modified by adding MnO_2 . The dissolved MnO_2 particles are deposited and distributed on the high surface area of activated carbon and the multivalency nature of manganese ion facilitates the storage of extra charges in the electrodes of the supercapacitors.

Keywords: Activated carbon, Electric double layer, Manganese dioxide, Organic electrolyte, Supercapacitor

PRESSURE DEPENDENCE OF ELECTRICAL CONDUCTIVITY OF CARBON POLYMER COMPOSITES

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Electronically conducting polymers are used in flexible electronic devices. The composite materials based on a polymer and conducting particles are easy to manufacture and cheap. The aim of the research was to prepare a low cost, electronically conducting polymer composite material. The research was focused to investigate the suitable types of carbon and polymer materials, appropriate techniques of pulverizing, effect of particle size and preparation methods of composites. Variations of electrical conductivity with the content of carbon filler and applied pressure were studied. Carbon black, activated carbon, graphite and graphene were tested as different types of carbon and poly(ethylene oxide), poly(vinylidene fluoride) and polyisoprene were used as polymers. In order to prepare composite samples, different amounts of carbon fillers and polymers were dissolved in toluene or acetonitrile to obtain a viscous homogeneous mixture. The mixture was poured on to a teflon mould and dried under vacuum to get a thin membrane of polymer carbon composites. These membranes were cut into thin circular films and sandwiched between stainless steel electrodes for conductivity measurements. Then, AC impedance and DC resistance were measured as a function of concentration or pressure. All the composites have shown a very large abrupt change in conductivity at different concentration of carbon filler showing percolation threshold. The result confirms that polymer composites with reversible and stable physical properties can be prepared using small carbon particles. The critical point at which the conductivity variation occurs can be varied by changing the type of polymer, the type of carbon and size of carbon particles. The conductivity variation in changing concentration and pressure is in the order of 10^3 - 10^5 S cm⁻¹. The best polymer is polyisoprene and the best carbon material is carbon black. The abrupt change in conductivity with applied pressure of carbon-polymer composites is a new discovery and can be used for pressure sensitive applications.

Keywords: Conducting polymer, Percolation threshold, Polyisoprene, Polymer carbon composite, Pressure dependent conductivity

DEVELOPMENT OF ELECTROSPUN PVdF-HFP/PEO BLEND POLYMER MEMBRANE ELECTROLYTE FOR DYE SENSITIZED SOLAR CELLS

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The electrolyte is an important component in the fabrication of dye-sensitized solar cell (DSSC), which plays a significant role in the reduction of the oxidized dye by the reduced species of a redox couple and assists the charge transfer mechanism. In this work, a novel polymer blend electrolyte has been prepared using electrospun poly(vinylidene fluoride-co-hexafluoropropylene) (PVdF-HFP) and poly(ethylene oxide) (PEO). Electrospun blend polymer membranes were immersed in a liquid electrolyte made with tetrapropylammonium iodide (Pr₄NI), 1-butyl-3-methylimidazolium iodide (BMII) and iodine (I₂) dissolved in propylene carbonate (PC). SEM images of the electrolyte membrane showed the formation of a 3-D network of blend polymer fibers. The DSSCs fabricated with this gel electrolyte were characterized by photocurrent-voltage and Electrochemical Impedance Spectroscopy (EIS) and compared with the conventional gel and liquid electrolytes. The ionic conductivities were measured for these three types of electrolytes. The PVdF-HFP/PEO blend polymer membrane electrolyte showed an ionic conductivity of $8.50 \times 10^{-3} \text{ S cm}^{-1}$. The DSSCs fabricated with electrospun blend polymer membrane-based gel electrolyte showed an energy conversion efficiency of 8.58 %, under the solar illumination of 100 mW cm^{-2} , whereas the efficiency of the DSSC made with the liquid electrolyte-based cell was 8.82 % and DSSC made up with conventional gel electrolyte-based cell was 8.17 %. EIS spectra show the intermediate charge transport resistances for electrospun membrane gel electrolyte. This study shows the possibility of replacing the liquid electrolyte in DSSCs by electrospun blend polymer membrane-based gel electrolyte and thereby minimizing some of the major drawbacks associated with liquid electrolyte based solar cells while maintaining an efficiency close to liquid electrolyte based cells.

Keywords: Blend polymer membrane, Dye-sensitized solar cell, Electrolyte, Electrospun membrane

EXPLORATION OF THE EXISTING STATUS OF THE SCHOOL BASED ASSESSMENT SYSTEM IN G.C.E. ADVANCED LEVEL CHEMISTRY

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It is an utmost requirement to practice a new School Based Assessment (SBA) system as it can play the key role in evaluation of teaching-learning process. This study is mainly based on the views and practices of teachers and students on how the SBA system is conducted in the schools and how it benefits to the students in G.C.E. (A/L) examination. Main objectives were to analyze the nature of existing SBA and to identify the drawbacks of the current SBA system of Sri Lanka. Quantitative data have been collected from the evaluation reports of G.C.E. (A/L) examination published by the Department of Examinations from 2012 to 2015 and questionnaires given to 356 students of seven provinces from two schools of each province and 170 teachers from nine provinces. Data collected from the Evaluation Reports were analyzed through five streams in chemistry: Inorganic, Organic, Physical, General and Industrial & Environmental by taking the ten lowest facility indices. It was found that the total number of candidates have increased continuously (54217- 79174) while the total pass rate has increased from 60.93% to 65.92%. The alarming outcome was more than 50% of the total candidates have scored 40 or below to the chemistry paper. According to the findings, the conceptual development, practical knowledge and analyzing ability of students are required for physical chemistry. Teachers and students who participated in the survey have identified the worthiness of SBA (75%). Most of them (67%) had suggested that this system required a student and teacher friendly change. Teachers require more guidance from higher authorities, proper training and well organized assessments. According to the student point of view they (60%) require more help from teachers to comprehend the subject matter with reliable assessments and marking system.

Keywords: G.C.E (A/L) examination, Chemistry, Practical knowledge, School Based Assessment (SBA)

**A CASE STUDY OF STUDENT-CENTRED CHEMICAL LABORATORY
ACTIVITIES FOR GRADE 11 STUDENTS' CHEMISTRY LEARNING IN
VAVUNIYA DISTRICT**

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Laboratory activities for Grade 11 are essential components of science teaching and learning with the aim of developing students' scientific knowledge and concepts of science. The purpose of this study is to reveal the effect of student-centred laboratory activities of Grade 11 students' on chemistry learning. This was an experimental research with mixed methods. As the sample, 158 students (61 from 1AB, 51 from 1C and 46 from Type II schools) were selected from Grade 11 in Vavuniya district using purposive sampling technique. The students of each school were divided separately into two groups as 'experimental' (83) and 'control' (75) based on their term test marks. Day-to-day regular procedure was carried out for the control group. Student-centred practical manual consists of six approaches such as pre-lab test, engaging activity, step-wise guidance, recording sheet, assessment and an activity on day-to-day applications for three chemistry lessons (Grade 11 syllabus) was developed and used for the experimental group. The approaches of pre-lab test and assessment in the practical manual were considered as pre-test and post-test for experimental group respectively. The achievement test was given to both groups at the end of the study. During the implementation of laboratory activities, qualitative data were collected through photographs, videos, field notes, students' reflections and semi-structured interviews. For the control group, the field notes were taken as unobtrusive participation. In the paired t-test analysis of pre-lab test and assessment, p-values for 1AB, 1C and Type II schools were 0.001, 0.000, 0.000, 0.003, 0.012, 0.006, 0.000, 0.000, and 0.032 for lesson 1, 2 and 3 respectively. Thus, the results indicate that a significant achievement of subject knowledge through student centred laboratory activities. The independent t-test analysis of the achievement test results of experimental and control groups and qualitative data analysis confirm the above finding with the development of students' achievement and positive attitudes towards chemistry learning. Although the teacher faces some impediments in organizing of practical work in the student-centered manner, this approach will bring fruitful outcomes among the students through understanding of chemistry concept with positive attitudes in learning chemistry.

Keywords: Chemistry learning, Grade 11, Student-centred, Chemical laboratory

FACTORS AFFECTING STUDENTS' LOWER ENROLMENT IN G.C.E. ADVANCED LEVEL SCIENCE STREAM: A CASE STUDY IN KULIYAPITIYA EDUCATION ZONE

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This case study was designed to explore factors affecting students' low enrolment in G.C.E. Advanced Level science stream. A mixed methods approach was employed, and the data collection and analysis were performed according to the concurrent triangulation design. The study was undertaken in five purposely selected mixed schools in the Kuliypitiya Education Zone, and the sample was consisted of science stream students (100), non-science stream students (100) and science teachers (15). The quantitative data were collected using survey questionnaires and were analyzed using MS Excel while the qualitative data were obtained from semi structured interviews and were analyzed using thematic analysis technique. The results revealed that students select science stream based on their interest, their ability to learn science, to acquire higher education opportunities, to find good career opportunities, and to seek foreign job opportunities. It was also revealed that the students' poor interest in science, poor results for science and mathematics in ordinary level examination, lack of knowledge about higher education opportunities, lack of knowledge about career opportunities, lack of qualified teachers and school facilities, as reasons for not selecting science stream. The results further revealed that the extensive curriculum but insufficient time allocation for learning, and poor self- concepts, motivation and aspirations of students are also factors which influence students' decision making for not selecting science stream. The study recommends that the authorities should take necessary measures to overcome this issue.

Keywords: Lower enrolment, Motivation, Science stream, Self-concepts, Students' perception

**GUIDING THREE SELECTED STUDENTS OF GRADE SIX TO SOLVE
STATEMENTS BASED MATHEMATICAL PROBLEMS**

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Mathematics is a methodical application of logical reasoning. Thus, the subject will be very much useful and important for solving problems. Hence, there is a big role to play for mathematics education in the school curriculum. However, students' G.C.E. (O/L) mathematics results are not very satisfactory. Incapacitation of students to solve the mathematical problems through statements can be one of the the main reasons. To remedy the above situation this study was conducted to examine Grade 6 students in a school of Kuliypitiya Zone. The aim of this study was to bring up the performance of students who failed to solve the mathematical problems with detailed statements. This study was carried out as an action research and mixed methods approach was used in the data collection. Sample consisted of three Grade 6 students who have been selected through a pre-test. These students have been driven to the target in two stages. In the stage one their reading ability was improved and in the stage two easy methods were introduced to solve the problems in four steps. During this exercise, a test was conducted in every stage in order to assess their achievement levels. Reflective journals, observation sheets, interviews, and question papers were used to collect data. The results revealed that the students' performance has increased to a higher level through the above intervention. Thus, it could be clearly highlighted that the individual attention for the students is highly useful and helpful in learning mathematics concepts meaningfully.

Keywords: Easy methods, Individual consideration, Mathematics problems solving

**APPLICATION OF COMPUTER ASSISTED LEARNING MATERIAL IN A
SELECTED TOPIC OF G.C.E. ADVANCED LEVEL PHYSICS: A CASE STUDY
IN GIRIULLA ZONE**

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Science subjects contribute massively for economic development of the individuals in the society. Physics is one of the most interesting subjects where many instruments and technical equipment are related with. Sri Lankan government reserves a large allocation of funds for a fruitful physics education with modern technology expecting successful results. However, during the past 13 years of education, students' G.C.E. (A/L) physics results were not up to the expected levels. This is evident by the National Education report and other achievement test results of G.C.E. (A/L) students. Hence, in order to support the learners new technological systems and applications could be used. Thus, this study was aimed at investigating the use of Computer Assisted Learning (CAL) to enhance students' level of achievements in physics. This is a mixed methods study where both quantitative and qualitative approaches were used. Prepared new CAL material on electronic spectrum was used in the teaching and learning process with Grade 12 students. CAL material consisted text, graphic, audio, animation and video with hypertext facility. A sample of 40 students in physical and biological sciences was selected with the equal number of boys and girls. The data were collected using observations and interview schedules along with other assessing exercises. Quantitative data were analyzed using Ms-excel and qualitative data were subjected to thematic analysis. Results from Quantitative data analysis revealed that students' performance on the selected topic has been enhanced through new CAL material. Moreover, it was found that students like very much the new CAL material in the learning process with higher motivation. Thus, the present classroom practices in teaching physics need to be reconsidered with the aim of facilitating students for a meaningful learning to achieve the national goals.

Keywords: CAL material, G.C.E. (A/L), Performance, Physics, Technology

**SCIENCE PERFORMANCE OF INDIGENOUS STUDENTS AND THEIR
NON-INDIGENOUS COUNTERPARTS IN MAHIYANGANAYA EDUCATION
ZONE IN SRI LANKA**

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Veddas represent a group of indigenous people in Sri Lanka. Their children attend schools with non-indigenous students and follow the national curriculum including science. However, there is paucity in research on their performance in science. This quantitative study compares science performance of secondary level indigenous students and their non-indigenous counterparts in two secondary schools (1C and 1AB) in Mahiyanganaya Zone of Education. In order to achieve this objective, the science marks of indigenous students and their non-indigenous counterparts in above schools were compared. Their interests and attitudes towards science and the support they get from teachers and families were also explored using a questionnaire survey (surveyed a total of 27 and 114 indigenous students and non-indigenous counterparts, respectively). All indigenous students (identified by their surnames e.g. Uru Warige) and their non-indigenous counterparts (a total of 30 and 339 students, respectively) who sat for science term tests during 2018 were sampled (Grade 6 to 11). Science term test marks were compared grade-wise, school-wise and between two schools by Mann-Whitney U test with SPSS. Science performances between indigenous students and their non-indigenous counterparts in 1C school and 1AB school, indigenous students in 1C school and 1AB school, and non-indigenous counterparts in 1C school and 1AB school were not significantly different ($p > 0.05$, e.g. $U = 850.000$) except in third term between non-indigenous counterparts in 1C school and 1AB school. Survey depicts science is a favourite subject of the indigenous students and their non-indigenous counterparts. They have also identified science as an important subject for their day-to-day life. Moreover, their science education is supported and encouraged by school teachers and family members. Relatively similar interests, and attitudes of indigenous students and their non-indigenous counterparts on science and the support they get from teachers and families towards science education could be the reasons for the insignificant difference in their science performance. However, a qualitative approach can be adopted to understand the factors affecting science performance of indigenous students further.

Financial assistance from University of Peradeniya, Sri Lanka (Grant No: URG/2018/45/S) is acknowledged.

Keywords: Indigenous, Performance, Science, Term test

EFFECTIVENESS OF TEACHING ALIPHATIC HYDROCARBONS IN G.C.E. (A/L) CHEMISTRY THROUGH COMPUTER ASSISTED LEARNING TOOLS

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The competency of students in science, particularly units which involve abstract concepts is lacking. Computer assisted learning (CAL) is widely considered a supplemental tool which could aid in the teaching-learning process. This study was focused on the G.C.E. (A/L) Chemistry units related to Aliphatic Hydrocarbons to explore the effectiveness of teaching these units with CAL tools. A qualitative, quasi experimental method was used, sampling 120 students. Two 1AB schools offering G.C.E. (A/L) science and having computer facilities in Embilipitiya educational zone were purposively chosen. Initially, a pre-test was administered to separate selected students into control and experimental groups, such that statistical analysis shows no significant difference in the performance of the experimental (mean, $\mu = 81.12\%$, standard deviation, $\sigma^2 = 4.264$) and control group ($\mu = 82.36\%$, $\sigma^2 = 4.061$), according to independent sample t-test ($p = 0.585$). Thereafter, the experimental group (60 students) was taught using CAL tools while the control group (60 of students) was taught without any special access to CAL materials. The CAL tools used included multimedia presentations, visualization software and animations. After the lessons were completed, students in both groups were subject to a post-test. Results showed a significant difference ($p = 0.00$) in the post-test performance of the experimental group ($\mu = 94.48\%$, $\sigma^2 = 1.501$) and control group ($\mu = 71.28\%$, $\sigma^2 = 1.612$). Pre-test and post-test performance of experimental group ($r = 0.825$, $n = 60$, $p = 0.000$) and control group ($r = 0.944$, $n = 60$, $p = 0.000$) are separately positive correlated at a 0.01 level. Thus, it can be concluded that, for the given units of G.C.E. (A/L) chemistry, utilizing CAL tools could be an effective teaching and learning method compared to traditional methods.

Keywords: Chemistry learning, Computer assisted learning, Secondary education

USE OF A PRACTICAL COMPONENT TO IMPROVE STUDENTS' BASIC SCIENCE PROCESS SKILLS

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The purpose of this research is to show that the Grade 6 students' Basic Science Process Skills (BSPS) can be improved within a short period of time using specially designed activities to formulate strategies to enhance science education. The quasi-experimental quantitative method was used for this study. The sample consisted of 60 Grade six students in one IAB School (Thirty students in each experimental and control groups). The purposive sampling method was used to select the sample. Specially designed 17 activities for BSPS were introduced to the experimental group within two weeks and both groups were given the same Basic Science Process Skills Tests (BSPST) as pre-tests and post-tests while none of the special activities were given to the control group. The independent variable was the time that students undergo activities to develop BSPS and the dependent variable was scores for the BSPST. T-tests were used to analyze the data using SPSS statistical software. The paired sample t-test results for the experimental group showed that there was a significant difference in BSPST scores of pre-test ($M = 22.83$, $SD = 9.3$) and post-test ($M = 34.40$, $SD = 12.76$). However, there was no significant difference between pre-test ($M = 22.73$, $SD = 10.17$) and post-test ($M = 23.40$, $SD = 11.08$) marks for the control group. There were significant differences between pre-test and post-test marks for every six skills in the experimental group. According to the results it can be concluded that a specially designed practical component can be used to develop students' BSPS within a short period of time.

Keywords: Basic science process skills, Practical component, Science education

**TEACHERS' VIEWS ON TEACHING-LEARNING PROCESS OF G.C.E. (A/L)
BIOSYSTEMS TECHNOLOGY IN KANDY DISTRICT**

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In Sri Lanka, Technology is a newly introduced subject stream for General Certificate of Education (G.C.E) Advanced Level (A/L) which was introduced in 2013. Biosystems Technology (BST) is one of the main compulsory subjects in the Technology stream. This study was designed to find out the views of teachers on the teaching-learning process on BST to explore their suggestions to improve the practices. In sampling, Kandy District was divided into six strata. In each stratum the sample consisted of 50% schools which were implemented Technology stream. All the teachers (n = 12) in those schools were included in the study. Convergent parallel mixed method which comes under mixed methods design was used in the research study. Cross sectional survey design was used to collect quantitative data. A questionnaire and semi-structured interview schedules were used as data collection instruments. Data were analyzed using MS Excel. All teachers in the sample were educationally qualified to teach BST. Approximately 50% of teachers had more than five years of teaching experience and about 92 % had more than one year experience in teaching BST. Teachers expressed that students were actively participated in lessons asking questions during the lesson time. Furthermore they responded that the students were not completing their home work on time. It was further revealed that although students were actively participating in practical work, they did not discuss issues and complete their practical reports. Results also showed that some schools (20.1%) do not have sufficient laboratory facilities and equipment to conduct practical classes. Students' involvement in learning theoretical knowledge and doing practical is at satisfactory level. However, recording practicals is not satisfactory. Thus, students should be supported to complete their practical recording properly to enhance meaningful learning.

Keywords: Biosystems Technology, G.C.E. (A/L), Learning, Teaching

LEARNING SCIENCE IN BILINGUAL MODE: TRENDS AND ISSUES IN MONARAGALA DISTRICT

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The aim of this research was to explore the trends and issues of teaching and learning of science as a bilingual subject in schools in Monaragala district. Specific objectives were to explore the present status of learning science in bilingual mode (BM), to investigate the student's perception toward learning science, to identify problems teachers encountered in teaching in BM and to find out suggestions to enhance teaching and learning science in BM. This is a mixed methods study and used the concurrent triangular design. The sample consisted of purposively selected 120 students from six schools in Monaragala and one science teacher from each school. A data sheet, and a questionnaire were used to collect quantitative data and an interview was conducted with teachers to collect qualitative data. Quantitative data were analyzed using MS Excel and qualitative data were analyzed using thematic analysis technique. According to the findings, in Monaragala only 9 schools offered bilingual education in 2010 and it has been increased to 19 by 2017. The number of students following science in BM increased from 900 (in 2010) to 2320 (2017). The percentage of passing rate of science in O/L examination were 95%, 88%, 96%, 100%, 93%, 97% and 92% respectively from the year 2010 to 2016 and it was 100% in 2017. According G.C.E.O/L results in 2017, there were 36% of "A" passes, 30% of "B" passes, 24% of "C" passes and 11% of "S" Passes and there was not any week passes. Quantitative results show that 114 students selected BM based on their choice, and they thought BM is important for their higher education and to improve English proficiency. Teachers thought teaching science in BM is a challenge; they satisfied about the school community support and provided suggestions to enhance BM in Monaragala district.

Keywords: Trends, Learn, Science, Bilingual mode, Monaragala

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AUTHOR INDEX

A

Abayasekara, C.L.	77, 113, 123
Abeywardena, M.	108
Abhayawickrame, A.S.M.C.D.	61
Adassooriya, N.M.	74, 137
Alles, N.	117
Alukumbura, D.W.G.A.S.	101
Alwis, S.M.D.A.U.D.	22
Amarasekara, M.G.T.S.	11
Amarasinghe, A.A.D.R.G.	57
Amaratunga, H.P.	7
Anand, S.	12
Ananda, N.D.J.L.	120
Appuhamy, P.A.D.A.N.	49
Arachchi, S.P.K.	68
Ariyaratna, H.A.C.K.	81,98
Ariyaratne, S.N.H.	72
Athapaththu, A.H.L.C.M.	9
Athapaththu, A.M.M.H.	94, 95, 97
Athapaththu, I.S.B.	110
Athukorala, N.	89
Athukorala, S.N.P.	113
Attanayake, A.	100
Attanayake, R.N.	118

B

Balasooriya, B.A.A.R.	134
Balasooriya, S.	7
Bandara, A.C.	77
Bandara, A.M.D.	56
Bandara, A.M.R.S.	146
Bandara, B.M.R.	76, 78, 79, 120, 121, 123
Bandara, G.G.H.M.H.S.	148
Bandara, J.	125
Bandara, K.M.E.N.	61
Bandara, L.R.A.K.	132
Bandara, N.C.	76, 78, 79, 120, 121, 123

Bandara, W.M.A.T.	20, 141
Bandaranayake, P.W.S.K.	126, 127, 138, 139
Benjamin, S.P.	89
Bopearachchi, D.P.	89
Boyagoda, W.A.L.S.	43, 61

C

Chandana, G.A.D.	110
Chandrajith, R.	7, 12, 15, 23
Chandrasena, W.D.	144, 145
Chandrasiri, M.K.D.C.K.	43
Chandresene, P.G.S.M.	81
Charles, E.Y.A.	45, 55
Chathuranga, W.G.D.	106
Chathurani, K.A.T.	55
Chinthaka, S.D.M.	8
Cooray, A.	85
Cooray, R.	80
Costa, A.Y.D.	61

D

Damunupola, J.W.	78
Daundasekara, W.B.	54, 59
Dehigama, D.G.S.D.	34, 38, 47
Devaisy, S.	13, 25
Dhananjaya, K.D.E.	34, 38
Dhanapala, M.P.C.S.	101
Dharmabandu, N.	53
Dharmadasa, R.M.	75
Dheerasekera, O.	87
Dilakshana, K.	76
Dilrukshi, A.M.A.E.	74
Dissanayaka, D.M.N.K.	67
Dissanayake, D.C.T.	16
Dissanayake, D.M.C.P.	22
Dissanayake, D.M.T.B.	34, 38, 47
Dissanayake, M.A.K.L.	119, 140
Dissanayake, Y.	80
Diyabalanage, S.	7

Dunuweera, S.P. 128

E

Edirisooriya, E.M.A.S. 127
Ekanayake, A. 76
Ekanayake, E.M.A.P.B. 20
Ekanayake, E.M.P. 49
Ekanayake, E.M.U.S.B. 59
Ekanayake, T.M.S.S.K.Y. 141, 142, 143,
146, 150

F

Fernando, P.S. 111

G

Gajanayake, G.K.S.N. 98
Galagoda, C.P. 30
Gamagedara, T.P. 43
Ganegoda, G.S.S. 8
Ganehenege, M.Y.U. 130
Geekiyana, D.M. 57
Ghouse, M.B.A. 50
Gunarathne, S. 105
Gunaratne, A.M.T.A. 103
Gunasekara, T.M.V.D. 42
Gunathilaka, U.G.S.A. 92
Gunathilaka, U.M.T.M. 109
Gunathilake, W.S.S. 21
Gunawardana, G.A. 110
Gunawardana, G.D.N. 121
Gunawardane, P.H.S.A. 57

H

Haider, L. 12
Halpegama, J.U. 14
Hamna, N. 58
Hansika, G.K.S. 67
Hathurusinghe, H.D.K.D. 144
Herath, A.C. 14
Herath, H.M.S.B. 88
Herath, H.M.S.S. 10
Hettiarachchi, C.V. 27, 29

Hettiarachchi, P.L. 100, 115, 116
Hettige, L.M. 143
Hewavitharane, H.P.M. 12, 15
Hijas, M.F.M. 136
Himalini, K. 37
Hirimuthugoda, G.N. 93
Hossain, M.D.S. 5

J

Janeni, J. 137
Jarashanth, S.T. 69
Jaseetharan, T. 119
Jayakody, M.M. 90
Jayalal, U. 99
Jayalath, C.P. 133, 136
Jayalath, J.A.C.P. 135
Jayamaha, J.H.P.K. 79
Jayaneththi, J.P.H.U. 11
Jayarathna, I.P.L. 20
Jayasekara, D.T. 64
Jayasekara, P.P. 110
Jayasinghe, J.D.U.K. 145
Jayasinghe, R.D. 113
Jayasinghe, J.M.S. 107, 114
Jayasundara, J.M.C.N. 149
Jayasundera, A.C.A. 74
Jayasuriya, K.M.G.G. 103
Jayathilaka, J.A.M.S. 113
Jayatilake, J.A.M.S. 86, 96
Jayaweera, A.T. 107
Jayaweera, H. 13
Jerom, Y. 44
Juman, Z.A.M.S. 41, 58

K

Kanesharatnam, N. 89
Kapuruge, T.N. 94, 95
Kariyawasam, K. 106
Kartheeswaran, T. 44
Karunadasa, A.D.N. 147
Karunarathna, S.P.D.S.S.K. 66
Karunarathne, E.A.C.P. 60
Karunarathne, R.M.M.B. 12

Karunaratne, A.M.	77
Karunaratne, D.G.G.P.	30
Karunaratne, D.N.	107, 114
Karunaratne, V.	107, 114
Karunathilaka, K.M.A.	112
Kayanan, M.	48
Kayathiri, S.	36
Kethmi, G.A.P.	32
Kodituwakku, S.R.	65
Kosgahakumbura, K.N.M.H.H.	29
Kottegoda, M.N.S.	124
Kulasekara, S.R.T.	70
Kulathunga, K.M.W.K.	131
Kumara, G.R.S.P.	150
Kumara, W.G.C.W.	68
Kumarachchi, N.P.N.R.	131
Kumarasiri, H.N.T.M.	115
Kumari, J.M.K.W.	140
Kumari, W.H.P.	132
Kumari, W.M.R.	71
Kumburegama, S.	93

L

Labutale, S.M.T.K.	139
Laheetharan, A.	36
Lakkana, P.H.T.	93
Lakmali, S.M.M.	52
Lakmali, W.G.M.	113
Li, S.	23
Liyanapathirana, L.V.C.	76

M

Madawala, H.M.S.P.	11, 29, 88
Maddumage, D.C.	129
Madhushani, K.G.S.	28
Madubashetha, H.	80
Madusanka, H.D.S.I.	57
Madushani, A.P.	39
Mahesan, S.	51
Malaviarachchi, S.P.K.	24
Mallikaarachchi, M.A.D.K.S.	86, 137
Manage, P.M.	8
Manchanayake, S.M.T.S.	111

Manthrithilake, H.	9
Mantilaka, M.M.M.G.P.G.	30
Marapana, R.A.U.J.	85
Marasinghe, M.P.C.K.	79
Mathanaranjan, T.	37
Meegaskumbura, M.	84
Meepegamage, S.W.	102
Mendis, A.S.S.	122, 134
Meruja, S.	45
Munasinghe, M.L.A.M.S.	17

N

Nakandala, A.S.	57
Nanayakkara, D.K.K.	10, 135
Nanayakkara, N.	12, 15
Nandasena, B.G.T.L.	96
Nanthakumaran, A.	13
Navaratne, S.B.	92
Nawarathna, L.S.	43, 52
Nawarathna, R.D.	65, 69
Nawarathne, N.G.S.A.	41
Nirath, P.L.T.	116
Nishadi, W.V.	46
Nishantha, K.M.D.W.P.	78, 79
Noordeen, F.	108

P

Panagoda, G.J.	77, 113
Paranagama, M.P.	96
Paranagama, P.A.	118
Pathirana, N.U.K.	84
Peiris, M.A.L.M.	91
Pemasiri, B.M.K.	129
Perera, A.A.I.	34, 38
Perera, A.C.G.	47
Perera, A.D.L.C.	114, 124, 142
Perera, A.G.C.	46
Perera, G.G.P.S.	141
Perera, G.I.S.	111
Perera, H.A.I.R.	27
Perera, H.K.I.	87
Perera, K.K.K.R.	31
Perera, P.K.	73

Perera, S.	33, 137	Rodrigo, W.W.P.	72, 75
Perera, S.J.	10	Rukshagini, P.	14
Perera, W.A.J.S.	94, 95	Ruparathna, K.A.A.	128
Perera, W.T.R.	117		
Pitawala, H.M.T.G.A.	30	S	
Piyasiri, L.	80	Sakeetharan, T.	142
Poornima, W.W.S.	133	Samaradiwakara, R.K.D.S.	30
Prabodanie, R.A.R.	60	Samarakoon, S.M.N.S.	82
Premarathna, L.P.N.D.	32	Samarasinghe, B.R.C.P.	103
Premarathna, M.P.G.D.L.	130	Samarasinghe, S.K.A.M.R.	19
Premarathne, O.S.S.	15	Samarasinghe, V.G.A.U.	78
Premaratne, K.	23	Samarathunga, D.M.	54, 70
Prematunga, C.	99	Samaraweera, P.	112
Priyadarshane, G.	124	Sandaruwan, M.K.D.D.	54
Priyantha, M.A.R.	111	Sanjeevani, R.D.J.	85
		Saranya, B.	62
R		Sasanthika, K.K.H.H.	115
Rabindran, M.	138	Sasna, S.W.S.	57
Rajakaruna, R.S.	73, 84, 106	Satkunanathan, N.	50
Rajapakse, R.G.S.C.	82, 86, 102, 124,	Sayakkara, K.S.	97
	137	Schensul, J.	12
Rajapakse, R.M.G.	109, 122, 128, 134	Schensul, S.	12
Rajapakse, R.P.N.R.	126	Senadeera, G.K.R.	119, 140
Rajapaksha, M.C.M.	125	Senanayaka, S.M.C.	103
Rajapaksha, P.S.	113	Senarathna, T.D.	95
Rajapaksha, R.D.D.	60	Senevirathne, D.G.N.S.	6
Rajkumar, P.	18, 26	Senevirathne, W.I.N.S.	100
Ramanan, A.	33, 40, 42	Seneviratne, G.	11, 99, 102, 104, 105
Rambandara, R.D.S.S.	60	Senthuja, K.	51
Ranasinghe, J.G.S.	117	Sepalage, C.S.	73
Ranasinghe, P.G.R.S.	39	Shih, T.K.	68
Ranasinghe, U.D.S.S.	28	Shirooza, M.F.	135
Ranatunga, R.J.K.U.	131, 147	Silva, D.S.O.D.	61
Ranawaka, R.A.C.S.	66	Silva, K.T.	12
Ranawaka, T.P.	133	Silva, L.G.D.	49
Ranawana, K.B.	10	Silva, N.D.	80
Rathnasekara, A.N.L.	10	Silva, T.C.D.D.	50
Rathnathilaka, A.T.D.	104	Silva, T.H.K.R.D.	57, 61, 67
Rathnayaka, G.R.A.I.	96	Silva, T.M.M.D.	66
Rathnayake, I.V.N.	6	Silva, W.A.P.P.D.	106, 109
Rathnayake, R.M.S.W.	16	Sivakumar, V.	133, 135
Ratnayake, N.P.	23	Siyambalapitiya, R.	56, 64
Reesha, M.F.F.	114	Sooriyapathirana, S.D.S.S.	83

Srikaran, R.	19	Weerasooriya, H.M.	71
Siriwardena, V.K.	94	Weerasooriya, K.M.S.G.	111
Sukumaran, H.	75	Weerasooriya, R.	14
Sumanarathne, W.G.A.S.	83	Weerasooriya, S.V.R.	20
Suthakar, S.	62	Wei, Y.	14
T			
Tharmini, T.	40	Wickrama, W.A.S.S.	108
Tharshan, R.	63	Wickramasingha, W.G.D.	107
Thavaranjit, A.C.	19	Wickramasinghe, D.	9
Thennakoon, W.M.M.T.	17	Wickramasinghe, K.G.M.U.	31
Thilakarathne, K.G.D.D.	93	Wickramasinghe, S.	80
Thilakarathne, S.	123	Wickremasinghe, W.N.	71
Thirukumaran, S.	53	Wijekoon, N.	99
Thotawatthage, C.A.	140	Wijekoon, P.	35, 48, 52, 63
Thushanthani, R.	37	Wijemuni, M.I.	111
Tian, B.	14	Wijerathna, H.M.K.B.	43, 61
U			
Udapitiya, U.G.N.S.	137	Wijerathne, W.M.K.P.	12
Uduwarage, U.D.T.M.	25	Wijeratne, A.M.G.K.	24
V			
Vanniarachchy, M.P.G.	90	Wijesekara, I.	90
Varathan, N.	35	Wijesinghe, W.R.P.	91
Vitharana, P.R.K.A.	148, 149	Wijesundara, C.S.	18, 26
Vlahos, P.	12	Wijesundara, D.S.A.	76, 78, 79, 88, 120
W			
Waduge, R.	117	Wijesuriya, S.D.K.	108
Walpolage, S.	122	Wijethunga, W.M.R.R.	110
Wanninayake, W.M.L.N.	65	Wijetunga, C.B.	124
Warnakula, L.	80	Wijewardhana, U.S.	92
Waseem, M.I.M.	58	Wijewickrama, M.P.T.	88
Wathulanda, H.M.C.B.	27	Wijeyamohan, S.	13
Weeragoda, S.K.	14	Wimalagunaratne, R.	110
Weerakoon, G.	118	Withana, W.T.G.S.L.	97
Weerarathna, M.D.M.C.P.	34, 38, 47	Y	
Weerasekera, D.S.	10	Yakandawala, D.M.D.	100
Weerasinghe, D.S.D.	21	Yatigammana, S.K.	111
Weerasinghe, P.V.T.	137	Z	
Weerasinghe, W.R.H.	118	Zumaira, M.A.N.F.	116

