2nd National Research Symposium
National Research Council of Sri Lanka
2023

Proceedings

Proceedings of the
2nd Research Symposium
National Research Council of Sri Lanka

13th & 14th November 2023

Proceeding of 2nd Research Symposium on National Research Council of Sri Lanka 2023

Published by
National Research Council
120/7, Vidya Mawatha,
Colombo 07

Telephone: +94 (0)112 675430
Fax: +94 (0)11 2675136
Website: www.nrc.gov.lk
ISSN: ISSN 2961-5305

Acknowledgement

I thankfully acknowledge and place on record my deep gratitude to Honorable Dr. Susil Premajayantha, the Cabinet Minister of Education for the blessings on the initiatives of the National Science Week, promoting science popularization all over the country and for having accepted to grace the second research symposium of the National Research Council (NRC), despite a busy schedule.

The guidance provided by the Secretary, Ministry of Education, Mr. Nihal Ranasinghe, Additional Secretaries, Senior Assistant Secretary, Director General (Research), Director General (Planning), Chief Financial Officer, Chief Accountant and all the officials of the Ministry of Education is much appreciated for having extended their support in planning this symposium.

My sincere gratitude to the Chairman, Prof. S. H. Dodampahala and all the Council members of the NRC and the Chief Executive Officer, Dr. Shanika Jayasekera for their concurrence to organize the second research symposium and for extending their intensive involvement and support for the success of the program. The members of the proceedings editorial committee and the reviewers who supported in evaluating the extended abstracts submitted to the symposium, are deeply appreciated for their guidance and the expertise in making the accurate selection.

It is my pleasure to gratefully acknowledge Emeritus Prof. Vajira H. W. Dissanayake for delivering the eloquent keynote speech and Senior Professor Thakshala Seresinhe for her invaluable thoughts shared through the invited lecture.

I express my heartfelt gratitude to all scientists who have been selected for delivering presentations and recognized for their contribution to national development through research.

My sincere appreciation is extended to the chairpersons and co-chairs of all four technical sessions and the Symposium Moderator who served so ably and illuminated this event.

My warmest thanks to all the staff members of the NRC comprising of Assistant Director, Scientific Officers, Accounts Officer, Procurement Officer, Administrative Officer, Management Assistants and support staff for their continuous support in making this event a success.

Mahesha Perera
Scientific Officer / Investigator Driven Grants Program
National Research Council

Preface

It is with contentment that the editorial board unveils the proceedings of the 2nd Research symposium of the NRC in the Science Week 2023.

NRC has taken a step forward by organizing the NRC Research symposium annually as one of the mechanisms of disseminating research findings of the NRC funded research projects. For the second research symposium NRC has taken into consideration the research projects which have completed successfully in year 2019, 2020, 2021.

Hence, on behalf of the editorial board, I would like to extend our deepest gratitude to speakers and all authors for their intellectual input and commendable cooperation in compiling the proceedings of the 2nd Research symposium of the NRC.

Prof. S. H. Dodampahala
Editor-in-Chief
Proceeding – NRC - 2023

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Day 2: 14th November 2023

Message from Chairman, National Research Council

It is with pleasure that I write this message for the Second Research Symposium of the National Research Council, which is a step forward NRC has taken in communicating the research findings of the NRC research projects to a larger audience.

The Research Programmes the NRC has been meticulously designed to address the research challenges of our nation and to achieve greater heights in R&D.
Although research is conducted and completed successfully, keeping the relevant authorities and any interested parties informed is also an important aspect in research communication. NRC therefore, considers this event as one of our duties to strengthen communications of the research deliverables and an opportunity to bring to light the hard work of our researchers to the interested stakeholders. Apart from this event NRC has also taken action to strengthen dissemination of research findings to the stakeholders through the NRC newsletter and the webinars conducted at the completion of the research projects, which I find is an integral part of achieving successfully, the carefully laid goals of the NRC since the inception and I hope to take this event forward by organizing this symposium annually.

Further, I take this opportunity to place on record my appreciation and admiration for the untiring efforts and dedication provided to the NRC to design and implement the research programmes by the former Chairpersons of the NRC, Prof Eric Karunanayake and Prof Janaka de Silva, the Council members and the former CEO, Mrs Manisha Rajapakse.

While appreciating the contribution of former and the present, members of the Council, CEO and staff, I also wish to express my gratitude to the Ministry of Education, for their support and encouragement granted to NRC.

I wish the Second Research Symposium of NRC every Success.

Professor Hemantha Dodampahala
Chairman
National Research Council

Message from Chief Executive Officer

It is my pleasure to give this message for the second Research Symposium, of the National Research Council (NRC).
NRC has played a pivotal role as a prime funding agency to nourish and sustain Research, Innovation and Development for Sri Lanka and recognizing the scientist for their outstanding contribution to research while connecting to the National Development goals. Research programmes of NRC have been developed meticulously to address research gaps and challenges while giving researchers the necessary facilities and flexibility to succ-essfully complete their research programmes.

Taking a step forward in strengthening communication of the successfully achieved research deliverables, NRC has decided to conduct a Research Symposium annually to convey the valuable research findings of the NRC research projects through a single platform to a larger audience to keep the stakeholders informed. I sincerely hope that in this manner NRC will be able to connect well to a larger audience for communicating the research outputs of NRC funded research projects.

NRC has made great achievements through its research funding mechanism which has nurtured to build up a strong research culture for Sri Lanka in par with the international research community. This would not have been possible if not for the dedication and meticulous research programme formulation under the leadership of former chairpersons, Prof. A. Kovoor, Prof E. Karunanayake, Prof H. J. de Silva the former council members and Mrs. M. C. Rajapakse former CEO of NRC. I therefore place my appreciation to all of them as well as the present council headed by Prof. S. H. Dodampahala, council members and my staff.

I sincerely hope that in unity we will all be able to take NRC to greater heights.

My best wishes for the Second Research Symposium of NRC.

Dr. (Mrs) S. Jayasekara
Chief Executive Officer
National Research Council

Message from Symposium Secretary

I'm pleased to add a few words to the proceedings of the second annual research symposium of the National Research Council (NRC) of Sri Lanka. Since the inception, NRC has been unique in its approaches in assisting the government in Science & Technology by means of funding mechanisms, institutional capacity building, recognition of scientific excellence and many more. That uniqueness has created the history of not only the NRC, but also the rising of many young scientists.

As a pioneering institute for research funding in Sri Lanka, it is one of our duties and a timely need, to ensure that public funds are invested in research which can yield the highest benefit to the public in return. Nowadays, applied research which leads to innovations are much more focused, for a healthy economy. The concept of the symposium, being a formal platform where our successful achievers / our grantees can share their research findings with a broader community, serves to increase the visibility of NRC's contribution to the national Science & Technology ecosystem and its healthy existence.

I would like to thank all our Council members including the Chairman, Professor Hemantha Dodampahala and our Chief Executive Officer Dr. Shanika Jayasekera for their guidance and continuous cooperation to make this event a success. While this symposium is going to be a significant item in the NRC's event calendar, I would like to convey my sincere gratitude to our peer reviewers and all our research grantees, especially those who extended their supportive hands to NRC in taking part in this symposium. We look forward to your continued cooperation with the NRC. My special thanks to Ms. Mahesha Perera, the scientific officer who coordinated this year's symposium and Ms. Nadeeka Dissanayake, the officer in charge of the NRC Outreach and Public awareness program, for their passion to make this event a success. I also thank all the staff members of the NRC for their time and efforts contributed for this second version of the symposium.

A. S. R. Nonis
Symposium Secretary
Assistant Director (Scientific Affairs)
National Research Council

Message from the Coordinator of the Symposium

I am elated to send this message for the 2nd Research Symposium of the National Research Council (NRC).
NRC has been instrumental in creating a favorable environment to conduct scientific research, and to strengthen Research, Innovation and Development for Sri Lanka while contributing to create an able research community. This would not have been possible without the commitment and dedication of the former Chairpersons, Council members and former CEO Mrs. M. C. Rajapakse.
The present council headed by Prof. S. H. Dodampahala, Chairman NRC all the council members and Dr. Shanika Jayasekara, CEO/NRC are also extremely dedicated towards steering NRC to greater heights of success and growth and performing the mandatory functions effectively.
NRC has always played a pivotal role in funding research to address the research of requirement of our nation. In doing so NRC has also been vital in capacity building, facilitating M/Phil and PhD opportunities, infrastructure development and publication of research findings in reputed journals.
Successful completion of a research project entails the dissemination of research findings to ensure that society remains well-informed.
The Annual Research Symposium is part of this initiative, and NRC plans to conduct the NRC research symposium annually in alignment to the National Science Week.

Thus I genuinely hope that our participants will find this symposium helpful to enhance their knowledge and find the proceedings beneficial for future work.
I wish this symposium great success.

Ms. Mahesha Perera
Coordinator of the Symposium
Scientific Research Officer
National Research Council

Re-engineering Healthcare: Digital Technologies, Artificial Intelligence, and Genomics

Introduction:

The healthcare industry is on the cusp of a digital revolution, driven by advancements in technology such as digital platforms, artificial intelligence (AI), and genomics. These transformative tools have the potential to re-engineer healthcare, improving patient outcomes, enhancing diagnostics, and revolutionizing treatment strategies. This talk explores the integration of digital technologies, AI, and genomics in healthcare, highlighting their applications, benefits, and the challenges that lie ahead and Sri Lanka's readiness to embrace them.

Digital Technologies in Healthcare:

Digital technologies have already begun to reshape the healthcare landscape. Electronic health records (EHRs) have streamlined patient information management, enabling seamless data sharing between healthcare providers. Telemedicine has expanded access to care, allowing patients to consult with healthcare professionals remotely. Wearable devices and mobile health applications have empowered individuals to monitor their health, promoting preventive care and early intervention. Moreover, big data analytics and machine learning algorithms have the potential to uncover patterns and insights from vast amounts of healthcare data, aiding in disease prediction, personalized medicine, and population health management. The health care system in Sri Lanka, although unknown to many, has been developing its digital health manpower and digital health tools over the past decade and we are currently on the verge of scaling up digital health systems. In this talk I shall give a glimpse of that highlighting how frugal innovations – highly effective, low cost, digital health innovations built on open source platforms and using open standards – are now ready to be scaled up.

Artificial Intelligence in Healthcare:

AI has the potential to revolutionize healthcare by augmenting human capabilities and improving clinical decision-making. Machine learning algorithms can analyze medical images, such as X-rays and MRIs, with greater accuracy, aiding in early detection and diagnosis of diseases. Natural language processing algorithms can extract valuable information from unstructured medical records, facilitating clinical research and improving patient care. AI-driven chatbots and virtual assistants can provide personalized healthcare information and support, enhancing patient engagement and satisfaction. Furthermore, AI-powered predictive analytics can assist in identifying patients at risk of developing certain conditions, enabling proactive interventions and preventive care. Building AI capabilities on top of the already existing digital health infrastructure should be a natural progression in our digital health journey.

Genomics in Healthcare:

The field of genomics has made significant strides in recent years, with advancements in DNA sequencing technologies and the understanding of the human genome. Genomic information can provide valuable insights into an individual's predisposition to diseases, enabling personalized treatment plans and targeted therapies. Pharmacogenomics, the study of how genes influence drug response, can optimize medication

selection and dosing, minimizing adverse effects and improving treatment outcomes. Additionally, genomics can aid in disease prevention by identifying individuals at high risk, allowing for early interventions and lifestyle modifications. In this talk I shall highlight how unique insights from genomic research in Sri Lanka can be used to reshape healthcare.

Challenges and Considerations:
While the integration of digital technologies, AI, and genomics holds immense promise, it also presents challenges. Data privacy and security concerns must be addressed to ensure the protection of sensitive patient information. Regulatory frameworks need to keep pace with technological advancements to ensure the safe and ethical use of AI and genomics in healthcare. Additionally, there is a need for robust training and education to equip healthcare professionals with the skills required to leverage these technologies effectively.

Conclusion:
The re-engineering of healthcare through digital technologies, AI, and genomics has the potential to revolutionize patient care, improve outcomes, and drive preventive strategies. By leveraging the power of data, AI algorithms, and genomic information, healthcare providers can deliver personalized, targeted, and efficient care. However, it is crucial to address the challenges and ethical considerations associated with these technologies to ensure their responsible and equitable implementation. With careful planning, collaboration, and innovation, the future of healthcare holds the promise of a more efficient, effective, and patient-centric system.

Vidya Jyothi Prof. Vajira H. W. Dissanayake
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Day 1: 13th November 2023

Abstracts

Technical Sessions:

Medical Sciences, Food & Nutrition

ANALYSIS OF SOMATIC MUTATIONS AND PROTEIN EXPRESSION OF *TP53* GENE IN SELECTED CANCERS IN A COHORT OF SRI LANKAN PATIENTS

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TP53 is a tumour suppressor gene, and mutations in *TP53* disrupt the function of its protein product, p53, and lead to carcinogenesis. Head and neck cancer (HNC) and breast cancer (BC) are the commonest malignancies among Sri Lankan males and females, respectively, and colorectal cancer (CRC) incidences are also higher in both genders in the Sri Lankan context.

The most commonly used chemotherapeutic drugs are widely based on DNA-damaging combination therapy (DDCT) and microtubule-stabilizing therapy (MST). DDCT is effective in patients with wild-type p53, whereas MST is effective in p53 mutants. Thus, knowledge of *TP53* mutation status is important in deciding treatment options. Pathogenic nucleotide variants of *TP53* and their respective p53 protein expression have not been analysed concurrently in Sri Lankan cancer patients. The current study was conducted to investigate the pattern of *TP53* variants in Sri Lankan patients with the above-mentioned cancers.

Surgically excised tumour tissues from patients with HNC (N=44), BC (N=30), and CRC (N=21) were used in the current study, while an equal number of healthy controls were screened for the mutational status of *TP53* using their blood samples. A subset of these samples was analysed for protein expression of p53 and compared with the respective mutational status of TP53.

A total of 47 sequence variants of the *TP53* gene were found, including 13 novel variants. Pathogenic variants were detected in 14 HNC, 9 BC, and 7 CRC tumour samples. The prevalence rates of pathogenic somatic TP53 variants were 31.8%, 30%, and 33.33% in the studied HNC, BC, and CRC cohorts, respectively. All pathogenic variants found were located between exons 4–8. Pathogenic missense variants showed a strong positive signal for p53 immunohistochemistry, whereas truncated proteins showed a complete absence of positive signals. However, wild-type *TP53* showed either rare positive cells or a complete absence of positive signals, regardless of the type of cancer.

The TP53 mutation profile established in three selected cancers in Sri Lankans and the demonstration of the limitations of immunohistochemistry in detecting truncated TP53 mutations in this study will be useful in the management of cancer patients.

Keywords – TP53, Sanger Sequencing, Immunohistochemistry, Head and Neck Cancer, Breast Cancer, Colorectal cancer

SICKLE CELL DISEASE IN SRI LANKA: CLINICAL AND MOLECULAR BASIS

Thamal Darshana[1]*, Dayananda Bandara[2] , Upul Nawarathne[3] , Udaya de Silva[4] , Yasinta Costa[5] , Kalavitigoda Pushpakumara[6] , Sumithra Pathirage[7] , Seuwandi Basnayake[8] , Chamila Epa[9] , Pradeepa Dilrukshi[10], Maheshaka Wijayawardena[11], Angela A. Anthony[12], Rexan Rodrigo[13], Aresha Manamperi[14], Frances Smith[15], Angela Allen[16], Stephan Menzel[17], David Rees[18] and Anuja Premawardhena[19]
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BACKGROUND

Although previous literature has presented case reports and limited case series of Sickle cell disease (SCD) in Sri Lanka, a comprehensive analysis into the genotypic-phenotypic correlation within this 'rare' group of patient cohort has not been undertaken thus far.

OBJECTIVE

The present study intended to elucidate the clinical presentation of SCD in Sri Lanka, analyse its molecular basis, and examine genetic modifiers and their impact on the observed phenotype.

RESULTS

Between December 2016 and March 2019, a total of 60 accessible SCD patients were recruited for the study. This group consisted of 51 patients with Sickle β-thalassaemia (SBT) and 9 patients with homozygous sickle cell disease (Hb SS). These patients were sourced from seven thalassaemia treatment centres. The majority of patients were of Sinhalese ethnicity (n = 52, 86.67%). In terms of geographical distribution, the analysis revealed the presence of two prominent patient clusters. Furthermore, the distribution of Sickle haemoglobin across the island exhibited a pronounced disparity in comparison to other haemoglobinopathies. Among the cohort of SCD patients, three out of nine with Hb SS and three out of fifty-one with SBT were undergoing regular transfusion therapy. Joint pain emerged as the most frequently encountered clinical symptom among all SCD patients (n = 39, 65.0%). Dactylitis exhibited a significantly higher incidence within the Hb SS group in contrast to the SBT groups ($p < 0.027$). Two distinct genetic origins of Hb S mutation were identified and confirmed namely, Arab Indian and Benin. Within the group of Sickle patients examined in this study, the rs1427407 G > T variant was the most prominent regulator of foetal haemoglobin, exhibiting a statistically significant association with foetal haemoglobin levels ($p < 0.04$).

CONCLUSIONS

The predominant sickle haplotype in Sri Lanka is Arab Indian and the disease overall is very variable in severity.

Keywords: Sickle cell disease, Sri Lanka, Genetic origin, Clinical, Severity

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`GENETIC PROFILING OF TEN X-CHROMOSOMAL SHORT TANDEM REPEAT LOCI AMONG THE SRI LANKAN ABORIGINALS (“VEDDAHS”)

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X-chromosomal short tandem repeats (X-STRs) hold importance in forensic and kinship analysis owing to their unique inheritance pattern, especially in the occurrence of complex cases and pedigrees involving at least one female. Even though X-STRs are already being used in individual identification of the main Sri Lankan ethnicities of Sinhalese, Sri Lankan Tamils, Indian Tamils and Moors, its applicability for the Sri Lankan aboriginals (“Veddahs”) has not been tested as of yet. Owing to the unique genetic composition of the “Veddahs” as put forward by previous population genetic studies, already existing allele frequency databases might also not be appropriate for forensic casework concerning them.

Hence, this study aimed at testing forensic efficiency and establishing a preliminary X-STR allele frequency database for the Sri Lankan aboriginals (“Veddahs”) using ten X-STR markers of three linkage groups (DXS10148-DXS10135-DXS8378, DXS7132-DXS10079-DXS10074-DXS10075 and DXS6801-DXS6809-DXS6789). Finger pricked blood collected from 50 unrelated “Veddahs” residing in “Dambana” (50% male) were used to extract DNA using the Chelex-100 method, which were then amplified using a previously published multiplex PCR system. Genotyping data were used in allele and haplotype frequency calculations and analysed for conformity with the Hardy Weinberg Equilibrium (HWE) using Arlequin 3.5.2. Thereafter, forensic efficiency parameter calculations were performed using chromosome X web (https://www.chrx-str.org).

A total of 80 alleles were reported from the ten X-STR loci of the “Veddahs” of which each marker had between 4-19 alleles. All markers showed no deviations from the HWE expectation. Allele frequency distribution of the ten markers also did not differ between the males and females (P=1.0000). Allele frequencies for the ten markers were: DXS10148: 0.01-0.20, DXS10135: 0.01-0.15, DXS8378: 0.05-0.66, DXS7132: 0.04-0.39, DXS10079: 0.03-0.38, DXS10074: 0.03-0.24, DXS10075: 0.01-0.47, DXS6801: 0.03-0.55, DXS6809: 0.03-0.35, DXS6789: 0.01-0.32. Haplotypes of all males were unique. In all selected loci, polymorphism information content (PIC) exceeded 0.47. The power of discrimination in females (PDf) reached above 0.71 and the power of discrimination in males (PDm) went beyond 0.51. The mean paternity exclusion chance (MECDesmarais-duos) stood between 0.32-0.84. Thus, the forensic efficiency parameters of all 10 X-STR markers were satisfactory and the study succeeded in providing the preliminary data necessary to establish X-STR profiling among the “Veddahs” to resolve deficient cases in individual identification.

Keywords: forensic efficiency, population databases, haplotypes, individual identification, X-STR

ACKNOWLEDGEMENT

The financial assistance from National Research Council (Grant no:16-023) is acknowledged.

IMMUNITY AGAINST MEASLES AMONG A COHORT OF PREGNANT WOMEN IN SRI LANKA

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ABSTRACT

INTRODUCTION

Measles in pregnancy could cause severe complications to mother and fetus. After three decades of immunization against measles, the population immunity in Sri Lanka is considered to be high. However, measles seroprevalence data among pregnant women is not yet available. This study was conducted to determine the immunity against measles among a group of pregnant women and to determine factors associated with presence of immunity.

METHODOLOGY

A descriptive cross-sectional study carried out at antenatal clinics of a leading tertiary care maternity hospital in Sri Lanka. Laboratory work was carried out at the Department of Microbiology, Faculty of Medicine, Sri Lanka. Sociodemographic data was collected through an interviewer administered questionnaire. Immunity against measles was determined by detection of measles IgG using a validated commercial assay. Samples that initially tested equivocal were then re-tested in duplicate and results of two out of the three tests was taken. For quality assurance, a 10% random-sample repeat of the entire specimen collection set was performed.

RESULTS

Of 391 participants, measles IgG was detected in 91.3% (95% CI 89.5-95.0%). Eleven (2.8%) had equivocal results. Seropositivity fell from 100% in the oldest age group (41-45 years) to 71.4% in the youngest age group (≤19 years). Measles immunity showed a statistically significant rising trend across the age groups The Geometric Mean Titer (GMT) remained around the population mean (0.48 IU/ml) in most of the age groups except in the youngest age group (0.51 IU/ml) and oldest (0.38 IU/ml). However, these differences were not statistically significant. Having ≥4 household members during childhood was the other only factor associated with seropositivity apart from age.

CONCLUSIONS

Immunity against measles was high among the study population. However, the younger age groups had a higher susceptibility.

Keywords: measles, Sri Lanka, pregnant, immunity, seroprevalence

SUSCEPTIBILITY FOR VARICELLA AND FACTORS ASSOCIATED WITH IMMUNITY AMONG PREGNANT WOMEN IN A TERTIARY CARE HOSPITAL IN SRI LANKA- A CROSS-SECTIONAL STUDY

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BACKGROUND

Primary varicella zoster infection (chickenpox) during pregnancy can lead to serious maternal and fetal consequences. Although an effective vaccine is available, it is not incorporated in to the routine vaccination programs in most of the Asian countries.
Objectives of the study were to determine the susceptibility to varicella and factors associated with immunity, among a group of pregnant women attending to a tertiary care hospital in Sri Lanka.

METHODS

A hospital based descriptive cross sectional study was carried out at De Soyza maternity Hospital, Colombo. A sample of 385 pregnant women was selected. Data were collected through an interviewer administered questionnaire. Presence of varicella zoster IgG in blood was assessed by a validated commercial ELISA (Enzyme Linked Immunosorbant Assay.

RESULTS

The sample had a mean age of 28.5 years and the majority was educated beyond General Certificate of Education (GCE) Ordinary Level. We found that 34% of study population was susceptible for the infection. A past history of chickenpox had a 89.5% positive predictive value and 53.1% negative predictive value for varicella immunity. Varicella sero-positivity was only associated with a lower educational level and number of childhood household members more than four. There was no association of sero-positivity with age.

CONCLUSION

This study demonstrates that a significant proportion of pregnant women of the study population are susceptible for varicella. Pre-pregnancy screening and preventive strategies including vaccination should be evaluated. History of past varicella infection could be a useful screening tool to exclude patients for vaccination.

Keywords: Chicken pox, Pregnancy, Seroprevalence, Sri Lanka, Varicella

MOLECULAR CHARACTERIZATION OF CARBAPENEMASE-PRODUCING ENTEROBACTERIACEAE (CPE) ISOLATED FROM A TERTIARY CARE TEACHING HOSPITAL IN SRI LANKA AND VALIDATION OF A RAPID CPE DETECTION PROTOCOL

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INTRODUCTION

The emergence and spread of carbapenem-resistant Enterobacteriaceae (CRE) is increasing globally, resulting in the failure of almost all the available antibiotics. Therefore, accurate and timely detection of carbapenemase-producing Enterobacteriaceae (CPE) is essential to streamline the optimum antibiotic therapy. This study was carried out to determine the current status of CRE in Sri Lanka and to evaluate the performance of several CPE detection methods.

METHODOLOGY

A cross-sectional study was conducted at Colombo North Teaching Hospital during 2017-2018. Extended-spectrum beta-lactamase-producing Enterobacteriaceae (ESBL-PE) and CRE were identified by the disc diffusion method. CRE isolates were identified up to the species level using a rapid identification kit. The genetic background of CPE was determined by PCR. Four CPE detection methods, namely CNPt, CNPt-direct, mCIM, and MHT were evaluated.

RESULTS

The estimated overall prevalence of ESBL-PE and CRE were found to be 26.0% and 9.6%, respectively. The highest prevalence of ESBL-PE and CRE were found amongst uropathogenic (30.8%) and respiratory (20.8%) Enterobacteriaceae, respectively. K. pneumoniae (80.7%), E. coli (5.3%), C. freundii (7.0%), P. rettgeri (3.5%), E. cloacae (1.7%), and E. aerogenes (1.7%) were identified in CRE cohort. Of CRE, 94.7% were found to be CPE. Only amikacin showed reasonable sensitivity (>50%) for CRE among the routine antibiotic panel whereas a higher level of susceptibility was noted for fosfomycin (92.9%), ceftazidime-avibactam (85.9%), and colistin (92.9%). The carbapenemase encoding genes detected were blaKPC, blaNDM, and blaOXA-48-like. blaOXA-48-like (88.9%) was the most prevalent. The overall sensitivity and specificity of CPE detection tests were as; MHT-90.7%, 92.1%, mCIM-100%, 100%, CNPt-75.9%, 100%, and CNPt-direct-83.3%, 100%, respectively.

CONCLUSION

Conclusion: This study reports an alarming rate of CRE and the emergence of blaKPC harboring K. pneumoniae in Sri Lanka. The need for preventive measures is highlighted to limit the spread of these difficult-to-treat bacteria in the country. mCIM was the most sensitive assay for the identification of CPE. As a rapid test, CNPt-direct performed better than CNPt. An algorithm consisting CNPt-direct and mCIM was proposed to allow rapid and reliable detection of carbapenemase production in resource-limited settings.

ACKNOWLEDGEMENT

NRC grant 17-055

Keywords – Enterobacteriaceae, ESBL, carbapenem resistance, carbapenemase, CNPt

Technical Sessions: Agricultural Sciences

AN OUTSTANDING RENEWABLE SOURCE OF BIOACTIVE SMALL MOLECULES FROM ENDOLICHENIC FUNGI IN MANGROVE ECOSYSTEM OF PUTTALAM LAGOON

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Endolichenic fungi (ELF) have been recognized as a promising source of bioactive secondary metabolites. Sri Lanka, a biodiversity hotspot, harbours a remarkable diversity in mangrove ecosystems and ELF associated with mangrove lichens. In the present study ELF obtained from mangrove lichens of Puttalam lagoon were studied for their secondary metabolites. Hundred isolates were identified using rDNA-ITS region sequence homology. The effectiveness of ethyl acetate extracts of the ELF isolates were investigated against antioxidant activity, anti-inflammatory, antibacterial, tyrosinase inhibitory antilipase activity and α-amylase inhibition activity in *in-vitro* conditions. An endolichenic fungus, *Neurospora ugadawe*, isolated from the lichen host *Graphis tsunodae* Zahlbr. The crude extract of *N. ugadawe* showed promising antioxidant and anti-inflammatory activities. Active crude extract was partitioned with hexane, chloroform and MeOH in order to separate nonpolar, moderately polar and polar compounds respectively. Antioxidant assay was repeated for each partition and chloroform partition showed the highest activity. Bioassay-guided separation on silica gel column chromatography and preparative TLC were performed to isolate the bioactive pure compounds. Structure of the pure compound was determined using LCMS, 1D and 2D NMR data. Two novel bioactive pure compounds were identified as Neurosporalol 1 and Neurosporalol 2. Neurosporalol 1 showed the highest antioxidant activity compared with the positive control BHT. Further this compound showed very low anti-inflammatory activity compared to that of the positive control aspirin. Neurosporalol 2 is a dimer and showed comparable antioxidant and moderate anti-inflammatory activities. Novel compound isolated from *Xylaria psidii* showed significant anticancer activity with IC50value of 27.18µg/mL. It was named as (Z)-3-((3-acetyl-2-hydroxyphenyl)diazenyl)-2,4-dihydroxybenzaldehyde. The extracts of *Daldinia eschscholtzii* and *Aspergillus aculeatus* had the highest radical scavenging activity with smaller IC50values (26.25 µg/mL and 29.31 µg/mL) compared to the IC50values of BHT (76.50 µg/mL). Antilipase assay results revealed that compounds isolated from *Xylaria psidii* showed good activity and Amylase inhibitory assay indicated that the test extracts do not contain antidiabetic secondary metabolites. This study further highlighted the importance of studying ELFs in mangrove ecosystems in search of novel bioactive compounds.

Keywords: Endolichenic fungi, Secondary metabolites, mangrove lichens, bioactive compounds.

INCREASING THE VALUE OF SEA CUCUMBER HARVESTS BY IMPROVING POSTHARVEST PROCESSING

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The reduced catch rates and poor processing practices have led to many challenges in the sea cucumber industry in Sri Lanka. This study assesses the fishery and processing status, aiming to propose sustainable improvements and value addition. The fishery and processing data were collected from northern Sri Lanka from November 2015 to January 2017. Different processing methods, strengths, weaknesses, opportunities, and threats in current processing practices and the impact of processing on nutritional composition were assessed through questionnaires, direct observations, and laboratory experiments. Species-specific processing methods were designed for three sea cucumber species (*S. naso, H. spinifera, B. vitiensis* and a ready-to-drink soup mix using highly abundant *B. vitiensis* was prepared as a value-added product. Nine sea cucumber species; *Bohadschia marmorata, Stichopus chloronotus, Holothuria spinifera, Thelenota anax, Holothuria scabra, Bohadschia vitiensis, Bohadschia* sp. 1., *Holothuria atra* and *Stichopus naso* were reported in the catches having highest and lowest catch rates for *B. vitiensis* (486±86) and *Holothuria atra* (1±1). These species were mainly harvested using four fishing methods: SCUBA diving, breath-hold diving, gleaning, and surrounding nets. SCUBA diving is the dominant fishing method for which divers reported the highest catch rates and income levels. Domestically processed *bêche-de-mer* had higher moisture, crude ash, and crude fat percentages but lower crude protein percentages than industrial processing ($p<0.05$; ANOVA). Processing led to reduced SFA and MUFA in most species, while PUFA increased. The most suitable processing steps for *S. naso, H. spinifera* and *B. vitiensis* were identified and major processing steps were found to be varied with species. The organoleptically best soup mix contains high protein (21.43±1.21%) and low fat (4.98±0.23%) and it is safe for human consumption. The Polyester-Aluminum-PE was selected as the best packaging material with 6 weeks shelf life at room temperature. The research provides valuable insights into the management and sustainable utilization of sea cucumber resources in Sri Lanka and can guide authorities in implementing effective management measures to preserve these important marine resources.

Keywords: Sea cucumbers, Fishery, Sustainable utilization, Processing, Value-addition

Day 2: 14th November 2023

Keynote Address : A climate resilient dairy sector for food security

Increasing quality milk production is a priority of Sri Lankan government and it would have substantial benefits for the entire economy. It would reduce the growth of imports, which are a foreign exchange burden to the economy, increase rural incomes, contribute to rural poverty alleviation and provide quality dairy products for consumers. In terms of nutrition and food security, per capita consumption of milk is around 52 liters per year (DAPH, 2022) and demand for dairy products is projected to continue to grow rapidly as a consequence of population growth. Total milk production from dairy cows in 2022 was 506 million liters. Milk production is only sufficient to satisfy 40% percent of the national demand; the rest is imported. Sri Lanka imported 83,024,406 kg of milk powder in 2022.

Livestock especially dairy cattle is an important component of the environment, on which it exerts a strong influence. Similarly, it has an impact on climate change., Dairy production contributes greenhouse gases (GHG) to the atmosphere both directly and indirectly. The majority of direct CO2 emissions from animal agriculture are usually from fossil use; for example, the use of propane or natural gas in furnaces or incinerators and the use of fuel to operate farm equipment and generators. This type of emission can be described as “mechanical emissions.” For non-mechanical emissions, methane from enteric fermentation and manure management are the main sources of CH4 emissions from agricultural activities and of all domestic livestock, dairy and beef cattle are the largest emitters of CH4. Enteric fermentation produces methane as a natural part of digestion in ruminant animals. It accounts for 33 percent of the total GHG emissions in agriculture and 71 percent of all agricultural sources of methane.

The majority of the N2O emission from animal agriculture is from manure management which is the second largest (a far second to cropping practices) N2O emitter in the agriculture. Indirect emission of N2O occurs when nitrogen is lost from the system through volatilization as NH3 and N2O. Also, indirect emissions can result from nitrogen that is runoff or leached from manure management systems in a form other than N2O and is later converted to N2O offsite.

Nearly 53 percent of agricultural GHG emissions are from nitrous oxide. Ninety-two percent of nitrous oxide is from agricultural soil management. Other significant sources include manure management and the burning of agricultural residues.

The degree to which human activities, including animal agriculture production, contributes to climate change is largely unknown however, the strategies aimed at reducing these emissions and to improve the productivity of dairy cattle will be discussed

Adopting a low-carbon and climate resilient growth pathway for the dairy sector could benefit Sri Lanka in several ways: Improving animal and herd productivity is one of the key pathways to reduce enteric CH4 emissions per unit of product. Methane is produced in the process of feed energy utilization by the animal. Changes in the efficiency of feed energy utilization therefore influence enteric methane emissions of animals. The efficiency of feed energy utilization depends on the type of animal, the type or quality and quantity of feed, environmental conditions, etc. The way feed energy is partitioned between the different body functions (maintenance and production) also explains the variation in emission intensities.

Research shows that there are several technologies that if comprehensively applied throughout the sector would make a rapid and important contribution to improving the technical performance and profitability of dairy production while reducing GHG emissions. Improved practices and technologies such as strategic supplementary feeding, and improving the diet quality, adequate animal health control, and improved animal husbandry practices are some of the techniques that can improve dairy productivity and reduce emission intensity. Overall, the analysis shows that their scope to reduce emission intensities; methane emission intensity (kg CO2 /kg FPCM) can be reduced by 10 percent to 29 percent, the magnitude of impact will vary depending on the intervention and production system; not all systems have equal opportunity to mitigate emission.

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Technical Sessions: Ecology & Environment

IDENTIFYING MINERAL DEPOSITS BY ANALYSING PLATINUM GROUP ELEMENTS, COPPER AND GOLD IN SRI LANKAN ROCKS

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ABSTRACT

This research focused on major, trace and precious metal geochemistry of some representative meta-igneous rocks from the Highland and Vijayan Complexes and Katargama Kilippe (HC, VC, KK, respectively) of Sri Lanka. Our data show different geochemical trends in chemical-discrimination diagrams, indicating each lithological unit has distinct genetical environments. Most of the mafic samples of the HC and the KK fall geochemically in the tholiietic field. In contrast, the garnetiferrous charnockitic samples of the HC and majority of the VC samples plot in the calc-alkaline field. Rocks of the VC and KK and mafic rocks of HC, deviate from typical magmatic differentiation patterns probably due to a later interaction with secondary melts or fluids. There is a clear distinction of Pt/Pd and Au/Pt vs. MgO, in which all the samples except for the garnetiferrous charnockites of the HC show a negative correlation implying a sequestration of chalcophile melts from protolith magmas. Therefore, our data indicate that possibility of occurrence of gold (Au) and other precious metals (e.g. Pt and Pd) within the meta-igneous rock units of the HC, VC and KK is reasonable except for the garnetiferrous charnockitic rocks of the HC. The garnetiferrous charnockites of the HC do not account for any geochemical evidence sensitive to precious metal enrichments in protoliths. Our estimates show that the highest (in average) Au, Pt and Pd contents are found in the rocks of VC (8 mg/ton), KK (7 mg/ton) and HC (7 mg/ton), respectively. Although these precious metal abundances in the above prospective rock units are not as high as those present in global ore-grade rocks, yet 'hard rock mining' technique could be feasible to utilize as a small-scale industry to extract these metals, especially using rock-aggregates/rock powders dumped as wastes from rock quarries in Sri Lanka.

HISTORICAL TRENDS IN AVERAGES AND EXTREMES OF RAINFALL, TEMPERATURE, AND RUNOFF OF SRI LANKA

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ABSTRACT

Historical trend assessment is an essential part of the climate change investigation efforts. Due to several reasons, including regional climatic fluctuations, Sri Lanka is likely to have a feedback effect on the local climate, especially the changes in the trends of averages and extremes of rainfall, temperature and runoff events. In this study, a comprehensive set of climate indices was used to investigate the historical trends in averages and extremes of rainfall, temperature and runoff in Sri Lanka. The dataset comprised 55 years (1961–2015) of unadjusted daily rainfall and temperature records from 20 synoptic meteorological stations, as well as 53 years (1961-2013) of monthly runoff data collected from 28 gauging stations distributed across Sri Lanka. The linear trends were analysed using the nonparametric Mann–Kendall test and Sen–Theil regression. The pre-whitening method was first used to remove autocorrelation from the time series and the modified seasonal Mann–Kendall test was then applied to the seasonal data. Although variable rainfall pattern is typical in Sri Lanka, during the southwest monsoon (SWM), 15% of the stations showed a statistically significant ($p<0.05$) decrease in wet days. The increasing tendency in 2-day, 3-day and 7-day mean rainfall events indicates consistent trends in short-duration rainfall events. Warming of nighttime and daytime temperatures is apparent due to the increase in daily minimum temperature and the daily maximum temperature as observed in 70% and 55% of the stations, respectively. In the wet and dry zones, the decreasing trends in the daily temperature range (DTR) were most evident in the southwestern part of Sri Lanka while increasing DTR became more common in the dry zone. While most of the wet zone stations show a decreasing trend in the annual maximum runoff, at least 21% of the stations demonstrate a statistically significant decline during June and July, coinciding with the period of significant SWM rainfall. The research demonstrates evident patterns in the averages and extremes of rainfall, temperature, and runoff. Nonetheless, these patterns are not consistent throughout the entire country, emphasizing the requirement for region-specific adaptation strategies to address the evolving climate.

Keywords: Mann–Kendall test, nonparametric regression, rainfall extremes, runoff trends, Sen–Theil regression, temperature extremes.

COMPARISON OF PHYTOREMEDIATION POTENTIAL OF THREE INVASIVE FLOATING MACROPHYTES IN SEWAGE SLUDGE CONTAMINATED WITH HEAVY METALS

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The land disposal of heavy metal contaminated partially treated sewage sludge generated from many industrial waste water treatment plants is a rising environmental issue at present. The present study was thus planned to compare the phytoremediation potential of invasive floating macrophytes *Eichhornia crassipes, Salvinia molesta* and *Pistia stratiotes* in partially treated sewage sludge contaminated with heavy metals. A preliminery study confirmed that these macrophytes grow satisfactory in a medium with partially treated sewage sludge and water at 1:5 ratio. Approximately 500.0 g of the second generation of cultured *E. crassipes*, *S. molesta* and *P. stratiotes* were introduced into batch type constructed wetlands (CWs) having sludge and water at 1:5 ratio. A control setup without having macrophytes was also arranged. All the set ups were triplicated and repeated at two cycles. The weekly harvested macrophytes (cut into shoots and roots) and sludge were pre-treated, digested and analyzed for Zn, Fe, Cu, Cr, Pb, Cd and Ni using standards methods. Percentage reduction of metals in sludge and translocation factors (TFs) in macrophytes were determined. Arc-sin transformed data were subjected to One-way ANOVA followed by Tukey's pairwise comparisons in MINITAB 17. The results revealed that higher concentrations of heavy metals (more than 50.0%) retained in roots than their shoots showing lower TFs. S. *molesta* based wetlands showed the significantly highest percentage reductions of Zn (36.0 % in cycle-1 and 40.1 % in cycle-2), Ni (26.9 % in cycle-1 and 33.7 % in cycle-2), Fe (26.6 % in cycle-1 and 25.6 % in cycle-2), Cu (32.6 % in cycle-1 and 35.1 % in cycle-2) and Cr (58.6 % in cycle-1 and 57.3 % in cycle-2) in sludge for both cycles ($p < 0.05$; ANOVA) while P. stratiotes based wetlands showed the highest Cd reductions (27.1 % in cycle-1 and 29.3 % in cycle-2). The highest reduction of Pb (42.4 % in cycle-1 and 46.4 % in cycle-2) was shown by E. crassipes based CWs. Metal reductions in sludge of controls were less than 10.0%. At the end of the experimental period, all metals were within the acceptable levels in phytoremediated sludge. The study confirmed that these macrophytes have different remediation capacities for selected metals in sludge and more or less similar capacities in each cycle for the remediation of same metal species.

Keywords: *Eichhornia crassipes, Pistia stratiotes, Salvinia molesta,* phytoremediation, partially treated sewage sludge

The authors would like to express appreciation for the support of the National Research Council-Sri Lanka (Grant No. 15-147)

ACTIVATED SAWDUST AND RICE HUSKS AS EFFECTIVE DECOLORIZERS FOR TEXTILE WASTEWATER

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ABSTRACT

Wastewater containing reactive dyes is environmentally problematic due to their high water solubility and stability towards sunlight, heat and oxidation. Impact of H_3PO_4 activated sawdust and rice husks on decolorization of textile wastewater was studied. Activated carbon was prepared using a simple and low cost method. Decoloration efficiency was studied using both synthetic and real textile wastewater containing Reactive Black 5 dye. Various experimental factors including initial dye concentration, activated carbon dose, pH, particle size, contact time and temperature on color removal were investigated. Activated carbon was characterized using several experimental techniques. SEM analysis showed an enhanced pore structure for activated carbon. 0.10 g of activated sawdust carbon decolorized 88%, 97% and 75% of neat RB 5 solution, synthetic textile wastewater and real dye bath wastewater, respectively. Langmuir and Freundlich isotherm models were used to analyze the equilibrium adsorption data. Only the Langmuir isotherm model shows a correlation with experimental data. Adsorption kinetics were studied using Lagergren pseudo-first-order model and pseudo-second-order model. Kinetic data matches well with the pseudo-second-order model and the calculated rate constants are 6.09 $x10^{-3}$ g/mg min and 9.88 x 10^{-3} g/mg min for activated sawdust and rice husks carbon, respectively. Thermodynamic parameters were calculated using three different methods. Calculated thermodynamic parameters, $\Delta G0$, $\Delta H0$ and $\Delta S0$ for both activated sawdust and rice husks carbon show that the adsorption process is favorable, endothermic and spontaneous.

Key words: Textile wastewater, Reactive dyes, Adsorption

ACKNOWLEDGMENT

Authors thanks NRC Sri Lanka for the financial support under NRC15/155.

TREATMENT OF TEXTILE WASTEWATER BY COAGULATION AND ADVANCED OXIDATION PROCESSES

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ABSTRACT

The textile industry uses huge amount of dyes and chemicals in their production process and consequently generates a large amount of colorful wastewater. Treatment of textile wastewater is highly important as dyes and their breakdown products are toxic. Current study focused the application of chemical coagulation and Fenton oxidation on the color and the COD reduction of textile wastewater. Reactive Black 5 (RB 5) dye solution, the synthetic textile wastewater (STW), and the real dye bath wastewater (RTW) were analyzed. Efficiency of Polyaluminium chloride, Alum and Fe coagulants were compared. Among three coagulants used, Polyaluminium chloride (PAC) decolorized more than 98% of RB 5 dye at a dosage of 200 ppm and pH = 5, while the other commonly used coagulants, alum, and $FeSO_4$, removed only 11% and 6% of RB 5 dye, respectively. Polyaluminium chloride removed also 80% of the COD at 300 ppm dosage. All the three coagulants failed to decolorize highly saline synthetic textile wastewater containing RB 5 dye, but 80% decolorization was successfully achieved for the real textile dye bath wastewater by the polyaluminium coagulant dosage of 400 ppm while alum and $FeSO_4$ of the same dosage reduced only about 66% and 75%, respectively. Fenton oxidation reduced 98% of the color and 61% of the COD in 100 ppm RB 5 dye at pH = 3 and dosage of 0.2 mM Fe^{2+} and 2.0 mM H2O2. The COD was reduced by 90% when Fe^{2+} dose was increased to 0.5 mM keeping the Fe^{2+}:H_2O_2 ratio 1:10. When pH was increased from 3 to 7, the color reduction decreased from 91% to 78%. STW was decolorized to 87% by 0.25 mM Fe^{2+} and 2.0 mM H_2O_2 at pH = 3. For the discoloration of RTW, the optimum Fenton condition was 0.1 mM $Fe^{2+}$and 0.5 mM H_2O_2 at the same acidic condition. The current study reveals that the coagulation with PAC and Fenton oxidation can be successfully used to treat the real textile dye bath wastewater containing reactive dyes.

Key words: Textile wastewater, Reactive dyes, Coagulation, Fenton Oxidation

ACKNOWLEDGMENT

Authors thanks NRC Sri Lanka for the financial support under NRC15/155.

COMPARATIVE PHYTOREMEDIATION POTENTIALS OF *Impatiens balsamina* L. AND *Crotalaria retusa L.* FOR SOIL CONTAMINATED WITH USED LUBRICATING OIL

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ABSTRACT

Soil contaminated with used lubricant oil (ULO) has become an emerging environmental threat. Phytoremediation is a cost effective, environmentally friendly and novel technique with great potential for remediation of soils contaminated with used lubricating oil (ULO). Therefore, the aim of this study was to investigate the phytoremediation potentials of Crotalaria retusa L. and Impatiens balsamina for ULO contaminated soil. A randomized block pot experiment was conducted for each species under plant house conditions in soil contaminated with ULO at a concentration of 5,000 mg kg^{-1} (0.5% w/w) - 30,000 mg kg^{-1} (3% w/w). The percentage biodegradation of ULO in the rhizosphere soil of both species following 90 days exposure indicated significant ($p < 0.05$) time dependent increases compared to the respective control carried out in contaminated soil without plants. Comparatively higher biodegradation of ULO was recorded from the rhizosphere of *C. retusa* L. than that of *I. balsamina.* The measured total microbial activity and cultivable population size of hydrocarbon utilizing bacteria (HUB) suggest that phytoremediation might have occurred mainly via rhizodegradation. The *Allium cepa* bioassay revealed the reduction of potential cytotoxicity and genotoxicity with the decrease of ULO in phytoremediated soils. The results further revealed significant ($p<0.05$) positive correlation of $N{-}NO3^{-1}$, extractable P concentration and significant ($p < 0.05$) negative correlation of soil pH with percentage ULO degradation. Therefore, phytoremediation using the test plant species not only reduced ULO levels, cytotoxicity and genotoxicity but also improved overall soil quality. These results highlight the higher phytoremediation potential of C. retusa than that of *I. balsamina* for soil contaminated with ULO.

Key words: *Crotalaria retusa L., Impatiens balsamina,* used lubricating oil, phytoremediation, rhizodegradation

Technical Sessions:
Engineering Technology, IT, Space, Physical Science & Electronics

MULTI-SCALE MODELLING OF ULTRA-THIN SHELLS MADE OF WOVEN FIBRE COMPOSITES

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While plain woven composite has been widely used over decades most studies are limited to predicting in-plane properties of multi-layer laminates or overall response of single-layer composites. Deployable space applications require them to be ultra-thin and hence generally made of one to six layers of thin-woven composites where out-of-plane behaviour is dominant. Classical lamination theory overpredicts the out-of-plane stiffness when they are made of one to two layers and relative positioning of each layer can have a significant effect on predictions for two-layer composites.

The initial phase of this research concentrated on predicting micro-mechanical behaviour of two-ply plain weave laminates under small strains. A representative volume element and its properties were obtained through micrographs to develop a homogenised Kirchohoff plate model for predicting constitutive relationship in the form of a six by six ABD stiffness matrix. Effect of different idealisation of cross-sectional and weave profiles was examined using five different tow models and the predictions were validated against experimental results obtained from uniaxial tension and four-point bending tests performed on 0/90 and ± 45 laminates. Further, it was shown that relative positioning of plies influences both axial stiffness and bending stiffness of the laminate.

The insights gained from the micromechanical model were then applied to simulate a macro-scale model of a dual-matrix composite boom. This boom featured glass fibres in an epoxy matrix in its rigid sections and glass fibres with a silicone matrix in the flexible region, enabling higher compaction. The ABD stiffness matrices derived from the micromechanical models for these two regions were incorporated into the macro model to predict highly nonlinear behaviour. The proposed simulation technique accurately captured both overall geometric deformation and localized behaviour, aligning well with experimental studies. Moreover, the simulation technique accurately represented the moment-rotation response of the proposed boom, a vital aspect of the design optimization for self-deployable space structures.

In summary, this research delves into the unique challenges posed by ultra-thin woven composites in deployable space applications. By bridging the gap between micro-mechanical and macro-scale models, authors have developed a comprehensive understanding of material and structural response, which is vital for the design and deployment of space structures.

Keywords: multi-scale modelling; woven fibre composites; thin-shells

GROWTH OF CZTS THIN FILMS BY SEQUENTIAL AND SINGLE STEP ELECTRODEPOSITION TECHNIQUES

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The development of a solar energy converting device using environmentally friendly and low-cost materials and techniques is a prime need for the present energy crisis. In this respect, CZTS (Cu_2ZnSnS_4) thin films have been studied for possible applications in thin films solar cells. In this study, CZTS thin films were grown on Mo substrate using sequential and single step electrodeposition techniques and compared the optoelectronic properties. In the sequential electrodeposition technique, Cu thin film on Mo substrates was electrodeposited at – 0.89 V versus Ag/AgCl in an aqueous solution of 0.4 M $CuSO_4$ and 3.0 M lactic acid. Electrodeposition of Sn thin film on Mo/Cu electrode was carried out at -1.2 V versus Ag/AgCl in a bath containing 0.055 M $SnCl_2$, 2.25 M NaOH, and 8 mL of sorbitol. Zn thin film was electrodeposited on Mo/Cu/Sn electrode at -1.2 V versus Ag/AgCl in a bath containing 0.2 M $ZnSO_4$. The Cu/Sn/Zn stack layers were then annealed in N_2 at 300 °C for 30 min to form an alloy and the alloys were annealed at 550 °C for 60 min in H_2S for sulfurization. In the single step electrodeposition technique, CZTS thin films ware grown at -1.05 V versus Ag/AgCl in a bath containing 0.02 M $CuSO_4 \cdot 5H_2O$, 0.01 M $ZnSO_4 \cdot 7H_2O$, 0.02 M $SnSO_4$, and 0.02 M $Na_2S_2O_3$ at a pH value of 5 and then films were annealed at 550 °C for 30 min in H_2S. Growth conditions of both techniques were optimized based on photoactive performance of CZTS in a photoelectrochemical cell (PEC) containing 0.1 M sodium acetate. CZTS films prepared using optimum growth conditions both sequentially and single-step electrodeposition methods were characterized by XRD, reflectance, spectral response Mott–Schottky (Capacitance-Voltage) and dark and light current voltage measurements. Results revealed that photoactive structurally good CZTS films can be prepared using both techniques. Moreover, optoelectronic properties of CZTS films reveal that CZTS films prepared using the single-step electrodeposition have better photoactive properties and improved doping densities. This important finding shows that when developing CZTS based solar cells using the inexpensive electrodeposition technique, single step electrodeposition is more advantageous.

Keywords: CZTS, sequential electrodeposition, single step electrodeposition

We gratefully acknowledge the financial supports through the research grants of National Research Council NRC 15-41

DEVELOPMENT OF CU_2O HOMOJUNCTION SOLAR CELL BY DEDUCTION OF INTERFACIAL DISCONTINUITIES

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Cuprous oxide (Cu_2O) is a lattice defect type low-cost environmentally friendly photoactive semiconducting material. Both n- and p-type Cu2O thin films can be fabricated using a simple low-cost electrodeposition technique. However, the reported efficiencies for the Cu_2O thin film solar cells are below the theoretical efficiency limit. Of course, the interfacial mismatching at the p-n junction contributes to the reported poor efficiency. Suppose it is possible to shift the relative band edge positions of n- and p-type Cu_2O which could eliminate the interfacial discontinuities and improve the overall efficiency of Cu_2O thin film solar cell. Thereby, the objective of this study was to enhance the performance of Cu_2O homojunction solar cell by minimizing the interfacial discontinuities at the p-n junction. In this study, we have observed that the pH of the Cu2O thin film deposition bath is sensitive to the shifting of the relative band edges of n- and p-Cu_2O thin films. This was realized by observing the shifting of the flat band potential of capacitance voltage measurements of n- and p-type Cu_2O thin films. Therefore, n- and p-type Cu_2O were grown by altering the pH of the Cu_2O film deposition bath so that expecting to form homogeneous band line up at the interface. The n-type Cu_2O thin films were potentiostatically electrodeposited in an acetate bath containing 0.1 M sodium acetate and 0.01 M cupric acetate. Subsequently, the p-type Cu_2O thin films were similarly grown in a lactate bath containing 3 M lactic acid, 0.4 M copper sulphate and 4 M sodium hydroxide. The front contacts were made by sputtering a grid of Au on the p-n junction electrodes. The best cells observed in this study were the n-type Cu_2O grown at a pH value of 6.1 and the p-type Cu_2O grown at a pH value of 13. Further, application of well tuned post treatments such as annealing and sulphidation would improve the device performance.

Keywords: Cu_2O homojunction, electrodeposition, interfacial properties, CV measurements

We gratefully acknowledge the financial supports through the research grants of National Research Council NRC 15-41

SYNTHESIS OF rGO WRAPPED Cu_2O/Cu NANOCOMPOSITES FOR PHOTOCATALYTIC AND WATER SPLITTING APPLICATIONS

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Nano sized Cu/Cu_2O composites wrapped with multi layered reduced graphene oxide (rGO) were synthesized to study their photocatalytic applications. Cu_2O films were fabricated by electrodeposition on Ti substrates using an acetate bath as the electrolyte. Synthesis of graphene wrapped Cu/Cu_2O composites was achieved by ultrasonically mixing the peeled off Cu_2O films with graphene oxide obtained using improved Hummers' method and subsequent reduction with ascorbic acid for 30 minutes. The resulting composite consisted of Cu_2O nanoparticles embedded in Cu domains of nanoscale wrapped with rGO which appeared in the form of multi layered graphene structures. Characterizations made using FTIR, XRD, XPS and TEM confirmed the formation of the composite. Composites made using different Cu_2O/GO weight ratios were tested for photocatalytic and water splitting behavior and a weight ratio of 125:10 showed its ability as a candidate to be employed for water splitting and photocatalytic degradation of organic dyes. Water splitting was achieved by irradiating the composite added water under the visible light in the presence of methanol. Photocatalytic activity of the composite was demonstrated by the degradation of Methylene Blue as well as a commercially available dye. The observed behaviors are attributed to the combined roles played by Cu_2O as a cocatalyst and Cu as particles which show plasmonic resonance during irradiation aided by the enhanced electron transport provided by rGO. This study therefore introduces a composite prepared using a novel synthesis route which can be used for photocatalytic and water splitting applications.

Keywords: Photocatalyst, Reduced graphene oxide, Cuprous oxide, Co-catalyst, Nanocomposite

Financial assistance from the research grant of National Research Council (NRC/16-094) is gratefully acknowledged.

REVOLUTIONIZING MICROALGAE CELL WALL DISRUPTION: INVESTIGATING THE EFFECT OF ELECTRO-FENTON PROCESS WITH SACRIFICIAL STEEL ANODE

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Microalgae are renowned for their ability to hyperaccumulate lipids, which can be extracted and converted to biodiesel. The disruption of microalgae cells is a crucial step in biodiesel production as it enhances product yields by facilitating the release of intracellular lipids into the extraction solvent by rupture of cell walls. The use of the Fenton reaction for microalgae cell disruption is a novel approach which has the potential to be effective in the recovery of lipids. The Fenton reaction generates hydroxyl free radicals by the reaction between Fe^{2+} and H_2O_2, thus initiating a chain reaction which leads to microalgae cell disruption. However, the use of the conventional Fenton reaction is associated with several challenges, mainly in terms of sustainability due to excessive chemical usage. Thus, the electro-Fenton process (EFP) which involves the continuous electrochemical generation of H_2O_2 at a suitable cathode in the presence of Fe^{2+} has been developed to improve the overall sustainability of the process.
The current study was conducted to evaluate the viability of EFP for cell disruption and recovery of lipids from the wet biomass of the microalgae *Chlorella homosphaera.* The study adopted the novel strategy of electrochemical dissolution of a sacrificial steel anode to provide the Fe^{2+} ions necessary for the Fenton reaction. Response surface methodology (RSM) was used to optimize the EFP variables and maximize the lipid yield. The RSM model indicated that a maximum lipid yield of 18.29% could be obtained (R^2 = 90.66%, Adj.R^2 = 87.71%) under a 40 min of reaction time and 4.38 g/L biomass concentration. The lipid yield obtained from the experimental validation was recorded as 19.99±1.33%, which was significantly higher than the yield obtained via wet lipid extraction without cell disruption. Nonetheless, analysis of the fatty acid profiles showed that the biodiesel produced from lipids recovered through EFP would comply with the ASTM D6751-12 standard.

Key words: Microalgae, cell disruption, lipid extraction, Fenton reaction, sacrificial steel anode

SECURE SOFTWARE ENGINEERING: A KNOWLEDGE MODELING BASED APPROACH FOR INFERRING ASSOCIATION BETWEEN SOURCE CODE AND DESIGN ARTIFACTS

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Secure software engineering has evolved over recent decades, emphasizing the integral role of software security throughout the software development lifecycle. Each phase of this lifecycle is accompanied by security-specific best practices, including threat modeling and static code analysis. However, it has been observed that various artifacts generated through these practices (i.e., security requirements, architectural diagrams, bug reports), tend to remain isolated from one another. This segregation presents a substantial obstacle to addressing security issues during the implementation phase, as most of these artifacts originate during the design phase.

To address this issue, this research introduces a knowledge modeling-based approach to semantically establish associations between architectural-level security flaws and code-level security bugs, which is manually tedious. Threat modeling and static code analysis are leveraged to identify security flaws and security bugs, respectively. The case study-based experimental results revealed that the architectural level security flaws have a significant impact on originating security bugs at the code level. Additionally, the evaluation of this approach demonstrates its scalability in the context of large-scale industrial software products. This research contributes to the enhancement of secure software engineering practices by facilitating a more integrated approach to identifying and mitigating security vulnerabilities throughout the software development process.

Keywords—Software security; Threat modeling; Knowledge modeling; Security flaws

KINETIC STUDY OF HYDROXYAPATITE ORGANIC HYBRID SYSTEM USING THE QUARTZ CRYSTAL MICROBALANCE

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Development of controlled release biomolecules by surface modification of HA-Np has found potential applications in broader fields of medical and biotechnology specifically in relation to sensing, drug and nutrient delivery. However, understanding the kinetics and reaction mechanisms at the interface is vital for making these applications a reality. To date, tailoring HA-Np surface to match application specificities remains a challenge and requires a systematic understanding of the mechanism of its interfacial interaction with biomolecules. These interactions, to which considerably less attention is given, will govern the kinetics that makes the process viable for specific applications. This study investigates the effect of HA-Np crystal orientation on film stability in different media, interfacial kinetics, and surface binding mechanism with urea. The urea moiety is important in medicinal chemistry, and it is used as a structural motif in therapeutic drugs and is an essential plant nutrient whose release properties to soil can be optimized through its interaction with HA-Np. The latter area recently has become a major focus in smart agriculture. Therefore, in this study, urea is used as a model molecule with the expectation of developing a broader understanding of the interaction properties of urea-based bio molecules. Nano-gravimetry, based on QCM provides a unique experimental platform to study above in situ and real time with nano gram resolution. Further, it also provides the possibility to carry out spectroscopic and microscopic characterizations on the same sample surface. It is shown that the HA-Np film stability largely depends on the surface crystal plane orientation for a given medium. This finding provides important information, specifically related to HA-based sensor fabrication, where the sensor would remain for prolonged periods in the subject medium. Furthermore, the results also elucidate on different HA-Np, urea binding mechanisms associated with HA-Np surface crystal orientation that controls interfacial kinetics. The results in this study will create a paradigm for future studies on the evolution of nano-hydroxyapatite based bio sensor fabrication and for structurally optimizing hydroxyapatite nanoparticle surfaces to control interfacial kinetics for applications in bio nanotechnology and nanomedicine.

Keywords: Hydroxyapatite nanoparticles; Urea; Surface morphology; Interfacial kinetics; Controlled release; Bio interfaces

Extended Abstract

Technical Sessions:

Medical Sciences, Food & Nutrition

ADDITION OF PROPRANOLOL IN RESISTANT ARTERIAL HYPERTENSION TREATMENT (APROPRIATE STUDY) – A RANDOMIZED, DOUBLE BLINDED, PLACEBO CONTROLLED CLINICAL TRIAL

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1.INTRODUCTION

Uncontrolled blood pressure (BP) (>140/90 mmHg or >150/90 mmHg in those≥60 years of age) in spite of treatment at best tolerated doses with at least 3 anti-hypertensives (including a diuretic), is called resistant hypertension (RHT) [1,2]. Resistant hypertension (RHT) is associated with a significantly higher incidence of morbidity and mortality. Treatment options for RHT are limited. To accurately diagnose RHT it is essential to exclude causes for pseudo-resistance, which includes poor adherence to treatment, incorrect methods of BP measurement, and white-coat hypertension [3]. Mechanistic studies indicate the probable effectiveness of propranolol in RHT, but evidence from randomized controlled trials is not available.

2.MATERIALS AND METHODS

In this randomized, double-blind, placebo-controlled trial, patients from the clinics of the National Hospital of Sri Lanka with RHT, aged between 18-70 years of age were assigned to receive propranolol or identical placebo for 3 months. The primary outcomes of the study were to evaluate the fall of mean systolic (SBP) and diastolic blood pressure (DBP) measured by office blood pressure monitoring (BP) and 24-hour ambulatory BP monitoring (ABPM). The sample size calculated estimating for a difference of systolic BP (SBP) by 10 mmHg (SD: 18) and diastolic BP (DBP) by 5 mmHg (SD: 10.7) between groups (alpha: 0.05; beta: 0.10). Using the above parameters the calculated sample sizes were 140 and 180 patients to detect differences in systolic and diastolic blood pressures respectively. Using the higher number and adjusting for drop out and non-compliance rates a sample of 200 patients will be recruited with a 1:1 allocation per group. Informed written consent was obtained from all patients prior to recruitment. Subsequently, participants were randomised using computer generated random number allocation tables. Patients were assigned a recruitment number initially, which was subsequently allocated a computer-generated study number with a corresponding treatment kit number

that determined allocation to the treatment or placebo groups. The manufacturer was responsible for the labelling of kits, and the investigators and study participants were blind to treatment allocation.

Detailed of inclusion/exclusion criteria: patients aged between 18-75 years with essential hypertension with BP consistently >140/90mmHg (<60 years) or >150/90mmHg (>= 60 years) despite treatment with a 3 or more antihypertensive agents (including a diuretic) were recruited. Patients with SBP >220 mmHg, renal insufficiency with glomerular filtration rate <30ml/min, history of bronchospastic disorders, heart failure class III or IV, heart rate <50/minute, AV block (2ndor 3rd degrees), history of hypersensitivity to propranolol, patients already using beta blockers, women who were lactating or pregnant were excluded. All eligible patients were evaluated for compliance, adherence to lifestyle advices, measurement technique of BP, use of other medication interfering with control and subsequently underwent ambulatory BP monitoring (ABPM) for exclusion of white coat hypertension. Only patients who had BP an average BP of >140/90 (ABPM) were randomised.

3.RESULTS AND DISCUSSION

A total of 160 patients were included based on initial selection criteria to enter the screening phase following exclusion of white coat hypertension. Forty patients with RH were allocated into treatment and placebo groups (1:1 allocation).

The two groups were uniform with respect to mean age, gender distribution, entry BP and number of medications at baseline except for a significantly lower office SBP in the treatment group.

At the end of the study the mean office SBP was significantly reduced in the propranolol group (-29.72±12.9`8mmHg) compared to placebo group (-18.07±14.6mmHg) (p=0.046), with a non-significant yet similar higher reduction in office DBP (-12.44±12.82 vs. -6.33±16.59mmHg). ABPM demonstrated statistically significant reductions in total mean DBP from baseline to endpoint (p=0.031) with a reduction of 5.42± 6.14 mmHg in the propranolol group in comparison with a rise of -3.48±15.59 mmHg in the placebo group. The propranolol group had reductions in mean total ambulatory SBP, awake SBP and awake DBP. However, these observations were not statistically significant.

In the evaluation of the biochemical parameters, a reduction in serum sodium, potassium and serum renin was observed in the propranolol group when compared to placebo. The reduction of these parameters in the propranolol group was statistically significant. (Table 3). The mean difference of AOC levels in propranolol group (-1741.3±1159.5 μM) as well as in placebo group (-1895.1±869.4 μM) at baseline and after 90 days drug therapy was statistically significant ($p< 0.001$). The mean difference of NOx and nitrite ($NO2^-$) levels at baseline propranolol group and after 90 days drug therapy (-2.3± 1.5 μM) and (-0.8± 1.4 μM) respectively. The mean difference of NOx and nitrite ($NO2^-$) levels at baseline placebo group and after 90 days drug therapy (-1.2± 0.7 μM) and (-0.5± 3.1 μM) respectively.

No serious adverse effects were noted during the study period and none of the participants in either group were hospitalized due to adverse effects related to therapy. One patient in the propranolol group required cessation of the drug due to symptomatic sinus bradycardia. Hypersensitivity (immediate and/or delayed) was not observed in any of the study participants. There were no significant differences between the mean percentage (%) adherences of the two groups: propranolol 95.1% and placebo 98.1%.

The results of this RCT provide preliminary evidence as a proof-of-concept for the effectiveness and safety of propranolol in patients with RHT. Our results showed a -

statistically significant difference in the mean reduction of office SBP and end-point SBP in the treatment group compared to placebo group. Furthermore, ABPM demonstrated significant reductions in mean DBP from baseline to endpoint. In addition, propranolol achieved lowering of BP to the standard treatment target of <140/90 mmHg recommended by the 2018 hypertension guidelines issued by the European Society of Cardiology[5]for both office SBP and DBP, as well as ambulatory DBP. It is further notable that end point BP achieved values close to 130/80 mmHg or less for office BP and diastolic ABPM. The magnitude of reduction in BP achieved by propranolol was comparable to that observed in the ASPIRANT trial [6]. It is notable that the values of reduction were higher for mean office SBP (-11.6mmHg) and DBP (-6.1mmHg) even though the latter was not statistically significant. For ABPM values these were mean total SBP -7.1 mmHg (non-significant) and mean total DBP -8.9 mmHg ($p<0.05$), which were more than those observed in the above trial.

Increased sympathetic drive is now recognized as a determinant of RHT. In two post-hoc analyses of large outcome trials, patients with heart rates >80 bpm had higher mortality [7,8]. Hence, recent recommendations on the management of RHT suggest use of beta - blockers as an extended option [9]. Furthermore, there is recent interest on treatment directed at neurogenic hypertension as it is considered an important component in the treatment RHT[10]. This is evidenced by the consistent demonstration of increased sympathetic tone in hypertensive populations, particularly so in patients with severe hypertension. Neurogenic hypertension may be associated with psychological factors. However, the nature of this link has not been clarified[11]. Propranolol has been identified to reduce the tonic sympathetic nerve outflow from vasomotor centres in the brain, thereby reducing the central sympathetic tone. Furthermore, the anxiolytic properties of the drug may also play a role in BP reduction. Other mechanisms that contribute to the anti-hypertensive action of propranolol include inhibition of renin release from the kidneys[12]. Blockade on the renin pathway is fundamental in the management of hypertension as was illustrated by the effectiveness of mineralocorticoid blockade by spironolactone in the ASPIRANT trial. Although total peripheral resistance may increase initially, it readjusts to or below the pre-treatment level with the chronic use of propranolol[12].

Clinical trial evidence on the use of beta blockers in RHT is scarce. A recent clinical trial demonstrated that bisoprolol was not effective when compared to Spironolactone in the treatment of RHT [4]. However, bisoprolol has a restricted beta-1 selective action and may not be comparable to the effect of propranolol. The adverse effect profile in this trial was favourable with only one patient developing bradycardia requiring termination of medication. Urinary sodium excretion is noted to have a linear relationship with hypertension via multiple pathogenic mechanisms. It also has a relationship with sympathetic activity and is postulated to decrease with administration of beta blockers, which retard sympathetic activity. Furthermore, patients who have significant reduction in urinary sodium excretion are hypothesized to have an increased response to medication, like that observed with administration of spironolactone [13]. We did not observe any significant differences in urinary electrolytes levels in this trial. But we observed significant differences in serum electrolytes and plasma renin activity in this trial. However, further primary pathogenic and mechanistic studies are recommended.

This clinical trial compared the effect of propranolol to placebo. In order to establish the place of propranolol in the treatment of RHT comparison with other medication such as spironolactone should be conducted. Furthermore, the mortality outcomes produced by propranolol need to be studied. This study was not designed to examine this outcome. The premature termination of this trial resulted in reduction of sample size.

Therefore, further studies are needed to further consolidate the observations derived from this trial.

Tables and figures

Table 1: Baseline characteristics of the study population

Baseline characteristic	Propranolol	Placebo	P value
Mean age	56.45 ± 9.89	56.85 ± 10.07	0.900
Weight	66.65 ± 10.74	71.75 ± 12.95	0.182
Height	152.86 ± 7.15	156.05±9.13	0.223
BMI	28.42 ± 3.81	29.33 ± 4.39	0.491
Antihypertensive medication	3.5	3.5	0.587

Table 2: Office and ambulatory blood pressure in the propranolol and placebo

	Mean (±SD) (mmHg)					
	Visit 0 (Baseline) (n=40)	Visit 1 (1 month) (n= 38)	Visit 2 (2 months) (n= 34)	Visit 3 (3 months) (n=33)	Change Visit 0 to 3	P Value
Office SBP Placebo Propranolol	159.25±11.97 159.65± 10.53	140.79±13.57 141.84± 19.52	152.06±24.24 141.67± 20.93	139.93±14.17 130.00±13.24*	-18.07±14.63 -29.72±12.98	0.046
Office DBP Placebo Propranolol	90.75±11.89 92.35± 10.95	81.58±8.34 83.42± 8.83	84.39±13.00 83.33± 13.72	82.66±8.58 77.83±9.65	-6.33±16.59 -12.44±12.82	0.142
Total ambulatory SBP Placebo Propranolol	148.58±7.72 153.58± 12.74	NM NM	NM NM	149.17±12.51 137.28±12.55	-4.1±13.34 -11.21±14.69	0.080
Total ambulatory DBP Placebo Propranolol	84.34±6.83 81.82± 18.75	NM NM	NM NM	84.08±8.44 79.40±5.52*	+3.48±15.59 -5.42±6.14	0.050
Ambulatory awake SBP Placebo Propranolol	151.69±6.29 155.77± 12.21	NM NM	NM NM	143.68±12.36 138.31± 11.52	-12.49±1.70 -13.64±15.06	0.805
Ambulatory awake DBP Placebo Propranolol	86.54±6.97 87.85± 7.31	NM NM	NM NM	83.61±9.49 80.83±5.99	-3.88±4.51 -6.27±4.51	0.331
Ambulatory sleep SBP Placebo Propranolol	135.19±35.23 147.61± 20.02	NM NM	NM NM	118.72±62.65 134.80±19.79	-26.58±64.38 +1.18±32.32	0.942

Ambulatory sleep DBP Placebo Propranolol	75.72±19.78 80.06± 10.02	NM NM	NM NM	71.97±30.99 76.64± 8.49	-6.54±27.75 +1.03±19.27	0.322
Reduction of Mean office SBP Propranolol	159.65± 10.53	141.84± 19.52	141.67± 20.93	130.00±13.24*	-29.72±12.98	0.021
Reduction of Mean Ambulatory DBP Propranolol	84.34±6.83	NM	NM	79.40±5.52*	- 5.42 ± 6.14	0.031

DBP – Diastolic Blood Pressure; NM – Not Measured; SBP – Systolic Blood Pressure; SD – Standard Deviation

Table 3: Changes in biochemical parameters in the propranolol and placebo groups during the treatment period ITT analysis

	Mean (±SD)				
	Visit 0 (Baseline) (n=40)	Visit 1 (1 month) (n=38)	Visit 2 (2 months) (n= 34)	Visit 3 (3 months) (n=33)	P Value
Serum creatinine (µmol/L) Placebo Propranolol	0.99 ± 0.29 0.89 ± 0.22	NM	NM	1.14 ± 0.52 0.91± 0.21	0.467
Serum sodium (mmol/L) Placebo Propranolol	137.55 ± 3.02 129.67 ± 30.56	NM	NM	134.53 ± 2.00 136.33± 3.14	0.124
Serum potassium (mmol/L) Placebo Propranolol	4.08 ± 0.46 3.96± 0.54	NM	NM	4.04 ± 0.49 3.98 ± 0.43	0.609
Urinary sodium (24 hour) (mmol/L) Placebo Propranolol	139.61 ± 70.20 142.58± 67.91	NM	NM	136.75 ± 56.51 129.48± 53.92	0.415
Urinary Potassium (24 hour) (mmol/L) Placebo Propranolol	30.64 ± 13.20 33.76± 17.55	NM	NM	26.06 ± 11.88 26.42± 12.60	0.415
Plasma renin activity (mg/ml/h) Placebo Propranolol	7.86 ± 13.26 15.36± 21.56	NM	NM	4.47 ± 4.65 5.66± 10.02	0.415
Antioxidant level (µM) Placebo Propranolol	404.5 ± 385.7 299.1± 117.3	NM	NM	2195.1 ± 961.9 1924.2± 1085.5	0.431

NM – Not Measured

4.CONCLUSION

This study data demonstrate efficacy of propranolol in patients with resistant hypertension in comparison to placebo with minimal adverse effects in the 12-week period of follow up.

Further large prospective randomised trials are recommended to consolidate the evidence from this pilot study and also elucidate mechanisms responsible.

5.ACKNOWLEDGMENT

This work was supported by the National Research Council of Sri Lanka under grant number: NRC 15-070.

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IMPACT OF CLIMATE FACTORS ON THE PREVALENCE OF CUTANEOUS LEISHMANIASIS: A RETROSPECTIVE CROSS-SECTIONAL STUDY FROM KURUNEGALA DISTRICT, SRI LANKA

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Abstract
Human health is one of the aspects that have been directly or indirectly affected by the modified weather patterns derived from climate changes. The alterations that affect ecological aspects of the infectious agents and the vector species is likely to directly affect the incidence of vector-borne diseases. A retrospective cross-sectional study was conducted to assess the correlation of meteorological variables on reported leishmaniasis cases during 2014-2019 in Kurunegala District and meteorological variables on measured sand fly densities in selected areas in the district during May 2017- December 2019. The number of patients had a moderately strong positive correlation to the maximum temperature at a lag of one month ($r=0.417$, $P<0.05$). The average relative humidity showed a weak positive correlation at a three months' lag ($r=0.291$, $P<0.05$). The sand fly abundance was positively affected by the relative humidity and the rainfall. The impacts of climate change on leishmaniasis are logically possible and currently well supported by the study results. The assessment of effects on sand fly populations further confirms the retrospective study results. The higher temperatures may be increasing the parasite growth and development rates, while the humidity and rainfall modifies the vector densities. Future studies on the nature of these impacts and mathematical modelling based prediction systems are also required for more conclusions.
Keywords: leishmaniasis, climate change, parasite growth, vector density

1. INTRODUCTION
Human health is one of the aspects that have been directly or indirectly affected by the significant changes in climate. Unlike other diseases, vector-borne diseases should be viewed from an ecological point of view. Leishmaniasis is a vector-borne disease caused by parasites from the genus Leishmania (*Trypanosomatida: Trypanosomatidae*), transmitted by the bites of an infected female Phlebotomine sand flies (Diptera: Phlebotominae). In Sri Lanka, the disease is caused by *Leishmania donovani*. Among the three major forms of the disease; namely, cutaneous leishmaniasis (CL), visceral leishmaniasis (VL) and muco-cutaneous leishmaniasis, CL is the most common form in Sri Lanka (Karunaweera et al., (2007); Wijerathna et al., (2017). Over 3,000 cases are reported per year from the country and Kurunegala district has the majority of these cases among all the districts. Although a total of 22 species of sand flies are reported from the country (Wijerathna and Gunathilaka, 2019), the main suspected vector species is *Phlebotomus argentipes* (Senanayake et al., (2015); Wijerathna et al., (2021). Leishmaniasis is one of the diseases with a high likelihood of being affected by the climate change. (WHO, 2023). Therefore, the objectives of this study were to assess the correlation of meteorological variables on reported leishmaniasis cases during 2014-2019 in Kurunegala District and meteorological variables on measured sand fly densities in selected areas in the district during May 2017- December 2019.

2. MATERIAL AND METHODS

A retrospective cross-sectional study was conducted in Kurunegala District, Sri Lanka to assess the effect of climatic factors on the vector abundance and Leishmaniasis transmission. The recorded cases of leishmaniasis during January 2014 to December 2019 in the Kurunegala district were retrieved from the office of the Regional Director of Health Services (RDHS). Monthly mean values from January 2014 to December 2019 of the six climatic parameters (rainfall, average temperature, minimum temperature, maximum temperature, wind speed, and relative humidity) were obtained from the Department of Meteorology, Sri Lanka. The spearman's rank correlation was used to determine the associations between climatic variables with number of recorded patients. Field entomological surveillance was carried out on a monthly basis from May 2017 to December 2018 using 4 different field collection techniques: hand collection (HC), light traps (LT), sticky traps (ST) and cattle baited net trap Collection (CBNT) at selected MOH areas (Polpithigama, Maho and Galgamuwa) in Kurunegala District by the research team.

3.RESULTS AND DISCUSSION

Direct correlation analysis using spearman's rank correlation did not show significant associations between the monthly numbers of patients with the climatic factors of the same month. The cross-correlation analysis of the number of patients against each climatic factor after pre-whitening indicated a moderately strong positive correlation with the maximum temperature at a lag of one month ($r=0.417$, $P<0.05$). The average relative humidity, on the other hand, showed a weak positive correlation at a three months' lag ($r=0.291$, $P<0.05$). The correlation of the number of patients with other climatic factors did not reach the significant levels. The increased temperature may affect the disease incidence in two ways.

The sand fly abundance was highest when the relative humidity and the rainfall are highest (Figure 2) supporting the above explanations of sand fly abundance being affected by relative humidity, though the average temperature and maximum temperature have different impacts. During the main peaks observed in the sand fly abundance, the average temperature was low. A considerable drop of the average temperature could be seen in the month with the highest number of sand flies. The wind speed was also lower in the months of higher sand fly abundance. A significantly a higher sand fly density was identified in April 2018. Other than that the sand fly density was almost uniform in the study sites with minor variations.

Phlebotomus argentipes was identified as the predominant species (99.50%, n=38,147) (Wijerathna et al., (2022). The main peaks of the sand fly abundance were followed by an increase in the number of cutaneous leishmaniasis patients. Cross autocorrelation indicates that the number of patients shows a strong positive correlation ($r=0.516$, $P<0.05$) with a lag of 7 months. Thus, the direct determinants of the sand fly abundance could be considered as indirect determinants of the leishmaniasis incidence in the area. The present study suffers several limitations. This study used the climatic data collected from a district center and generalized to the whole district. Therefore, fine-scale spatial and temporal variations in climate and disease transmission, potentially overlooking local factors that influence leishmaniasis prevalence may not be possible to describe. In addition, the entomological surveys were conducted at selected locations in the district which may not be sufficient to extrapolate it to the whole district. Finally, there was no attempt made to link three data types (Patients, climatic and vector) used in this study to predict the disease occurrence in the district.

4.CONCLUSIONS

The number of patients indicated a positive correlation to the maximum temperature after one-month lag and a weak positive correlation was observed with relative humidity a three-after a three-month lag period. Despite the on-going debates regarding the effects of climate change, research generated knowledge consistently confirms that the successful mitigation of climate change will ameliorate many issues associated with climate change including the burden of the vector-borne diseases. Future studies are required to provide more direct evidence to show the nature of these impacts.

5.ACKNOWLEDGMENT

The authors would like to acknowledge National Research Council (NRC), Sri Lanka (Grant No. 16-142) for the financial assistance.

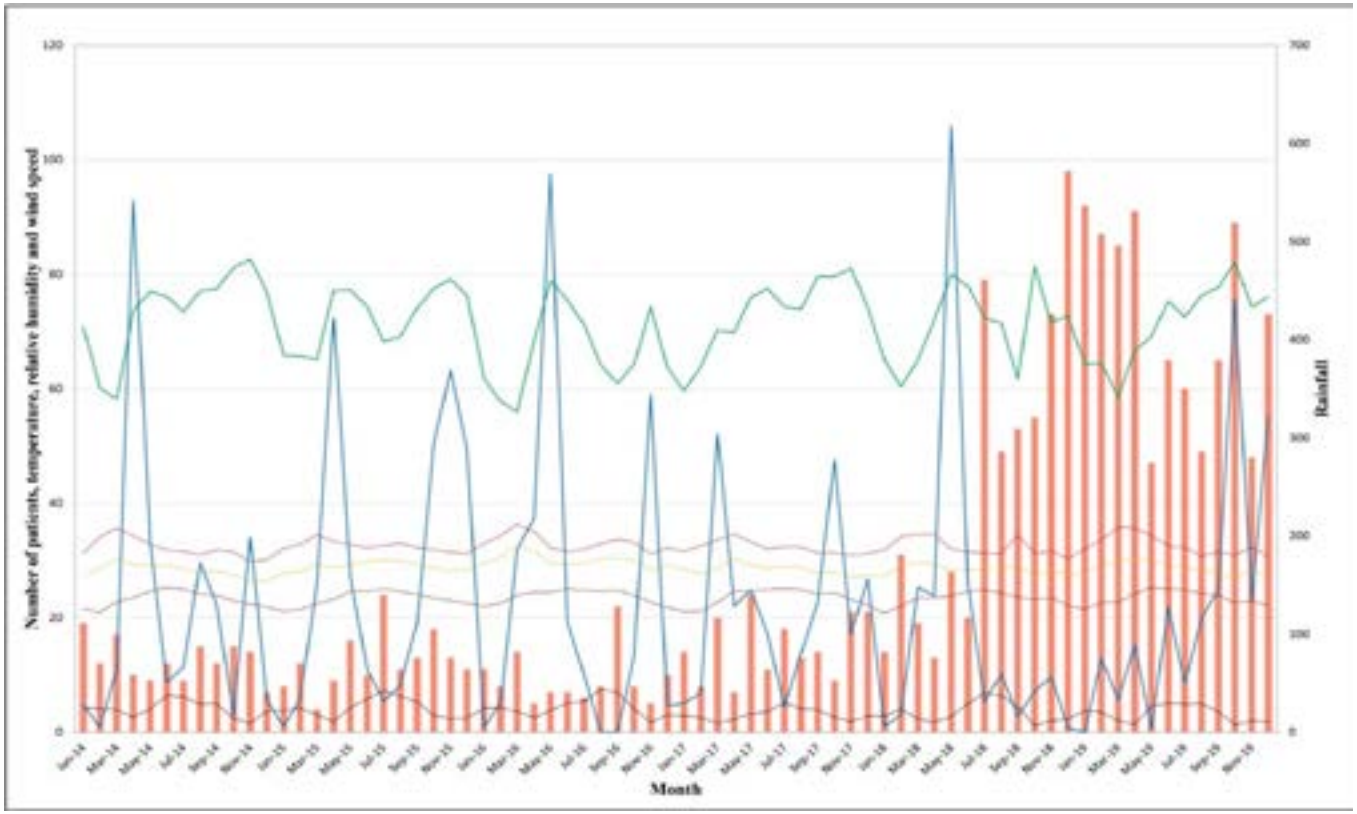

Figure 1. Variation of the number of leishmaniasis patients (red bars) and the climatic variables: rainfall (blue), relative humidity (green), wind speed (black), maximum temperature (red), average temperature (yellow), minimum temperature (maroon) in Kurunegala District Sri Lanka from January 2014-December 2018 in relation to the climatic factor

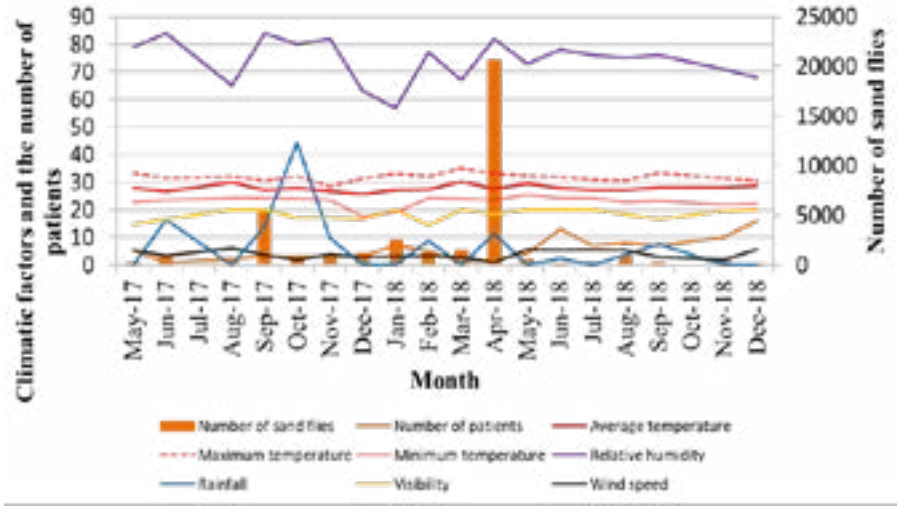

Figure 2. Variation of the number of sand flies and the leishmaniasis incidence in Polpithigama, Maho and Galgamuwa MOH areas in Kurunegala District from May 2017-December 2018 with the climatic factors.

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Technical Sessions: Ecology & Environment

ECOLOGICAL AND SOCIAL IMPACTS OF BAMBUSA *BAMBOS (L.)* VOSS: A SYNTHESIS

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1. INTRODUCTION

Bamboos show some invasive traits such as fast growth rate, clonal reproduction, competitive ability and formation of monocultures (Lima et al., 2012). Due to fast growth rates and clonal reproduction, bamboos show an exceptional ability to occupy and dominate native forests through competition for space and resources (Ben-Zhi et al., 2005). Bambusa bambos is a native woody bamboo species in Sri Lanka that spread naturally in moist evergreen forests (TMEFs) and dry mixed evergreen forests in intermediate and dry zones, respectively (Wijewickrama et al., 2017). Due to its thorny nature, it is also known as thorny bamboo or "Katu Una" in Sinhala. B. bambos is identified as an invasive species elsewhere with its ability to outcompete co-occurring native species. Gunatilleke et al., (2008) predicted that the rapid spread of B. bambos may alter the vegetation structure and species composition in native forests in Sri Lanka. Due to its native status, no comprehensive studies have been carried out previously to assess the ecological or socio-economical impacts of the expanding nature of B. bambos in Sri Lanka. The present study was aimed at evaluating the ecological and social impacts of the B. bambos spread in secondary forests in the Intermediate Zone of Sri Lanka. The study evaluated the potential impacts of B. bambos dominance on the existing vegetation, regeneration potential, edaphic properties, soil microbial communities and litter-dwelling insect assemblages. In addition, a social survey has also been carried out among the local communities to explore the awareness, perceptions and views of the bamboo spread.

2. MATERIALS AND METHODS

Field sampling, laboratory analysis and statistical analysis

A vegetation study was carried out in forest patches with and without bamboo (B+ and B-) from three localities in the Matale District viz., Galboda (GAL), Moragolla (MOR) and Maragomuwa (MAR). Six 100 m2 quadrats were placed at different distances from the forest edge towards the forest interior along three transects in both bamboo and non-bamboo forest patches per site totaling 108 quadrats. In each quadrat, vegetation was enumerated in the layer above 2 m in height. The regeneration potential was evaluated using 1 m2 quadrats, where seedlings (< 50 cm in height) were recorded monthly for a year. Ten well-represented soil samples were randomly collected from each forest type (B+/B-) to analyze edaphic properties.

10 composite soil samples were collected from both bamboo- and non-bamboo sites,- to determine the arbuscular mycorrhizal fungal (AMF) spore counts. To enumerate litter-dewelling arthropods, litter samples were collected using a 1 m × 1 m wooden quadrat randomly (n = 108). The litter-dwelling arthropods were extracted using Winkler Extraction Method (Bestelmeyer et al., 2000). AMF spores and arthropods were identified to thier generic and order levels, their abundances were also recorded. A questionnaire based-survey was conducted using 78 households from three villages to gather their perceptions and views on the ecological and socio-economic impacts of the bamboo spread. Due to high site-specific differences, the results were analyzed and presented site-wise. The mean comparisons were performed using one-way ANOVA, repeated measure ANOVA, General Linear Model, two-sample t-tests etc. in Minitab 17.0. In addition, Diversity indices, SIMPER analysis, Correspondence analysis (CA) and Principle Component Analysis (PCA) were performed.

3. RESULTS AND DISCUSSION

Higher plant abundance and richness, lower stature together with low stem density of larger trees in MAR indicated its place in relatively lower successional stage than that of GAL and MOR, highlighting, high site-specific differences. Results showed a clear compositional separation of forest communities with and without bamboo attributing to bamboo- driven micro-climatic modifications (Wijewickrama et al., 2020; Figure 1). In bamboo forests, light-loving early successional species were more prevalent than that in non-bamboo forests, where late-successional species are more prevalent. The patchy spread of bamboo and its spreading habit disturb the almost continuous forest canopy, thus allowing more sunlight to reach the forest floor, favouring the establishment of early-successional species. Previous studies noted that the floristic assemblages in young secondary forests cannot be easily distinguished as they are determined by a culmination of several factors such as post-disturbance soil seed bank, nature and the intensity of disturbances as well as micro-climatic conditions (Perera, 2001).

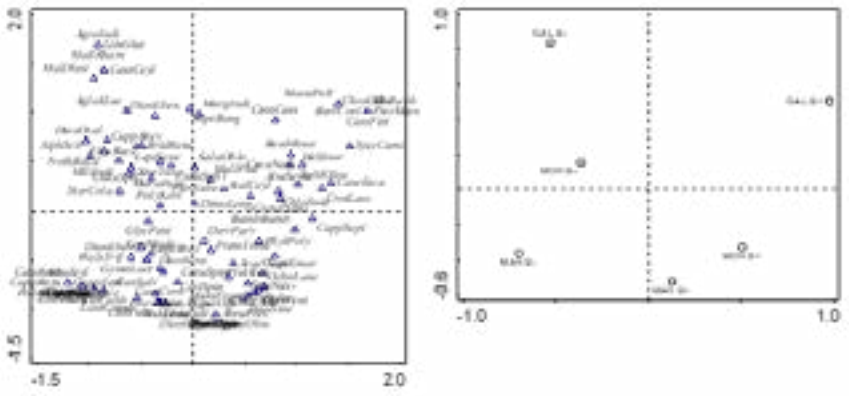

Figure 1: The ordination diagram following correspondence analysis (CA) of the relative abundance of species in B+ and B- forest patches in three different locations, GAL, MOR and MAR.

In addition to *B. bambos*, *Pterospermum suberifolium*, more prevalent in bamboo-dominated forests, and *Nothopegia beddomei*, more frequent in forests without bamboo, have contributed markedly to the disparity between bamboo- and non-bamboo forests in all study sites.

The SIMPER analysis showed that all three species have contributed approximately to 50 % of the total dissimilarity between the two forest communities. Being one of the most dominant tree species in tropical moist evergreen forests in Sri Lanka (Gunatilleke et al 2008), *N. beddomei* was recorded in bamboo-free forests more frequently while almost absent in bamboo-rich forests, suggesting its high vulnerability to disturbances caused by the spread of *B. bambos.*
The study also revealed consistently higher tree mortality incidences in bamboo forests irrespectiv of study sites, further highlighting the detrimental impacts of the bamboo spread on the forest health (Wijewickrama et al., 2022; Figure 2).

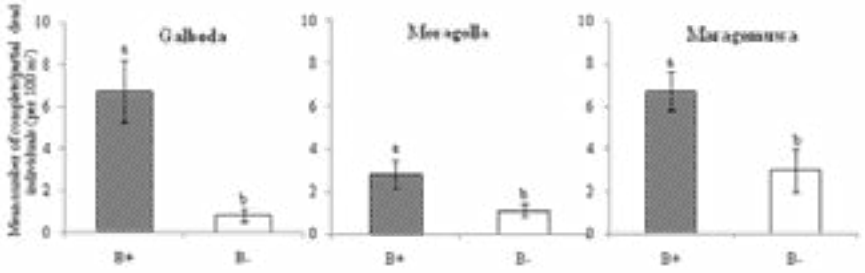

Figure 2: Mean number of completely/partially dead trees between B+ and B- sites in GAL), MOR and MAR, Sri Lanka. Vertical lines indicate the standard error of the mean (SEM).

Frequent forest fires and allelopathy can be speculated as possible causes behind this high mortality incidences reported in bamboo forests. Light-weight bamboo litter could provide fuel for man-made fires during dry seasons, possibly contributing to high mortality incidences in TMEFs. These fires may contribute to tree mortality, while facilitating the bamboo spread by providing more vacant spaces and resources. It is also known that bamboos thrive well under disturbed conditions mainly owing to their ability to reporduce through clonal growth (Gagnon and Platt, 2008). Therefore, both the frequency and intensity of fires may alter the forest succession, and facilitate the superiority by *B. bambos*. The patchy distribution of man-made fires can thus be considered as a decisive factor for interpreting bamboo-driven impacts and other site specific differences.

The study also demonstrated impacts of the bamboo spread on the regeneration potential of these forests, suggesting long-term impacts. Though abundance and richness of the recruits were higher in bamboo forests in comparison to non-bamboo forests, however, these increases are mainly due to liana and herbaceous species. Tree and shrub seedlings belonged to species that are common to TMEFs were notably absent or low in abundance in bamboo-dominated forests (Wijewickrama et al., 2022; Table 1). In favour, previous studies too have demonstrated that the single-species dominance of bamboos may arrest natural recruitment of tree seedlings (Griscom and Ashton, 2006).

Table 1: Mean survival (per 1 sq. m) of seedlings of different life forms in B+ and B- forest patches at GAL, MORand MAR, Sri Lanka. Only significant differences are indicated in lowercase letters.

Site	Type	Mean survival			
		Tree	Shrub	Liana	Herb
GAL	B+	2.47[b]	1.02	3.17[a]	1.18
	B-	4.88[a]	1.21	2.22[b]	0.85
MOR	B+	1.84[b]	0.67	2.17[a]	2.61[a]
	B-	2.42[a]	0.90	1.61[b]	0.04[b]
MAR	B+	1.60	1.52	2.60	1.36[a]
	B-	1.76	1.72	2.59	0.08[b]

Compositional changes were noted in both the seedling community as well as in extant vegetation. Thus, high mortality and the lack of tree seedling emergence may eventually lead to altered native forests in terms of structure and composition over time.
The findings also suggest that the occurrence of *B. bambos* increases the abundance, richness and diversity of the AMF community as well as the litter-dwelling arthropods (Mafaziya et al., 2019; Wijewickrama et al., 2021; Table 2).

Table 2: Comparison of characteristics of AMF and litter arthropods in B+ and B- forest patches at GAL, MOR MAR, Sri Lanka. Significant differences are indicated in lowercase letters.

		GAL		MOR		MAR	
		B+	B-	B+	B-	B+	B-
AMF spores	S-W Diversity	2.446	2.353	2.25	2.204	2.201	2.205
	Abundance/100 g soils	41.2[ab] (20.1)	30.2[b] (13.3)	56.3[a] (20.6)	40.1[b] (13.7)	60.2[a] (25.5)	19.5[b] (8.1)
	Richness/100 g soils	10.9[a] (3.1)	8.4[ab] (1.8)	9.9[a] (1.7)	9.8[a] (1.9)	8.8[a] (1.5)	6.5[b] (2.1)
Litter arthropods	Density/sq.m.	33.2[a] (26.6)	8.0[b] (4.3)	30.7[a] (18.3)	14.7[b] (7.6)	14.0 (8.3)	9.3 (5.6)
	Richness/sq.m	6.8[a] (1.6)	3.4[b] (1.2)	6.8[a] (1.5)	5.9[b] (1.6)	6.3 (2.2)	5.1 (2.3)

The microclimatic modifications and the high heterogenity of the forest floor caused by the bamboo spread (through changing litter quality and quantity, sunlight seeps through the open canopy etc.) may have provided suitable conditions for the litter-dwelling arthropods and mycorrhizae, thus increasing their abundance and richness. The PCA biplot too revealed a clear separation of B+ and B- forests in terms of the abundance and richness of litter-dwelling arthropods (Figure 3). A higher prevalence of plant debris in bamboo forests driven by high litter fall and mortality incidences seems to provide a favorable substrate for detritivorous arthropods. Coarse woody debris is known to increase the habitat complexity while providing food and habitat for the litter-dwelling fauna to thrive in forests *(Tews et al., 2004).*

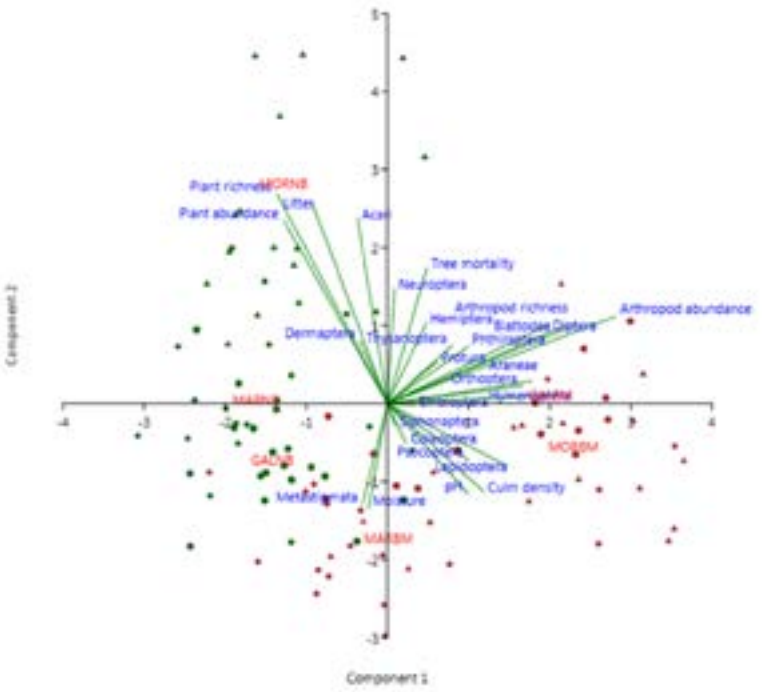

Figure 3: Biplot of the Principal Component Analysis (PCA) on abundance and richness of litter-dwelling arthropods and environmental variables (soil, litter and vegetation).

The study also confirms that the bamboo spread has no direct impact on the income of the local communities. However, due to strict regulations, the community's dependence on bamboos for cultural and religious purposes has also been in the decline over time (Wijewickrama et al., 2020). Despite some negative influences of the bamboo spread, their perceptions on the issue are highly divided.

4. CONCLUSION

The study concludes that the bamboo spread can cause long-term impacts on these native forests threatening their quality and resilience in the face of emerging threats such as climate change. Modifications to the microclimate of the forest floor due to the bamboo spread seem to enrich the soil fauna and flora, with a possible risk of increasing nutrient dynamics, which could eventually expedite the probable consequences of climate change. In addition to ecological impacts, the study also highlights the importance of considering community perceptions when introducing landuse planning and other management strategies to minimize impacts caused by the bamboo spread.

5. ACKNOWLEDGMENT

The authors wish to thank the National Research Council, Sri Lanka for providing financial support (Grant No: 16-054) to conduct this study.

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