irc | 2022

Hosted by

SLTC Research University

International Research Conference of SLTC 2022

Technological Advancements for Sustainability

29th & 30th September 2022

SLTC Main Campus | Hybrid Mode

CONFERENCE PROCEEDINGS

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Conference Proceedings

International Research Conference 2022

29th and 30th September 2022

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IRC 2022

https://irc2022.sltc.ac.lk/

Conference Venue

SLTC Main Campus | Hybrid mode

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Contents

Welcome from the Founder President/CEO of the SLTC Research University

It is with great pleasure that I write this message of felicitation on the occasion of the International Research Conference 2022 (IRC2022) of SLTC Research University to be held on 29th & 30th September 2022.

The International Research Conference held annually at SLTC provides a forum for the academics and research students from all Schools to present their research findings at one venue to an audience with high intellectual capacity. The constructive feedback that the researcher would gather from deliberations may pave the way to new frontiers in research.

This year the theme of this IRC is "Technological Advancements for Sustainability" under 09 thematic areas. Thus, IRC2022 is open to wider participation from other academic and research institutions within and outside Sri Lanka.

On behalf of the SLTC, I wish to express my deep gratitude to the Chief Guest, Dr. Harsha Subasinghe, President and Chief Executive Officer CodeGen Group of Companies for accepting our invitation despite his busy schedule to grace this occasion. My gratitude also goes to the Keynote Speakers and the Chairpersons and judges of Sessions. I take this opportunity to compliment the Chair-person and the Organizing Committee who had an enormous task at their hands in handling and processing a large number of abstracts, proceedings, and other necessary arrangements to make IRC2022 a great success.

I welcome all participants and presenters to the SLTC and wish their participation at IRC2022, a memorable and rewarding experience.

Eng. Rangith G. Rubasinghe
Founder President/ CEO SLTC Research University

Welcome from the General Chair

The International Research Conference (IRC) is one of the most important annual events for the SLTC Research University. The IRC highlights the research findings of undergraduates, postgraduates, and academia in one forum, with all the six schools and five centers of the SLTC Research University, other local and international universities and research organizations. IRC2022 will be the second of its kind, organized and hosted by the SLTC Research University.

The theme "Effective Response to Unfolding Sustainability Advances" embraces the IRC 2022 with 13 tracks of engineering and built environment, electrical and power engineering, machine learning, artificial intelligence and robotics, telecommunication engineering, social sciences, humanities, & culture, innovative education, chemical process technology, waste management, food and food security, forestry and land use, aquaculture & aquatic life, agronomy & biotechnology, and nanotechnology. IRC2022 will provide a forum for academics, industrialists, government, and non-government officials, and research students from the SLTC, over 25 other Sri Lankan universities and institutes, and over 20 foreign universities and institutes to present their research findings a t o ne venue to an audience with high intellectual capacity. The constructive feedback that the researcher would gather from interactive discussions may pave the way to new frontiers in research. Further, the organizing committee hopes IRC2022 will help to spread knowledge and will trigger innovations that are needed to meet the Sustainable Development Goals.

I wish to thank the Chief Guest, Dr. Harsha Subasinghe, President and Chief Executive Officer, CodeGen Group of Companies and the distinguished Ke ynote Speakers. A key figure in guiding and enriching the event is Eng. Ranjith G. Rubasinghe, Founder President/CEO of the SLTC, with the ardent support of Prof. Dush Jayakody, the Director of Postgraduate Research and Impact, SLTC / General Cochair of IRC2022, Dr. Nanda Gunawardana, the Director of International Affairs, S LTC Research U niversity/ G eneral Cochair of IRC2022, Dr. Udesh Oruthota, Director Resources, SLTC, Dr. Jagath K. Wijerathna, Director Academic Affairs, Dr. Amali Guruge, the Secretary IRC2022, the Head of Faculties, the Head of Schools, the Members of the Senate and the administrative officials.

Therefore, I, on behalf of the Organizing Committee, acknowledge the valuable contributions made by them all, towards achieving our goals. I take this opportunity to extend my sincere appreciation to members of the Organizing Committee, Leads and Members of the Sub-Committees, Editorial Boards, the expert panel of reviewers, sponsors, and all the others who contributed in numerous ways, working tirelessly to accomplish our targets and make this event a great success.

It is my honor and privilege to welcome all the distinguished delegates and researchers to IRC2022 and I hope that you will find the conference extremely productive, interactive, and inspirational.

Dr. Renuka Ariyawansha,
Senior Lecturer / Faculty of Engineering and Technology
Lead / Office of Research and Innovation Services (ORIS)

Welcome from the Co-Chair - Prof. Dushantha Nalin K. Jayakody

Please accept our sincere welcome to the 2nd International Research Conference (IRC 2022) of SLTC Research University, Padukka, Sri Lanka on 29-30 Sept 2022 under the theme of Technological Advancement for Sustainability. IRC 2022 focuses on 9 themes, namely, Biomedical Engineering, Civil Engineering & Built Environment, Electrical, Electronics, Mechanical & Systems Engineering, Information and Communication Technology, Machine Learning, Artificial Intelligence & Robotics, Mathematics and Statistics, Social Sciences, Humanities, Culture & Education, Economics and Business Management, Sustainable Agriculture, Environment, and Food Security.

This conference brings together thought leaders from industry, academia, government agencies and other institutions to exchange information and ideas on advancing the state-of-the-art under the theme "Technological Advancement for Sustainability". While this is the 2nd edition of this IRC 2022 conference, we have received a notable amount of high-quality submissions providing a basis for an excellent technical program.

I my express my sincere gratitude to all our distinguish keynote speakers; Prof. Yonghui Li, ARC Future Fellow, Fellow IEEE, University of Sydney, Australia on "Beyond 5G towards a super-connected world", Dr. Rostislav Yavorski, Exactpro Systems keynote on "Artificial intelligence in software testing", Prof. Benedict F.A. Basnayake, University of Peradeniya on "Agriculture in the living environment for safe food supply" and Prof. Rangika Halwathura, University of Moratuwa and Commissioner at Sri Lanka Inventors Commission, "Invention/innovation and sustainability" and Prof. Lahiru Jayakody, Southern Illinois University, USA on "The hybrid thermo-biological process to upcycle agricultural waste plastic".

We are indebted to the entire organizing and technical program committee, especially to the Chairs, namely Dr. Renuka Ariyawansa, Dr. Amali Guruge, Dr Sangeeth Rathnayake, Ms Vishaka Basnayaka, Ms. Anushka Maduwanthi, Ms Dhanesha Nanayakkara, Ms Warunika Hippola, Mr. Chathuranga Basnayaka, Mr Pasan Maduranga, and many colleagues. Needless to say that countless further volunteers contributed in numerous ways to the success of the conference.It is our privilege to convey the community's gratitude to the conference patrons as well, who appear on the conference home page. The conference received a sponsorship from the Exactpro Sri Lanka, in which, we are very grateful to the Global CEO Iosif Itkin and Mr. Jagath De Silva, CEO, Sri Lanka.

Our program features an astonishing collection of keynotes, tutorials, and technical talks by distinguished researchers in the field. We also have a rich program for students/recent results consisting of abstract paper submission sessions. Our hope is that you, dear colleague, will enjoy the technical discussions, meeting old/new friends and forging new professional links, but that you will also be able to sample the local culture and history - we look forward to an enlightening and enjoyable event with you at the SLTC Research University, Padukka, Sri Lanka!

Prof. Dush. N. Jayakody
Professor/ Director Postgraduate, Research & Impact
SLTC Research University

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Workshop on Underwater Wireless Communications (UWC)

Underwater Wireless Communications (UWC) are significantly important during marine activities such as environmental monitoring, underwater exploration, and scientific data collection. In this workshop, potential research communities will be enlightened about the state-of-the-art contributions, and recent advances in UWC, and encouraged toward future research directions.

Session 01: Introduction to 5G Wireless Communications

Prof. Ammar Munthana

Bonch-Bruevich Saint-Petersburg State University of Telecommunications, RUDN University, Russia

Bio Information

Ammar Muthanna is an Associate Professor at the Department of Telecommunication networks, Deputy Head of Science, and Head of SDN Laboratory. He received his B.Sc. (2009), M.Sc. (2011) and as well as Ph.D. (2016) degrees from Saint-Petersburg State University of Telecommunications. From 2017 to 2019 he worked as a Postdoctoral Researcher at RUDN University. In 2012 and 2013, he took part in the Erasmus student Program with the Faculty of electrical engineering, University of Ljubljana, and in 2014 he was a visiting researcher at Tampere University, Finland. Ammar is a senior Member of the IEEE and an ACM member. He has been an Active Member of the Technical Program Committee on many international conferences and journals. He has been an expert at the Judges Panel and Challenge Management board at AI-5G-Challenge, ITU and Russian host organizer. His areas of research are: wireless communications, 5G/6G cellular systems, IoT applications, Edge computing, and software-defined networking.

Session 02: Introduction to 6G Underwater Wireless Communications (UWWC)

Prof. Dushantha Jayakody,

Sri Lanka Technological Campus, Sri Lanka / TECHLAB, Universidade Autónoma de Lisboa, Portugal

Bio Information

Prof. Dushantha Nalin K. Jayakody, Senior Member IEEE, Fellow, IET, received a Ph.D. degree in Electronics and Communications Engineering, from University College Dublin, Ireland. He received his MSc degree in Electronics and Communications Engineering from the Department of Electrical and Electronics Engineering, Eastern Mediterranean University, Turkey (under the University full graduate scholarship). From 2014-2016, he was a Postdoc Research Fellow at University of Tartu, Estonia and University of Bergen, Norway. Since 2021, he has been employed at the Autonoma TechLab, Portugal and Sciences and Technologies Department (STD), Universidade Autónoma de Lisboa, Portugal. From 2016 to date, he is a Professor at the School of Computer Science & Robotics, Tomsk Polytechnic University (TPU), Russia. He also serves as the Head, School of Postgraduate Studies & Research, Sri Lanka Technological Campus, Sri Lanka. He has supervised 15 PhD students and many master and undergraduate students. He held visiting and/or sabbatical positions at the Centre for Telecommunications Research, University of Sydney, Australia in 2015 and Texas A&M University in 2018. In July 2019, Prof. Jayakody received the Education Leadership Award from the World Academic Congress in 2019. In 2017 and 2018, he received the outstanding faculty award by Tomsk Polytechnic University, Russia. He has published nearly 200 international peer reviewed journal and conference papers and books.

Session 03: Recent Challenges in UWC

Mr. Furqan Ali

National Research Tomsk Polytechnic University, Russia

Bio Information

Mohammad Furqan Ali (Graduate Student Member IEEE) is working as a research engineer since 2019 and pursuing Ph.D. (under the Russian government fully funded scholarship) in Computer Science and Wireless Communication Engineering from the School of Computer Science and Robotics, National Research Tomsk Polytechnic University, Russia. He received M.Sc. degree (Distinction & Gold medalist) from National Research Tomsk Polytechnic University Russia in 2018, and B.Tech (Bachelor of Technology) degree in 2013 from UP Technical University Lucknow, India. His current research interests include optical communication, underwater visible light communication (UVLC), 5G and 5G beyond (5GB) wireless networks, Internet of underwater things (IoUTs), hybrid cooperative and multi-hope underwater wireless communications.

Session 04: Applications and Emerging trends in UWC

Dr. Ambrish Kumar

Sri Lanka Technological Campus, Sri Lanka

Bio Information

Ambrish Kumar, received his Ph.D. degree in Wireless Communication from the department of Electronics and Communication Engineering (ECE), University of Delhi, New Delhi, India, and M.Tech. degree in Optical & Wireless Communication Technologies from the department of ECE, Jaypee University of Information Technology (JUIT), Solan (H.P.), India. He was Sr. Scientific Officer in Technology Information Forecasting Assessment Council-Centre for Research and Excellence (TIFAC-CORE), at Delhi Technological University (Formerly Delhi College of Engineering), New Delhi, India, and a Teaching-cum Research Fellow (TRF) in the department of ECE at Netaji Subhas University of Technology (Formerly Netaji Subhas Institute of Technology (NSIT)), New Delhi, India and Lecturer in Amity School of Engineering & Technology (ASET) at Amity University Rajasthan, Jaipur, India. He was a full-time Researcher in the Mobile Transmission Systems Laboratory within the Artificial Intelligence Research Center at Pukyong National University (PKNU), Busan, South Korea. Presently, he is a Postdoctoral Researcher at the Centre of Research and Telecommunication (CRT), Sri Lanka Technological Campus (SLTC), Sri Lanka. Also, he is a Lecturer at Liverpool John Moors University (LJMU), UK. His research interests are Physical Layer Security, Visible Light Communication, Underwater VLC, Ultraviolet Communication, Free-Space-Optics, and Cognitive Radio Networks.

Session 05: UWC Hardware Demonstrations

Rear Admiral Wiraj Leelarathne

Sri Lanka Navy

Bio Information

Rear Admiral Wiraj Leelarathna received B.Sc in Electrical and Electronics Engineering from General Sir John Kotelawala Defence University, Ratmalana. He is currently the Direction General Electrical and Electronics Engineering at the Naval Headquarters, Colombo. Moreover, he is a Chartered Engineer and a Fellow member at the Institution of Engineers India since 2018.

Inauguration Ceremony

Thursday 29th September 2022

2.30 pm	Registration
3.30 pm	Arrival of the Chief Guest, Dr. Harsha Subasinghe
	President and Chief Executive Officer
	CodeGen Group of Companies
3.45 pm	Ceremonial Procession
3.55 pm	Lighting of the oil lamp
4.05 pm	Traditional Dance
4.25 pm	Welcome address by Dr. Renuka Ariyawansha, General Chair, IRC2022
4.30 pm	Address by Prof. V. Kamakoti, The Director, Indian Institute of Technology Madras (IITM)
5.00 pm	Research Highlights of SLTC
5.10 pm	Address by Prof. Dush Jayakody, the Director of Postgraduate Research and Impact, SLTC Research University
5.15 pm	Launching of the Conference Proceedings
5.20 pm	Musical Performance by the School of Music, SLTC Research University
5.35 pm	Address by the Chief Guest, Dr. Harsha Subasinghe
	President and Chief Executive Officer
	CodeGen Group of Companies)
5.45 pm	Address by Eng. Ranjith G. Rubasinghe, Founder President/CEO of the SLTC Research University
5.55 pm	Creative Dance by the Performing Arts Club of the SLTC
6.00 pm	Keynote by Dr. Rostislav Yavorski, Head of Research, Exactpro Systems Limited | Title: Artificial Intelligence in Software Testing
6.20 pm	Vote of thanks by Dr. Amali G. Guruge, Secretary, IRC2022
	National Anthem

Keynote on Thursday 29th September 2022

Keynote Speaker

Dr. Rostislav Yavorski

Head of Research,
Exactpro Systems Limited

Keynote Title: Artificial intelligence in software testing

Keynote Abstract

Modern software systems are highly complex and contain many components and configuration parameters, all of which have to be tested to ensure the quality. This lecture will provide an overview of using machine learning and AI tools in software testing. Particular applications include event clustering for system log analysis and anomaly detection for non-functional testing.

Bio Information

Rostislav got his PhD in Theoretical Computer Science from Moscow State University in 1998. After 10 years in academia, he shifted to industry while continuing part-time teaching CS&IT at different universities. For more than 20 years he has been building bridges between industry and academia by organizing conferences, joint educational programs and collaborative research projects with Microsoft, Intel, Thomson Reuters, Exactpro, Higher School of Economics, Skoltech, ACM, IEEE etc. He is interested in software testing, formal verification, applied data science, social network, analysis, visualization, mathematical models and formal logic.

Technical Programme

Friday 30th September 2022

Room 01 - Research Building, Room GF3

Track	Time	Abstract ID	Abstract Title
	9.00 - 9.30 am	**Keynote Address by Prof. Ben Basnayake, University of Peradeniya | Title: Agriculture in the Living Environment for Safe Food Supply @ Main Auditorium - GF3**	
R1-01 Civil Engineering and Built Environment	9.30 - 9.45 am	3780	Impact of Work Pressure on the Construction Site Safety in the Covid- 19 Pandemic: A Study in Sri Lanka
	9.45 - 10.00 am	3219	Mix-Design Decision making of Gap-graded Porous Concrete
	10.00 - 10.15 am	7938	Comparison of Urban and Rural Public Transport Characteristics: A Case Study in Trincomalee
	10.15 - 10.30 am	5990	Nexus between the Concepts used for Enhancing the Sustainability of Existing Buildings
	10.30 - 10.45 am	9326	Perception of Living Walls in the Context of Sri Lanka
	10.45 - 11.00 am	4539	Technologies for Green Buildings: A Review of Energy Efficiency Perspective
	11.00 - 11.15 am	**Tea Break**	
	11.15 - 11.45 am	**Keynote Address by Prof. Rangika Halwathura, University of Moratuwa | Title: Invention/Innovation and Sustainability @ Main Auditorium - GF3**	
R1-02 Electrical & Power Engineering	11.45 am - 12.00 pm	6578	Dual-Power Charging Station for Mobile Devices with Renewable Energy
	12.00 - 12.15 pm	307	Single Axis Sun Tracking System and Solar Power Back-up System

R1-02 Electrical & Power Engineering	12.15 - 12.30 pm	5746	Reliability Enhancement of Industrial Capacitor Banks through Smooth Engagement to the Grid
	12.30 - 12.45 pm	8214	A Machine to Remove the Seed from Ceylon Olive (Veralu)
	12.45 - 1.00 pm	8553	Design and Fabrication of a Rooftop Mounted Vertical Axis Wind Turbine
	1.15 - 2.00 pm	**Lunch & Poster Session**	
	2.00 - 2.30 pm	**Keynote Address by Prof. Yonghui Li, University of Sydney, Australia | Title: Beyond 5G towards a Super-connected World @ Main Auditorium - GF3**	
R1-03 Machine learning, Artificial Intelligence and Robotics	2.30 - 2.45 pm	4194	Virtual Telepresence Sample Collecting Robot
	2.45 - 3.00 pm	2418	Multi-Layered Electronic Security System for Vaults
	3.00 - 3.15 pm	5615	Smart Gate Locking System with Dual Authentication
	3.15 - 3.30 pm	7148	Automatic Railway Level Crossing Controller with Train Tracking and Mapping System in Sri Lanka
	3.30 - 3.45 pm	1083	Multi-Layered Quick Response Code
	3.45 - 4.00 pm	7787	Comparison of Different Pre-Trained Neural Networks for Gesture Recognition
	5.15 - 5.30 pm	**Tea Break**	
	5.30 - 6.00 pm	**Keynote Address by Asst. Prof. Lahiru Jayakody, Southern Illinois University, USA | Title: The Hybrid Thermo-Biological Process to Upcycle Agricultural Waste Plastic @ Main Auditorium - GF3**	
	6.00 - 6.30 pm	**Closing Ceremony**	

Room 02 - Research Building, Room FF3

Track	Time	Abstract ID	Abstract Title
	9.00 - 9.30 am	**Keynote Address by Prof. Ben Basnayake, University of Peradeniya | Title: Agriculture in the Living Environment for Safe Food Supply @ Main Auditorium - GF3**	
R2-01 Social Sciences, Humanities, & Culture	9.30 - 9.45 am	3004	Extent, Nature and Consequences of Intimate Partner Violence: A Qualitative Study about Intimate Partner Violence in Sri Lanka
	9.45 - 10.00 am	6886	Rural Development, Resettlement and Social Exclusion: A Case Study of Nelugama village, Sri Lanka
	10.00 - 10.15 am	3363	Translating Culture-Specific Items (CSIs) in Michael Ondaatje's Runnwing in the Family into French and Sinhala
	10.15 - 10.30 am	4964	Protecting Traditional Knowledge: Can Sui Generis Regimes Help?
	10.30 - 10.45 am	2035	Online Grocery Shopping Intention during a Period of Economic Crisis
	10.45 - 11.00 am	1323	Impact of Banning Agro-Chemical on Low-Country Tea Production
	11.00 - 11.15 am	**Tea Break**	
	11.15 - 11.45 am	**Keynote Address by Prof. Rangika Halwathura, University of Moratuwa | Title: Invention/Innovation and Sustainability @ Main Auditorium - GF3**	
R2-01 Social Sciences, Humanities, & Culture	11.45 am - 12.00 pm	946	Detecting Trends from Accumulated Changes in the Prices of a Stock
	12.00 - 12.15 pm	9901	Loan Default Detection with Real-World Existing Imbalanced Financial Data
	12.15 - 12.30 pm	2596	Relevance and Importance of Cyber Diplomacy for Developing Countries
R2-02 Innovative Education	12.30 - 12.45 pm	4876	Student Perception on Online Flipped Classroom in Engineering: A Case Study of Thermodynamics

R2-02 Innovative Education	12.45 - 1.00 pm	4444	Parents' and Students' Perceptions of the Education System of Sri Lanka
	1.00 - 1.15 pm	7302	Contextualizing and Infusing Gross National Happiness (GNH) Values Through Teaching Primary Schools Mathematics: Approaches and Relevancy
	1.15 - 2.00 pm	**Lunch & Poster Session**	
	2.00 - 2.30 pm	**Keynote Address by Prof. Yonghui Li, University of Sydney, Australia | Title: Beyond 5G towards a Super-connected World @ Main Auditorium - GF3**	
R2-02 Innovative Education	2.30 - 2.45 pm	616	Transforming Indigenous Knowledge and Skills for Achieving Sustainable Business: Evidence from Nepal
	2.45 - 3.00 pm	9233	Educational Pathways of Bhutan: Transition to Transformation
R2-03 Tele-communication Engineering	3.00 - 3.15 pm	9319	Path Planning for UAVs: A Survey
	3.15 - 3.30 pm	7728	Optimization of Secure Emergency Call Services in Asynchronous-NOMA D2D Network
	3.30 - 3.45 pm	8655	SDMA Based Multi User VLC System for Indoor Office Environment
	3.45 - 4.00 pm	314	Integration of SWIPT Enabled UAV Assisted NOMA in 5G and Beyond Wireless Network
	4.00 - 4.15 pm	5376	A Short Survey on Ultraviolet Communication Systems
	4.00 - 4.30 pm	3133	Indoor Air Quality Monitoring and IoT Platform for Smart Building Management
	4.30 - 4.45 pm	6088	On the Competitiveness of LDPC Codes in 6G Wireless
	4.45 - 5.00 pm	4409	5G Key Technologies Adopted in South Asian Countries
	5.15 - 5.30 pm	**Tea Break**	
	5.30 - 6.00 pm	**Keynote Address by Asst. Prof. Lahiru Jayakody, Southern Illinois University, USA | Title: The Hybrid Thermo-Biological Process to Upcycle Agricultural Waste Plastic @ Main Auditorium - GF3**	
	6.00 - 6.30 pm	**Closing Ceremony**	

Room 03 - Research Building, Room FF1

Track	Time	Abstract ID	Abstract Title
	9.00 - 9.30 am	**Keynote Address by Prof. Ben Basnayake, University of Peradeniya | Title: Agriculture in the Living Environment for Safe Food Supply @ Main Auditorium - GF3**	
R3-01 Chemical Process Technology	9.30 - 9.45 am	8487	Enlargement of Interlayer Spacing of Molybdenum Disulfide on Graphene Oxide for the Hydrogen Evolution Reaction
	9.45 - 10.00 am	1735	Effect of Graphite Oxide Loading on Tensile Properties of Natural Rubber Composites
	10.00 - 10.15 am	1359	Investigation of Environment-Friendly Skin Whitening Agents from The Plant Polyscias Balfouriana L.H.Bailey
	10.15 - 10.30 am	5637	A Low-Cost Air Purifier for Killing Harmful Airborne Microorganisms with a Combination of an Electric-field and an Ultra Violet Light
R3-02 Waste Management	10.30 - 10.45 am	7709	Potential Reuse of Greywater using Constructed Wetland: Design and Implementation of Vertical Constructed Wetland System: A Case Study
	10.45 - 11.00 am	1669	Disparity among Urban, Rural and Estate Sector Communities in Solid Waste Management
	11.00 - 11.15 am	**Tea Break**	
	11.15 - 11.45 am	**Keynote Address by Prof. Rangika Halwathura, University of Moratuwa | Title: Invention/Innovation and Sustainability @ Main Auditorium - GF3**	
R3-02 Waste Management	11.45 am - 12.00 pm	5100	Removal of Spilled Engine Oil Using Dendro Biochar as an Adsorbent
	12.00 - 12.15 pm	6785	Microplastics-Assisted Hexavalent Chromium Transportation in Soapy Water Environments
	12.15 - 12.30 pm	2170	Life Cycle Energy Utilization, Economic Feasibility, and Climate Change Impact Assessment for End-Use Options of Waste Plastic Pyrolysis Oil in Sri Lanka

R3-02 Waste Management	12.30 - 12.45 pm	1452	Kinetics Modeling of Hydrolysis in Anaerobic Digestion of Food Waste
	12.45 - 1.00 pm	9627	Performance Evaluation of an Up-Flow Anaerobic Sludge Blanket Reactor with a Bio-Filter Liner System
	1.00 - 1.15 pm	3770	Development of Silica Gel from Rice Husk and Evaluation of its Application
	1.15 - 2.00 pm	**Lunch & Poster Session**	
	2.00 - 2.30 pm	**Keynote Address by Prof. Yonghui Li, University of Sydney, Australia | Title: Beyond 5G towards a Super-connected World @ Main Auditorium - GF3**	
R3-03 Food and Food Security	2.30 - 2.45 pm	5832	Obstacles Faced by Women in Urbanized Areas in Kandy District Related to Food Crop Cultivation.
	2.45 - 3.00 pm	6680	Potentials and Future Prospects of Major Fruit Exports in Sri Lanka
	3.00 - 3.15 pm	9156	Use of Sound Waves in Increasing Shelf Life of Banana
	3.15 - 3.30 pm	2069	Sauerkraut as a Probiotic Food
	3.30 - 3.45 pm	6849	Conceptualizing a Mobile Application Aimed at Enhancing Food Security
	3.45 - 4.00 pm	2561	The Awareness of Traffic Light Labeling System and Nutrition Information on Packed Food Labels among Young Generation in Sri Lanka
	4.00 - 4.15 pm	1407	Awareness and Perception of Functional Foods among Undergraduate Students in Sri Lanka
R3 - 04 Nanotechnology	4.15 - 4.30 pm	985	Multi Responsive, Anisotropic Colloidal Mixture Using 2D -ZrP Nanoparticles
	4.30 - 4.45 pm	1974	Electrically Tunable Liquid Crystal Lens based on Zirconium Phosphate Nano Colloid
	4.45 - 5.00 pm	8419	pH-Induced Structural Changes in mRNA Lipid Nanoparticles

R3 - 04 Nanotechnology	5.00 - 5.15 pm	1057	Chemical Bath Deposited ZnO Nanowires for H2 Gas Sensors: Optimization of Deposition Time
	5.15 - 5.30 pm	8321	Automated Instrument to Measure Specific Surface Area of Powders using the Brunauer Emmett–Teller Method
	5.30 - 5.45 pm	**Tea Break**	
	5.45 - 6.15 pm	**Keynote Address by Asst. Prof. Lahiru Jayakody, Southern Illinois University, USA | Title: The Hybrid Thermo-Biological Process to Upcycle Agricultural Waste Plastic @ Main Auditorium - GF3**	
	6.15 - 6.30 pm	**Closing Ceremony**	

Room 04 - Research Building, Room FF2

Track	Time	Abstract ID	Abstract Title
	9.00 - 9.30 am	**Keynote Address by Prof. Ben Basnayake, University of Peradeniya | Title: Agriculture in the living environment for safe food supply @ Main Auditorium GF3**	
R4-01 Forestry and Land Use	9.30 - 9.45 am	3021	Deforestation Monitoring System (DMT) to Reduce Deforestation and Protect the Environment in Sri Lanka
	9.45 - 10.00 am	8353	Fluoride Release from the Weathered Rocks in Chronic Kidney Disease of Unknown Etiology Endemic Regions in Sri Lanka
	10.00 - 10.15 am	408	Factors Affecting the Soil Conservation Practices of Upcountry Vegetable Farmers in Sri Lanka
	10.15 - 10.30 am	7418	Greater Reduction of Soil Erosion Rates after the Introduction of Simple Conservation Measures to a Small Tank Cascade System in Palugaswewa, Sri Lanka
	10.30 - 10.45 am	714	The Abundance of Rare Earth Elements in Tropical Montane Forest Soils in Sri Lanka
	10.45 - 11.00 am	6542	Variation of Soil Physical Properties of Kanneliya and Sinharaja Tropical Lowland Rainforests of Sri Lanka along an Altitudinal Gradient
	11.00 - 11.15 am	**Tea Break**	
	11.15 - 11.45 am	**Keynote Address by Prof. Rangika Halwathura, University of Moratuwa | Title: Invention/Innovation and Sustainability @ Main Auditorium GF3**	
R4-01 Forestry and Land Use	11.45 am - 12.00 pm	5751	Study on Land Surface Temperature and Land Use / Land Cover Distribution in Weligama DS Division, Matara, Sri Lanka
	12.00 - 12.15 pm	8737	Us e of 95th Percentile Temperature Data to Identifying the Heatwaves: Case Study in Anuradhapura, Sri Lanka
R4-02 Aquaculture and Aquatic Life	12.15 - 12.30 pm	4948	Adsorption of Methylene Blue onto Blue Water Lily Stalks

R4-02 Aquaculture and Aquatic Life	12.30 - 12.45 pm	6691	Habitat and Breeding Ground Preferences of the Vulnerable Fish Species Sri Lankan Cherry Barb (Puntius titteya) according to the Water Quality in Aquatic Habitats in Lowland Wet Zone, Sri Lanka
	12.45 - 1.00 pm	9079	The Content of Lead and the Presence of E. coli in Tilapia of Static and Dynamic Waters
	1.00 - 1.15 pm	5348	Aquatic Life Health Quality Assessment in a Selected Region of Mahaweli River in Kandy District, Sri Lanka.
	1.15 - 2.00 pm	**Lunch & Poster Session**	
	2.00 - 2.30 pm	**Keynote Address by Prof. Yonghui Li, University of Sydney, Australia | Title: Beyond 5G towards a Super-connected World @ Main Auditorium - GF3**	
R4-02 Aquaculture and Aquatic Life	2.30 - 2.45 pm	1975	Prevention and Control of Whitefly (Bemisia tabaci) in Two Selected Aquatic Plants (Echinodorus Bleheri, Echinodorus 'Little Bear')
	2.45 - 3.00 pm	9822	A Mathematical Model of Crocodile Population
R4-03 Agronomy and Biotechnology	3.00 - 3.15 pm	9494	Feasibility of Water Hyacinth (Eichhornia crassipes) as a Component for Potting Media of Dendrobium Orchids
	3.15 - 3.30 pm	9108	Identification of Major Weed Types in Broadcasted Paddy Fields Using Multispectral UAV Images
	3.30 - 3.45 pm	7450	Evaluation of Nitrogen Leaching Losses from Leafy Red Onion Cultivation under Growers' Practice of Fertilizer in Kalpitiya
	4.00 - 4.15 pm	564	Effect of Organic and Inorganic Fertilizers and Their Combinations on the Growth and Productivity of Groundnut
	4.15 - 4.30 pm	6439	Study on the Low-Cost Methods for Tissue Culture Applications in Orchid
	5.15 - 5.30 pm	**Tea Break**	
	5.30 - 6.00 pm	**Keynote Address by Asst. Prof. Lahiru Jayakody, Southern Illinois University, USA | Title: The Hybrid Thermo-Biological Process to Upcycle Agricultural Waste Plastic @ Main Auditorium GF3**	
	6.00 - 6.30 pm	**Closing ceremony**	

Poster Session

Friday 30th September 2022, Research Building at 1.15 - 2.00 pm (IST)

Research Building at 1.15 - 2.00 pm		
Abstract ID	**Poster ID**	**Abstract Title**
370	P001	Design of a Higher Order Modulator/ Demodulator for VLC by Combining ASK and FSK
7804	P002	Sri Lankan Sign Language Detection Using Machine Learning
5161	P003	Abstract on HID Theory (Hidden Ignitable Domain) for Management
5077	P004	Effects of Compost, Biochar, and Inorganic Fertilizer Combinations on the Growth and Yield of Bushita Bean (Vigna unguiculata)
1878	P005	Effect of Salinity Stress on Brix %, Growth, and Yield in Chili Pepper.
9003	P006	Effect of Phosphorus Fertilizer and Temperature on Plant Growth and Fruit Parameters in Capsicum spp.
7969	P007	Agronomic Performance and Varietal Evaluation of Cowpea [Vigna unguiculata (L.) Walp] under Organic and Inorganic Fertilizers in Sri Lanka
5903	P008	Leaching of Trace Elements, Heavy Metals and Antimony from Polyethylene Terephthalate Bottled Drinking Water in Sri Lanka
9198	P010	Blue and Gray Water Footprint Assessment: A Case Study from a Small-Scale Batik Industry in Sri Lanka
6716	P011	Demanding for Higher standards to safeguard Laboratory Animal Rights in Sri Lanka, A Legal Analysis
2317	P012	Factors Influencing Student Dropouts in the Postgraduate Online Programs
1424	P013	A comparative Study of Chamber Music Groups, Orchestras & Bands
3619	P014	Key Challenges Faced by Households for Food Access by Covid19
9838	P015	An Overview of Microplastic Contamination and Research Gaps in Sri Lanka

Keynote on Thursday 30th September 2022

Keynote Speakers

Prof. Benedict F.A. Basnayake

Department of Agricultural Engineering, University of Peradeniya

Keynote Title: Agriculture in the living environment for safe food supply

Keynote Abstract

The debate on inorganic versus organic agriculture, whether regenerative or not, depends on the policy and the people's confidence. Fear psychosis without inorganic caused one-third of the farmers to avoid toiling the soil, thus ending up with a 50% yield reduction as predicted. Over time, it will plateau at half the yield, equaling traditional rice harvests. The synthesis of two important scientific findings could explain the behavior of ferruginous soils prevalent in Sri Lanka. The formation of sesquioxide to lock phosphate is one. The other carbon, nitrogen, and C/N ratio are inversely proportional to pH. The application of biochar is the remedy. It allows the recycling of precipitated phosphates between growth phases, behaving as a receptor-store and supply of nutrients when the plant needs them. Examining microbiomes will permit to develop site-specific biochar biofertilizer since biochar-compost applications show wide variations of yield from 7.5-3.5, averaging at 5.4 tones/ ha. It will be a treatment for acidulated soils over the years in tea plantations and could even incorporate integrated nutrient management. The target is then to double the yields in organic compared to inorganic agriculture productions. Such intensive farming should be within ecological farming, unlike the direct movement of heavy metals from inorganic fertilizer to final products, causing obesity, diabetes, and cancer. Pesticides make the complexities of cultivation and products even worse, making farmers' and agriculturalists' minds sterile. Sacrificing part of the crop to pests is safer than high casualties. Applying smart agriculture within Integrated Pest Management could give early warnings for silage making of infested crops and the like. Timing of cultivation, coinciding with the lunar cycle augments nutrient uptake while reducing post-harvest losses. Safe storage of products is equally important to regulate markets and food security, giving much emphasis on developing human resources in plant scientists than plant breeders.

Bio Information

Benedict F.A. Basnayake is an Emeritus Professor at the University of Peradeniya. He obtained B.Sc. in Agricultural Engineering from Cranfield University, UK., and DEA and D.Eng. from the University of Pierret Marine Curie, France in Applied Kinetic Chemistry. He has five recognized patents. He has 43 years of teaching and research experience and 27 years of research in Municipal Solid Waste as the principal investigator in many projects. He was the pioneer in the use of char as a fertilizer. His primary research interests are energy and waste management, and biochemical transformation kinetics. Secondary research interests are effluent treatment and inventions in the field of agricultural engineering.

Prof. Yonghui Li

ARC Future Fellow, Fellow IEEE, School of Electrical and Information Engineering, University of Sydney, Australia

Keynote Title: Beyond 5G towards a super-connected world

Keynote Abstract

Connected smart objects, platforms, and environments have been identified as the next big technology development, enabling significant society changes and economic growth. The entire physical world will be connected to the Internet, referred to as Internet of Things (IoT). The intelligent IoT network for automatic interaction and processing between objects and environments will become an inherent part of areas such as electricity, transportation, industrial control, utility management, healthcare, water resources management, and mining. Wireless networks are one of the keys enabling technologies of the IoT. They are likely to be universally used for last mile connectivity due to their flexibility, scalability and cost effectiveness. The attributes and traffic models of IoT networks are essentially different from those of conventional communication systems, which are designed to transmit voice, data and multimedia. IoT access networks face many unique challenges that cannot be addressed by existing network protocols; these include support for a truly massive number of devices, the transmission of huge volumes of data burst in large-scale networks over limited bandwidth, and the ability to accommodate diverse traffic patterns and quality of service (QoS) requirements. Some IoT applications have much stringent latency and reliability requirements which cannot be accommodated by existing wireless networks. Addressing these challenges requires the development of new wireless access technologies, underlying network protocols, signal processing techniques, and security protocols. In this talk, I will present the IoT network

development, architecture, key challenges, requirements, potential solutions, and recent research progress in this area, particularly in 5G and beyond 5G.

Bio Information

Yonghui Li received his PhD degree in November 2002. Since 2003, he has been with the Centre of Excellence in Telecommunications, the University of Sydney, Australia. Li is now a Professor and Director of Wireless Engineering Laboratory in School of Electrical and Information Engineering, University of Sydney. He is the recipient of the Australian Research Council (ARC)Queen Elizabeth II Fellowship in 2008 and ARC Future Fellowship in 2012. He is an IEEE Fellow for contributions to cooperative communications technologies. His current research interests are in the area of wireless communications, with a particular focus on IoT, machine to machine communications, MIMO, millimeter wave communications, channel coding techniques, game theory, machine learning and signal processing. Li holds a number of patents granted and pending in these fields. Professor Li is an editor for IEEE transactions on communications, IEEE transactions on vehicular technology and guest editors for several special issues of IEEE journals, such as IEEE JSAC, IEEE IoT Journals, IEEE Communications Magazine. He received the best paper awards from IEEE International Conference on Communications (ICC) 2014, IEEE PIMRC 2017, and IEEE Wireless Days Conferences (WD) 2014. He has published one book, more than 160 papers in premier IEEE journals and more than 100 papers in premier IEEE conferences. His publications have been cited more than 15000 times, with an h-index of more than 60. Six of his papers have been included as ISI high cited papers by ESI Web of Science, defined as the top 1% of papers in the field. Several of his papers have been in the top most 10 most cited papers in the respective journals since the year it was published. Li has attracted more than $6 million in competitive research funding over the past 10 years, including 10 ARC grants. He has participated in $500 Millions Australia national demonstration project “Smart Grid Smart City” and designed last mile access networks. He is the founder and director of IoT undergraduate major at the University of Sydney.

Prof. Rangika Halwathura

Department of Civil Engineering, Faculty of Engineering, University of Moratuwa and Commissioner at Sri Lanka Inventors Commission

Keynote Title: Invention/innovation and sustainability

Keynote Abstract

Nature is a huge teaching space that offers many lessons for those who take the time to reflect and discover. Scientists and inventors study characteristics of things in nature and comes up amazing technologies and products invented as a result of studying nature. However, instead of looking forward consider looking backward and analyse methods and technologies that were existed and used by our ancestors for their building industry can be a grand saving in environmental impact. In addition, sustainability and the adoptability was with their bloodline throughout and the real practice of sustainability can be witnessed in their all actions. The world is running into a disaster and the whole ecosystem is currently at great risk. COVID is just another hint given by nature for us to rethink what are we doing. Not the visible impact, but the invisible factors are life threatening to the whole future. Hence, going for sustainable inventions has become a must to at least to hold this disaster for a while. Such as, starting from sunbaked brick and to using earth as the primary building material. Furthermore, employing industrial waste as stabilizer or filler material can reduce environmental adulteration. Further, they are economically beneficial as construction materials because they are less expensive. Sustainability has become the most important challenge for the building and construction industry, not just for the present, but also for the decades to come. Scientifically-based solutions should drive technological inventions that enable compliance with the still growing environmental constraints. Research in this particular field of interest is advanced from the physical, chemical, biological, lifecycle assessment, engineering, and materials science perspective, often leading to synergistic approaches. The whole concept is all about finding solutions in a natural or near natural way. It's not merely finding new ideas, which is called inventions, but it should go beyond and take this sense to the masses and hence, trying for a global attitudinal change has become a must to reverse these unpredicted, unforeseen disasters, which are surely possible in the near future.

Bio Information

Prof. Rangika Halwathura graduated with first-class honors from the University of Moratuwa with a bachelor's of science in engineering. He later completed his doctorate degree in structural and building services engineering in 2008 from the same institution. Currently, Prof. Rangika Halwathura is a Prof. Department of Civil Engineering, Faculty of Engineering, University of Moratuwa and Commissioner at Sri Lanka Inventors Commission. In 2016, Halwatura received the Committee of Vice-Chancellors and Directors' (CVCD) Most Outstanding Young Researcher award. He also won the Sri Lanka 2016 Energy Globe Award. Halwatura was nominated by the National Academy of Sciences and subsequently won the 2017 The World Academy of Sciences Young Scientist Award.

Asst. Prof. Lahiru Jayakody

Department of Microbiology, Southern Illinois University, USA

Keynote Title: The hybrid thermo-biological process to upcycle agricultural waste plastic

Keynote Abstract

Today, 7.4 million tons of petroleum-derived synthetic plastic film are used annually in the agricultural sector as packing and mulching material. Bioplastics like poly (butylene adipate-co-terephthalate) [PBAT] are a suitable alternative to synthetic plastic. However, techno economically feasible recycling technologies are not available to alleviate the negative environmental, energy, and social impacts of petroleum-based agricultural waste plastics. Hence, we have developed an innovative biochemical approach by engineering robust microbial cell factories to bio-upcycle agricultural plastic and produce high-value bioplastic precursors. We leverage advanced biomass hydrolyzing techniques, namely oxidative hydrothermal dissolution (OHD) and engineered microbial bio funneling techniques, to generate high-value precursor chemicals. Indeed, we have developed an innovative hybrid thermo-biochemical approach to selectively degrade high crystalline polyethylene terephthalate PET (hard to break) by leveraging OHD and engineered P. putida EM42 and E. aphidicola LJJL01. We rewired the P. putida EM42 and E. aphidicola LJJL01 aromatic catabolism to bio funnel and functionalize plastic-derived monomers to upcycling monomers with built-in versatility. Those monomers can be used to produce new advanced polymers to replace petroleum-based plastic equivalents. The developed green technology establishes a circular material economy with profound environmental, energy, and economic impacts, and long-term sustainability of agricultural systems.

Bio Information

Lahiru Jayakody is an assistant professor at Southern Illinois University Carbondale and has a joint appointment in the School of Biological Sciences and Fermentation Science Institute. He also serves as Editor in Chief to Critical Reviews in Biotechnology, one of the prestigious journals in Biotechnology. His research studies aim to develop robust microbial cell factories using systems biology, synthetic microbiology, metabolic engineering, and green chemistry approaches to valorize conventional (biomass) and unconventional substrates (industrial waste). His findings contribute to understanding cellular processes of fundamental and industrial interests to tailor model and non-model biocatalysts to enable engineering microbes to high-value fuels, chemicals, and bio-materials from waste, including plastic. He has several impactful publications and patents on waste valorization via engineered microbes, and currently, his research team works on developing microbial cell factories to Upcycle Plastic.

Track 1

Civil Engineering and Built Environment

Impact of Work Pressure on the Construction Site Safety in the Covid-19 Pandemic: A Study in Sri Lanka

S.M.T.M. Samarakoon[1], M.G.S. Dilanthi[2]
Faculty of Technology[1], Faculty of Science[2] Wayamba University of Sri Lanka
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Abstract - The covid-19 pandemic has drastically impacted on workers and workplaces across the globe; hence, the productivity of the employees has become a crucial factor today. This has been caused by the work pressure of them. Therefore, this study aimed to investigate the factors affecting work pressure and its impact on the construction site safety in Sri Lanka. The recent literature revealed high absenteeism, overloading of work, employee anxiety, family issues, economic problems, delays in work completion, work shifts, lack of resources, and environmental problems to be the major factors affecting work pressure in the construction sites safety. They were selected as the indicators of the work pressure being the independent variable of this study. The construction site safety was measured referring to the number of accidents occurred in a selected construction site for the past two years. The accidents included falling from a height, falling on objects, by equipment or machinery, exposure to electric shocks, heat and harmful substances, slipping and epidemic diseases. The data were then collected from randomly selected 200 workers using a questionnaire. Then, the data were descriptively analyzed and found that the majority of accidents were happened causing the epidemic disease while the least was causing slipping. Further, the data were analyzed respectively using correlation analysis and regression analysis to find the relationships among the dependent and independent variables and then the level of impact of the work pressure on the construction site safety. The research showed that the work pressure is increased when the workload is increased. Several recommendations are made, including on-the-job training, work pressure reduction programs, and appropriate employment policies, to enhance safety behavior and decrease the number of accidents on construction sites.

Keywords: Construction Industry, COVID-19 Pandemic, Safety, Work Pressure

I. INTRODUCTION

Work pressure is the pressure that anyone experiences at work with the pressure. Thus, a certain amount of tasks should be finished within a certain timeframe. Otherwise, various problems can be created. Then, employees get overly tired and panic; hence, the safety challenges in the construction industry have become vital. The Covid -19 has now been able to further increase the aforementioned work pressure.

The spread of the Covid-19 led to an increase in workload due to overwork of one employee and project stoppages or staff shortages caused by been quarantined. Employees' exposure to the virus results in lower wages, which in turn increases their economic risk. By reducing the transport service, their lives become more uniform. A large number of people work in such workplaces. Those people come to work with a lot of problems. They also come to work without freedom and under a lot of pressure to work in residential areas. Then they work under stress and unhappily. Then, the chance of happening of an accident is high and the quality of the work is decreased. It also causes creating damage to the people, equipment, and property of the project. Thus, a lot of money is wasted, and time and labor have to be spent. Also, if a person dies, the institution will have to face lot of problems. Therefore, this study aimed to investigate the impact of work pressure on the construction site safety in the Covid- 19 pandemic.

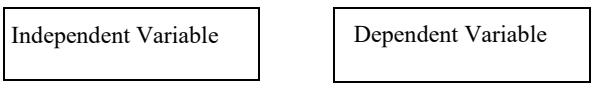
II. LITERATURE REVIEW

A comprehensive literature review was conducted to explore the structural dimensions impact of the work pressure of construction workers during the covid-19 period, to enable the development of an appropriate work pressure measurement. Thus, accidents and safety issues caused by the above impacts were considered in the review.

Work pressure can be defined as stress that is generated due to conflicting demands in one's job. While all work pressure is harmful in that an employee has an emotional and physical reaction to job demands that are difficult to control. The mental and health damage caused by increased work requirements is greater than the capacity to give the individual. The NIOSH (National Institute for Occupational Safety and Health) reported in 2005 that 1,224 construction workers died on the job over one year, making the construction industry the most dangerous industry in the country (Keller, 2022). Also, Safety behaviors are the basic safety activities that individuals must perform to be maintained. Thus, it is primarily measured by lagging indicators such as accidents.

III. METHODOLOGY

The research was designed quantitatively. The respective hypotheses according to the identified dependent and independent variables were then developed after a comprehensive literature review. Accordingly, the research framework was designed as depicted by the Figure 1.



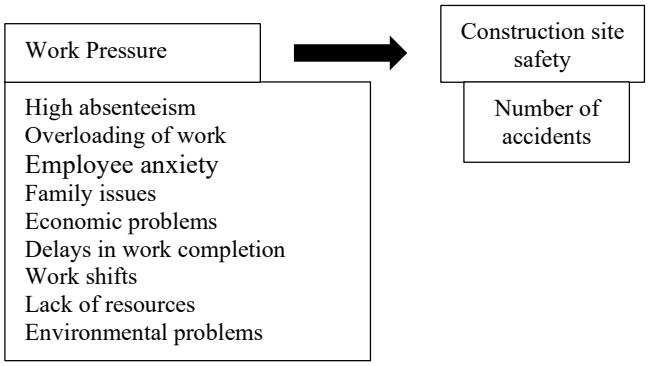


Figure 1: Research Framework

Then the questionnaire was developed using a Likert scale to collect primary data. The sample was randomly selected to be 200 from the labourers and officers in a selected construction site. They were interviewed for further verifying the reliability of the items in the questionnaire. Then, the SPSS software was used as the analysis tool in this study. The data were descriptively analyzed to find the frequency of happening each accident type in the construction site. Thereafter, the data were tested with normality test and reliability test to confirm their suitability to test with statistics. Further, the data were analyzed using correlation analysis to statistically test the relationships among the dependent and independent variables. Further, regression analysis was done to identify the level of impact of each measurement scales of the work pressure on the construction site safety. Based on the analysis, certain recommendations were done in this study.

IV. Results And Discussion

The following Figure 2 depicted the descriptive analysis of the number of accidents. The majority of accidents were recorded causing the epidemic diseases while the least was causing slipping. However, all of these accidents were caused by the work pressure.

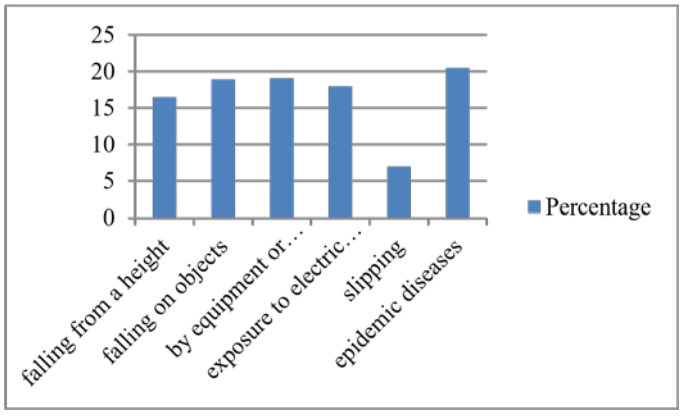


Figure 2: Frequency of Happening of Each Type of Accidents

The Cronbach's Alpha was 0.670 with a significance of P<0.005 hence, the internal consistency was acceptable; the value being closer to 0 .7. The analysis was further continued with normality test and proved that the data are normal. Thus, statistical tests could be continued.

The correlation between the work pressure and the construction site safety in the Covid-19 pandemic was statistically significant and positive at 0.01 levels with a Pearson correlation coefficient of +0.153. This meant that as the Covid-19 crisis intensifies, so does the work pressure on workers. The analysis was further continued with regression analysis to identify the level of the impact of each factor creating work pressure on the construction site safety. Accordingly, high absenteeism, overloading of work, employee anxiety, family issues, economic problems and lack of resources were significantly impacted on the construction site safety while others were not significant. Amongst, the most significant factor was employee anxiety creating the highest impact on the work pressure. High absenteeism, family issues, lack of resources and overloading of work were respectively created an impact on the construction site safety. Moreover, the least impact was created by economic problems. Also, work shifts and environmental problems did not show any significant relationship with construction site safety in the Covid-19 pandemic.

V. Conclusions

Based on the above results, the study concluded that the construction site safety was highly impacted by the employee anxiety during the Covid-19 pandemic. It could be due to been quarantined for several weeks. In that period, they had to stay at home without going out from the house and contacting even relations. That created their anxiety not having relaxed minds. Therefore, this factor was highly significant in the study. Moreover, other reasons also respectively affected for the construction site safety as the study analyzed. Accordingly, several suggestions were made to reduce work pressure through this research. The following were some suggestions,

1. Distribution of the work
2. Arrange a weekend plan and build up the employer's mind by organizing some instruction programs at least once per week.
3. Provide safety programs and provide personal protective equipment
4. Giving time extensions for projects due to the lack of progress during covid-19 affected periods.
5. Share the workload with subordinates and transfer the pressure into proper parts.

Also, the highest number of accidents in the site was reported causing epidemic disease; hence, necessary precautions could be made to reduce the number of accidents. For that, the following suggestions were made.

1. Wash hands frequently in the site.
2. Avoid touching eyes, nose and mouth; hence, the employees must wear masks at every time in the construction site.
3. Avoid close contacts with others and crowded places.
4. Collect information from trusted bases.
5. Conduct awareness programs on COvid-19 symptoms and related best practices.

References

[1] Keller, James. (2022). Construction Site Accidents, Keller & Keller,

Mix-Design Decision Making of Gap Graded Porous Concrete

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Abstract - Choice of aggregate particle size will affect the compressive strength of porous concrete. Using gap-graded aggregates to cast porous concrete will significantly affect the packing arrangements of concrete in a cube, and compaction of concrete mix would further affect the packing. To study the influence of aggregate gradation and compaction efficiency, the cubes with five different aggregate proportion of two size range aggregates (12 – 18 mm and 18 – 25 mm) and eight different level of compaction were practiced for two different aggregate to cement ratios of 2.5 and 5.0. The results show that the compressive strength of porous concrete is found to be depend on the aggregate gradation and also the compaction energy. The compressive strength varies around 4 – 16 MPa for Aggregate to cement ratio of 5.0 and around 4 – 30 MPa for Aggregate to cement ratio of 2.5. The rate of strength development is found to be more for the mixture with the higher proportion of smaller aggregate (P0.1 and P0.2) and with the adequate binder content.

Keywords: Gradation, Gap-graded, Porosity

I. INTRODUCTION

Porous concrete is widely used in constructing eco-friendly structures like permeable pavements, thermal insulator, noise absorber and concrete bed for vegetation. Especially it is used in large scale for load bearing, non-load bearing cast in-situ external walls for single story and multi-storeyed buildings. Even the mass production is high in the industrial applications, all the mix proportions used up to now is from the trial-and-error methods [1], because of the uniqueness of each application. And it is not cost-effective. So, the need of mix-design by optimizing porosity [2] with the compressive strength [3] is inevitable in successful industrial scale application

II. MATERIALS AND METHOD

Our project is aimed to prepare a mix design of gap graded porous concrete, for the gap gradation of aggregates, initially locally available aggregates were sieved with the range of 1inch 0.5 inch. Then all the aggregates which passes 1-inch Sieve net and retained on 0.50 sieve net is again sieved by 0.75-inch sieve net in order to get two size rage particles of 0.50-0.75 inch and 0.75-1.0 inch and finally these two rages of aggregates were separated. In order to ensure the quality of an aggregate, aggregate impact value test, aggregate absorption test and specific gravity test of the aggregates were carried out according to the ASTM (American Society for Testing of Materials) standard.

Generally, W/C (Water to Cement) ratio between 0.30-0.35 is practiced in order to get optimum results [4] but the results didn't indicate 0 slump. As per the theory, porous concrete should be having 0 slump, in order to attain 0 slump, the cubes of W/C ratios between the ranges of 0.30-0.35 are casted and the results were analysed. The cubes were casted with analysed water to cement ratio in order to develop the mix design.

Cement and the coarse aggregates are the material used to cast the cubes, the aggregates ranged between 0.75 inch to 1 inch is proportionally mix with the aggregates ranged between 0.5 inch to 0.75 inch for a constant water to cement ratio of 0.31 as optimum value obtained. And it is followed for two aggregate to cement ratios of 2.5 and 5.0 to evaluate the clear variations, also 8 different level of compaction up to 75 blows were practiced, in each mix proportion, 4 cubes were casted and average is taken for the analysis. For each time of preparing the concrete cubes. Coarse aggregate, cement and water are measured according to the specified proportion and initially weighed aggregates and the cement are well mixed for 2 minutes and then after water is added in two-time intervals to get a proper mixture. Then the concrete mixture is poured in 150*150*150 mm cube with the planned compaction blows using standard proctor. Control cubes were casted to ensure the quality of the results.

III. RESULTS AND DISCUSSION

Fig 1 shows the variation of the compressive strength and the porosity with eight different level of compaction for A/C (Aggregate to Cement) of 2.5; likewise, it was followed for A/C of 5.0. Density is an important factor in deciding a compressive strength.

The study resulted that the wet and dry densities are little same, and the density is decreasing with the increase of A/C, for all the aggregate proportions as it has less amount of cement content. The density is increased with the compaction because of reduction in porosity, even though the deviation of the resulted density for each A/C is very high for same compaction blow. The higher proportion of larger aggregates (P0.1) resulted high density for A/C-2.5 and less density for A/C-5.0

while the p0.5 resulting approximately same density for both A/C, but it shows a slight increment of density with compaction blows later, with that A/C-2.5 is considerable A/C of 2.5 showing unevenness in the variation of density up to 30 blows while A/C of 5.0 behaving it up to 15 blows.

As shown in the graph, porosity of the cubes decreases with the compaction blows and the reduction is low for A/C-5.0 than A/C-2.5, and also the rate of reduction for all aggregate proportion is same for all aggregate to cement ratio except P0.5. In the case of A/C-2.5 the proportions of 0.3, 0.4 and 0.5 has same initial porosity, later proportions 0.3 and 0.4 are eventually

decreases and showing similarities with the rest of proportions 0.1 and 0.2 while 0.5 has less reduction in porosity (highlighted in the graph).

The compressive strength variation for all aggregate proportion is not same for A/C -2.5, because of different packing structure due to the gradation of aggregate. Up to 30 blows of compaction, all the proportions are little linear in variation with a small deviation but at 75 blows it shows a huge deviation, because of sudden increment by the P0.1 and P0.2, and both proportions didn't reach the saturation level up to 75 blows while other proportions are reached, whereas in the case of A/C-5.0 it is going inverse that, P0.5 has more strength while other proportions are behaving less than and little same.

with a stable packing, as it has more number of aggregates inside the cube.

Higher proportion of 12-18mm (P0.5 and P0.4) aggregates is very supportive in developing compressive strength for mixture with adequate binder content. P 0.1 of A/C -5.0 and P0.4 A/C-2.5 are more effective in optimizing Porosity with Compressive strength.

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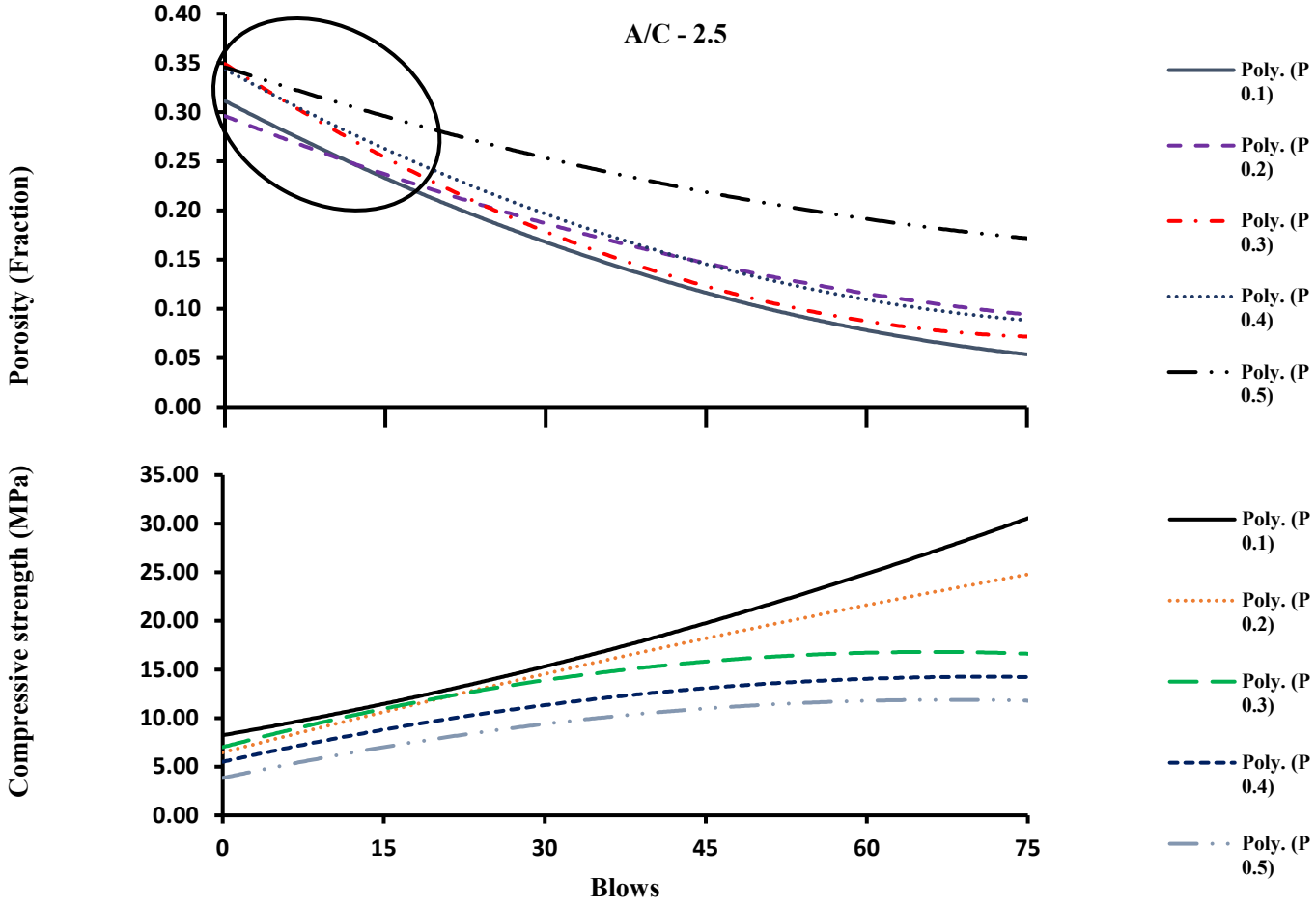

Fig 1: Variation of compressive strength and porosity with compaction blows for A/C-2.5

IV. CONCLUSIONS

The variation of porosity in A/C-2.5 is mostly depend on the portion of binder (filling the pores) rather packing of aggregate. The excess amount of paste content (A/C-2.5) is not suitable in bringing a proper mix design with compaction blows as it takes more amount of blows to reach the stable packing and showing randomness. Also, the effect of compaction on the porosity is very law for the mixture P0.5 because of all the aggregates are

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Comparison of Urban and Rural Public Transport Characteristics: A Case Study in Trincomalee

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Abstract - This research finds out the significant differences between rural and urban public transportation with reference to personal, trip, and access characteristics. Personal characteristics of trip maker include gender, age, employment status, vehicle ownership, possessing a driving license, monthly income, residence location, and PT usage time interval. Trip characteristics include type of journey, purpose of the journey, waiting time, and traveling time. Access characteristics include traffic condition, distance between public transportation and starting point, cost to reach PT station, and accessibility issues to PT services. Data were collected by distributing the questionnaire forms in Trincomalee district from 11th July to 01st August in 2022. The significant different characteristics were identified through chi square tests. It was found that, nine variables out of 18 variables were significantly different in urban and rural area public transportation. The significant variables were, age, employment details, having a vehicle, frequency of using public transportation, purpose of the trip, waiting time, type of transportation mode used to reach public transportation, distance between starting point to PT station, and accessibility issue. Understanding the public transportation characteristics differences between urban and rural area helps to enhance the existing public transportation and further develop the sustainable and accessible PT service in future.

Keywords: Public transportation, Chi squared test, Trip characteristics

I. INTRODUCTION

Town and cites are getting larger and busier also roads are becoming more congested. There are more private vehicles on the road now than before [1]. Therefore, people are being actively encouraged to use PT, when possible, to lighten the load and to ease the pressure [2]. Public transportation does a great job of moving multiple people around with the use of a single vehicle [3]. According to the National Geographic Society's 2009 Greendex report, a survey has been conducted around 17 countries regarding the frequency of using public transportation [4]. As shown in Figure 1, in America, only 5% of the people use PT every day and 61% of the people never use PT. About 52% of Russians use PT every day.

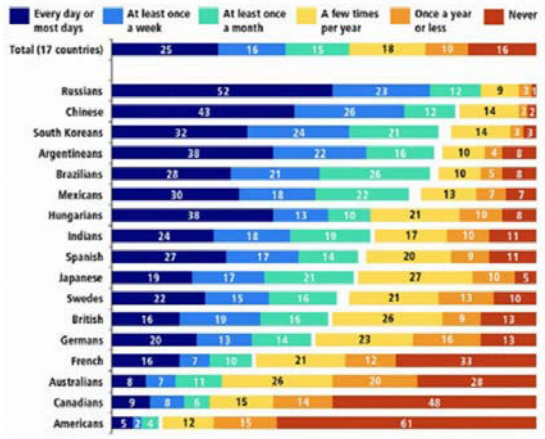

Figure 1: Public transportation user percentage (Source: [4])

In Sri Lanka according to Ministry of Transport, 32% of the people use private transportation and 68% of the people use public transportation [5]. The demand of public transportation is differed from one country to another country. But 68% of passenger in Sri Lanka use PT to get round in day-to-day life. Among that 63% of passengers use bus service and 5% of the passenger use rail services. In Sri Lankan Road 87.1% of private vehicles and 5.7% PT vehicles are moving in the road. As such public transportation in Sri Lanka is the very important service. Identify the PT user's characteristic will help to tune up the service of public transportation network, improve the level of service delivery and foreseeing the level of demand of public transportation [6]. Demand of the public transportation is mainly depending on the PT users' characteristics. Such as, gender, age, income level, household size, education level, employment level, and relationship status [7]. In Sri Lanka, research have been done in 2015 regarding the characteristics of public and private transport users in Colombo metropolitan area [8]. Much research has been done only in rural areas or only in urban areas around the world. Mainly they have focused on walking as a choice of mode to reach PT station. They have not analyzed the different characteristic of urban and rural area people how it influences on the mode choice to reach PT station [9]. The focus in this research is to analyze the characteristic of PT in Trincomalee district highlighting the difference between urban and rural PT services.

II. MATERIALS AND METHODOLOGY

As the first step, questionnaire was prepared with multiple choice questions in three active languages in Trincomalee which helps to understand the PT users' characteristics. Questions were included to collect data on age, gender, employment details, having a vehicle, having a driving license, monthly salary, frequency of using public transportation, type of the day, type of the public transportation, purpose of the trip, waiting time, travelling time on public transportation, type of transportation modes used to reach public transportation, traffic condition in the journey start point to public transportation, cost to reach PT, and accessibility issue. Then questionnaire was distributed in Trincomalee district for all eleven DS division. In Trincomalee district, out of the total population 73.1% people are Tamil speakers and 26.7% people are Sinhala speakers. Therefore, the same proportion was taken in the sample. Four hundred filled questionnaire forms were collected. The data in the questionnaire forms were fed into Excel sheet and chi square test was used for the analysis. The chi squared test is intended to test how likely it is than an observed distribution is expected [10]. A Chi-square test is a nonparametric test which used for hypothesis tests about whether your data is as expected. The Chi-square test statistics is calculated using Equation 01 [10].

$$x^2 = \sum \frac{(O_i - E_i)^2}{E_i} \quad (1)$$

Where; x^2 is the chi-square test statistic, O is observed frequency, and E is expected frequency. The basic idea behind the test is to compare the observed frequency in the data to the expected frequency that would be seen if the null hypothesis is true.

III. RESULTS AND DISCUSSION

Chi-squared tests were used to identify whether there were statistically significant differences between urban and rural PT users. Nine characteristics showed a significant difference as shown in Table 1.

Table 1. Chi Squared Test Relationship

Characteristics	P value
Age	0.029*
Employment status	0.003*
Gender	0.710
Having vehicle	0.000*
Having driving license	0.644
Monthly salary	0.590
Frequency of using public transportation	0.000*
Type of the day	0.084
Type of public transportation	3.230
Purpose of the trip	0.018*
Waiting time	0.000*
Traveling time on PT	0.149
Type of transportation mode use to reach PT	0.020*
Traffic condition in the journey start point to PT	0.063
Distance between stating point to PT	0.000*
Cost to reach PT	7.230
Accessibility issues	0.000*
Note- * Significant at 95% confidence level	

According to the results, in rural areas, school students and elders do not have an interest to travel on public transportation. But in urban all age category people use public transportation. In rural area mostly school students have a habit to travel public transportation. But in urban areas all employment stage people use to travel in public transportation. Shopping, medical purpose and schooling for this urban area people do not use public transportation. Because in urban area shops, hospital and school are near to the residence. But rural area they are not near to their home. Therefore, rural people want to travel long to reach destination. Because of that they use public transportation waiting more time than urban people. Another difference in urban and rural area is the type of access transportation mode. In urban area hiring three-wheelers are available with low cost as the bus stop is near to the origin. But rural area, sometime people need to travel another bus to access PT services. In some village people come to one main junction or main road to access public transportation. PT service is available few times per day into some villages. If people want to travel in other time want to come for main road or main junction which is so far from public transportation. But in rural area people can access public transportation services easily. Rural people face many difficulties to access public transportation than urban people.

IV. CONCLUSIONS

The objective of this study was to identify the significant differences between urban and rural of public transportation characteristics. The motivation factor of this study was the increment of private vehicle on the road. It was found out the most significant differences in PT between rural and urban areas related to the behaviour of trip makers with the aspect of characteristics of trip makers, characteristics of public transportation, characteristics of transportation modes used to reach public transportation. The analysis has found that characteristics of age, employment status, ownership of a vehicle, frequency of public transportation, purpose of trip, waiting time, access mode of transportation, access distance, and accessibility issues were significantly different between urban area and rural area. These differences between rural and urban, bus and train user's characteristic in Trincomalee can be very helpful in future to improve PT system in Trincomalee. The perception of the traveler related to the PT will be an essential requirement for the development of the area. As a future work of this study, it is needed to capture the traveler's implicit needs and wants of the mode of the PT.

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Nexus Between the Concepts Used for Enhancing the Sustainability of Existing Buildings

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Abstract - The significant portion of the building stock required for the future is already in existence. Demolishing existing buildings and constructing new ones is also not sustainable. Thus, the existing buildings need improvement towards sustainability. Various interconnected concepts which represent the sustainable performance of existing buildings seemed to have emerged and evolved in practice. The most suitable concept for achieving the sustainability of existing buildings is still not clear. Hence, this study aims to examine the relationship between the various concepts which represent the sustainable performance of existing buildings. A systematic literature review was conducted to explore the concepts. Five main concepts: adaptive reuse, retrofit, renovation, refurbishment, and circular economy were selected. As per the review, each of these five concepts has a distinct meaning, however, they are similar in extending the lifetime of a building to attain sustainability. The concepts of adaptive reuse, renovation, and refurbishment are attributed to the end-of-life stage of an existing building while retrofit refers to the operational stage of a building. Contrarily, the circular economy concept is applied to through life cycle stages of a building as well as its day-to-day operations. In addition, the circular economy is a much broader concept that encompasses other four concepts as part of its principles. This signifies that the adoption of the circular economy concept into the existing buildings would contribute more towards enhancing their sustainable performance.

Keywords: Adaptive reuse, Circular economy, Existing building, Refurbishment and Renovation, Retrofit, Sustainability.

I. INTRODUCTION

Building sector is one of the least sustainable industries since it uses a lot of resources and energy, contributing significantly to greenhouse gas emissions, resource scarcity, human-induced climate change, etc. [1]. On the other hand, [2] indicated that much of the building stock required for the next century already exists, and thus, existing building stock needs to be carefully managed to make a significant impact on sustainability. In addition, upgrading the existing buildings is more sustainable than constructing new buildings [3], since it prevents the growth of built areas and minimises material consumption and waste generation also allows for the preservation of the location's unique identity [4]. Moreover, existing buildings are seldomly considered for deconstruction, and also, less than 1% of that available today can be fully demountable [5]. As a result, various concepts have been put into action to enhance the sustainability of existing buildings. For example, adaptive reuse is strongly believed to enhance the sustainability of existing buildings as it encourages the maximum reuse of components and restoration of passive aspects of the original building [6]. In addition, one of the key benefits of adaptive reuse is that it preserves the embodied energy (the energy required to construct a construction project) of the original building [7]. Another example, retrofitting an existing building is a way to improve its sustainability [8]. It helps to improve energy and environmental efficiency by using less water and enhancing the quality of the air and natural lighting in the area [8]. A further instance, refurbishment of the existing house buildings requires less embodied energy (5.66 GJ/m^2) compared to the construction of a new house which requires 7.27 GJ/m^2 [9]. However, these concepts appear to be connected, and the concept that makes existing buildings more sustainable is still not clear. Thus, this study aims to investigate the nexus between these concepts for enhancing the sustainable performance of existing buildings.

II. METHODOLOGY

A systematic literature review was carried out to extract the alternative concepts used to represent the sustainable performance of existing buildings. In conducting this search, the search term "sustainable performance" AND "existing building" was used and turned up 53 and 71 papers in Science Direct and Google Scholar databases, respectively. This next section presents the review outcome in terms of the focus of the study.

III. RESULTS AND DISCUSSION

This section discusses the links established between the five concepts considered; adaptive reuse, retrofit, renovation, refurbishment, and circular economy (CE).

All five concepts are unique in terms of their meanings and coverage. Adaptive reuse refers to a significant change of an existing building function when the former function has become obsolete [10] while retrofit is defined as any work to a building over and above maintenance (e.g., adjust, reuse, upgrade) to change its capacity, function, or performance to suit new conditions or requirements [11]. Then, refurbishment is the set of interventions aimed at transforming the building through a systematic set of works that can lead to a building totally or partially different from the previous one [12]. Although renovation is commonly misunderstood as a kind of new construction, as per Cambridge Dictionary, it is “the process of repairing and improving a building so that it is in good condition again or the improvements that are carried out”. Moreover, retrofit denotes significant physical alterations to buildings and used for whole or parts of a building that is currently in operation. Renovation is transforming an existing building into something new, whereas refurbishment involves polishing or restoring an existing building to a good condition. CE is defined as the use of practices in all stages of the life cycle of a building to keep the materials as long as possible in a closed loop to reduce the use of new natural resources in a construction project” [13]. To conclude, retrofit is applied in the operational stage of an existing building, whilst adaptive reuse, renovation, and refurbishment are performed at the end-of-life phase. On a different note, the CE concept is applied to a building’s through life cycle stages as well as its day-to-day operations of it. In addition, the building will be like new or serve a different purpose after applying adaptive reuse, in contrast, buildings will serve the same function as before while they will be like new after applying the renovation concept.

However, all these concepts share the goal of prolonging the useful lives of buildings. For example, adaptive reuse is giving outdated structures, particularly historic structures a new life without unnecessary and premature destruction. It also preserves the buildings’ cultural heritage value while extending their lifespan [10]. Similarly, the refurbishment has the potential to increase a building's lifespan instead of adopting new construction plans [3] while retrofit entails changes to the built environment's fabric, shape, and systems that go beyond the frequently invisible maintenance and repair, hence helping

to extend the life of a building [14]. The ultimate aim of CE is to extend the life of a building [13], while the renovation of a building is expected to improve comfort and quality of life [15].

The ultimate aim of all five concepts is to achieve sustainability through various means of upgrading existing buildings. Adaptive reuse plays a key role in lowering emissions since it requires less energy and generates less waste than traditional demolition and reconstruction [10]. In addition, it provides significant social and economic benefits to society. Similarly, retrofit is primarily aimed to reduce the buildings' energy consumption while improving indoor environmental quality and minimising harmful emissions. Consequently, adopting it has the potential to generate a net economic benefit, simultaneously benefitting the environment and society at large [8]. CE is a practical solution to unsustainable practices which is achieved through maximizing the use of materials and preserving their value as long as possible, rather than using natural resources and disposing of them as waste [3]. Likewise, renovation and refurbishment are reducing adverse environmental effects, boosting economic viability, and as a result, improving societal well-being [12; 15]. Table 1 depicts the conceptual link between the considered five concepts.

Table 1. The conceptual link between concepts representing enhancing the sustainable performance of existing buildings

Criteria	**Adaptive reuse**	**Refurbishment**	**Renovation**	**Retrofit**	**Circular Economy**
Meaning	Give new life to outdated building	Restore an old building to a good condition	Transform existing buildings into something new	significant physical alterations to a building	Close the resource loop (reduce the use of new resources)
Objective	Extending the life of existing buildings toward Sustainability				
Building stage	End-of-life			Use	All stages
Building purpose	Change	No change			Both
Applicable to day-to-day operation	No: Occasionally during the building's lifetime				Yes: Throughout the use stage

Furthermore, the implementation of CE is being pursued through the use of the R-imperatives, which vary in quantity and order and also have changed over time [16]. Source [16] established a framework of R-imperatives (with 11Rs) of CE for the built environment, which includes refuse, rethink, reduce, reuse, repair, refurbish, remanufacture, repurpose, recycle, recover, and replace. Here, all four of the other concepts can be put into "refuse and reduce" (defined as avoiding or less creating materials as waste/consumption of any virgin materials). The concept of refurbishment is explicitly having the same meaning. Then, adaptive reuse can be categorised under reuse. Next, reconditioning and renovation are practically the same. Finally, the retrofit can be included into replace. Therefore, the CE includes the other four concepts as one of its principles. This reveals that the CE concept must be included in existing buildings to enhance their sustainability. However, research on the applicability of these principles as a whole to existing buildings is still lacking.

IV. CONCLUSIONS

The importance of this trend of adopting above mentioned concepts is to extend the useful life of existing buildings which supports the key concepts of sustainability through various means of upgrading the existing buildings. Accordingly, all of these concepts are based on the same idea, which is primarily to extend a building's lifetime. Further, since the concept of CE may integrate through its various principles, the rest of the four concepts can be incorporated into CE. Thus, it is necessary to promote its association with buildings to attain sustainability.

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Perception of Living Walls in the Context of Sri Lanka

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Abstract – Colombo City is vulnerable to rising temperatures due to the development of construction, lack of green spaces, and other factors. As a result of using materials like concrete and asphalt which absorb and store heat during the day, and release of heat at night, causing the temperature of the earth's atmosphere to rise. This initiated the Urban Heat Island (UHI) effect. The value of environmentally friendly design became extremely clear and innovative technologies like "living walls" started to be implemented in construction to address the urban issues. A research survey has been conducted to determine the perception of living walls among residents of the Colombo district in 13 District Secretariats. The "Statistical Package for the Social Sciences" (SPSS) program is used to analyze the data and 100 responses were selected for the analysis. The results show a higher rate of interest in gardening even though most of the participants living in the urban context lack garden areas due to the unavailability of spaces. However, the majority of the participants are aware of the 'Vertical Living Wall' system, but they are concerned about the cost, maintenance and complexity of the structure of the living wall systems available in the local market. In addition, a higher percentage of participants agreed on the fact that living walls can be accommodated in their premises in an affordable way. Thus, it is important to propose new strategies and products in the future in enhancing the sustainability of urban environments.

Keywords: Colombo District, Living walls, Urban Context, User Survey

I. INTRODUCTION

Colombo, the main economic hub of Sri Lanka has been continuously changed to make space for urban expansions and developments during the past two decades. Many claims that the rapid growth of Colombo would results in numerous environmental issues [1]. As a result of intense economic expansion and industrialization, opens the way for changes in surface properties leading from soft to hard surfaces. The use of non-reflective, heat absorbing, water resistant impervious surfaces (concrete, and asphalt) absorb high percentages of incoming solar radiation which results in formation of Urban Heat Island effect [2]. This effect may consequences in worsening in climatic conditions, increase in city's temperatures, increase in energy usage, enhance air pollution, heat-stress elongated illness and other sever conditions will result eventually [3]. In Sri Lanka, home gardens are one of the popular and sustainable land use systems. The structure and the composition of home gardens have contrived throughout the years. Mostly, home gardens in wet zone shows a significant degradation in past years. Pushpakumara et al. [4], have been highlighted that urban vs rural context and socio-economic condition of households are a few factors affecting the home gardens. Especially the size of the home garden, income status of the garden possessor, access to market and other issues will contribute to the deterioration of home gardens. The need for green architecture became increasingly clear in the twenty-first century, and new technologies like "Vertical living walls" started to be applied to construction. However, living walls need special maintenance in material and component repair, replacement, and also irrigation system repairs [5].

II. METHODOLOGY

A. The Research Context and Survey Design

Colombo districts consist of 13 Divisional Secretariat Divisions (DS Division) in a 699 Km2 area. With a population of approximately 2.3 million [1]. The Colombo DS division has a higher population density compared to other districts in the country. A survey questionnaire has been circulated concentrating on Colombo District's urban population around 13 Divisional Secretary's Divisions (DS Divisions), such as Colombo, Dehiwala, Homagama, Kaduwela, Kesbewa, Kolonnawa, Kotte, Maharagama, Moratuwa, Padukka, Rathmalana, Seethawaka and Thibirigasyaya area, have been earmarked for the study. The survey study consisted of quantitative and qualitative questions categorized into 3 sections.

All questions were in different formats to grasp direct and understandable responses. There are no open-ended questions in the survey, and it was composed so that the survey could be completed within 2 to 5 minutes. In the first section, the respondent's demographic data were involved while the second section questions were aimed at personal garden experiences. The last section concentrated on the application of 'Living walls' in an urban context where responders' senses and values on living walls were examined respectively. The questionnaire survey was shared on Google forms, and it took 2 weeks in June 2022 to complete the field study of the survey. A total of 100 individuals were chosen as respondents and to assess the data, 'Statistical Package for the Social Sciences (SPSS) program has been initiated to analyse and display the collected data.

III. RESULTS AND THE ANALYSIS OF THE SURVEY

A. Demographic Data

Colombo City marks the highest responded area representing 17% out of 100 participants. While Dehiwala Divisional Secretariat represents 7.5%, Homagama 5.3%, Kaduwela represents 10.6% from the total. Also, Kesbawa 8%, Kolonnawa represent 2%, Kotte 13%, Maharagama 18%, Moratuwa 5%, Padukka2% and Ratmalana, Seethawaka and Thibirigasyaya represent 4%,3% and 5% respectively. Moreover, the age of the questionnaire participants ranges across different age groups. 22% were between 16-25 years old, 45% were between 26- 35 years old, 17% were between 36-45 years, 10% were between the years of 46-55, while 5% represents the years 56 to 65. Only 1% represents 66 or older years of age.

Table 1. Demographic details of the survey respondents

	Variable	Percentage (%)
Type of Residency	Apartment	9
	Own home	73

	Boarding house	2
	Rented house	16
No of people in the household	1 person	0
	2 people	19
	3 people	22
	4 people	31
	5 people	16
	6 or more people	12
Monthly Income	Rs.0- 25,000.00	6
	Rs.25,000.00-143.750.00	34
	Rs.143,750.00-262,500.00	40
	Rs.262,500.00-381,250.00	13
	Rs.381,250.00-500,000.00	8

Table 1 represent further details on demographic of the survey respondents where the type of residency, number of people in the household and monthly income were questioned. However, only 88% have responded on monthly income status.

B. The findings of the second section

The survey results show that the rate of interest in gardening ranges with an average mean of 6.4. The majority of the respondents show a medium and a high scale of interest. Out of all the respondents, 40% showed a 0 to 5 lower range of interest while 60% were on a higher scale of interest ranging from 6 to 10.

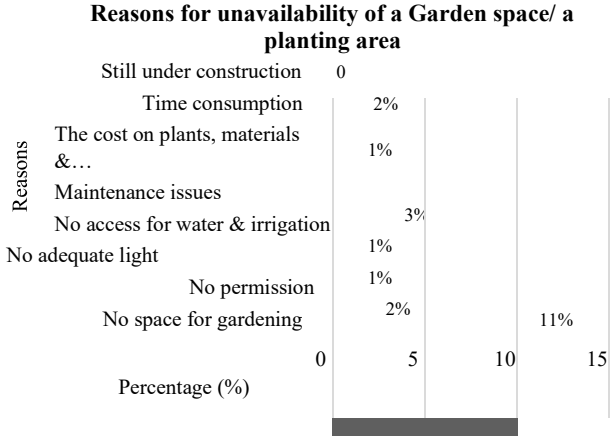

Fig. 1: Participants' responses on reasons for the unavailability of a gardening space/ planting area.

Furthermore, the survey indicates the number of respondents who possessed a garden space in their residences. Out of all respondents, 85% possessed a garden space while 12% were not practicing gardening. 3% have failed to answer the question. Also, the respondents were asked to indicate the location of their garden space. Seven options have been specified, such as; a) at the front of the house, 23% occupy a garden space, b) at the rear side of the house; 12%, c) at both front and rear side; 15%, d) at the front, rear and sideways occupy 10%, e) at balcony and rooftops represent 7%, f) only at sideways and courtyards represent 9%, g) at the front, rear, balcony and roof terraces represent 11% respectively.

Moreover, areas of garden spaces are in different proportions. 13% of the participants own garden below 5sqm while 19% own an area in-between 5sqm-10sqm, 9% in-between 10sqm-15sqm, 27% in-between 15sqm-20sqm and 17% over 20sqm. The respondents who do not possess a garden space have determined their reasons. Figure 1 shows the participants' responses to the unavailability of a garden space where out of 12 participants who do not possess a garden, 11% have issues with a lack of space for planting. Also, maintenance, no permission for gardening and time consumption were the other issues addressed, representing 3%, 2% and 2% respectively. Furthermore, 11% of participants were wishing to have a garden in the future but 1% were unwilling to have one because of a lack of time and skills for maintenance, no motivation and due to hard maintenance.

C. Perception of living walls

The research determined that 70% of respondents were aware or familiar with 'Vertical living walls' and 30% were unfamiliar with the type. However, out of all the responses, 52% agreed to the possibility of implementing a vertical living wall at their premises. 48% disagreed with the fact and the survey further highlights the following participants' perceptions of living walls, such as 17% of the 100 participants strongly agreed, 44% Agreed, 32% were undecided, 6% disagreed and 1% strongly disagreed with the item, "Do you think living walls are a high-cost product in the local market?". Furthermore, 41% have a median rate of scale on the simplicity/ complexity of the living wall structure while 16% have a low scale and 42% have a higher rate of scale on the matter. Following, 28.3% strongly agreed with the fact that living walls need high maintenance while, 52.2% agreed, 9% disagreed and 10% were unaware of the fact. Finally, 8% of the total respondents strongly agreed that living walls can easily accommodate their future home garden in an affordable way. Also, 44% agreed, 40% were undecided, 3% strongly disagree and 4% disagreed with the fact.

D. Conclusions

The Colombo District deteriorates its vegetated land surfaces day by day. Due to urbanization and developments, concentration on home gardens are also reducing. This study was conducted to investigate Colombo District's urban populations' garden experiences and availability of garden spaces. Along with the possession towards adaptation of living walls. However, out of 100 participants 85% possessed a garden space and the rest are willing to have a garden in the future. Many have issues with space limitations and adaptation of living walls may have concerns in implementing. Future developments and studies should focus on new less complex products which caters the local market with a low profile in cost, maintenance and durability.

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Technologies for Green Buildings: A Review of Energy Efficiency Perspective

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Abstract – The energy crisis is one of the prominent current issues drawn all over the world. The construction and occupational phases of buildings are one of major contributors to this problem. Modern buildings are created with advanced technologies to optimize the energy consumption of buildings while managing the occupants' requirements sufficiently. To this end, the green building concept is becoming increasingly popular worldwide. In green building construction, green technologies play a significant role when achieving building energy efficiency, hence have drawn the attention of recent researchers to investigate the energy-efficient technologies applicable to green buildings. However, it seems to be the application of these technologies is limited due to the poor public and investors awareness regarding these technologies. Therefore, this study aims to review the energy-efficient technologies that have been implemented in green buildings to achieve sustainability, through a desk study. The review focused on two types of green technologies: (1) implemented in new construction and (2) implemented in existing buildings. However, it seems to there is no significant difference in energy-efficient technologies in terms of new and retrofit. Review results further show that energy-efficient technologies can be classified into two categories: energy conservation techniques and energy generation techniques. Under the energy conservation twenty, (20) techniques were identified under five main elements: Heating, Ventilating, Air Conditioning (HVAC), lighting, window, roof, and walls. Soar lighting and solar wind hybrid system are the two main identified energy generation techniques identified through the review. It is expected that the findings of this study would enrich industry practitioners with knowledge of green technologies and thereby facilitate the selection of the most suitable technology to improve energy efficiency in buildings.

Keywords: Energy efficiency; Green building; Technologies.

I. INTRODUCTION

Sustainable development can be identified as the development which meets the needs of the present by compromising the ability of future generations to meet their own needs [1]. Green building is a major aspect that comes under the promotion of sustainability [2]. A green building can be defined as a design, construction, and operation which directly minimizes negative impacts and produce positive impacts on climate and the natural environment [3]. The global sustainability goals have led to the development of this green building movement within the construction industry [4]. The popularity and the acceptance gained by the green building practice have in turn resulted in the development of a variety of green technologies for enhancing sustainability performance during the construction process [2]. Adopting green technologies provides a wide variety of economic, social, and environmental benefits along with the growing awareness of climatic changes [5]. Green technologies implemented in green buildings can be classified under five main green features that are specified in green certification systems: sustainable site, water efficiency, energy and atmosphere, indoor environmental quality, and material resources. Among those green features "energy and atmosphere" feature become the most prominent because it took the highest portion in green certification (i.e., 35 out of 110 in LEED certification and 21 out of 113 GREENSL certification). One reason could be the current energy crisis in the world. These energy and atmosphere-related green technologies would encourage building owners and designers to complete a proper, systematic look at the building and site's energy flows to lower energy bills, assess the potential for renewable energy use, and improve environmental health impacts. For example, the application of high-energy efficient windows and green wall technology in a housing development can help to save 14-20% and 33-60% of operational energy [4]. In addition to that, a survey of 99 green buildings showed that they use 30% less energy than conventional buildings [3]. Even the developers tend to adopt green technologies such as solar technology and optimization of the thermal performance of building envelope, as it increases the market opportunities [6]. The forgoing literature confirms that green technologies would help to enhance the energy efficiency in green buildings. Further, existing literature evidence that several technologies could be used for green buildings in terms of energy efficiency. However, it seems to be there is less application of those technologies. One reason could be the lack of awareness among the investors as well as the public on those technologies. Hence, reviewing the available literature regarding the green technologies that can be applied for green building construction from an energy-saving perspective will help to address the energy crisis issues while increasing the performance of green buildings toward more sustainability

II. MATERIALS AND METHODS

To fulfill the research aim, a thorough literature review was conducted through the desk study. As a result, the available literature on green technologies has been gathered from journal articles, electronic sources, papers from the conference proceedings, and books.

III. RESULTS AND DISCUSSION

As suggested previously, the adoption of green technologies in buildings would enhance their sustainable performance, particularly in existing and new buildings. Two main ways can be applied green technologies for green buildings; new technologies and retrofit technologies. The technologies that can

be used to improve the green building performance in the initial phases of construction are new whereas technologies that are used for any refurbishment of an existing building aiming the increase green building performance are retrofit technologies. As per the review results, in terms of energy and atmosphere green feature, there seem no differences in technologies applicable to new construction and retrofit buildings. It was identified that available green technologies can be discussed under two main categories as energy conservation techniques and energy generation techniques. Energy conservation techniques referred to the decision and practice of using less energy whereas energy generation techniques discussed the sources. Table 1 shows the technologies that can be used for green buildings to enhance energy efficiency under each category.

Table 1: Technologies used in green buildings toward energy efficiency

Criteria	Technology
Energy Conservation Techniques	**HVAC** • Optimum Start/Stop Controller • Variable Frequency Drives (VFD) for Motors • Free Cooling Applications • Energy Recovery Ventilator (ERV) • Demand Control Ventilation (DCV) **Lighting** • Light Emitting Diode (LED) Lighting • Occupancy-Based Lighting Control System • Daylight Linked Lighting Management System • Lighting Controlled by Time Scheduling **Window** • Low Emissivity Application • Multi Pane Glazing • Vacuum Tube Window • Window Frame **Roof** • Roof insulation • Green roof application • High-albedo roof paintings • Transparent roof / Sustainable daylighting **Wall** • Wall insulation • Solar Shading Elements • Green Wall
Generation Techniques	• Solar Lighting • Solar-Wind Hybrid System

Source [1-6]

As observed in Table 1, approximately twenty (20) energy conservation techniques were identified under five main elements: Heating, Ventilating, Air Conditioning (HVAC), lighting, window, roof, and walls.

The HVAC system is the largest energy consumer out of the systems in a building. Hence, considerable energy savings may be achieved through energy efficiency measures. Building HVAC systems are designed for high-load conditions that are only experienced for short durations. Therefore, the installation of variables and controllers will maintain the required speed of the fan, and pump for the load requirements (i.e., Optimum Start/Stop Controller, VFD, and DCV). Free cooling application is another technology that would reduce energy consumption using Phase Change Materials (PCM) which store the abundant atmospheric night cool energy and use that energy during daytime to keep room comfort conditions within the desired level. ERV improves an HVAC system's energy efficiency by preconditioning outdoor ventilation air with the aid of indoor exhaust air. Along with the HVAC system, the lighting system is comparatively one of the biggest energy consumers within buildings. Through the appropriate selection of light sources, energy-efficient equipment usage, and effective controls, vast amounts of energy can be saved. When considering the power consumption, Luminous flux, efficiency, and energy cost LED lights to show more performance (More than 75%) than incandescent and fluorescent lights. Occupancy-based control systems, daylight-linked control systems, and time-scheduled control systems belong to the automatic lighting control systems where turning lights on and off to precisely control bulb illumination based on a particular purpose. Windows provide residents with light, a view, and fresh air, they are the most essential factor in a building's energy use. Window's overall heat transfer coefficient (or U-value) is generally five times that of other building envelope components (e.g., walls, doors, etc.) and around 20-40 percent of energy in a building is wasted through windows. Roofs and walls considerably engage in heating and cooling in buildings and utilized appropriate technologies effectively in minimizing cooling and heating demand in buildings. Soar lighting and solar wind hybrid system are the two main identified energy generation techniques. Solar and wind are two renewable energy sources that are vast, long-lasting, and pollution-free. Photovoltaic (PV) technology is one of the main outcomes of electricity generation through solar radiation. Durable, simple designs, require little maintenance, and convert solar radiation directly into electrical energy features increase the willingness towards those techniques. Solar wind hybrid systems utilized the advantage of high solar radiation and less wind speed at daytime and less solar radiation and high wind speed at nighttime.

IV. Conclusion

Many recent studies reported the significance and necessity of energy-efficient building designs to reduce the energy crisis and other negative effects of high energy consumption. This improvement can be fulfilled with the selection of suitable green technologies for buildings as stated in Table1. However, Table 1 is limited to the identification of technologies that would help to minimize energy usage, and it is recommended that further exploration of the significance of those techniques towards each sustainable pillar helps to increase sustainability performance.

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Track 2

Electrical & Power Engineering

Dual-Power Charging Station for Mobile Devices with Renewable Energy

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Abstract - There is a vast challenge to provide reliable charging of mobile devices and other electronic devices in remote locations where there is no reliable power supply. Thus, in this project an automated mobile phone charging station with renewable energy such as solar and wind is proposed which is suitable for areas without electricity and for urban environments that require electricity due to emergencies. The electronic circuit in the project will also be powered by a solar cell, which means that the entire project will be made entirely from renewable energy sources. The prosed design is implemented with an initial model and the expected outcome was validated with the results.

Keywords: dual-power charging, renewable energy, automated charging station

I. INTRODUCTION

In recent years, energy has played a critical role in human and economic growth while affecting the global peace. The entire yearly energy consumption of the world has grown, where three-quarters of the total came from fossil fuels. With the conflict between fast advances, oil will last around 40 years and natural gas will last about 60 years. Renewable energies, such like wind and solar, are built on current technology provide both clean and efficient energy output

Cell phones are one of the most popular ways of communication today and one of the most affordable electronic devices due to technological advancements. Aside from network service availability, a consistent power supply on the mobile unit is the primary concern of every mobile phone user, which is reflected by the battery indicator icon, which shows the amount of charging and draining of the phone's battery [1]. Cell phones, like many other electronic devices, are powered by electricity and must be recharged on a regular basis. This is especially true for smart Android phones, which deplete battery power much more quickly than standard mobiles [2]. Power banks are available on the market for quick emergency charging where they are expensive. Even though battery technology has advanced in terms of performance and capacity, smartphone batteries are unable to meet power needs [1].

Charging stations seem to be a feasible option in remote areas without access to the grid, where people have a low income yet high energy usage. Charging stations can be powered by diesel or renewable energy sources (primarily solar, but also wind and hydro), and they can charge mobile phones, batteries, lanterns, and other electronic devices, as well as serve as a shop, cultural or recreational center. The municipality, a private entrepreneur, a local area, a village association, or a non-governmental organization (NGO) may own or operate these stations. The user can pay a per-charge fee or a monthly or weekly fee, depending on whether they own or rent the charging station.

The system should be as convenient to use as possible, since users may misuse the system, the use of unneeded components should be avoided, and all connection options should be addressed in the system's architecture [3]. To avoid the duplication of malfunctioning systems, systems must be field-tested before replication. The system's components include PV modules, wind turbines, batteries, an inverter, and different controllers. These parts collaborated to provide enough energy to power the phones. As the user is usually concerned whenever the battery power level is getting low, especially when there is little hope of electricity restoring energy for the phone, this project provides an alternative charging system for many phone users today without relying on the national electricity grid, which is unpredictable, but instead relying on the natural gift of the sun to generate electricity [1]. The solar and wind powered mobile phone charging systems, which contain a rechargeable battery and charge adaptors for various phones, can be newly installed in public places like bus stops, children parks, and junctions. As a result, the user can just plug his phone into the system to charge it.

As aforementioned, there is a challenge to provide reliable charging for mobile devices in the event of an electrical outage or failure to carry an energy store in an emergency. Thus, the main focus of this study is to set up an automated mobile phone charging station using energy sources that are renewable such as solar and wind, suitable for rural areas without electricity and for urban cities that require electricity on emergencies. A novel cost-effective wireless charging system has been introduced to the design with the use of inductive coupling where pre-trial test bed results were obtained with a range of distance for the designed transmitter and receiver circuits. A general model of the proposed design has been implemented and tested to prove that the design provides accurate results where the product can be introduced to the marked as a cost-effective solution for the energy requirement.

II. METHODOLOGY

Any autonomous electricity producing system that incorporates more than electricity power to the grid or on site is referred to as a dual power system. The main benefit of dual-power energy is that it can get energy from both solar and wind sources. The sun's rays are absorbed by the solar panel and converted into DC electricity. And the wind turbine revolves owing to the force of the wind, and its rotor is connected to a generator, which likewise rotates and produces AC electricity. With the aid of an AC-DC converter, this AC current is converted to DC. Both currents now run at the same time and flow to the circuit board, where they charge the mobile phones

connected by wires. The system is consisting consists of a microcontroller, solar panel, DC motors, wind turbine, batteries, an LCD display and an automated cell phone charging system.

The basic block diagram of the system is shown in Fig.1. A solar panel with an 18V, 10W output is employed, with the output varying depending on the intensity of incident light. In addition, a dynamo was used for windmill, where the output variation depends on the trinity of the wind and direction. A voltage amplifier is used to increase the voltage produced by the wind system while a voltage multiplier is used as an AC to DC converter. The voltage generated by the solar cell and windmill connected to the load switch.

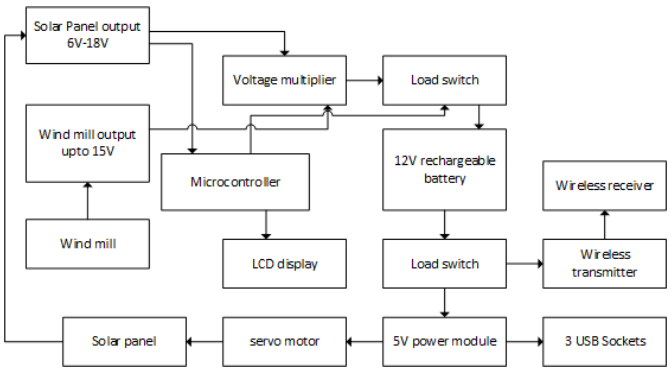

Fig. 1 Block diagram of the proposed design

The load switch consists, IRF9540N MOSFETs, 2SC1815 transistor and 10k resistor. The load switch consists, IRF9540N MOSFETs, 2SC1815 transistor and 10k resistor. Here the load switch working on the signal given by the microcontroller. In this circuit load switcher act as an overcharging protector and protect the battery from over discharging. If battery voltage is below 13.4V, load switch is enabled to charge the battery from the renewable sources, else if the battery voltage is below 11.5V, load switch is disabled to charge the devices from battery. The microcontroller displays the amount of solar, wind and battery voltages. It also displays the battery is charging enable status and battery is charging disable status. Battery output is connected to two 5V power modules, where they are used to drop the volage to 5V and connect it to the servo motor and three USB hubs respectively. The wireless charger directly connect to the battery is supported by the load switch.

The designed circuits for the transmitter and the receiver can be shown as in Fig. 2 (a), (b) respectively. The resonance frequency of transmitter will be impacted by the coil's manufacture where an optimal value was obtained with experiments as 6 cm in diameter, and 24 loops. The circuit generated the resonance frequency automatically and adapted if the load is modified. The receiver coils are comparable to the primary coils. Running the secondary and primary at the same resonant frequency allows reduced secondary resistance and optimal energy absorption at the transmitter's frequency.

LM2596 was used as the buck converter module for the system since it is with a good efficiency rating, consists of built-in thermal shutdown and its capability to limit the current.

III. Results and Discussion

With continuous experimentation from the designed circuits, it was found that on average 4V output can be obtained with a distance of 1.5cm from the unit with the input of 0.01V_{p-p} and 12MHz condition. The output can be increased and decreased gradually with the decrement and increment of the distance from the unit to the mobile device. The solar panel provided maximum 12V and 165mA current while single axis solar tracking was used to maximize the output of the panel. The output readings were displayed on LED display. The final product is shown in Fig.3.

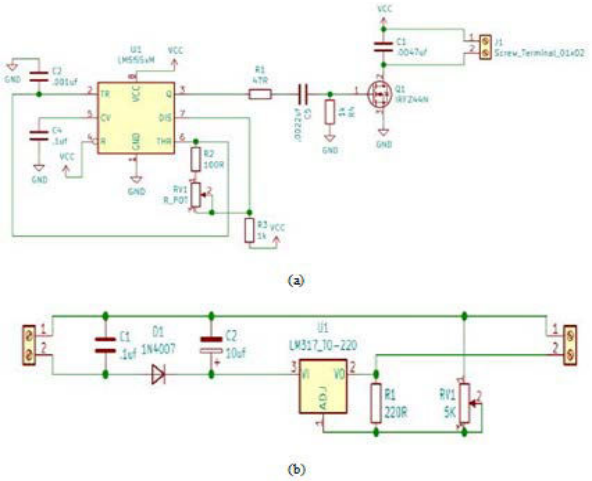

Fig. 2: (a) Transmitter circuit; (b) Receiver circuit

Fig. 3: (a) Physical appearance; (b) Final PCB; (c) LED Display

IV. Conclusion

A dual-power charging station with solar and wind power was designed and implemented in this study. A solution for electricity scarcity in rural location was provided with a cost effective and easy to install design. The design can be improved to a portable charging station with four wheels in the bottom stand and the charging rack can be further improved by adding 230V AC plug to support laptop charging. As a developing country with continuous wind and solar energy availability, this design could provide the general public more feasible access to

charge their smart devices with low cost and user-friendly manner.

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Single Axis Sun Tracking System and Solar Power Back-up System

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Abstract - As a solution to the studded power outages in Sri Lanka and considering the possibility of earning a comparatively higher solar energy yield, this system is proposed in this paper. 'Solar tracker system', 'charging control unit', 'off - grid inverter' are the prioritized systems of this project. There are other sections such as the 'Changeover unit' and the 'Monitoring system' as well. A low-cost, high-efficient solar inverter with a solar tracker and power backup is also a part of the proposal here. The solar tracker system would track the direction of more sunlight falling with the help of the LDRs present and allow the solar panels to move East or West in order to receive efficient sunlight for power generation.

Keywords: Solar tracker, off-grid inverter, charging control unit, power back-up

I. INTRODUCTION

Solar energy has gained more attention over the last decade and Sri Lankan domestic consumers are showing an interest in installing solar power systems in their households. But, the cost of solar systems cannot be afforded by the majority of domestic consumers. As a solution, this project proposes a low-cost and efficient solar power system for both domestic and industrial consumers. The efficiency of the system is enhanced by the solar tracker which helps to harvest the optimal amount of power from the solar energy. A few problems were identified in order to put forward this particular project into action. The pattern of the rise and setting of the sun differs due to the seasonal changes in Sri Lanka. Therefore, a specifically coded sun tracking method would not be suitable, as the weather and the climatic changes at present are quite unpredictable. When the solar panels are fitted to the rooftop or railing just as usual, then it is not very accurate that a good amount of solar energy from the panels would be received [1] . Also in Sri Lanka, the solar panels are mounted in a specific direction (towards the south) at an angle of 9 degree or 10 degrees, as Sri Lanka is close to the equator and the possibility of receiving efficient and maximum sunlight to fall on the surface of the solar panel(s). According to the Sri Lankan context, hybrid and on-grid solar power systems are more popular due to consumers being able to maintain a continuous energy supply with the help of the national grid [2]

The aim of the project is to bring power to the life of anyone and everyone. The hybrid inverter which is the only possible way of having power when there is a power - cut. But the hybrid inverter is not affordable for everyone. For example, it is very dangerous for anyone who has an aquarium to be unable to maintain, as the fish needs oxygen supply continuously, which uses power. So, it is very important for people like them to have continuous power supply. So, in situations like these this project will be very convenient and will be handy. So, this complete system of solar power generation and power back - up is going to be compromising and very useful.

II. SYSTEM MODEL

Fig.1 shows a simple block diagram of the proposed system where the sun tracker is built on a small solar panel. The feedback of the tracker is sent to the motor control unit and the required angular rotation can be estimated accordingly. To avoid mechanical interruptions, solar tracker is built on a separate small-scale panel rather than connecting it directly to the main solar panel.

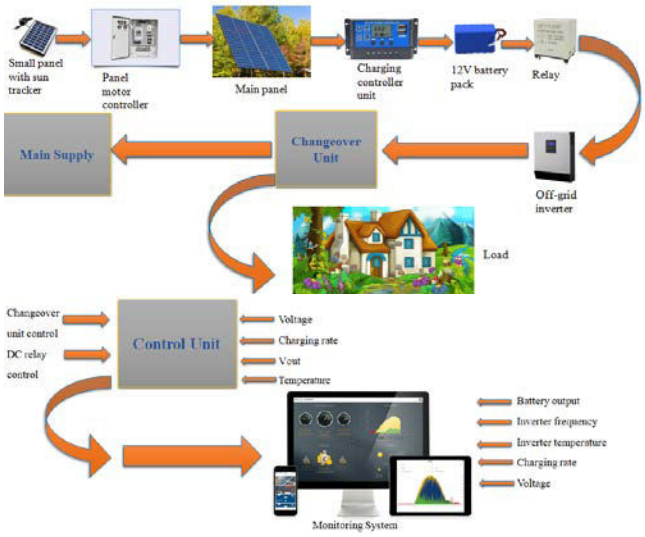

Fig. 1 System architecture for the proposed solar system

The charging controlling unit is fed specified voltage and the charging rate to the control unit. Then the relay with suitable rating is connected to the battery which is simply operated by the charging controller unit. When the relay is switched on,

generated power is coupled with the inverter, and then to the changeover unit which is again controlled by the charging controller unit. The details on charging rate, temperature, and output voltage reach the main controller unit, by switching on and off the 12V relay that is in the control unit. And the monitoring system would be helpful in monitoring the temperature, charging rate, and checking on the power, battery output, off - grid inverter, and voltage. This would be done by a remote monitoring system, and here the monitoring system would also be in connection with the control unit. The system would have the minimum power point, tracking charging and a standby power solution. Individual blocks of the system are detailed out in the following subsections.

A. Solar Tracker

The main solar panel(s) are usually mounted and fixed to the rooftop or on a railing, in order to receive direct sunlight. Here, one side of the solar panels is fixed onto the railing or the rooftop and makes it possible to tilt over the single axis up and down at an angle of 30^{o}. The panels will be tiltable so that it would be possible to position itself to the peak value when the solar intensity is low. The small panel of size (2x2) inches, would be capable of movement but one side of it would be fixed. It is going to be possible to produce a 1.5V with the help of this small panel, which would move in two directions but in a single direction with respect to the angle of 30^{o}. It would be possible with a motor that would change the direction of the panel when there is low sunlight in contact with the small panel. The motor movement would then be stopped, when the signal is received for the specified position where the panel gets the maximum sunlight for the generation of optimum solar energy. The small solar panel would pass the signal to the motor control unit, which would then be passed to the bigger panel. The small panel sends a pulse or signal to the motor control unit, which would then be directed to the bigger panel for the movement of the bigger panel to be accordingly. The specific direction in which the big panel has to move and the exact position it would be located, will be provided to the big panel through the motor control unit from the small panel to which the solar tracker is connected.

B. Charging Control Unit

The production of constant voltage would be achieved using an adjustable voltage regulator (LM317). The diode is used to protect LM317. The output voltage can be adjusted with the help of this LM317. Overvoltage cut – off facilities. The battery of 12V and 1.3A per hour is also a part of the charging – controller unit. The capacity of the charging controller unit can feedback the drop signal coming to it and give it back. If the battery is thirteen volts, a protection circuit is included inside the IC to prevent it from overcharging. Here no matter how high the input voltage is, the output voltage will not be higher than the pre-specified value in the system.

C. Off Grid Inverter

The 555 timer IC in an off-grid inverter circuit is used to drive a D-type flip-flop produced using a CMOS type 4013 IC. The timer IC produces perfect complementary square-wave signals [3]. Darlington power transistors are used to arrive at the necessary output current. MJ3001s are cheap and readily available. The square wave coming into the inverter is converted into a modified sine wave. After applying a DC voltage to the transformer, the next step is to oscillate. The signal from that oscillator is a very small signal. But when the system converts this signal into energy, it will amplify. This happens in the Driver unit. Then the output is taken according to the amount that has to be output. From the output, it is fed into the transformer directly. The filters are added to make corrections in the waveforms [3].

D. Change Over Unit

This unit has one-time and two on/off functions. Also, all the following units are connected to this controlling system. If there is Voltage, charging rate, Temperature, and V out. The purpose of this unit is to isolate the circuit from the grid. It is a system that is in the middle of the load and the off – grid inverter (system) [4].

E. Monitoring System

With the help of the monitoring system, able to track the functions that were proposed. The software will be developed to display the line voltage, battery charge, power generation, and status of the inverter [3]. The monitoring system can be put in action by using a Wi – Fi module and also it can be done by merging it with the IOT [5].

III RESULTS AND DISCUSSION

The ‘Solar tracker’, ‘Charging control unit’ and ‘Off - grid inverter’ were designed in the Proteus 3.0 simulation software and tested. The output of the solar tracker system was checked by adjusting the resistance of the LDR and changing the values of the variable resistors as inputs. The prototypes made were tested. The solar tracker system was tested by giving an input of 12V with the help of the power generator and the DC motor that was a part of the system rotated. The charging control unit was also tested, in the same way as the solar tracker system. Power supply was given for the input of charging control unit with the help of the power generator in the laboratory. The observation was made by connecting a bulb and the bulb lit brightly.

IV. CONCLUSION

The uniqueness of the project is to make it possible for everyone to afford power generation and a power back - up. In future, it could be expanded by introducing it to large-scale companies and industries that have more needs and necessities. Increasing the number of batteries, and or increasing the storage power of the battery will give us more room for storing more energy. As mentioned in section III

'Results and Discussion', the solar tracker system and the charging control unit were tested. But, the off – grid inverter was not tested as the required component for it was unavailable in Proteus. So, that can be overcome by trying to redesign the off – grid inverter system in another simulation software and then testing it. There are many systems that have the solar tracking method, inverter system, control units, separately. But this would be the very first time that all the unique and important systems are combined together to give amazing results for efficient power generation and power back-up system during power failures.

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Reliability Enhancement of Industrial Capacitor Banks through Smooth Engagement to the Grid

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Abstract - Most of the industries with inductive loads, results in a lower power factor due to the lagging power factor quality of inductive loads. In order to maintain a better power factor, capacitor banks are used in industry. Due to the leading power factor quality of capacitors, capacitor banks neutralize the effect of inductive loads to improve the power factor. However, these capacitor banks are having less lifetime. This is due to adverse effects of transient voltages and currents mainly owing to capacitor bank Energization and switching. Existing methods of grid engagement; the switch or connector module which connects capacitor banks to the grid, can be considered as a main reason for this. In this study the behavior of transients in the capacitor banks and power system was analyzed using MATLAB Simulink and a better switching mechanism was introduced. By advancing the existing Pre-Insertion Resistor capacitor banks protective mechanism, the Pre-Insertion Resistor Intermediate Step (PIRIS) mechanism was developed. An Intermediate resistive path has been introduced for the Pre-Insertion resistor mechanism in order to further mitigate the switching transients. Switching times and resistor values were optimized using simulations.

Keywords: Capacitor banks, Condition monitoring, Pre -insertion resistors, Transients, Power factor

I. INTRODUCTION

Power factor is the ratio of working power to apparent power used in a power network. It also can be defined as the power efficiency. To counterbalance the adverse effects of inductive loads, capacitor banks are used as they possess leading power factor quality[1]. Improvement of the power factor maintains the quality of the power system; by avoiding any blackouts due to excess demand of power, increases energy efficiency and reduces electricity costs, and reduces failure of electric instruments[2].

However, the reliability of capacitor banks which are used for the power factor improvement is a problem, because failures of capacitors are more frequent in the industry. There are considerable occurrences which affect the lifetime of the capacitor banks and quality of the power system due to generation of high voltage and current transients originating from various artificial and natural occurrences [2,3].

As an industrial practical solution, introduction of smooth capacitor banks switching mechanism mainly for the mitigation of voltage transients due to switching of capacitor banks was concerned in this study. More Importantly, cost effectiveness and simplicity of the protective mechanism were prioritized when considering the practical constraints in developing countries like Sri Lankan industry.

II. METHODOLOGY

A thorough literature reviews mainly based on the research papers was done to get a broad idea about disturbances from capacitor banks to the power system and effects to the capacitor banks from the grid.

In order to get a better understanding about practical conditions, using the information of an industrial application (WTC, 36 stories building) model of this existing power system was designed in the MATLAB Simulink software. In this study potential solution tests were carried with a MATLAB model. Practically it's challenging to switch capacitor banks on zero voltage points to eliminate inrush current [4,5]. Therefore, intermediate Step Switching Mechanism was developed to mitigate switching/ energization inrush transients in the power system. Pre-insertion resistor intermediate step switching Mechanism is an advancement of the existing pre-Insertion resistor protective mechanism.

Pre-insertion resistor procedure initially uses a higher resistive path for the connection of capacitor banks to the power system, then the high resistive path will be bypassed [4,6]. The basic architecture is shown in figure B. Even though the transients were mitigated when connecting capacitor banks to the grid in the conventional method, noticeable transitions were generated when switching from the resistive path to the direct path.

In PIRIS mechanism switching transitions have been further decreased by introducing an intermediate resistive path with having any effect to the power factor. Figure A shows the basic architecture of the mechanism.

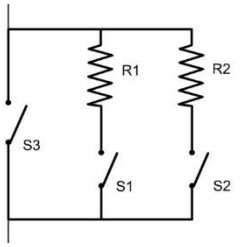

Figure A

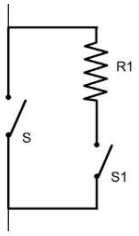

Figure B

When introducing a high resistive path according to V = IR and P = V^2/ R voltage, current transient due to sudden voltage difference can be mitigated. For a short period of time transient energy will be wasted as P= V^2/R.

Based on research publications, a range of switching times were tested to get the optimal values of resistivity for better performance.

III. RESULTS AND DISCUSSION

The pre insertion resistor path was an acceptable solution for the mitigation of transients in the switching process which is already existing. But still, the variation from an infinite resistance value to a particular resistance and then from a high value to null can still create harmful transients. The intermediate step pre insertion was proposed with the idea of smooth engagement of the capacitor bank to the power system.

The MATLAB simulation model of the common area of WTC building Colombo (model used for the solution testing) is mentioned below. Some figures were slightly altered in order to obtain clear wave forms.

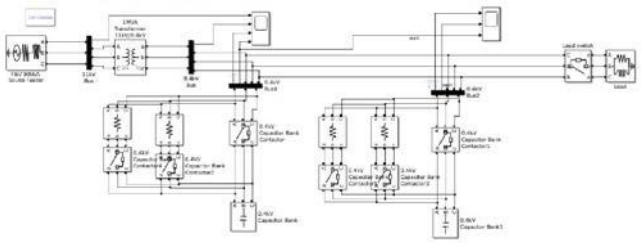

Figure C: MATLAB Simulink model (Ref: WTC common area power system)

Here the capacitor banks energization, back to back switching of capacitor banks were analyzed under conditions of no protective mechanism, with Pre-Insertion resistor protective mechanism and proposed PIRIS protective mechanism. The results obtained from the above scenarios were demonstrated in the below table.

	Capacitor Bank Energization		Capacitor Bank Back to Back switching	
Transient	Current	Voltage	Current	Voltage
Without any protection	497.3 A	671.6 V	1440 A	441 V
With Pre Insertion	385.6 A	337.4 V	434.5 A	360.1 V
With PIRIS mechanism	349.8 A	235 V	367.7 A	358.9 V

Table 1: Results table with and without PIRIS initial stage

Above results demonstrate that 10.23% and 30.34% percentages of current and voltage transients were mitigated when comparing the existing Pre-Insertion resistor mechanism and PIRIS mechanics in the Capacitor Bank Energization scenario. While in the Back to Back switching scenario 18% and 0.33% respectively the current and voltage transients were further mitigated.

Then the optimization of resistive paths was done by testing the range of resistor values (20 - 80 ohms with 5 ohm gaps) in the MATLAB model. From here the optimal resistor value was taken as 40 ohms which mitigated the transient values the most.

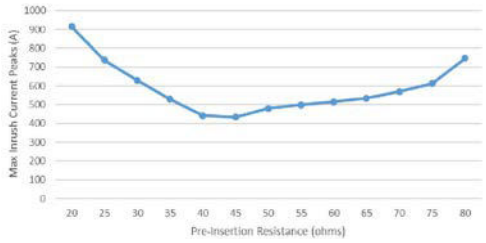

Figure D: Variation of peak inrush current with Pre-insertion resistance

Optimization of switching times of the resistive paths also were done using a range of durations [5] for both Energization and Back to Back capacitor bank switching scenarios. Here, noticeable differences were not analyzed, therefore continued with the 6ms switching period for both resistive paths.

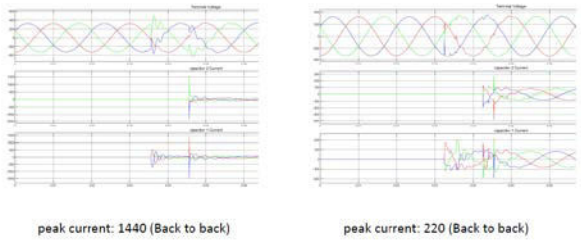

Figure E: Comparison of with and without pre insertion resistance

Finally, a comparison of current waveform graphs, peaks currents of the transients with and without the PIRIS protective mechanism using optimized resistor and resistive paths switching times were demonstrated in figure E.

IV. Conclusion

From the simulations carried out using MATLAB-Simulink and the above evaluations it is clear that a reliability enhancement method was required for a better life expectancy for capacitor banks.

Among the existing protective methods, conventional Pre-Insertion Resistor protective mechanism was simple and effective. Therefore, priority was given for its advancement. In the PIRIS mechanism a new resistive path was introduced to mitigate the capacitor bank switching transients in power systems. When considering the back to back capacitor bank switching scenario current transients were able to suppress up to 18% and in the single capacitor bank energization 10.23% of voltage transients were mitigated compared to the existing Pre-Insertion Resistor method without affecting to the power factor by any means.

With the above demonstrated results it can be concluded that the PIRIS mechanism has a good potential as an Industrial solution. For further studies development of a prototype for this concept and incorporating this mechanism with synchronous switching mechanism can be suggested.

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A Machine to Remove the Seed from Ceylon Olive (Veralu)

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Abstract - Veralu (Ceylon olive) is a fruit commonly found in many areas of Sri Lanka, especially in wet and intermediate zones. Olives and Veralu are fruits of the same category, large quantities of olives are imported to Sri Lanka annually and large portion of Veralu is wasted without consumption. Countries which produce and exports olive, such as Spain, Greece, Portugal, Morocco, earn a lot of income. If veralu can be given such added value, it could create a source of foreign exchange to our country. It has been experimentally proven that in terms of the nutrition and healthy aspects Ceylon olives possess a higher nutritional value compared to olives. Bottled pitted olives (seed removed olives) are readily available in local supermarkets and groceries. If value added pitted Ceylon olives could be introduced to the market, it can easily complete with imported olive products. Removing seeds from Veralu has not been tried out or done previously. Removing the seed without damaging the flesh is a challenging task. To promote the Veralu based industry in Sri Lanka, a suitable automated seed removal mechanism should be developed which was the main aim of this study. A machine was designed and developed. The developed prototype was tested and expected outcome could be achieved. The productivity of the developed machine was 7.2 kg per hour or about 1200 fruits per hour. The total cost of the prototype is LKR 50000.00.

Keywords: Ceylon Olive (Veralu), seed removing, pitted Ceylon Olives

I. INTRODUCTION

This Elaeocarpus serratus also called Ceylon olive or wild olive, is a species indigenous to Sri Lanka. Locally known as Veralu. The Ceylon olive trees are naturally grown in home gardens across the country. Ceylon olives can be seen about twice a year, in March, April, and October.

In Sri Lanka, Ceylon olives are popular as only street food during veralu season. In addition, high-value-added products can be prepared from veralu. Those can be in the form of pitted veralu cans or jars, stuffed veralu, etc. These kinds of value-added products are not currently produced in Sri Lanka. But a large quantity of foreign olives-based products is imported to Sri Lanka. According to the data from Keells supermarket chain, about 20000 bottles of processed olives are sold each year. Pitted and stuffed veralu bottles are good substitute for this, and it is also a very nutritious product. To prepare this product, removing seeds from Ceylon olive is essential. Under this study a machine to remove the seed from Sri Lankan olive was designed and developed and tested for its functionality.

II. MATERIALS AND METHODS

The Product Design and Development approach was adhered to throughout the study. Data was gathered from the literature, conduct experiments, trial and error techniques, studying existing fruit pitting machines and their mechanisms, and by discussing with experts. Analysis part was conducted using gathered data and suitable mechanism was selected. The aspects such as size of the fruit (average diameter between 18 to 21 mm, average length between 25 to 28mm and average diameter of the seed between 8 to 10 mm) condition of the fruit (matured or ripe) and required force to remove the seed from veralu fruits and costs were considered in developing conceptual designs. Then the most appropriate design was selected and developed.

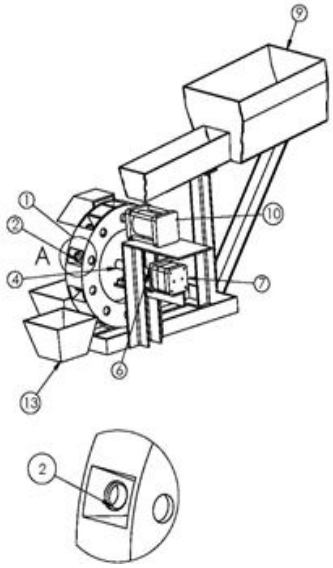
This machine was manufactured and fabricated using locally available materials. The drawing and components of the machine are shown in Figure 1. The machine consists of a hopper, guide path, a pneumatically operated plunger driving mechanism (punching unit), rotary Ceylon olive carrier, and collecting trays. The punching and cutting unit was mounted on the main frame of the machine. It contains a pneumatic actuator, which helps to create pressure and can easily push plunger back and forth. The punching plunger was directly attached with the pneumatic actuator which penetrates the fruit when actuated. After this operation, the plums seeds are dropped directly into the seed collector. Also, the fleshes of Ceylon olives were gone to the flesh collector, which is placed under the rotor. The back-and-forth movements of the plunger depend on the sensor signal and this process occur continuously. The other important part is the rotor and same size pockets are located around the rotor. The size of the pocket is about the size of the Ceylon olive fruit. Function of the rotor is to transport Ceylon olives to the deseeding point. Rotor is driven by stepper motor according to the program. Guide path was used to guide, and gates were used to control the flow. The operational control unit of this machine was fitted with the main frame of the machine. It helps control the sensor and all types of operation using certain programs and electric circuits. Arduino was used to program the machine. Seed removing process steps are,

- Ceylon olive guiding
- Ceylon olive transport to the deseeding point
- Punching
- Separation of fruit flesh and seed

III. RESULTS AND DISCUSSION

The veralu samples to evaluate the performance of the machine were collected from different trees. An electrical weighing balance and venire caliper were used for the weight, length, width, deseeding force measurements. Average force to remove the seeds were assessed as 300N and 65N for matured and ripe fruits respectively. According to the calculations and experimental data, FESTO pneumatic actuator with 32mm bore diameter, displacement of 100 mm and working pressure of 450N was used. Effectiveness of the machine was calculated for both ripe fruits (15 weeks after flowering) and matured fruits (12 weeks after flowering). Effectiveness of the machine for ripe fruits and matured fruits for 63.25% and 86.35% respectively. According to that matured fruits are more suitable. It takes a lot of force to remove the seed from the well matured Ceylon olives and the fruit wastage is low. Ripe fruits required less power and fruit wastage is high.

Actual image of the machine is shown in figure 1



ITEM NO.	PART NUMBER
1	Rotor
2	Cutter
3	Pillow Block Bearing
4	Main Shaft
5	Base
6	stepper bracket nema 17
7	NEMA17
8	flex coupler
9	Hopper
10	Pnumatic Cylinder
11	Pnumatic Shaft
12	Discharger
13	Basin

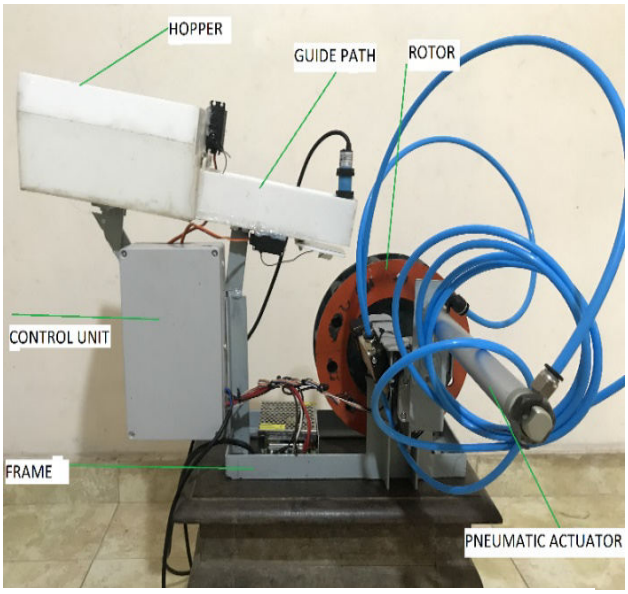


Figure 1: Drawing and actual image of the machine

IV. CONCLUSION

The Ceylon olive seed removing machine was designed, constructed and evaluated for removing the seeds from the Ceylon olive fruits. The effectiveness of the machine and fruit pulp

wastage varied with the condition of fruit that means ripe fruits and unripe fruits. This machine is designed to reduce human efforts and increasing the production. It also limits the human contact with the fruit thus maintaining the hygiene. This machine can be easily operated for similar types of fruits and be actually changed its different type of parts and components very simply. As examples for similar fruits, Olive, cherry, dates, aonla, plums etc. The capacity of the developing machine was around 1200 fruits per hour. In this machine, single actuator was used to remove seeds from Ceylon olives but it can be improved to use number of actuators with advanced feeding mechanism. Capacity of the machine depend on the business scale. Also, it would encourage small to medium traders and entrepreneurs to improve the fruit processing industry in Sri Lanka. Future works may be carried out on effective continuous feeding mechanism to increase the capacity of the machine.

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Design and Fabrication of a Rooftop Mounted Vertical Axis Wind Turbine

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Abstract - Renewable energy projects have gained attention due to the lack of resources for conventional energy generation. It is highly effective for power generation from the participation of the general public in small-scale renewable energy generation for individual household appliances. As an initiation, promoting vertical axis wind turbines (VAWT) for the altitude of rooftops with low cost, simple maintenance, and fewer impacts compared to horizontal axis wind turbines (HAWT). The VAWT is designed with symmetrical blades of NACA (National Advisory Committee for Aeronautics, US) airfoil with concluded chord length, circular angle, twist angle, radius, and height to maintain maximum wind-harnessing efficiency. The turbine shaft is connected to the generator along with the system controller through appropriate control and supply functions of the turbine with battery storage system and an inverter to supply household appliances.

Keywords: Renewable Energy Generation, VAWT, NACA Airfoil

I. INTRODUCTION

Energy is a critical component of both social and economic development. Fossil fuels are the "principal source" of electricity generation in many countries. In Sri Lanka, electricity is mainly produced by imported fossil fuels. Nevertheless, Sri Lanka has a tropical environment with renewable resources [1]. Within the country, wind is a precious source and can be harnessed as electrical energy through turbines. The conventional wind turbine design is the horizontal axis wind turbine (HAWT). These turbines require steering control, yaw control, and rotor control [2].

The unconventional vertical axis wind turbine (VAWT) turbines rotate parallel to the ground and the direction of wind through aerodynamic or drum blades, using lift force or drag force respectively. In particular, VAWTs are the first known wind chargers. VAWTs are most suitable for small-scale generations since they are omnidirectional. As advantages, VAWTs are possible to place together, they are quiet in operation, do not require much wind to generate power, have low noise and vibration to the basement, and are easily installed and maintained [3].

By means of its catching method, there are two major types of VAWT blades, which are the drag type and the lift type. Moreover, drag mechanisms are conceptually simple, but they have some drawbacks compared to the lift mechanism. On the rooftop, the wind is relatively low in speed but frequent in flow. The VAWT is effective in the comparison of wind-harvesting turbines. There are a lot of research studies carried out based on the VAWT model with its different rotor types, catching methods, numbers of blades, and covering methods [4].

Further, the aerodynamic performance is ably studied with CFD (Computational fluid dynamics) simulations considering the flow around airfoils. Typically, low-speed airfoils are used for wind turbine applications. NACA (National Advisory Committee for Aeronautics, US) airfoils are used for simulations. The airfoils are differed by symmetrical/ asymmetrical, maximum camber thickness, and distance from the leading edge. The airfoil, chord length, circular angle, twist angle, radius, and height of the blade affect the power output of the turbine [5].

II. METHODOLOGY

A. Turbine Blade

The NACA0012 airfoil was chosen as the cross-section for the final turbine blade. The other specifications of the blade were, chord length of 15cm, a circular angle of 10°, a twist angle of 5°, a rotor radius of 30cm, and a blade height of 25cm. These decisions were concluded and impacted by the performance and cost analysis of turbine blades. Eventually, blades were fabricated through the 3D printer.

Assembly of the turbine is carried out as per Figure 1: Design of the turbine. The blade angles were maintained as 120° for effective harnessing mannerism.

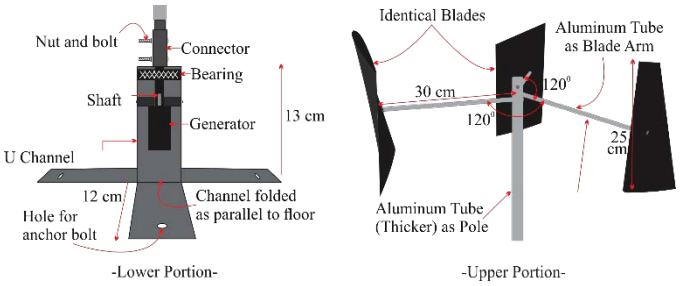

Figure 1: Design of the turbine

B. Generator, Battery and Inverter

The generator is a permanent magnet and 12V DC geared motor with 80 rpm. The battery is sealed lead acid 12V with a 7AH capacity for daily consumption of 20W LED bulbs for 4 hours. In order to convert DC into 220V AC, used a 25W booster inverter module with overload and overheat protection.

C. System Controller

The system controller is used to control and monitor the VAWT system. Within the control circuit, there are sub-systems such as analog sensing for both current and voltage, a charge pump, and three pulse-controlled switches.

The charge pump is a DC-DC converter circuit which is added to harness the slow and frequent wind. It boosts the output voltage by storing energy in a capacitor through a PWM (Pulse Width Modulation) signal. The voltage divider method is used to measure the voltage up to 15V from the calculated resistor ratio. The current is calculated from Ohm's Law Equation using a known resistor. The pulse switching is designed using a combined switching circuit of a transistor and a MOSFET while taking flow current and switching frequency into account.

The system is programmed in endless loops between several functions. The function charge pump was declared with a 120 duty cycle analog output. Three separate sensing with defined calculations within the reading function to determine generated current, generator, and battery voltages. A parameter is sensed a couple of times and averaged before its calculations. The power and energy are calculated from previous read function outputs. And that data is displayed on an LCD display and a serial monitor, with emergency notifications provided by LEDs and buzzers.

III. Results and Discussions

The turbine blade is the primary component used to harness energy from wind power. The lift force mechanism was further developed for the blade by referring to previous studies. As VAWT design, the three-bladed helical rotor setup was used. Furthermore, QBlade was chosen for turbine design, which is a wind design and simulation software. The simulations followed after designing the turbine with appropriate entities of airfoil, chord length, circular angle, and twist angle. Table 1: Constant parameters of the air were defined before simulation are listed.

Table 1: Constant parameters

Parameter	Value	Remarks
Wind Speed	2 m/s^2 – 12 m/s^2	From weather analysis
Rotational Speed	70 – 85 rpm	From specification of generator
Air density	1.16 kg/m^3	From weather data analysis
Viscosity	0.00001511kg/ms	Kinematic Viscosity at 25°C
Mach number	0.01	The ratio of flow velocity; value from minimum wind speed
Reynolds number	20000	Predicted flow pattern of fluid; value from minimum wind speed
Ncrit value	9	Measure of free flow turbulence; value of average wind tunnel

Airfoil is the most important specification of turbine blade. The NACA 4-digit airfoil series were considered for airfoils in both symmetrical and asymmetrical genres, and compared the speed vs. power graphs for selection. From the peak power outcome of the turbine, NACA 0012 airfoil was chosen. The next following entity is chord length, which increases with output power but also influences a negative torque in the 360° rotation of the turbine. Nevertheless, the negative torque is under control through circular and twist angles.

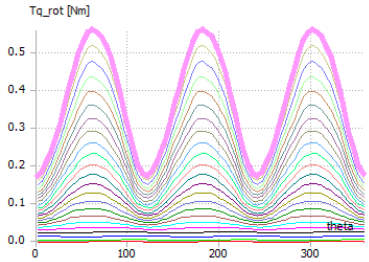

Figure 2: Azimuth angle vs. rotor torque graph

The circular angle acts around the center point of the turbine, and the twist angle adds a twist at the edges, corresponding to the middle of the blade height. Further, change of twist angle acts quite similar to change of circular angle, but the higher increments interfere with the balance of the turbine. Therefore, the combination is more effective in order to maintain the positive torque with stability. For this case, power vs. speed graphs are quite similar among the collections since the cross-section matters most for those variations. But as shown in Figure 2: Azimuth angle vs. rotor torque graph for the final combination on behalf of peak net positive torque.

The increase in turbine height and radius had a direct effect on harnessing wind energy and torque, but this was limited by considering the strength of the turbine pole. Theoretically, for defined specifications and parameters, the acquired peak power output is 5W for 12 m/s wind speed and cutoff wind speed is 1 m/s from the final turbine simulation.

IV. Conclusion and Future Developments

The rooftop-mounted VAWT power generation helps to involve ordinary people in sharing their contribution to green energy. Furthermore, it will be a complete integrated system for consumers with a user-friendly system controller. The project was an initiation of the VAWT system by delivering power to household appliances. For future development, the efficiency of the system can be increased further, by replacing the DC motor with a synchronous motor along a multi-step converter to convert whatever AC input to 12V DC. Therefore, the turbine rotation speed is no longer a limitation for the system.

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Track 3

Machine Learning, Artificial Intelligence and Robotics

Virtual Telepresence Sample Collecting Robot

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Abstract – The continuous growth of the field of automation technology has created may pathways for the general community to make their lives easier in almost every aspect of their lifestyles. Virtual telepresence is one of the key research components in robotic filed, where the users are interested in controlling the robots though a remote location with enhanced security. A virtual telepresence sample collecting robot design is proposed as discussed in this study for the purpose of collecting distinct samples to be analyzed from remote locations. The design is to be implemented in several stages as the navigation system controlled by the joystick and the robotic arms to be controlled by the haptic gloves. For the purpose of introducing a cost-effective product to the market a specific in-built haptic glove controller design is proposed to be implemented. Each section is discussed in comprehensive details where the final design is to be implemented and presented as a future result of the study.

Keywords: virtual telepresence, navigation system, robotic arm, haptic glove

I. INTRODUCTION

In modern world, telepresence could be a considerable necessity as a person cannot be everywhere since the world is rapidly breaking its physical barriers in automation. Thus, a telepresence robot presents an ideal solution since apart from having the telepresence feature, it can be used for a variety of other activities according to the user preference as the robot consists of robotic arms which can be controlled both manually and automatically through a distinct location. The controlling features can be very useful in defences and for scientific research activities along with many more uses as a customised end product.

This project is mainly consisting with a virtual telepresence vehicle [1] and virtual haptic gloves robotic arms. Here the robot is continuously controlled by head movement of the user and since a mobile phone is using as the VR lens, the built-in accelerometer is used to collect the data emerges when the user rotates his head and those data is used to rotate the camera which is built-in the moving robot. Live footages added with live streaming video which are captured by a camera of the robot gives the user real time experience as if he is present at the location. By using the live video streaming, user can virtually tele present in another location. Apart from that robot vehicle consist with a virtual robotic arm, it can be also controlled with virtual haptic gloves. At the end, user will be able to watch the live footages from a remote location and he or she will be able to control the movements of the robot with certain tasks with in their own physical limitations.

Prior to the design and implementation, a comprehensive review on various robots with virtual telepresence abilities and technologies was carried out to select the most cost effective, energy efficient latest technologies which can be adapted to the design.

II. METHADOLOGY

Prior to the design and implementation, a comprehensive review on various robots [2][3] with virtual telepresence abilities and technologies was carried out to select the most cost effective, energy efficient latest technologies which can be adapted to the design.

Processor: As the total project consists of several key technologies together, it is essential to have a processor with higher capacity. Therefore, developers have used Raspberry pi 3 module as their processor with a built in wi-fi module. Apart from that, due to the higher capabilities it has in terms of processing, RPI module is best matching for real time video streaming as well. The microprocessor used in is the Raspberry Pi 3 Model B+. There have been many significant upgrades made in the latest version of the Raspberry Pi board in comparison to the Raspberry Pi 2, which make it more suitable. The SOC in the Raspberry Pi 3 Model B+ is Broadcom BCM2837B0, which is almost 50% faster than the Raspberry Pi 2. The CPU is also faster, at 2.4GHz, in comparison to the 900MHz Quad Cortex A7 in Pi 2. The Graphical Processing Unit is clocked at 400MHz compared to the 250 MHz Video Core IV in Pi 2. Above all, the Raspberry Pi 3 Model B features an on-board Wi-Fi and Bluetooth, which makes it easier to use in IoT applications. All the peripherals required in [] are connected to the Raspberry Pi 3B+ which contains the programs required for controlling the movements of the robot.

Communication: The communication between the virtual reality (VR) headset and the robot is conducted via the wi-fi technology. VR headset need to be capable of displaying the live footages. Therefore, a higher data rate would apply in communication. Apart from that, radio communication is used when communicating with robot for the navigation.

Navigation: The remote connects to the smart phone via Bluetooth technology and is also used to control the bot's movement. By using the navigation buttons on the remote control, the user can control the motion of the bot. Once the user wears the VR headset, he can control the operations on his smartphone using the remote control. A special button is designed in the remote for asking queries and actively participating in classroom activities.

VR lenses: VR lenses or the VR headset is the main tool which is used to navigate the camera where VR head set is required to display a live footage for the purpose of navigation. Therefore, a smartphone compatible with raspberry pi board is used with

the features such as gyroscopes that provide good orientation tracking and accelerometers, cameras, and GPS sensors for position tracking.

Robotic hands: The controlling of the robotic arm is based on fingers and hand gestures. We use the fuzzy logic method to process the input values of several flex sensors, Arduino microcontroller, and hand gestures. The output of the fuzzy logic process is used to decide the robotic arm movement. We use the gyroscope model to determine the slope of the movement of fingers and human hands followed by the movement of a robotic arm. The main construction consists of the component of an Arduino Uno microcontroller, sensors, servo motor, driver, Bluetooth, and power supply. Parts of this robot are composed of shoulders, upper arm, lower arm, wrist, and gripper.

The navigation of the robot is initiated with the use of the VR lens where a mobile phone is used as the screen of the lens. It is compulsory to have a screen for user to observe the surrounding from the point of view of the camera. Camera will transmit the live video footages to the mobile phone where mobile phone's wi-fi module will be able to receive those footages and casted in the screen. There is a camera in the moving robot and it should be rotated and tilted based on the navigation path according to the user requirement. We plan is to rotate the camera according to the VR lens (mobile phone) rotation and tilt to the direction which the VR lens moves vertically. VR lens with mobile phone will act as both an input and output mode of communication. The hardware block diagram of the system model is illustrated in Fig.1.

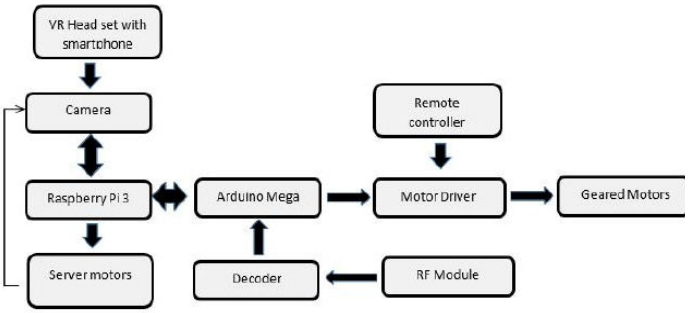

Fig. 1: Hardware block diagram of the proposed system

The basic structure of the moving robot will be built on four wheels and with a camera, two robotic hands and other accessories to measure different measurements. Raspberry pi module is used as the main processor of the robot where the built in Wi-Fi module transmits the live footages. Robot is to be moved by taking the navigational instructions from the received signal. The navigational instructions will be received via a wi-fi module and be processed by the microcontroller itself and navigate the motors through the components. In addition to that, there are different types of sensors to measure the important measurements such as temperature, humidity etc. The readings which are going to collect from those sensors will also be transmitted to the VR lens as well. There will be a lithium-ion battery to supply the power to navigate the robot.

The robotic arms are to be made with a specific controller design. The ability of the flex sensors to be able to measure physical stress and stain lays the foundation of gesture recognition. Parts of this robot are composed of shoulders, upper arm, lower arm, wrist, and gripper. The robot arm will be controlled using fingers and hand movements which are connected via Bluetooth. Several sensors on the fingers and push-button will be used to control the arms which will be processed with fuzzy logic.

Interacting with a computer through a mouse or a joystick can be rather mundane and sometimes (especially in video game play and robotics) it's necessary to encode the movements of our fingers in to electrical signals that a microcontroller can read. Once we can interpret the flexing of our fingers, we can interact with virtual worlds inside a computer or control servo motors to mimic the movements of our fingers. First, we need to be able to read the flexing of our fingers which is by using a flex sensor. Flex sensors are like variable resistors where their resistance changes as they bend and flex. If we can read the resistance of a sensor, we can interpret how much it has been flexed. For that we need to develop the haptic gloves system. As the flex sensors in the market is expensive, we propose to build a home version haptic glove to control the robotic arm using cable ties, core wires, 10k resistors and conductive bag.

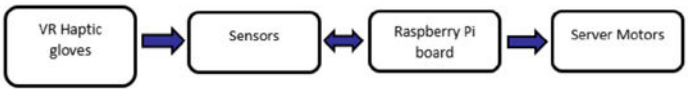

Fig. 2: Navigation of the haptic gloves and robotic arms

III. Results And Discussion

The robot is designed to navigate via a joystick. There will be a camera mounted on the robot and it rotates according to the direction of the moving of the VR lens. The navigation path and a real time footage will be displayed through a mobile phone. By reaching the planned destination, the robotic arm will be controlled with the use of haptic glove and the required samples will be collected. As the design and implementation is in the preliminary stage and with the limited space to illustrate the design, a comprehensive results analysis will be presented in future. By initiation the implementation through the navigation system the movements and the controllers are tested and to be troubleshooted in each stage where the final design is concluded by combining the navigation, robot arm and the haptic glove systems.

IV. Conclusions

A design of a virtual telepresence sample collecting robot is proposed and discussed in this paper included with comprehensive details of the navigation system and the robotic arm to be controlled by the haptic glove. Due to the complexity of implementation, the design is proposed to be implemented in three stages initiated with the navigation system and joystick, robotic arm latter combined with the haptic glove. An optimal

system with a haptic glove design is proposed instead of using flex sensors to minimize the cost of the product. With the implementation of the final product an inbuilt screen for the VR lens and proposing a unique processor design with minimal power consumption will be the future pathways of the study to be extended.

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Multi-Layered Electronic Security System for Vaults

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Abstract - Vaults in the banks are mainly used to store valuable assets; for instance, cash, jewelry and documents, where they provide adequate protection from theft, fire, cataclysmic events, and other possibilities which can cause damages. In considering security systems for vaults, mechanical keys and the vault's exterior play a major role even though they are unable to guarantee an effective protection and the limited number of security layers has made it easy for burglars to break in. Henceforth, we have proposed to develop a multi-layer security system for vaults which mainly focuses on keeping the unauthorized people and/or thieves away from the rightful user's belongings. This paper discusses a system that consists of three independent layers where it includes fingerprint scanning, radio frequency authentication, face recognition through a software application included with a random code generator. The proposed system will be a smart reliable secure solution in compared with existing designs and an initial model will be implemented to validate the outputs.

Keywords: Authentication, face recognition, random code generator, Radio frequency identification, Security System, software application

I. INTRODUCTION

Current security systems consist of various technologies which are built around the vault`s locks and has more of a traditional approach. Basically, it has one or two locks; a combination lock and/or a two key lock which is completely independent from one another. Some locks consist of a digital keypad where the user has to enter the password manually. The system inside varies from vault to vault. As of present, types of vaults/safes used by banks in Sri Lanka are BS 108, BS-125, executive safe with digital lock, defender, deluxe safe etc. Apart from the lock, one of the techniques used in vaults is the tool and torch resistances which are also known as burglar resistance where the protection from a torch and tool attacks are secured [1]. Some vaults are made to be fire resistant for about 1-2hours, in which the vault's safety is guaranteed in the event of fire or even water, anti-hold up resistance alarms when the safe is being removed from its original location. Fort Knox in United States [2] has an outstanding security system which includes a granite wall perimeter, squadrons of machine-gun wielding guards, armed military and a 22-ton vault door and it requires minimum of 10 people just to open the vault. In the New York federal reserve vault [3], pallets are moved around by robots.

The bank of England gold vault [4] is quite popular for having bombproof walls, a voice recognizing system which has 3-foot keys and other unknown security techniques. In 1914, The Dominion Bank Vault was renowned as the most secure bank vault in the world for its construction and the 40-ton vault door. These vaults are considered as safe, reliable and hard to break- in but one of the main drawbacks of these are that they focus on the exterior mainly. In most situations, anyone who has the key/keys will be able to open the vault even though the vault does not belong to them. It is hard to keep track of the vault's key/keys and even if the vault has a digital keypad, one must ought to remember the passcode. By any chance if you misplaced the key/keys or forgot the passcode, you won't be able to open your vault, at least not in that exact moment. Thus, key-based systems can have multiple safety concerns.

In general, people have limited access to bank vaults considering the fact that they are allowed to enter their bank's vault only when the bank is open, proving why the private safes/ vaults are getting more popular. Apart from the traditional approach and giving priority to the exterior, various systems have been proposed which does not require a lot of manpower and will be secured by a 3G Wi-Fi dongle, cameras and bio-metrics. Some are proposed to consist of several types of sensors including, gas, ultrasonic, laser, motion sensing etc. Even though it is admirable that people tend to seek for more modernized, software-based systems which focuses on authentication more, there are still areas to pay attention to and secure. Henceforth, as a smart solution we propose a four-layered, safer, more modernized and smart security system which can protect the vault from unauthorized people and/or theft. This system is a combination of a biometric system and an access control system where we expect to create a software platform with a random code generator to create specific codes for the authorized person as an input password to the system. The random codes will be validated twice through the software before entering to the system with a unique changing sequence.

II. MATERIALS AND METHODS

A. *Hardware subsystem:*

Fingerprint scanner: A fingerprint scanner is used as the first authentication layer for the bank vault system which consists of a universal asynchronous receiver-transmitter (UART) interface, hence it has to be interfaced with Raspberry Pi through a universal serial bus (USB) to serial converter module.

Radio Frequency Identification (RFID) system: An RFID tag is used as an authentication tool in which the system checks whether it is authenticated or not when the user places the RFID tag on the reader module.

Image capture system: A Pi Camera is used in the proposed vault system to capture an image of an intruder who tries to

access the vault. The captured image will be sent to a designated user as an email attachment.

Human machine interface: A liquid-crystal display (LCD) display is used to display instructions on entering the one time password (OTP) codes required to open the bank vault whilst an alphanumeric keypad was selected to enter the OTP codes required to open a bank vault.
Alarm system: An alarm is raised when the system detects unauthorized attempt to access the vault.

B. *Software subsystem:*
Random code generation algorithms: Two randomly generated OTP codes are created in two instances to open the bank vault, where the second codes map with a unique sequence.
Image capture and emailing: A photo of an unauthorized person is captured by a pi camera module is emailed to an authorized person using Wi-Fi.

Android application: This Android app is used to determine if the entered randomly generated code matches with the code that has been sent to the user's mobile. It also creates another randomly generated code by mapping the first code into an algorithm. This application will not be available to download from the play store; the user can install the application after making a request from the creator.

The flow chart of the proposed design is illustrated in Fig. 1. Prior to the vault security system, an RFID based identity card authentication is carried out to reach the vault by the user. Once the access to the system is provided, first a fingerprint scanner module and face recognition system are used parallelly to check if the person is authorized. This scanner module and the detection system are connected to the front surface of the vault. After the authentication, the user will have to enter the first pin code which will be generated randomly by the vault's system computer, which is sent to the user's mobile phone through a cloud data base. Internet connection to the vault's computer is established through a 3G modem/dongle. The user has to view the received OTP from their phone and enter this code into a software application which will be available for the authorized users only. Once the OTP is verified by the application, it moves to the third layer of security.

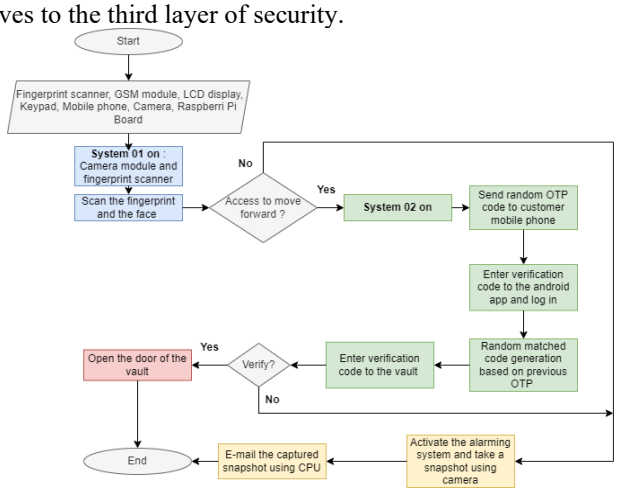

Fig. 1 Flow chart of the proposed design

The application will display another randomly generated code which is created by mapping the first generated code to another algorithm (Ex: 6789) in the app. So, the person will have to enter this code (6789) as the second pin code when it is requested by the vault. The verification will be done through a centralized cloud server, where the data is updated sequentially based on the user id and the application random code generation. After successfully completing all the above processes, the vault will be unlocked. In each step, if an unauthorized person attempts to open the vault and fails to verify themselves, a camera is installed on the vault to capture a photo of the suspect and send it as an email to an assigned authority. Simultaneously an alarm will also be raised. Here, a battery backup will be kept alongside rather than the power supply because it will increase the safety during a power failure or any other breakdown situation. For this purpose, a battery with a charging unit will be used.

III. Results And Discussion

In the Android app, the registration page in order to create an account, the login page which allows the user to login using a username and a strong password and a page to enter the first random generated OTP have been created thus far. The procedure to save this entered OTP in the Google Firebase has also been completed. Generating the OTP and sending it to the user's mobile phone through short message service (SMS) gateway and creating the image recognition algorithm will also be focused on. This process will let the user to verify themselves through the OTP and their facial features. In the fingerprint layer, the user will have to place their finger to get verified where an alarm system will go off in the event where an unauthorized person tries to break in to the vault. If the person who tries to open the vault is the rightful owner of the vault, they will be able to go to the vault once they verify themselves successfully in all these layers.

The proposed system has few limitations such as if the system is designed to be powered by an AC to DC adapter with no battery backup, a standalone power supply unit is mandatory since the system can become vulnerable to unauthorized access during a power failure. Even a legitimate user with proper access, will be barred from access to the vault contents during a power failure. Designing an adequate battery backup is a process that consumes some additional time and resources, which is proposed as a future development.

IV. CONCLUSION

This paper discusses on an authentication-based electronic security system which has the ability to provide protection to one's possessions while reducing break-ins where the vault's safety is ensured by creating a burglar deterrent environment. The system also provides protection to the user as well, since they will be prevented from confronting a burglar. This concept will be implemented further by granting access through voice recognition and in the event of power failure. Adequately encrypted data transferring and introducing a proper cooling mechanism are to be included in the future development while

creating future paths to raise awareness on upcoming and developing security-related technology features.

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Smart Gate Locking System with Dual Authentication

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Abstract – A smart solution for manual gate operation has been introduced in this study with automated gate operating system with dual authentication. The proposed system eliminates traditional gate locking mechanisms and introduce face recognition with the ability for an authorized person from anywhere to grant the access for the visitors though a secure communication channel, e mail by proving a password. As additional features, path finding lighting array and an alarm operation is introduced to the system to operate simultaneously with the gate lock provided with the access to the visitor. A training model has been implemented and tested with the proposed mechanisms where it is proved that the design can be introduced to the available market as a cost effective, user friendly and easy to install product.

Keywords: dual-authentication, automated smart lock, face recognition

I.INTRODUCTION

Recently, smart security systems [1] have been recognized as one of the vital concerns in modern domestic life styles. As an upcoming concept, technology based on biometric artificial intelligence is adopted for user authentication in security systems with the purpose of upgrading the smart security to a next level. With prevailing designs mostly, the users are to be provided their details manually though a password, radio frequency indentation (RFID), quick response (QR) code etc. for authentication where it is a burden for the user to memorize or keep the necessary information with them all the time through their busy schedules. Therefore, a smart solution has to be provided where user access is to be granted for a selected pool of people without compromising the security [2]. In this study we propose cost-effective, user-friendly dual-authentication system through face recognition [3, 4, 5] and with a secure communication channel, e-mail. The system is designed with a database with known set of images, while a histogram of an oriented gradient has been utilized to recognize the faces. When the camera module identifies the visitor as a known user and access is granted, an e-mail will be sent to the user with that live captured image to inform them of that access. To provide access to the unknown visitors, the system requires permission from the respective authority by simply accepting the received image. Furthermore, a path finding lighting array has been implemented focusing on disabled and elderly community to find the path to the door from the gate when automatic access is provided and as soon as the system identifies a visitor a door bell will ring at the end of the process.

II.METHODOLOGY

The design is consisting of three main sections such as, creation of the database, face recognition and providing remote access to the visitor as shown in Fig. 1. The initial phase is collecting precise images to create a dataset for the facility with known visitors with proper structuring to get obtain a quick output and reduce the latency, as the system stats to learn from the provided data set. When the live stream is captured though the camera, it uses face detection algorithm which is provided by OpenCV and uses the "Haar" cascade classifier along with it. Next the classifier will convert the caputured data to grayscale frame since the system is requires a grayscale image for further processing. When the images run through the detection algorithm there are two main scale factors to be assigned based on two functions as ‘detectmultiscale’ and ‘minneighbors. These factors will recognize a minimum distance to be set in between the user and the camera and the minimum number of neighbors to be retained in each identified rectangle. Then the facial features will be extracted such that detecting 128-d face vectors from the frames and a separate library known as ‘face_recognition’ will be used for the comparison of features with the trained images. If the recognition is successful a red color rectangle is drawn around the face with the name of the person and if not, it will indicate as a message as unknown person.

When the owner gets the e-mail with the image from the Raspberry Pi, it provides the owner with the option of granting or denying access to the visitor. This can be done by simply replying to the receiving e-mail, including the password assigned to the gate lock. Once the mail is sent, the Raspberry Pi opens the receiving e-mail and seeks whether the required password is included among the text in the e-mail. If it is present, then a controlling signal will be sent to the relay module to connect the power supply to operate the solenoid lock. If the password is not in the text, then it simply denies giving access to that visitor. Once the access is granted and the gate is unlocked, then the system would detect the lighting condition of the environment using an LDR. Based on the LDR output the lighting array will be operated and simultaneously when the door is unlocked a door bell will be operated.

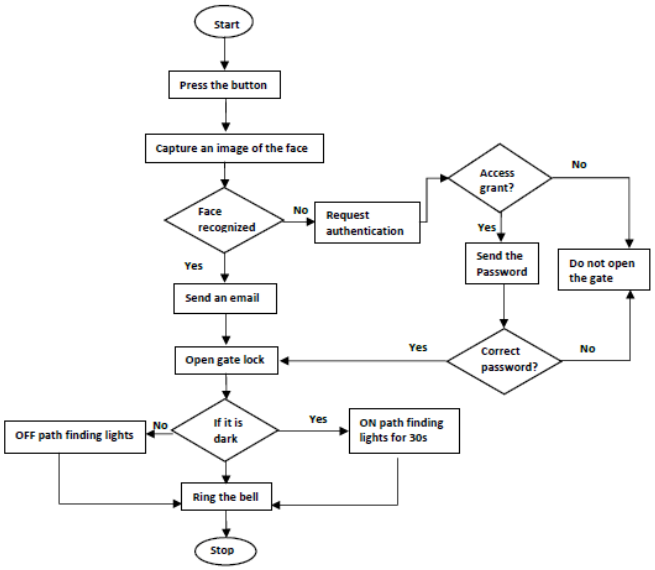

Fig. 1 Block diagram of the system

III. RESULS AND DISCUSSION

For the purpose of demonstration, a training model was implemented for the proposed design as shown in Fig. 2. In the model, the lock is located on the gate but it can be shifted to one of the gate towers. A separate tower has been used to locate the web camera since, it is difficult to capture a live image by correctly including the face of the visitor through this model. The scale factors for the functions 'detectmultiscale' and 'minneighbors. Were set aa, 1:3 and 5 respectively after numerous testings were conducted for maximum accuracy.

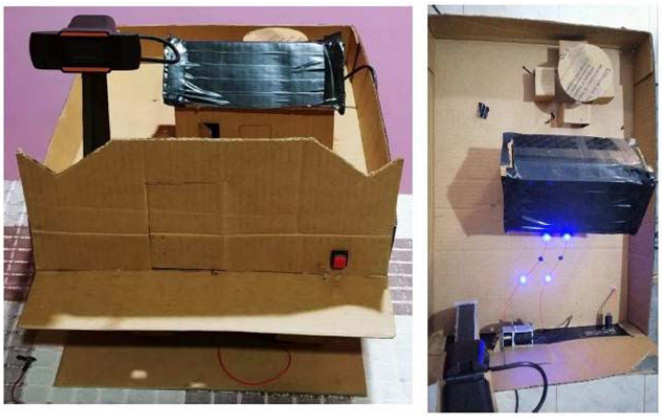

Fig. 2 Training model and operation of the lighting array

When the system has been trained with new users the face recognition detects the faces in a live video stream, where the face will be labelled as in Fig. 3 according to the state of the recognition. If the detected face is a frame which is already in the system the system will conduct the recognition with the name of user, else the system will output the detection as unknown.

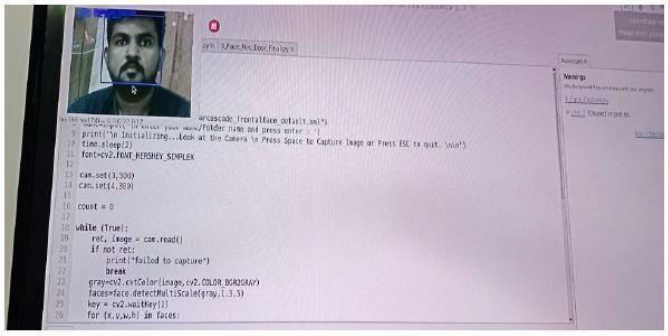

Fig. 3 Labelling the face recognition

The primary results of the system can be identified as, a gate locking system operates automatically for the known users or it will operate when an authorized person sends the gate lock password. Based on the lighting condition, a path finding lighting array will be operated simultaneously with a doorbell.

IV.CONCLUSION

A smart gate with dual-authentication has been designed and implanted in this project by including face recognition and e-mail authentication with the authorized person. The system has implemented as a simple design, user friendly, light weight, easy to install, small in size and most importantly cost effective in compared to the other existing solutions in the market. The design parameters can be customized based on the user requirement and if needed additional features such as speech reignition can be included in the system without compromising the initial design. Moreover, the system is with low power consumption tools where even an emergency battery bank also be used to power up if required. The design can be further developed to create an intruder alert mechanism such that if an unknown person visits the premises repeatedly the data is stored and shared with the respective authorities or to search with black listed criminals

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Automatic Railway Level Crossing Controller with Train Tracking and Mapping System in Sri Lanka

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Abstract - The purpose of this project is to create an automatic railway gate at a level crossing to replace the gates operated by the gatekeeper by detecting a train that has entered the level crossing, providing a corresponding warning signal, and controlling the gate after confirming that there are no vehicles between the barriers. The solution is provided by constructing a train detection module that uses global positioning system, a vehicle detection technique that uses a sensor grid, a signal lighting system, a siren, and a railway gate controller. The inbuilt global positioning system module identifies the train location with the highest accuracy. Experimental results demonstrate that the proposed technique produces a more cost-effective, reliable, and simple railway gate controller and it increases security in the risk zone than prevailing conventional systems. The data received at the centralized location enables the authorities to make effective and accurate decisions.

Keywords: Global positioning system, Level crossing, Gate controller, Train detection, Vehicle detection

I. INTRODUCTION

Recently, in current railway systems, it is becoming more necessary to have safety elements in order to avoid accidents. The number of collisions connected railway accidents shows a rapid increment world-wide year by year. The traffic related deaths and injuries due to lack of security measure in railway level crossings are currently seeking the attention of general community as an identified problem in Sri Lanka. Train accidents happen for a variety of causes, the majority of which occur at crossings due to human errors. The main focus of this project is to propose efficient methods to avoid railway accidents and prevent loss of human lives due to accidents as a composite unit of elements [1]. In addition, employing such automated system could save human labour as well as provide more efficient service to the community in with proper calibration of parameters. The proposed mapping system is able to identify the exact location of the train and can detect any prior errors to be happen at railway gates with the centralized data sharing mechanism though the server.

A. Train Tracking and Mapping System

In Sri Lanka, track circuits are being used in the current railway system to obtain the locations of the trains [2]. The railway line is divided into several track circuits. As shown in the Fig. 1, the track circuit is with a 6V operating voltage and a relay. When a train enters the track circuit, it is short circuit through the train's wheels and the current is reduced through the relay by detecting the train location based on the track circuit map. Once a detection occurs in the track circuit, the map at central traffic control (CTC) center, shows it as a red line. When a train moves from one track circuit to another track, a red line shift from the previous track circuit to the next. These movements can be observed from computerized screens situated CTC center at Maradana, Sri Lanka. This allows to get the track circuit which train is located at the moment, but it is difficult to get the exact location of the train. One of the other drawbacks of this method is that when there is a fault in the railway track, it is indicated by a red line, similar to that indicating the location of the train, which compromise the object identification and could lead to accidents.

B. Existing Gate Controlling Systems

In Sri Lanka, both manual and semi-automated type gates are operated. In manual gates, after the train leaves from the particular station, the gateman at the nearest level crossing is notified by phone based on the path of the train and the responsible person operates the gate. In semi-automated gates, train arrival is detected by a track circuit that is situated 800m before the level crossing and simultaneously a siren starts to ring near the level crossing. After 12 seconds have passed from the object detection through the track circuit, the gates start to close automatically. When they are completely closed, the gateman gives the train driver a green signal by a push button to move forward. And after detecting train departure by the track circuit which is situated 800m after the level crossing, the closed barriers are opened automatically. In Sri Lanka, the gate control system has not been fully automated due to the random behaviour of vehicle drivers, since they try to enter their vehicles into the level crossings even when there are signs which indicates a train arrival. In such cases, there is a risk of barriers being closed even with a vehicle is stuck in between them. Aforementioned situation can result not only property damage but also risk lives of humans.

II. MATERIALS AND METHODS

A. Proposed Train Tracking and Mapping System

The fundamental process in our proposed system is obtaining train's location using global positioning system (GPS) technology and transmitting the data via global system for mobile (GSM) [3, 4] network through the server and it allows to visualize, analyse and store live stream data. That data is sent to the map at centralized location and it is able to data processing and information analysis while taking appropriate decisions based on the received information. Then the control panel could observe the movement of all trains by a map on a single screen. The train traffic data store in server. Therefore, it is able to reclaimed that data if required.

There is a LED near the level crossing on map and when a train goes through a level crossing, the LED turns to green colour while indicating the barriers at the level crossing are closed and the train is moving through level crossing. After the train leaves the level crossing, the LED at map turns the green light to red by showing the barriers are open and vehicle drivers can cross the level crossing. And also, this mapping system can identify the errors that could happen at railway gates and it is easy to find the location of the train that has stopped due to a technical fault at a location other than a railway station.

B. Proposed Automated Level Crossing Controller

The proposed system is using GPS technology to identify locations of trains. Therefore, GPS must be ON when a train starts its journey.

Four ultrasonic sensors are using to avoid vehicles are getting stuck between barriers. The ultrasonic sensor 1 is placed on the base of the barrier which is parallel to the railway line. It will be scanning vehicles within the barrier closing area and it may avoid the barriers falling on to the vehicles when closing.

Ultrasonic sensor 2 is placed on the barrier, perpendicular to the railway line, and it scans whether there is any vehicle between the barriers on the railway.

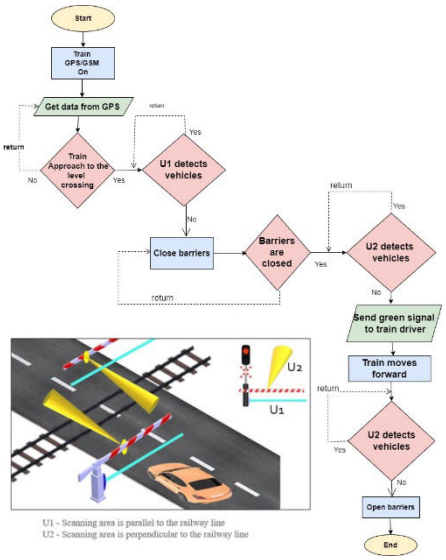

Fig. 1- Flow Chart

As shown in the Fig. 1, when the train approaches to the level crossing it indicates from a siren to the vehicle drivers and it checks the ultrasonic sensor 1 (U1) outputs which are placed parallel to the railway line. If the sensor output does not detect any objects, it is free from vehicles and the gates will be closed. After, receiving confirmation that gates are closed, the system checks Ultrasonic sensor 2 (U2) outputs which is placed perpendicular to the railway line. If it is not detecting any vehicle on railway line, the system sends a green signal to the train driver to move forward safely. Otherwise train driver has to stop the train before reaching the level crossing.

In comparison to existing system, the proposed system is efficient and more secure. The proposed system is to be built with ATmega 328p Ic, Ublox Neo 6M GPS module, mini SIM 800L GSM module, four ultrasonic sensors and two servo motors FG90. The captured data is sent to the server and store there. That data is sent to the map at centralized location through server. While train stops in between the level crossing, U2 detect it as an obstacle. As soon as the train leaves the level crossing, U2 sends output to gate controller and the. barriers will open.

III. RESULTS AND DISCUSSION

Based on the proposed system outputs the staff of CTC centre will be cable to clearly identify the location of the train with the GPS tracking system and the indications on the central map. They will be able to distinguish the train location from damaged tracks, which is one of the main drawbacks on the prevailing system. If there is any technical fault on the train, the map will indicate the exact location and the staff will be able to identify the errors and attend to them immediately with as an efficient service provider. Furthermore, the simple ultrasonic sensor placement provides a cost-effective design to minimise the rate of accidents on general community. Automated level crossing will increase the safety at the risk zone while reducing the possibility of a vehicle getting stuck between barriers. At present the initial phase of the GPS tracking system has been implemented on the system while the testing has to be carried out with real time data with the help of CTC. The testing with sensor unit will be carried separately with level crossings and the experimental results from GPS tracking will be integrated to test the system as a whole unit. The complete design will be introduced to the Sri Lankan railway system at the end of the study.

IV. CONCLUSION

The purpose of the project was to go beyond the standard mapping system by association with GPS technology, which can be directly connected to the trains to gain the real time location. The railway gate controlling system determines to commence the operation if no vehicle is detected between them with the simple yet efficient sensor arrangement design proposed, while mitigating the rate of accidents at railway level crossings. In future, as a solution for the unplanned power failures, the units can be arranged to power up with solar energy and it could be developed for the general public where they could access the information on current location of the train.

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Multi-Layered Quick Response Code

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Abstract – The quick response code has become more and more prevalent among us, due to their low deployment cost by appearing in leaflets, posters, magazines and other print materials which usually consist with visible black and white modules. The quick response code can be printed in a small space, allowing users to interact with the environment using their smartphone and store more information and data. The problem with the existing model of the code is; lack of security and data capacity. In this paper we provide a solution for the ‘’data capacity” in quick response codes by enhancing the data storage capacity by using a “weight assigned” algorithm with a multi layered approach. The encoding and decoding process of a layered quick response code is elaborated in detail where it is proved that the proposed algorithm can be extended for ‘n’ number of layers, while minimizing the marginal error and increasing the number of layers.

Keywords: quick response (QR) code, multi layer, weighted network, data capacity

I. INTRODUCTION

A quick response (QR) code is a two-dimensional (2D) barcode that can be grouped as a matrix with a high number of elements to store data, information based on its allocation capacity. The QR code is well-known for its prominent use in shipment tracking, item labelling, contact information, and ticketing as a user-friendly password mechanism for each environment, since it is served as a creator, allowing information to be decoded quickly. In general, a QR code is made up of two colors, black and white, in a square shape, where the black square represents 1 and the white square represents 0. Both colors black and white in the QR code are allowed to be engaged in the encoding and decoding process to acquire maximum capacity for each character [1, 2].

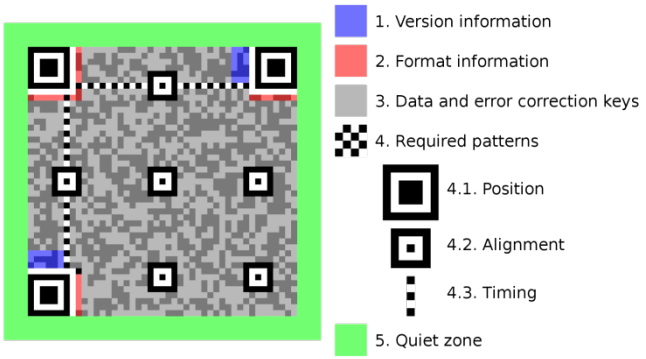

Fig. 1 Structure of the QR code.

The Fig. 1 shows the basic structure of a QR code. The lowest version of the code is version 1, which has 21 x 21 matrices, while the largest prevailing version is version 40, which has 177 × 177 matrices. The percentage of the error correction level and mask pattern are stored in this matrix by formatting the information. When the QR code is decoded, this pattern will be read first. Next to the separators section, the illustrated design above is consisting of 15 bits for formatting. For the purpose to be used as errors and data correction keys, the particular data is transformed to bits and stored in an 8-bit format. Each design as shown in Fig. 1 is a three-by-three matrix where black, white, and black again surround this matrix. The design joins three-position motifs together, which keep track of the density and definition of different QR Code variants. To recognize the finder pattern, a QR code requires a quiet zone that is equal to four module thickness and is bordered by white. The purpose of this pattern is to increase code recognition by decoder software when used in timing patterns. Except for version 1, all codes have the same pattern as the alignment.

In this study we focus on data capacity enhancement of the QR code by proposing a novel simple, user friendly encoding and decoding algorithm for a multi layered data storage pattern. The proposed algorithm will be discussed in detail by providing adequate information for a basic implementation of 8-layered QR code with lower data processing complexity.

II. METHODOLOGY

I. Encoding

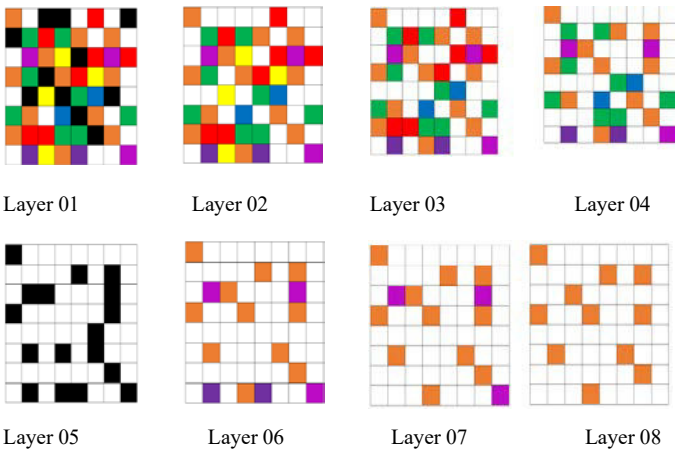

Fig. 2 Black and White QR codes that needs to be combined.

As mentioned in section I, the basic black and white QR codes are assigned with the numbers 1 and 0 respectively for data representation. In here, we propose to add 8 separate QR black and white codes which are represented as 8 layers, where with summation of each cell the maximum number of the data cell will be represented 8 and the minimum number will be

represented as 0. With such combination, it is difficult to decode back the multi layered version of the code to original QR code representations named as layer 1,2, 3, up to level 8 (Fig. 2). Therefore, as the next step of the encoding process we propose to multiply each layer of QR code with "$2^n - 1$", where 'n' represents the number of the layers in each code. Thus, instead of 1/0's these new QR codes are consisting of 1/0, 3/0, 7/0 which can be represented up to $(2^n - 1)/0$'s. By combining each level sequentially, we obtain 2^n amount of unique combinations where each number can be assigned with a unique color to represent each data cell. The final output QR code will be constructed by assigning colors according to the number of layers that used to construct the output QR code.

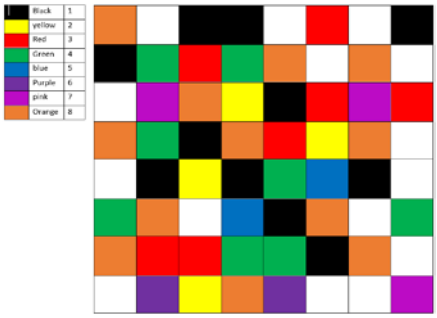

Fig. 3 Output QR code after combining all 8 layers of Black and White QR codes

For an example consider a scenario where number of layers that needs to be combined as 4. (layer 1+layer 2+layer 3+layer 4). Therefore, number of maximum unique numbers we can get from adding these 4 layers is 16. Instead of assigning one particular color to one combination, in here we assign color range to each unique combination. As we are required to print a color in practical implementation, we use exact middle hex code in particular color range as the color. Moreover, as an extra data we wish to include the number of layers which we have used to be printed in the QR code.

II. Decoding

As our input code in the decoding process, we obtain a QR code with multiple colors. When we scan it, first we need to identify the number of layers which were used to construct the composite code with the assigned color for each unique number. Next, we can identify the color ranges used in this particular QR code and begin the decoding process.
As an example, let us consider 2x2 multi-layered QR code with 4 layers as shown in Fig.4.

7	1
16	10

Fig. 4 2x2 Multi-Layered QR code

The unique way to construct these numbers with proposed algorithm are as follows.

Yellow = 7 7 (Layer 3)
green = 1 1 (Layer 1)
pink = 16 1 (Layer 1) + 15 (Layer 4)
blue = 10 3 (Layer 2) + 7 (Layer 3)

Thus, the decoded original layers of QR codes are as follows,

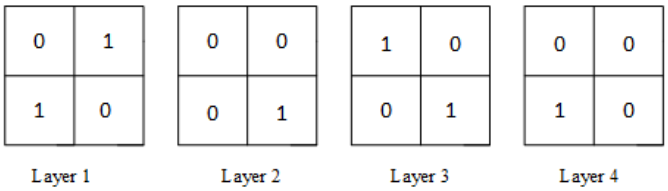

Fig. 5 decoded layers of multi-layered QR code

III. RESULTS AND DISCUSSION

As the proposed multi-layered QR code is scanned from a camera, depending on the device and its` accuracy, hex color code which the camera could identify can be varied. Therefore, to minimize the error we propose to use a middle hex code of our color range, where camera can identify any color within that particular color range. Table 1 illustrates from which factor these color values can be varied. All the values in the table are decimal values, according to the Hex color range values. Hex color range varies from #000000-#FFFFFF while its respective decimal range varies from 000000-16777215.

Table 1: Margin for error with respect to number of layers use in the input.

Number of layers	2	3	4	5	n
Color can be varies from this factor (decimal)	±4,194,303	±2,097,151.875	±1,048,575.937	…	$\pm\frac{16777215}{2^n}$
Color can be varies from this factor (Hex)	#3FFFFF	#1FFFFF	#FFFFF	…	
Number of Colors	4	8	16	…	2^n

From aforementioned data in table 1, it is observed that when the number of layers are increased, the margin for error is decreased accordingly.

IV. CONCLUSION

QR code is one of the prominent ways to convey valuable data and information along with user authentication for modern security systems. In this study a novel algorithm is proposed to enhance the data capacity of QR codes by adopting multiple layers within a single code representation. The proposed algorithm enhances the data capacity one to one with the increased number of layers and it is shown that with the increment of layers the marginal error is also decreased, thus increasing the accuracy of the proposed algorithm. A version 40 QR code with 15 layers can hold up to 45kb of data with a marginal error of ±512. The design can be easily implemented and in compared to the prevailing QR codes, by using this encoding and decoding process the user capacity for a single QR can also be easily increased by reducing the latency of processing for multiple QR codes assigned to each user.

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Comparison of Different Pre-Trained Neural Networks for Gesture Recognition

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Abstract - Gesture recognition is a complex task for computers. However, researchers have developed neural networks and techniques that can be used to recognize gestures with high accuracy. In this study, two models were built, using ResNet 3D-18 and ResNet MC-18 and applying transfer learning with a subset of the 20BN Jester dataset to recognize human gestures. Consequently, higher accuracy for gesture recognition was achieved using the smaller dataset and fewer resources. Finally, the generated results are compared with the published approaches.

Keywords: Deep Learning, 3D CNN, Transfer Learning, HDF5, ResNet 3D-18, ResNet MC-18, 20BN Jester dataset

I. INTRODUCTION

Deep learning is a subset of machine learning, and its functionality is similar to the human brain. To achieve this, it contains heavy mathematical tasks which consume more resources. Further, it needs a large dataset to achieve higher accuracy. Though parallel processing can reduce computation time, training deep learning networks with large datasets and deeper neural networks may take enormous time. However, to reduce the training time, the transfer learning (TL) approach has been used [1]. It reuses already trained networks for similar tasks. Transfer learning is used in computer vision and natural language processing applications as they require big datasets for training and consume a lot of resources and time. Human Gesture recognition is a computer vision, time series task. According to [1], TL can be efficiently used for time series classifications. In this paper, we tested two neural network models using TL with a subset of a larger dataset and compared them with already published neural networks.

II. METHOD

There are widely available neural networks such as AlexNet, VGGNet, ResNet, Inception, and GoogLeNet. Out of those, ResNet 3D-18 and ResNet MC-18 have been selected and trained, using TL. For the training, the 20BN Jester dataset is chosen [2] as some of the neural networks have been already tested with it. However, only a subset of the dataset was used for our approach. Finally, the generated models have been compared with the neural networks, Inception [3] and ResNet-101 [4], which used the whole dataset.

A. Selection of the Dataset

The 20BN Jester dataset contains 148,092 short videos of basic human hand gestures of 27 classes. As for the classes, this dataset has hand gestures such as zooming out with two fingers, swiping left, shaking a hand, and so forth. The training set contains 118,562 samples. Validation and test datasets contain 14,787 and 14,743 video samples, respectively.

We used a subset of the 20BN Jester dataset, which is already available on the Kaggle platform [3]. This dataset was created by extracting the videos that have 37 frames. It has 50,420 video samples in the training set and 7047 in the validation set. It also has the same 27 classes as the original. However, the size of this dataset is about 42% of the original one.

B. Preparation of the Dataset

Initially, it was attempted to train the neural network with the dataset given in [5] and observed that it took a considerable time for training. Further, the GPU utilization was low and did not exceed 24%. After some research, it was found that reading JPG frames and decoding them took a significant time. On account of that, GPUs had to remain inactive until frames were decoded. To decrease the decoding time of the frames, we created the HDF5 [6] (Hierarchical Data Format 5) dataset. Accordingly, JPG frames were stored as uncompressed bytes in the HDF5 dataset. Moreover, we removed the first and last five frames from every video sample as most of them do not contain gestures. Consequently, every video sample has only 27 frames in the modified HDF5 dataset.

C. Selection of the Neural Networks

For the neural network, the pre-trained 3D networks were selected. 3D CNN (Convolutional Neural Network) is a three-dimensional approach to CNN. Widely used 2D CNN uses 2D input and 2D filters. Because of that 2D input matrix is multiplied with a 2D filter to do 2D convolution. But in 3D CNN, it used multiple pairs of 2D CNN to compute 3D CNN.

We used two pre-trained neural networks for our purpose.

1. ResNet 3D-18 [7]
2. ResNet MC-18 [7] (ResNet Mixed Convolutional-18)

These two networks were chosen for several reasons: they were trained for human action recognition and built focusing 3D CNN. Accordingly, it avoids using any recurrent networks to identify the dynamic actions. Also, these networks are simple in comparison to other networks. Therefore, it may reduce the network training time.

Also, we developed our model for future analysis. It is a network which is an extension of ResNet 3D-18. We removed the last fully connected layer and added three new fully connected layers to it. They had 256, 128 and 27 neurons in each layer, respectively. The above mentioned network is referred to as xResNet 3D-18 (Figure 1).

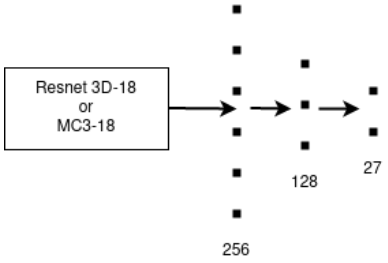

Figure 1. xResNet 3D-18

D. Training the Network

The models were experimented by adjusting the number of layers which being trained from the end. However, the same hyperparameters (Table 1) were used without changing them. Further, we used a random rotation of a maximum of 30° to add data augmentation.

No.	Parameter	Value
1	Learn Rate	1e-03
2	Optimizer	AdamW
3	Batch Size	50
4	Loss Function	Cross Entropy
5	Number of frames	27
6	Frame Size	150 * 150
7	Random Rotation	30° (max)

Table 1. Hyperparameters used

III. RESULTS

The last 11 convolutional layers and the output linear layer of the ResNet 3D-18 were trained for ten epochs. The results are given in Table 2. It achieved a training accuracy of 97.19%. Its top-1 validation accuracy is 92.91% and top-5 validation accuracy is 99.55%. After that, we tried the ResNet MC3-18 network. We trained the MC3-18 similarly but for nine epochs and got 95.41% training accuracy and 92.04% top-1 validation accuracy. Its top-5 validation accuracy is 99.43%. We used the same approach for training xResNet with different numbers of layers.

As shown in Table 2, ResNet 3D-18 and ResNet MC-18 performed better than the xResNet 3D-18. Therefore, we did not use the xResNet 3D-18 for further work. Finally, we compared our models with already published neural networks. The comparison is shown in Table 3.

IV. LIMITATIONS AND FUTURE WORK

We used the Kaggle platform for training the models. The major limitation we faced was the lack of a GPU cluster. Training video datasets with 3D CNN consumes a lot of time and resources. Therefore, we did not have enough resources to train the whole network (without transfer learning) with the 20BN Jester dataset. As for future work, we have planned to experiment with the full dataset (with 118,562 selections) and compare it with the half dataset (with 50,420 samples).

V. CONCLUSIONS

In conclusion, two models were built, using TL for pre-trained neural networks with a smaller 20BN Jester dataset. Those models were compared with the already published work that used the complete dataset. Accordingly, the results demonstrate that the proposed model performs with higher accuracy (92.91%) though the published work performs slightly better (96.9%). However, our model used only half of the dataset that was used by the published work. Further, it uses fewer resources than the other neural networks. Consequently, training networks with TL can achieve high accuracy without consuming enormous resources and time.

Network	Backbone	Training Samples	No. of Frames	Top-1 %	Top-5 %
TRG [6]	Inception	118,562	8	96.8	99.9
TRG [6]	Inception	118,562	16	96.9	99.9
MFNet-C50[7]	ResNet-101	118,562	10	96.7	99.8
Ours	**ResNet 3D-18**	**50,420**	**27**	**92.9**	**99.5**
Ours	**ResNet MC18**	**50,420**	**27**	**92.0**	**99.4**

Table 3. Validation accuracy comparison for 20BN Jester dataset

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Table 2. Training accuracy, validation accuracy and training time comparison

Network	Epochs	No. of convolutional layers trained	No. of fully connected layers trained	Training accuracy	Top-1	Top-5	Training time	Average time per epoch (min)
Resnet 3D-18	10	11	1	97.19%	92.91%	99.5%	575 min 5 s	58
ResNet MC-18	9	11	1	95.41%	92.04%	99.4%	686 min 45 s	76
xResNet 3D-18	20	0	3	33%	-	-	494 min 49 s	25
xResNet 3D-18	10	3	3	92.57%	81.58%	-	464 min 48 s	47
xResNet 3D-18	10	5	3	95.31%	87.47%	99.0%	462 min 30 s	46
xResNet 3D-18	10	10	3	96.19%	91.95%	99.3%	536 min 57 s	54

Track 4

Social Sciences, Humanities, & Culture

Extent, Nature, and Consequences of Intimate Partner Violence: A Qualitative Survey about Intimate Partner Violence in Sri Lanka

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Abstract - Intimate partner violence (IPV) has devastating consequences not only for survivors but also for society as a whole. Many people look at intimate partner violence as a private family matter; therefore, it should be dealt with privately. Even though it happens behind closed doors, it is very much a public issue that affects the entire society. The World Health Organization recently estimated that at least one in three women throughout the world has experienced physical or sexual violence by an intimate partner, or sexual violence by a non-partner. The mental health consequences of IPV can be severe and include posttraumatic stress disorder (PTSD), depression, anxiety, and eating disorders. IPV is also a major cause of mortality due to suicide and homicide. Out of all murders of women globally, approximately 38% were committed by a current or former intimate partner. This paper addresses the extent, nature, and consequences of Intimate Partner Violence and summarizes the current literature on the incidence, assessment, and management of IPV against women in Sri Lanka.

Keywords: Intimate Partner Violence, intimate partner, women, mental health

I. INTRODUCTION

Intimate partner violence (IPV) is considered a serious health issue and South Asia is especially known to have a high prevalence of IPV against women. Low socio-economic status, underutilized sex education, religious and cultural beliefs, and financial insecurity are some of the major causes of the prevalence of IPV. Therefore, the World Health Organisation has called for context-specific information about IPV from different regions. A review has been published by the WHO and grey literature over the last 35 years was conducted using various frameworks and reports suggest, the prevalence of IPV in Sri Lanka ranges from 20-72%. Most research about IPV has been conducted in a few provinces and is based on the experience of legally married women. Some of these studies have investigated the individual, family, and societal risk factors for IPV, but the complex nature of the relationships has not been comprehensively investigated [3].

A. Operational Definition

According to the WHO, intimate partner violence (IPV) is defined as physical, sexual, and/or emotional abuse by a current or former marital or non-marital partner in the context of coercive control. Most victims of IPV worldwide are women. The World Health Organisation recently reported that the prevalence of physical and sexual IPV among women is significantly high in the countries of South Asia. A review of data from 81 countries revealed that South Asia has the second highest prevalence of IPV and this has been reported as 41.7%. Despite sharing many characteristics with other South Asian countries, Sri Lanka consistently ranks better in terms of maternal and child health, life expectancy, and educational attainment of women, yet available research suggests that the country has high rates of IPV mainly due to low socio-economic status and the religious and cultural beliefs [3].

B. Research Questions

- What is known from existing literature about IPV in Sri Lanka?
- What are the long-term negative cognitive, emotional, social, or behavioral effects of IPV?

II. BRIEF LITERATURE REVIEW

Women in different locations in Sri Lanka have experienced IPV. As the literature suggests that 20-72% of the highest prevalence rates were reported by women living in tea plantations in the Central Province. This was significantly high reporting 72%, and in the urban poor areas of the Western Province, this has been reported as 60% [3]. We may not know the current statistics of IPV in Sri Lanka as some of these prevalence rates are from studies conducted 10-15 years ago [4]. Recent community-based surveys reported that nearly 25% - 35% of women in various regions of Sri Lanka experienced IPV and they are either legally married or in intimate heterosexual relationships [2]. A survey conducted in 2013, reported that 22% of women experienced IPV from a male partner, and 24% of male participants perpetrated IPV during their lifetime.

How violence is defined and classified is controversial. Violence is mainly defined as the use of physical force to harm, damage, or destroy someone or something. The definition of violence is oversimplified as it does not describe the verbal and emotional violence one can contextually face. However, many researchers narrowly define violence as acts of physical aggression (e.g., hitting, kicking, slapping, shoving, grabbing, biting, hitting with a fist, beating up). This definition ignores sexual abuse, maltreatment, and psychological and emotional abuse [9]. In addition to that, any individual in an intimate relationship can experience violence irrespective of their sexual orientation. The debate also continues over terms (e.g., wife

abuse, IPV, violence toward women, spouse abuse, domestic violence) thus various definitions and interpretations have emerged [6]. Intimate partner violence occurs in both homosexual and heterosexual relationships, and the abusive partner is not always a male [8]. Gaps in the literature include issues related to ethnicity and domestic violence with concern for the influence of socioeconomic status, violence during life, one's sexual orientation, and violence. Moreover, the long-term cognitive, emotional, social, or behavioural effects of domestic violence are not properly addressed or investigated. Women and children's well-being in violent households is a major concern that has not been explored. The impact that it can have on their adulthood personality and on society. Furthermore, it has not been addressed how IPV impacts one's overall physical and psychological well-being.

III. Methodology

A flexible research design was utilized within the qualitative framework, through semi-structured interviews, mainly face-to-face interviews but also a complementing phone interview. A flexible research design will be deemed suitable as it would allow for changes during the research process, as quoted by Robson (2011, p75); "A flexible design evolves during data collection". The interviews were semi-structured and the data was self-transcribing using the thematic analysis method of qualitative research. Women in intimate relationships, (married/ unmarried) for more than 2 years were interviewed ages ranging from 18 – 40 in Sri Lanka.

IV. Results

IPV negatively impacts women's overall health. Women who are victims of IPV experience unintended pregnancies and are therefore forced to go through abortions. IPV significantly impact women's mental health and put them at a greater risk of developing psychological disorders such as depression, anxiety, and post-traumatic stress. They will also face difficulty in decision-making, low self-esteem, feelings of worthlessness, and eventually suicidal ideations.

Moreover, IPV may affect women's socialization and may isolate them from the community. In addition to that IPV is also may associate with physical symptoms such as frequent headaches, and, hypertension.

However, most prevalence studies were carried out in healthcare settings, and they possibly missed the IPV victims who did not come to these healthcare institutions. Therefore, the actual prevalence of IPV in the country might be higher than what has been reported. So far, only one community-based survey has been conducted to assess the prevalence of IPV in Sri Lanka. That study also examined only physical IPV and has not included psychological or sexual IPV. Therefore, the prevalence of psychological and sexual IPV needs to be evaluated by community-based research in Sri Lanka. Further, a large-scale community-based study should assess the national prevalence and the prevalence of IPV among the different ethnic groups in Sri Lanka.

V. Conclusion

There is an immense need to work on this issue. At the individual level, girls and boys both should be provided with education to broaden their minds. A woman should also be provided with job opportunities as per her skills to enhance their self-esteem to fight against violence. At the community level, awareness should be provided to women about their sexual rights and services they can access in time of need. Healthcare providers such as doctors, nurses, midwives, mental health counselors, and psychologists too should openly discuss IPV and create awareness among the general public. There should be emergency services such as hotlines and rescue teams from the community level to help the victims of IPV. Both men and women should be given knowledge about violence against women and what can be done in such situations. In conclusion, IPV is a sensitive issue identified in many countries, especially in Sri Lanka which is badly affecting women's physical, emotional, psychological, and social health. The root causes are illiteracy and socio-cultural beliefs. So, there is an immense need to work on it in a collaborative manner to educate men and women and to eradicate those beliefs which give rise to gender inequality and degrades women throughout their life.

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Rural Development, Resettlement and Social Exclusion: A Case Study of *Nelugama* Village, Sri Lanka

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Abstract

Nelugama, is a village located in *Anuradhapura* district. The inhabitants of the village experienced an influx of new inhabitants due to a mega irrigation project, the *Yan Oya* project launched in 2016. The main purpose of this study is to understand rural dynamics, social processes, and social relations that impact on social, and economic changes of *Nelugama* as a result of the resettlement process. The research followed the qualitative approach, and it is a single case study considering the village as the unit of analysis. The research is a descriptive type of case study and multiple methods are used for the data collection. Data collection tools used for the study are field notes, interviews, Participatory Rapid Appraisal (PRA) tools. The influx of resettled families from *Yan Oya,* influenced the village economy and social structure. The favorable conditions and facilities provided for the resettled families for better housing, income generation, and land ownership made the situation more complicated and created tension among original and resettled families. Social and economic separation experienced by original families through the project made original families socially excluded with the sense of deprivation.

Keywords: *Social Exclusion, Poverty, Socio-Economic Changes, Original Families, Resettled Families*

I. INTRODUCTION

Nelugama is a village located along the *Colombo Pulmude* road in the *Anuradhapura* district. It is a hot, dry village consisting of 202 families. *Nelugama* consists of 3 sub-villages named *Nelugama*, *Olukada*, and *Nawawewa.* Original inhabitants of the village claim, they arrived in 1950. This village, bordering the Trincomalee district, went through several upheavals during the war, LTTE attacks, and being displaced. The village remained somewhat isolated and cut off from the rest of the district. The families who lived in *Yan Oya* were resettled in *Nelugama* in 2016, consequently, the village was expanded due to the influx of resettled families.

New families have received certain direct benefits from the project such as 1 ½ acre of paddy land, 40 perches of land for housing, compensation for their lost lands which were overvalued by the government and necessary village infrastructures such as concrete byroads, pipe-borne water supply project, preschool, community centre, and elephant fence. Through these changes, the *Yan Oya* project has influenced the village economy, social life, livelihoods, and natural environment in different ways. The main purpose of the study is to understand social and economic changes in *Nelugama* due to rural development initiatives and resettlement process. Further, this research aimed to examine how 'development' initiatives created inequalities and social exclusion among original and resettled families.

II. MATERIAL AND METHODS

The research followed the qualitative approach, and it is a single case study considering the village as the unit of analysis. The research is a descriptive type of case study and multiple methods are used for the data collection. Data collection tools used for the study are field notes, interviews, PRA tools (mapping, FGD, Observation, transact walk), and data recording was done through field notes, interview transcriptions, computer files, and audio recordings. Village heads, older people living in the village, grass-root level government officers and members and office bearers of the village institutes were interviewed other than villagers that belong to a wider scope. Participatory tools were selected (focus group discussions, community mapping), which come in Participatory Rural Appraisal (PRA), since PRA tools have been mostly used with rural communities that have a lower literacy level. Further, local people can easily understand them, interactive, stimulate the active participation of local people and origin of PRA tools have historically linked to the activist participatory research one of the sources and parallels to the PRA (Mukherjee, 1995). Community mapping is selected since maps can reflect relationships, losses and discoveries, the changes of the physical and political landscape, history and geographies of individuals and communities.

Social exclusion theoretically relates to four different dimensions (Jehoel-Gijsbers (2004) and Vrooman and Hoff (2013), and they have been identified as limited social participation, lack of normative integration, material deprivation and inadequate access to social rights by Vrooman *et al* (2013). Out of these four theoretical constructs two of these are forms of socio-cultural exclusion and two of these are forms of structure-economic. The scope of this study limited to the forms of socio-cultural exclusion. The main assumptions of this study are that an PRA instrument has validity to use for academic research and respondents answer questions truthfully. Implementation of data collection tools was challenged by the level of knowledge and literacy of the selected respondents and their level of understanding. Some data collection tools were taken from PRA methodology and validity of using those participatory tools that were designed for the use of the development sector, for the academic studies could have been challenged even though they are used to gather detailed information from the average level illiterate community.

III. RESULTS AND DISCUSSION

The original villagers of the village experienced economic changes along with the village expansion due to the resettling of families from *Yan Oya* and new development initiatives introduced by the project. The effects of development efforts impact the village irrigation system, paddy cultivation, water management, livelihoods, living patterns, culture, religious practices, traditions, natural environment, and social integration which directly impact the village economy.

A.Economic Changes

The main livelihood of the original villagers of the village is paddy cultivation, while simultaneously they were involved in fishing, animal husbandry and crop cultivation. Nevertheless, during the internal war period, the income level of the original villagers had gone down mainly because they abandoned the cultivation lands and lived in refugee camps for 30 years. Informal labor was the main source of income for them during the off-cultivation period and the civil war period. The trend of joining military service increased during the war period and this was evident mainly among youth population of the village. After original villager returned from the refugee camps, rain-fed paddy cultivation resumed. Some families that previously lived in urban areas or migrated temporarily to other villages during the paddy cultivation period and returned to their living places after the harvesting period. Even though paddy cultivation was expanded in

Nelugama before and after the resettlement process, the proportion of the population involved in non-agricultural jobs has increased along with rural-urban migration.

The impact of the government-aided poverty alleviation program on the village economy remained insignificant and shifting to informal work, service supply sector and off-cultivation income generation methods has contributed to increasing their income. But the *Yan Oya* project enabled access to those economic opportunities through improved road infrastructure and irrigation systems.

The direct benefits received by the original farmers through the *Yan Oya* mega irrigation project were the development of the village irrigation system and the internal road network. However, though the *Olukada* tank was renovated, the village irrigation system and paddy cultivation were threatened by other challenges such as the invasion of invasive plants in the tank, lower level of groundwater, long spells of the dry period, elephant intrusion and extreme climatic events. Therefore, rain-fed irrigation systems and rainfall patterns impact considerably on the village economy and are linked to irregularities in paddy cultivation, livelihood patterns and mobility of farmer families.

Village irrigation system, paddy cultivation and other emerging economic opportunities such as civil defense services, informal labour and unskilled labor for development projects play a significant role in changing the village economy and social life of the people. Although more favorable conditions for paddy cultivation exist in the village, new generations show trends of moving away from paddy cultivation and are keener on getting informal work in urban areas, government jobs, and other non-agricultural work.

B. Social changes

The influx of resettled families from *Yan Oya,* influenced the village social structure, in a way that the whole village is physically and socially divided as *Parana Gammanaya* (Old village consisted of original families) and *Nawa Gammanaya* (New Village consisted resettled families). The favourable conditions and facilities provided for the resettled families for better housing, income generation, and land ownerships made the situation more complicated and created tension among original and resettled families. Geographical, social and economic separation experienced by original families under different circumstances, created space for comparison, self-exclusion and a sense of deprivation.

But the project impact empowerment of women in original families. Women of the village actively engaged in the village economy and social life through their contributions to paddy cultivation, seasonal crop cultivations, domestic work, social welfare, and community development work. Even though the women in original villages spend the whole day in paddy fields during paddy cultivation and harvesting periods supporting their husbands and sons, their participation in farmer committee meetings and decision-making processes was almost insignificant. But during the off-cultivation period and tank rehabilitation period women were given the opportunities to participate in village development activities and they were paid by the project. Further micro-credit schemes introduced to the village from a local microcredit institute provided small loans to women to initiate household-level income generation activities. The women's participation in the village economy was strengthened through the establishment of the women's society, trainings provided by the non-government organization on savings and income generation and initiating the revolving fund for the women's society. The project has contributed to improving the economic status of women even though they were not empowered through capacity building.

Within the deprivation of economic benefits to the resettled families, the project provided more space for distancing from communication, interaction, sharing, and cohesion between original and resettled families. At the same time project design has not provided any room for social and cultural interaction, social cohesion, equitable sharing of resources and economic benefits. The cumulative effect of this situation led to social tension among original families and induced by comparisons, conflicts and mistrust.

The project showcased how other factors such as development inabilities, the inclusion of certain groups for the development process, and policy imperatives caused exclusion in certain circumstances, resulting in discrimination and disadvantages. According to Clert, while discrimination makes access more difficult, exclusion prevents access (1999: 184). It was hard for original families to access new social and physical structures build-up by the project for the resettled families, since they were excluded from the access to resources and opportunities at the very beginning.

There are some broad areas of agreement in the welfare, liberal democratic and postcolonial perspectives about how social exclusion has affected group inequalities. Kabeer (Kabeer 2008: 20)., has captured an important dimension of the experience of certain groups of being somehow "set apart" or "locked out" of participation. He mentioned that the concept of social exclusion focuses on the production of disadvantage through active dynamics of social interaction, rather than the anonymous processes of impoverishment and marginalization (Kabeer 2008: 20).

4. CONCLUSION

The rural developmental initiatives of the government have ignored development approaches such as integrated community development and participatory approaches that built up social integration, inclusion and participation. This situation was further accelerated by the absence of social mechanisms and interventions that encourage social interactions and integration among original and resettled families. This resulted in the social exclusion of original families from accessing assets and opportunities created through rural development initiatives contravening to the rural development concepts. Within this context, social changes experienced by original families and resettled families are contextual and complicated and the impact on the village economy, social life, political and social structure, and local institutions is unclear.

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Translating Culture-Specific Items (CSIs) in Michael Ondaatje's Running in the Family into French and Sinhala

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Abstract - The present study examines the translation of culture-specific items (CSIs) in Michael Ondaatje's *Running in the Family* (1983). In this particular source text (ST), Ondaatje, one of Sri Lanka's preeminent Diaspora writers, narrates his family history and anecdotes in a language influenced by Sri Lankan culture. The French translation *Un air de famille* by Marie-Odile Fortier-Masek and the Sinhala translation *Pavule Uruva* by Sepala Wijesekara are selected for this comparative study. The objective of the study is to investigate the strategies employed by translators and to understand the approach that they have adopted in their respective translations. The study refers to Peter Newmark's cultural categories (1988) and only three are selected for the present study: food, flora and fauna, and social organizations. The CSIs are identified in the ST and their equivalents in the translations are found, categorized, and analyzed. The foreignization and domestication strategies based on Aixelá (1996) and Newmark (1988) are applied to the analysis. The analysis reveals foreignization strategies such as Transference and Through-translation are frequently applied by the French translator while domestication strategies such as Limited and Absolute Universalization are also practiced. In Sinhala, the dominant foreignization strategies appear to be Orthographic Adaptation and Through-translation. Domestication strategies such as Deletion and Limited Universalization are also preferred by the Sinhala translator. By comparing the strategies used in the two translations to translate the CSIs, the study shows to what extent the translators have adopted foreignization and domestication in their translations.

Keywords: culture, domestication, foreignization, Sri Lanka, strategies

I. Introduction

Michael Ondaatje's *Running in the family* is set in Sri Lanka in the early 1900s when it was called Ceylon. It contains terms related to Sri Lankan culture which present numerous challenges to its translators. The strategies employed by the translators could either make these terms comprehensive to the reader or retain them to highlight their exotic nature. The present study examines the strategies used in the French and Sinhala translations of the ST aiming to understand to what extent they practice foreignization and domestication.

II. Methodology

Items related to culture are known by various terms: culture-bound, culture-specific, culture inferences (elements, terms, items, expressions), realia, 'allusions', or, more generally, 'cultural references' [1]. They include food, clothing, flora, and fauna, housing, and many more.

Broadening the concept, Basnet defines them as an "abstract or concrete source language concept". She further adds that they are unfamiliar to withe target culture (TC) [2]. Speaking of translation and culture, Peter Newmark divides various cultural aspects into five categories [3]. Given time and resource constraints, only three are selected for the study: Food from Material Culture, flora and fauna from Ecology, and Social Organizations (SO) including toponyms.

Running in the Family was translated into many languages. It was translated into French by Marie-Odile Fortier-Masek and published in 1991 ((Édition de l'Olivier). The Sinhala translation appeared much later in 2012, translated by Sepala Wijesekara (Sarasavi Publishers). In the ST, CSIs belonging to food, flora, fauna and SO are identified and presented in Table 1. Their equivalents in Sinhala and French are also listed. Once the CSIs are identified, the strategy employed by the translators to translate them is examined. For this purpose, domestication and foreignization strategies elaborated by Aixelá and Newmark are applied. Accordingly, Limited Universalization, Absolute Universalization, Naturalization, Deletion, and Synonyms are considered domestication strategies. Transference, Orthographic Adaptation, Extra-textual Gloss, Intra-textual Gloss, Through-translation, and Pre-established Translation are identified as foreignization strategies [4]. Lawrence Venuti describes domestication as an "ethnocentric reduction of the foreign text" that eliminates what is foreign and exotic while foreignization, which is preferred by him, is called an 'ethno-deviant pressure" that registers the cultural differences. Further, foreignization allows to emphasis presence of the translator [5].

The strategies employed by translators to translate the above-mentioned CSI categories are discussed. These strategies are analyzed and identified as belonging to foreignization or domestication. By comparing the strategies in French and Sinhala, the study reveals to what extent the two translators adopt foreignization and domestication. It also highlights strategies preferred by each translator when faced with the challenge of translating terms belonging to the chosen cultural categories.

II. Results and Discussion

The CSIs identified in the ST and the two target texts (TT) are listed and categorized in Table 1. Fifteen CSIs are analyzed in each category. Table 1 presents only the most significant CSIs.

Table 1 – Examples of CSI in ST and their translations in TTs

Category	ST	TT - French	TT- Sinhala
Flora and fauna	Scimitar babbler	Coucou-épervier	-
	The Karapothas	Les Karapothas	Karapoththo
	Jesus lizards	Lézards	-
	High flowers	Hautes fleurs	Pol mal
	Croton seeds	Le croton d'Inde	Croton beeja
	Syzygium	Le syzigium	Sisijium (isiscshï)
Food	Toddy	Le vin de palme	-
	Egg rulang	Œuf rulang	Biththara rulang
	String hoppers/ hoppers	Sauterelles	Indi appa/ appa
	Eggs cooked	Une omelette	Biththara thembuvaya
	Kurumba - the half form white	Kurumba - ce lait à demie caillé	Kurumba - londa
	Curd	Du fromage blanc	Mudavapu kiri
SO/ Toponyms	St. Thomas' Church	Église de Saint-Thomas	Santha Thomas dev medura
	Good Shepherd Convent	Le couvent du bon pasteur	Yahapath ederage kanyaramaya
	Mount Lavinia	Le mont Lavinia	Galkissa
	The Ceylon Cactus and Succulent Society	La société cinghalaise des cactus et plantes graisses	Lanka pathok ha mansala shaka sangamaya
	Marble beach	Marble beach	Mable beach (udn,a îÉ)
	Sigiriya	Sigiriya	Sinha gala

All the identified CSIs in the TTs are analyzed and the strategy applied by the translators is identified as favoring domestication or foreignization. In the first category, the French translator mainly opts for Transference, Through-translation, and Limited Universalization. In the Sinhala translation, Deletion stands out as a preferred strategy. Apart from it, the translator applies Orthographic Adaptation, ad Limited Universalization. Orthographic Adaptation is inevitable when English names are transliterated into Sinhala.

The second category of food reveals surprising or even shocking discoveries. The French translator uses Limited and Absolute Universalization misleading the reader. String hoppers and hoppers which are popular local dishes are translated into French as *Sauterelles.* It means grasshopper. The translator's lack of understanding of the ST culture leads to a grave error. Further, by replacing toddy and curd with wine and *Fromage Blanc* respectively, which are French food items more familiar to the TT reader, the translator shows a strong inclination towards domestication. Another example that is worth mentioning is the translation of cooked eggs. The term cook does not indicate a precise method. Therefore, TTs, it has been domesticated favoring the gastronomical tendencies of each culture. The French translator chooses an omelet while the Sinhala translator settles for boiled eggs. Transference and Through-translation are also practiced by the French translator as certain names of local dishes such as *mallung* and *egg rulang* are borrowed and some are literally translated. In the third category, the dominant strategy in French is Through-translation whereas in, Sinhala, it is Orthographic Adaptation. Both translators use Through-translation for social organizations such as The Ceylon Cactus and Succulent Society. Additionally, the Sinhala translator has recourse to Synonyms using a parallel term to translate Sigiriya as *Sinha gala*, even though Sigiriya exists in Sinhala.

III. Conclusion

It is evident that in each category, both translators have resorted to a combination of domestication and foreignization strategies. However, a particular tendency towards a certain approach can be discerned in each category. As Sri Lankan culture is new and exotic to the French reader, the TT contains more borrowings. Transference, a foreignization strategy, is frequently seen in French translation. The Sinhala reader is already familiar with the ST culture, and food or flora and fauna mentioned in the ST do not pose any difficulty. However, the Sinhala translator notably practices Deletion when the translation of certain species of fauna poses a challenge. For example, frog mouths, nightjars, flycatchers, and brain fever birds are eliminated in the Sinhala TT. Deletion is considered a domestication strategy. A dominant foreignization strategy visible in the Sinhala translation is Orthographic Adaptation mainly in Flora and fauna and Social Organizations including toponyms. Limited Universalization is particularly preferred by both the translators in each category offering familiar equivalents to each readership.

However, the risks of Absolute Universalization are clearly visible in the French TT. As discussed above, the strategy results in misrepresenting Sri Lankan cuisine. The importance of adequate knowledge of the ST culture is further emphasized by this example.

As the study is limited to only three cultural categories, the use of other strategies cannot be observed. For example, the practice of giving footnotes which are known as Extratextual Gloss, a foreignization strategy, is seen only in the French TT. A comprehensive analysis of all the cultural categories could shed more light on how CSIs are translated into French and Sinhala.

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Protecting Traditional Knowledge: Can *sui generis* Regimes Help?

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Abstract – The objective of this study is to identify and evaluate the effectiveness of the *sui generis* approach as a method of safeguarding Traditional Knowledge (TK). Traditional knowledge, which is generally passed down through generations, is an important component of the cultural identity of local communities. It is formed, nourished, maintained, and handed down through the generations within a social group. The final results of this study argue that conventional Intellectual Property tools are ineffective for safeguarding Traditional Knowledge in the modern, globalized world. By comparing *sui generis* regimes of various third-world countries pertaining to the protection of Traditional Knowledge, it is hypothesized in this study, that the *sui generis* approach is the most effective method for safeguarding Traditional Knowledge. In terms of Sri Lanka's scholastic contribution to the protection of traditional knowledge, this study has stepped into an uncharted territory. By conducting a thorough assessment of the effectiveness of a *sui generis* protection regime on the utilization of Traditional Knowledge, it is anticipated that this study will contribute to the theoretical foundation of Traditional Knowledge which will be important to all third-world countries. This study primarily adheres to the qualitative research paradigm of legal research and is focused on the Black-Letter approach of research methodology in order to accomplish the study's specific objectives. In order to incorporate numerous international legal perspectives and examine various authorities in the field of protecting Traditional Knowledge, the legal comparative analytical method was additionally employed.

***Keywords: Traditional Knowledge, Intellectual Property tools, sui generis* regime**

I. INTRODUCTION

This study's objective was to determine and evaluate the most suitable and efficient safeguarding strategy for Traditional Knowledge (TK). The driving factor of this study was to ultimately gain a deeper understanding of how Traditional Knowledge can be safeguarded in today's globalized economy while addressing pressing issues.

Traditional knowledge is defined as the abilities, knowledge, and traditions that are created, preserved and transmitted from one generation to the next within a community. As a result, it is possible to say that certain aspects of the community's cultural and spiritual identity are shaped by Traditional Knowledge. The communities and individuals who possess and safeguard TK encompass their knowledge, expertise, and cultural heritage to particular knowledge.

It can be recognized that traditional knowledge is based on sociocultural principles that are related to people, soil, plants, living creatures, water, and integrity. TK is repeatedly alluded to as the knowledge of the day-to-day life of the particular community and is extensive, premised on a system of belief. Additionally, it plays an important role in the community's culture and heritage. Traditional knowledge is frequently entangled with folklore, social norms, and traditional influences. Traditional knowledge thus reflects the spiritual and cultural aspects of the particular community.

Sui generis, a Latin phrase that means "of its own kind," refers to anything unique to it; belonging to a distinct kind or category. Sui generis refers to a distinct legal categorization in legal contexts. A *sui generis* system alludes to the restructuring of some aspects of the intellectual property system in order to properly facilitate the unique characteristics of its particular subject and the particular policy requirements that resulted in the creation of a different structure. A *sui generis* framework may include some standardizations of Intellectual Property protection associated with other types of protection for the protection of Traditional Knowledge and genetic resources. A *sui generis* system might be defined and utilized differently in distinct countries of the world. (Balavanth S Kalaskar,2012)

Moreover, in this globalized world, no one can live alone or remain isolated and should always try to preserve the existing value of their entitlements and reap their maximum results. As a consequence, the study's outcome is that Traditional Knowledge should be documented, closely monitored, and commercialized in order to distribute the benefits among community members who possess the particular knowledge.

To achieve the goal of safe commercialization of Traditional Knowledge, a strong regulatory mechanism should be established. Following that, the benefits of traditional knowledge can be enjoyed by current and future generations by ensuring the safe commercialization of Traditional Knowledge aligned with a sui generis mechanism, as well as preventing misappropriation and unauthorized utilization of particular knowledge and related products and services.

II. MATERIALS AND METHODS

This study mainly complies with the qualitative research paradigm, which draws on primary sources that demonstrate the law as it currently exists, such as statutes, regulations, and conventions, as well as secondary sources, such as books, research papers, and journal articles, that demonstrate how distinct authors observe or respond to the research question.
The black letter approach of legal research was mainly employed in this study to examine the theoretical underpinnings, interconnections, and prescriptive fundamentals, underlying concepts, principles, and understandings found in primary sources such as enacted laws, court decisions, international treaties, academic contributions, reference materials, journal articles, and discussions.

III. RESULTS AND DISCUSSION

Sui generis rights are frameworks that have evolved outside of the current intellectual property structure. Article 27(3)(b) of the TRIPS Agreement provides World Trade Organization (WTO) members the option of establishing a sui generis system. This allows countries to design their own protection structure,

which can aid in the safeguarding of their Traditional Knowledge.

Although such sui generis rights have been proposed as a method of safeguarding Traditional Knowledge, the perimeters of sui generis rights are questionable, as are the implies of enforcement. Moreover, it is unclear whether developed nations and the WTO will uphold rights defined by particular countries.

Peruvian *sui generis* law is regarded as one of the world's most productive and efficient *sui generis* strategies for the safeguarding of TK. The Peruvian *sui generis* Law clearly states that its goal is to promote the fair and equitable distribution of the advantages accruing from the use of collective Traditional knowledge. (Article 2, Peruvian Law No. 27811, Protection Regime for the Collective Knowledge of Indigenous Peoples derived from Biological Resources, 2002) Article 39 of the Law specifically states that funds from benefit-sharing will be directed to a Fund for the Development of Indigenous Peoples. (Article 39, Peruvian Law No. 27811, Protection Regime for the Collective Knowledge of Indigenous Peoples derived from Biological Resources, 2002)

Additionally, it has expanded the definition of "indigenous peoples," by defining them as indigenous peoples who possess rights that predated the establishment of the Peruvian State, uphold their own tradition, occupy a particular territorial region, and identify themselves as being such. These include rural and indigenous communities, as well as peoples who have chosen voluntary isolation or with whom contact has not been established. (Article 2, Peruvian Law No. 27811, Protection Regime for the Collective Knowledge of Indigenous Peoples derived from Biological Resources, 2002)

Another third-world country with an important sui generis law to protect Traditional Knowledge is Panama. Panama has passed legislation establishing a special regime for intellectual property relating to indigenous peoples' collective knowledge, in addition to the protection and security of their cultural identity and traditional knowledge. (Panamanian Law No. 20 of June 26, 2000, Special Intellectual Property Regime on Indigenous Communities' Collective Rights, 2000)

Remarkably, the Law establishes civil and criminal penalties for violations of the TK in Panama. The entirety of these rights will be granted to indigenous peoples only through the collective rights registration process. (Article 16, Panamanian Law No. 20 of June 26, 2000, Special Intellectual Property Regime on Indigenous Communities' Collective Rights, 2000) As per Article 55 of the Law, when it comes to criminal offenses concerning misappropriation of Traditional Knowledge and duplicating products while misusing the knowledge of Panamanian indigenous communities, half of the fine is apportioned to the advantage of the National Treasure, while the other half is apportioned to the advantage of the respective community. (Article 59, Panamanian Law No. 20 of June 26, 2000, Special Intellectual Property Regime on Indigenous Communities' Collective Rights, 2000)

It is regrettable to understand that Sri Lanka's Intellectual Property Act is the only legal instrument that protects traditional knowledge. (Intellectual Property Act, No. 36 of 2003) That is also restricted to folkloric manifestations. (Section 05, Intellectual Property Act, No. 36 of 2003) Folklore expressions are protected under Section 24 of the Act from duplicating, performing for the public, broadcasting, distributing via cable, and other types of communication, as well as from adaptation, transcription, and other forms of transformation when done for profit or outside of the context in which they are traditionally used. (Section 24, Intellectual Property Act, No. 36 of 2003)

The flexibility provided by TRIPs and other international agreements to which Sri Lanka is a partner must be fully utilized by Sri Lanka in creating a system that promotes and defends the rights of those who possess traditional knowledge. It is crucial to identify the exact requirements of those who hold traditional knowledge in order to design a suitable sui generis regime that will recognize and protect their rights. (Althaf Marsoof, 2010).

IV. CONCLUSION

The study's conclusion encourages Sri Lanka and other developing nations to adopt a framework not only for the regulation of Traditional Knowledge but also for the correctly utilizing value of Traditional Knowledge by enacting a sui generis legislation that matches the needs of the particular society. This would provide legal clarity for both communities that possess traditional knowledge and other entities looking to exploit that wisdom-related productions and services. In light of the benefits that Traditional Knowledge offers, the above-mentioned type of structure congruent with a sui generis regime might be assisting to make the Traditional Knowledge accessible for beneficial use to the whole society by reaping the fruits of that wisdom while also ensuring that particular community members are fairly compensated.

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Online Grocery Shopping Intention during a Period of Economic Crisis

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Abstract - A national economic crisis affects local consumer behavior, such as changes in how consumers shop for groceries. This study was conducted to investigate the intention of consumers in the Colombo district of Sri Lanka to use online grocery shopping (OGS) during a period of economic crisis. A descriptive cross-sectional study with an analytical component was conducted with the aim of benefitting entrepreneurs who are deliberating the adoption of OGS systems in the Colombo district. Perceived convenience, perceived risk, and perceived relative advantages were investigated as independent variables affecting consumer intention to use OGS. Further, the study scrutinized whether household uncertainty shocks experienced during the economic crisis impacted the possible relationship between OGS intention and the above-mentioned variables. Convenience sampling was employed and data was collected using an online self-administered questionnaire sent to 150 persons. The response rate was 95% (n=143). Findings revealed that consumers in the Colombo district did not have a significant intention to use OGS during a period of economic crisis (p=.79). Perceived convenience (p<.0001), perceived risk (p<.0001), and perceived relative advantages (p<.0001) were found to significantly impact the intention to use OGS. However, household uncertainty shocks (p=.91) did not have a significant impact on the relationship between the intention to use OGS and the independent variables. Social tension and the COVID-19 situation during the study period served as challenges for data collection. Further research with robust methodologies is recommended to illuminate whether the trend in intention to use OGS is likely to change after the economic crisis.

Keywords: intention, online grocery shopping, economic crisis, uncertainty shocks

I. INTRODUCTION

Businesses need to cater to consumer preferences in pursuing profitability and sustainability. This includes adapting to changes in consumer preference in crisis situations as well. Evidence from other countries indicates that economic crises can permanently mutate consumer lifestyles and behavior [1]. On the other hand, researchers have shown that an economic crisis presents a good opportunity for businesses to reinvent themselves, introduce new services, enter new markets, and seek the most appropriate ways to gain competitive advantages [1]. However, it is important to identify novel, feasible and user-friendly measures for attracting customers during such difficult times.

It is seen that e-commerce is becoming an increasingly important marketing and sales channel worldwide, even during crisis situations. Online grocery shopping (OGS) is a form of e-commerce that allows consumers to purchase grocery items over the internet. It is reported that OGS became popular during the COVID-19 pandemic, a biological crisis situation [2]. As in many other countries, Sri Lanka too experienced a boost in OGS during this time [3]. However, there is a paucity of evidence, world-over, on consumer intention toward OGS during an economic crisis.

Sri Lanka has been going through a period of an economic crisis that has presented a unique set of challenges to local consumers, including restricted mobility due to a lack of fuel, increased inflation, and financial hardships. If businesses are to remain profitable during this challenging period, it is necessary for them to anticipate and adapt to resulting changes in consumer behaviour.

Although limited studies have investigated different aspects of consumer behaviour during an economic crisis in other parts of the world, there is a paucity of empirical evidence on the impact of such a crisis on consumer intention to use OGS, especially in developing countries. Studies have not been conducted in Sri Lanka to investigate the intention to use OGS during the ongoing economic crisis.

Therefore, this study was conducted as a preliminary attempt to understand the intention of consumers in the Colombo district of Sri Lanka to use OGS during a period of economic crisis. The Colombo district was selected for this study as it had the highest district-wise share of OGS orders during the COVID-19 pandemic [3]. Hence, it was assumed that the consumers in this district had a reasonably good idea about OGS, regardless of whether they have previously used it.

Previous studies on the intention to use OGS have used extended versions of the Technology Acceptance Model (TAM) [3]. The TAM proposes that consumer intention to use a new technology depends on its perceived usefulness (PU) and perceived ease of use (PEU) [4]. Subsequent studies have further extended this model by introducing new dimensions, including perceived risk (PR) and perceived relative advantages (PRA) [5]. PR is the degree to which consumers feel that using OGS may result in unfavorable outcomes, such as receiving incorrect orders or having personal information stolen. PRA is the extent to which consumers view OGS as more beneficial compared to alternative methods of grocery shopping. However, none of these studies have investigated consumer intention to use OGS during an economic crisis. Thus, they have failed to take into account the impact of factors related to an economic crisis, such as a decline in individual income, savings, and expected future wealth and a reduction in household consumption on consumer intention to use OGS.

Therefore, the present study investigated OGS intention using an extended version of the TAM considering the above factors. Perceived convenience, PR, and PRA were selected as the independent variables of this study. Perceived convenience (PC) is an amalgamation of PU and PEU and it measures the degree to which consumers perceive OGS as useful and user-friendly. This study also investigated household uncertainty shocks (HUS) as the moderating variable. HUS is defined as an increase in uncertainty related to household outcomes such as household consumption, income, and savings.

II. MATERIALS AND METHODS

A descriptive cross-sectional study with an analytical component was conducted and data collection was carried out from June to July 2022. A pre-tested, self-administered online questionnaire was used as the study instrument. It consisted of quantitative and qualitative sections. The quantitative section included sociodemographic items and statements related to the variables which were measured using a five-point Likert scale. The study findings were not intended to be generalized to other parts of Sri Lanka due to the disparity in the availability of OGS

services. Hence, convenience sampling was employed. The questionnaire was sent to 150 persons and a response rate of 95% was obtained (n = 143). The sample consisted of consumers in the Colombo district of Sri Lanka aged eighteen years and above. As the study investigated consumer intention, previous experience in OGS was not considered mandatory.

Data was analyzed using SPSS version 26. The proportion of consumers with an intention to use OGS was determined. Associations were investigated using multiple regression analysis. Significance was set at $p < .05$. Deeper insight was gained through the analysis of qualitative responses.

III. RESULTS AND DISCUSSION

Out of the 143 respondents, 54.5% were female and a majority (55.2%) were aged eighteen to twenty-seven years. Most of the respondents were unmarried (56.6%) and the average family income was above Rs. 100,000 (60.1%). Majority (40.6%) shopped for groceries over 4 times per month.

The intention of consumers in the Colombo district of Sri Lanka to use OGS during a period of economic crisis was 44.8% (CI 36.4% - 53.3%). Findings revealed that consumers in the Colombo district of Sri Lanka did not have a significant intention to use OGS during the economic crisis ($p = .24$).

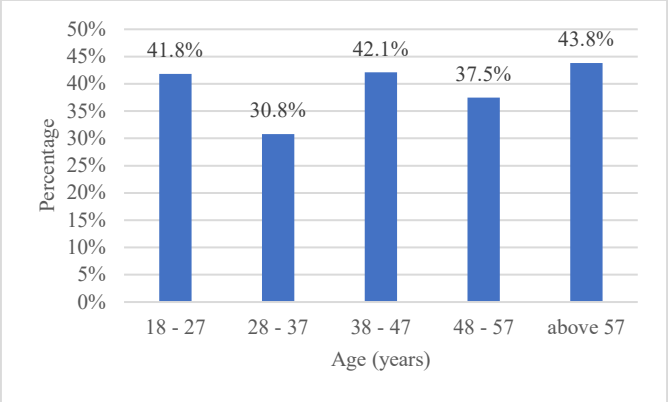

Fig. 1 Age vs intention to use OGS

As shown in Figure 1, the percentage of consumers who have an intention to use OGS are roughly similar across age groups.

Table 1. Summary of multiple regression model

Variables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
PC	.079	.011	.411	6.958	.000
PR	- .081	.009	- .484	-9.204	.000
PRA	.078	.014	.328	5.544	.000
HUS	- .002	.009	- .014	- .268	.789

The results of the multiple regression analysis indicated that the model explained 62.8% of the variance and that the model was a significant predictor of intention to use OGS, $F(4,138) = 58.30$, $p < .0001$. As shown in Table 1, while PC (B =.079, $p < .0001$) PR (B = -.081, $p < .0001$) and PRA (B = .078, $p < .0001$) contributed significantly to the model, HUS did not (B = - .002, $p = .79$).

Findings of this study are consistent with research on the significance of PC, PR and PRA on the intention to use OGS [5]. In a similar study conducted among 200 respondents in 2020 in the Colombo district, PR was revealed to be the least important association of consumer adoption of OGS [5]. However, according to the present study, PR had the largest impact. This indicates that consumers may be particularly apprehensive about the risk of using OGS during an economic crisis.

Qualitative analysis provided further insight, revealing that that there were concerns about delivery charges, lack of fuel and the resulting unavailability of delivery services, especially during the economic crisis.

IV. CONCLUSION

Findings of the study indicate that perceived risks play a greater role in impacting intention to use OGS among consumers in the Colombo district during the economic crisis. Entrepreneurs can use the study findings to reduce perceived risks and communicate the benefits of OGS to motivate consumers to use it during the economic crisis period.

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Impact of Banning Agro-Chemical on Low-Country Tea Production

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Abstract - The smallholding tea industry plays a significant role in the Sri Lankan economy for over a century as the main source of foreign exchange and employment provider. Due to the sudden implementation of banning Agro chemicals importation, the tea industry in Sri Lanka was greatly affected. This study assesses the effect of Low country tea smallholders' production before and after the chemical policy implementation examining the production level of fresh leaves supplier, factory production, factory distribution/farmers' purchasing of chemical and organic fertilizer(compost). Paired samples T-test and descriptive data analysis are used to analyze the production and supply data. Mean monthly fresh leaves supply quantities from April 2020 to March 2021 (46041.3Kg) and from April 2021 to March 2022 (39383.75Kg) showed a significantly different ($P<0.05$) before and after the banning policy. Moreover, the mean monthly factory tea production quantities from April 2020 to March 2021 was 49196.8Kg and from April 2021 to March 2022 was 41888.5Kg and showed a significant difference ($P<0.05$) from the production before the banning policy. Accordingly, it can be concluded that the banning policy has significantly affected the low country tea sector impacting factory production and processed tea production due to the reduction of tea Smallholder production and processed tea production due to the reduction of fresh tea leaves supply and fertilizer distribution. Gradual implementation of the banning policy with effective feasibility analysis would avoid the negative impact banning policy on the tea farmers.

Keywords: Banning policy, Chemical fertilizer, Compost quantity, production, Tea Smallholders

I. Introduction

Sri Lanka is well known as an island made for tea. In 2021, the tea industry's contribution to GDP was 0.7% and contribution over US$1.3 billion to the economy of the country [1]. Tea planting by smallholders is the source of employment for thousands whilst it is also the main form of livelihood for tens of thousands of families [2]. Sri Lanka is the world's fourth-largest producer of tea and the Ceylon tea industry maintains the highest quality in the global tea marked ISO 3720 is the minimum standard applies for the products [3]. The government passed a policy banning the import of chemical fertilizers, disrupting tea production in the country which is a major source of foreign exchange [4].

II. Methodology

The survey was conducted to analyze how the impact of banning the importation of chemical fertilizers on small tea industry production by studying the information 12 months before and after the implementation of the policy

The survey was conducted in the Neluwa area, Galle district, a southern province in Sri Lanka. Data was collected from 300 plantations/ farmers (randomly selected) from one factory, Madagama tea factory, Tea Smallholder Factories PLC, Neluwa.

A. Production of tea plantation before and after the agrochemical banning policy

Study on how the policy of banning the import of chemical fertilizers affects the production of tea plantations. 300 randomly selected farmers' fresh tea leaves supplied quantities were analyzed. The policy implementation and impact on production were studied by studying the monthly fresh leaf supply to the tea. factory within 12 months (from April 2020 to March 2021 and from April 2021 to March 2022).

B. Production of tea factories before and after the agrochemical banning policy

The impact of the policy of banning policy on the production of the factory was analyzed in this study for the period of 12 months, from April 2020 to March 2021 and from April 2021 to March 2022.

III. Results and Discussion

Impact of Prohibition/Banning Agro-Chemical on monthly fresh tea leaves supply

The mean monthly leaves supply quantities from April 2020 to March 2021 (46041.3 Kg) were higher than the mean monthly leaves supply quantities (39383.75 Kg) from April 2021 to March 2022 and there was a statically significant difference ($P<0.05$) of the mean monthly leave supply in these two time periods. From April 2020 to March 2021 monthly supply of tea leaves quantities gradually increased up to December 2020 and then fluctuated. From April 2021 to March 2022 monthly supply of tea leaves quantities gradually decreased up to December 202l and then fluctuated. The Higher differences in monthly fresh tea leaves supply of two periods were observed from October to December each year. Prior to

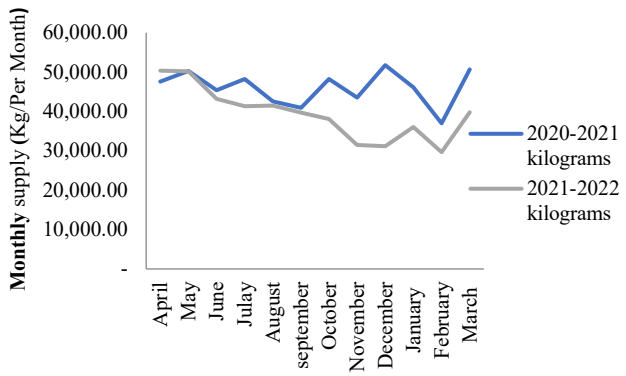

Figure 1. Impact of banning Agro-chemical onmonthly fresh tea leaves supply in two periods(Mean±SEM,n=12)

the implementation of the banning policy, the supply of fresh tea leaves to the factories was at an optimum level in the years 2020 and 2021. According to the previous analysis [5]. the absence of chemical fertilizer would drastically reduce the productivity of the Vegetative Propagated Tea with a 35 percent productivity drop.

Table 1. Kilograms per month production of processed tea (before chemical banning: from April 2020 to March 2021 and after chemical banning: from April 2021 to March 2022)

Month	kg/month (2020-2021)	kg/month (2021-2022)
April	48207	51302
May	49247	50378
June	47302	45445
July	48246	44151
August	46566	43045
September	42012	43019
October	53262	41782
November	49465	33292
December	58295	35717
January	51242	40668
February	40834	32251
March	55684	41613

Furthermore, the mean monthly factory tea production quantities (49196.8Kg) from April 2020 to March 2021 were higher than the mean monthly leaves supply quantities (41888.5Kg) from April 2021 to March 2022. Tea production difference between the two time periods showed a statically significant difference. From April 2020 to March 2021 monthly factory tea production quantities gradually increased up to December 2020 and then fluctuated. From April 2021 to March 2022 monthly tea production of the tea factory quantities gradually decreased up to December 202l. The Higher differences in monthly tea production of the tea factory in two periods were observed from October to December in each year. Analyzing the data on monthly green leaf supply and monthly tea production, it appears that there is a relationship between the two variables.

IV.Conclusions

This study showed that the Agro chemical importation banning policy has a significant impact on Smallholders' tea production and processed tea production due to the fresh leaves supply reduction. Therefore, the banning policy has a considerable impact on the low-country tea industry in Sri Lanka.

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Detecting Trends from Accumulated Changes in the Prices of a Stock

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Abstract – The paper presents a method to segment a time series by using trends estimated on it, trends that are formed by peaks and troughs produced by runs of increments and decrements. Each run measures the relative change produced by accumulating the increments or decrements from the previous run. A time series of daily stock prices is used to demonstrate the method. A series of consecutive price changes in the increasing or decreasing direction constitutes a run in the prices. In this view a run is broken when prices are repeated. Runs of price increases or decreases is used to estimate an increasing or decreasing trend in the prices. The trend is estimated between two points in the time series and relates the amount of accumulated change between the points to the number of data points between them.

The main contributions of the paper include a method to estimate the amount of linear change between the two points by using this accumulated change between two points in time. The linear change between the two points corresponds to an estimate of the average change in prices at each price change. A trend estimated over such runs in the prices also provides an estimate for the rate of return. It also provides an estimate for the average rate over time at which the prices rise or fall. The method also detects the size of a relative change in direction in the time series. This model of the trend is used to segment a time series of stock prices by detecting changes in the trend.

It serves as visual means to trade in the stock by providing information about the persistence of a series of price rises or falls, the relative size of each rise, fall or trend, the time interval of the trend and the rate at which trends change.

Keywords: Information, risk, volatility, trend, rate of return

I. INTRODUCTION

The paper develops a model of a trend that is used to segment a time series of stock prices. It also detects and measures a rising trend with rising peaks and troughs or falling trend with decreasing peaks and troughs. It detects changes in the trend by estimating the relative magnitude of a rise or fall in prices, an estimate for its steepness and the interval over the change.

Changes in this measure of the trend and the frequency of its changes can be used to generate signals to trade by observing past trends, measuring the relative steepness in the rises and falls in the prices, the variations in the trend and its period. It is a measure of variation in the variation in the prices or the time dependence of the volatility and its persistence over time.

II. A VISUAL MEASURE OF A TREND

Figure 1 depicts an example of a random walk. A segment where the accumulated changes are positive. It is used to illustrate the methods developed to detect trends and changes in trends in the time series.

Trends are detected by accumulating the changes in the data points over the period of the trend. In this view a trend is a series of increments or decrements. Those changes need not be linear. A difference between two points in the series can be used to estimate a linear trend where the changes are an average over the changes observed in that interval.

Each run measures the relative change produced by accumulating the increment or decrement from the previous run. The runs of increments and decrements can be depicted separately as in Figure 2. Each run is depicted as a vertical stem giving the accumulated change in the increasing or decreasing direction from the previous run. The time interval of the run is estimated by the separation between the trends.

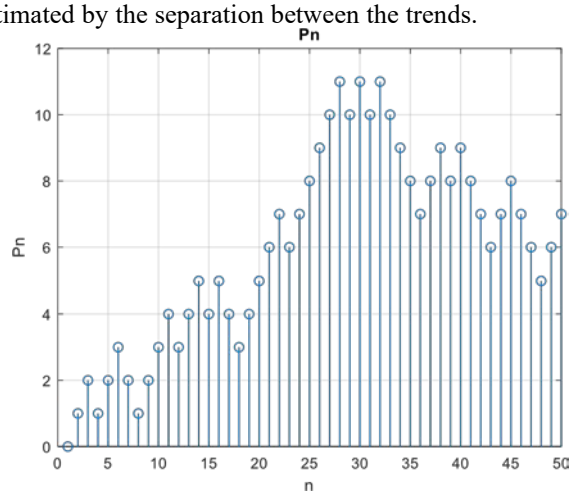

Figure 1. Random walk example of a random process

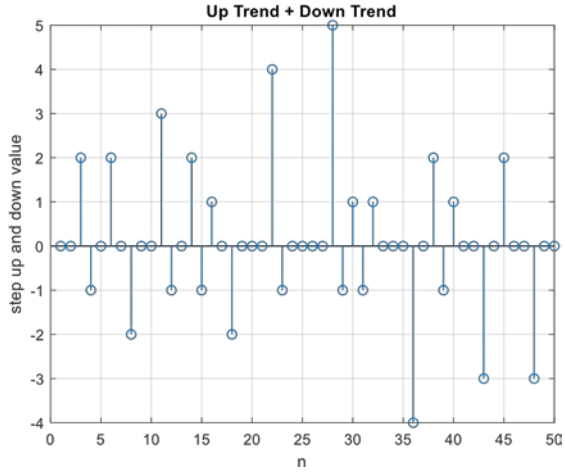

Figure 2. Accumulated changes in runs of increments and decrements

The runs in either direction can be combined over an interval to produce a series of data points that increase and decrease representing peaks and troughs observed over the interval. An interval defined by two points capturing the peaks and troughs over the interval of observation also forms a trend.

In the example of Figure 1, a trend is observed between data points 23 and 28. Another trend is observed between data points 18 and 22. These trends are depicted as stems of value 5 at n = 28 and 4 at n = 22 in Figure 2. These two trends can be combined to form a trend over a longer interval from n = 18 to n = 28 as observed in Figure 1.

When considering the trend defined by a line drawn between data points 18 and 28, the data point at n = 22 breaks the trend in to two segments.

The decision to join two adjacent trends to form a trend over a longer interval can be made by considering the incremental change in variation in the data points when one trend is merged with an adjacent trend to form a longer trend.

In this view, a linear trend is formed when the first differences in the series are equal, and the data points are evenly spaced in time. The variation in the first differences can be measured with respect to the mean of the first differences over an interval to estimate how well the data points form a linear trend.

This measure does not show each incremental change in either direction but can be used to assess the number of changes in direction over an interval.

Merging Trends over adjacent intervals

Trends can be merged to form a trend of longer length by accumulating the runs depicted in Figure 2 over a window. For example, a longer trend can be formed by accumulating the runs over a window formed over the interval [18, 28]. The change in value over the interval is 11 – 3 = 8, the change over the time axis is 28 – 18 = 10. The rate of change is 8/10 and the angle formed is 38.7 degrees.

The angle provides a measure of the steepness in the rise or fall between two points selected to define the trend. This is measure of the relative change between two data points in the time series including those intervening points where the changes can be both positive or negative.

III. DETECTING TRENDS AND CHANGES IN TREND

An interval of 100 consecutive days are selected from a 10 year period 2010 to 2020 of daily oil prices, depicted in Figure 3. It is intended to demonstrate the application of the method on traded oil prices.

Figure 4 captures the changes in trend in oil prices depicted in Figure 3 and shows the change in the accumulated change in the increasing and decreasing direction at the points where the trend changes direction. The peak at n = 11 demarcates a point where the trend changes direction after a series of price increases over the preceding interval [1,9]. The negative peak at n = 59 demarcates a point where the trend changes direction after a series of price decreases. Similarly, a peak can be demarcated between the negative peaks at n = 45 and n = 59 produced by the accumulated changes in prices between them. The peak at n = 59 is evidence of a series of price decreases over a relatively short time interval, a rapid decline in prices a measure of the time dependence in risk or change in volatility. The interval between the two points in time 48 days apart show periods of price increases and decreases where the trends are over shorter time scales. It shows the frequency at which the trend changes direction and the magnitude of the change in a direction. It can be used to estimate an average rate of price rise or fall over an interval. Its also a measure of the time variation in the volatility.

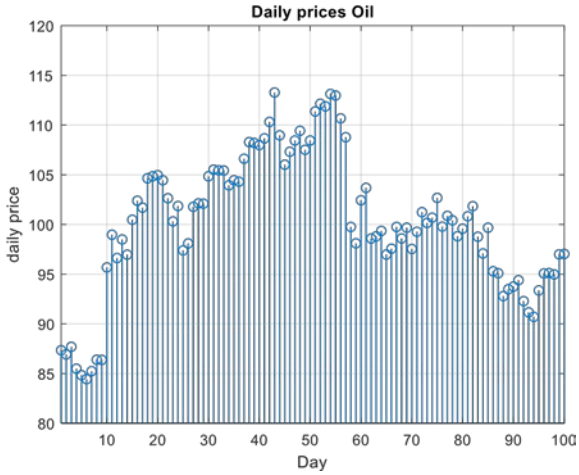

Figure 3. Daily Oil prices (USD)

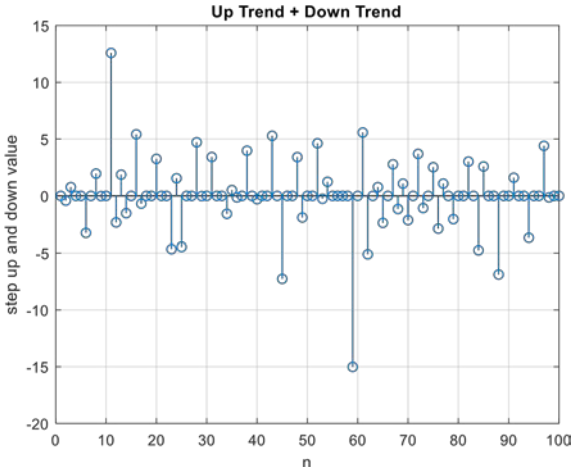

Figure 4. Trends and changes in trend in daily oil prices

IV. CONCLUSIONS

The paper developed a visual method to provide information about the direction of the trends and the variation in the trends in a time series of stock prices. It also provides a visual estimate of the time variation in the volatility in the prices and its clustering and the degree to which price trends vary over time. This visual method provides signals to trade by observing past trends and changes in the direction of the trend. It also provides information about periods of consecutive price rises and declines and of the periods where there is uncertainty in the direction of the trend.

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Loan Default Detection with Real-World Existing Imbalanced Financial Data

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Abstract - Credit payments are sure a hassle-free way to live life but also introduce some degree of uncertainty with regards to repayments. More banks and non-banking financial institutions are focusing on methods to predict defaults effectively. Default detection makes a strong use case in Supervised Machine Learning. The aim of this research paper is to evaluate multiple Machine Learning models like SVM classifier,Decision Trees, Logistic Regression, Ensemble Method LightGBM and ANNs. Real-world data has been used in the training process of the above-said models implying it is severely imbalanced. Multiple sampling techniques have been used to train and evaluate the models like under-sampling, over-sampling, and SMOTE. Multiple metrics were used to evaluate the effectiveness of the models and a high degree of over-fitting was observed. AUC-ROC Score was used for evaluation to get a clearer picture.

Keywords: Default detection, Supervised Machine Learning, Sampling, SMOTE

I. INTRODUCTION

Credit Cards have made it easier for one to make transactions based on credit with the ability to pay later, or in easy monthly installments. With the emergence of easier and hassle-free credit options and an increase in the number of non-banking financial institutions, these services are now also available to the common man. Common man, however, is susceptible to making impulsive decisions.[8][9]

As of January of 2020, before the pandemic, a study by Slickdeals, a crowd-sourced shopping platform, showed that an Americans spent $155.03 on impulse purchases on average each month. In another poll conducted in April, during the pandemic, there was an increase in that number by 18% as itjumped to $182.98. [10][11]

This research aims to evaluate multiple classifiers like SVM, Logistic Regression, Ensemble Methods like LightGBM, Decision Trees and ANNs to obtain a classifier that performs the best at the binary classification of defaulted cases.[4-6]

Forecasting of financial time series has been proven to be effective using these models [3].

The data comes from reliable agencies like the Credit Bureau and contains the credit history of both defaulters and non-defaulters making our task a binary classification problem. Due to the nature of the data, it is imperative that the data will contain empty column entries and would have a class imbalance as there are more non-defaulters in the world than defaulters.[14][15]

Hence, the data would need to be handled to mitigate these problems before modeling. In addition to improving loan evaluation based on credit history, our research will be of great value to banks and NBFCs.

II. LITERATURE REVIEW

It is biased to favor the majority class when data are class-imbalanced. Under-sampling and oversampling can attenuate the problem by producing class-balanced data. SMOTE has been investigated both theoretically and empirically in this paper using simulated and real high- dimensional data.[1]

Synthetic samples are generated through the SMOTE method, which can help mitigate class-imbalance issues. This study shows that SMOTE is not as effective on high-dimensional data, particularly in the cases where the signal-to-noise ratio is low, for the classifiers considered. [2]

[3] For regression and classification issues, Extremely Random Trees (ET) offers a tree-based ensemble method. ET trains the tree using the whole training set, instead of using bagging as in Random Forest. The main benefit of ET algorithm is the computation efficiency and its robustness. This algorithm is used as the basis for our proposed method.

[4] The article provided a method based on k-means SMOTE and back propagation neural networks. It tries to provide a solution for unbalanced financial information related to credit card data. The SMOTE algorithm improved version helps to solve this issue.

III. DATASETS

The datasets such as application_train.csv, bureau.csv, bureau_balance.csv, POS_CASH_balance.csv, credit_card_balance.csv, previous_application.csv, installments_payments.csv, HomeCredit_columns_description.csv are used in this work.

IV. METHODOLOGY

In the first phase, data was cleaned and multiple data engineering techniques were used. The data contained a high number of empty values. Due to data being in abundance, empty rows were dropped.

After cleaning the data, it was checked for class imbalance. This class imbalance was handled by using two techniques: Under-sampling and SMOTE (Synthetic Minority Oversampling Technique. [14]

The classifiers trained on these training sets were SVM, Decision Trees, Logistic Regression, LightGBM, ANN

The neural network had the following architecture: Dense(100,activation='relu'),Dropout(0.2), Dense(50,activation='relu'),Dense(1,activation='sigmoid')

V. RESULTS

A.Accuracy score

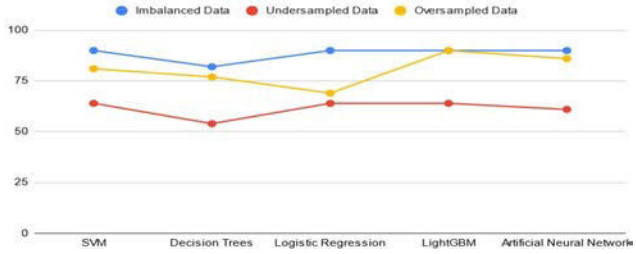

Fig. 1 Accuracy of the classifiers

B.AUC-ROC curve

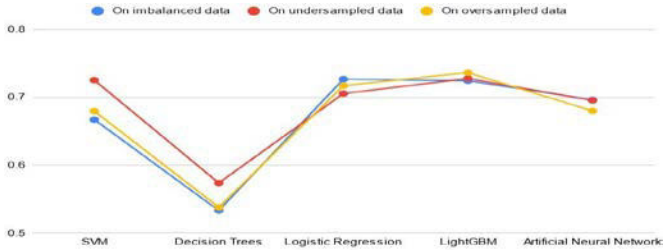

Fig. 2 AUC-ROC curve

The Light GBM classifier did a better job, it can not be ruled out that the classifier output was nowhere close to good by today's standards and business expectations.

VI. CONCLUSION

All of these modeling techniques are far from being perfect, as they; evidently, provide us with only half of the picture, giving us a weak estimate of a borrower's ability to repay his/her loan. However, more models like ARIMA can be used for financial data modeling they are reliable and are actively used by financial analysts all over the world to model and analyze the market and predict stock price patterns.

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Relevance and Importance of Cyber Diplomacy for Developing Countries

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Abstract - Modern societies, economies, and critical infrastructures of every country and organization are largely dependent on computer networks and information. The exponential growth of the Internet and its use by various emerging technologies such as social media, cloud computing, and smartphone technology has led to significant growth of cyber-attack incidents often with disastrous consequences. Forbes magazine reported that global cyber security crime in 2017 cost an estimated 1 trillion US dollars which are expected to increase to 6 trillion US dollars by 2021. Individual countries' efforts to ensure cyber security have been in existence for many years but it is difficult for national laws and policies to address global cyber security problems sufficiently. Therefore, experts have recommended Cyber Diplomacy as a way of combating global cyber threats. This paper addresses the current status of cyber diplomacy at the global level; cyber diplomacy policies and practices in developing/small countries; the relevance and importance of cyber diplomacy to developing/small countries, and cyber diplomacy models and practices suitable for such countries. Our analysis and conclusion are based on a comprehensive survey of the literature (journal articles, conference proceedings, and industry publications), industry and consultant white papers, expert opinion papers, and bilateral and multilateral agreements. Our Preliminary findings indicate that there is a need for cyber security at the global level and hence the value of cyber diplomacy even in developing countries. In cyber diplomacy, small states show a preference for engaging in dialogues among multilateral organizations with varying policies dependent on domestic conditions.

Keywords: Cyber security. Cyber diplomacy. Developing countries

I. INTRODUCTION

Modern societies, economies, and critical infrastructures of every country and organization are largely dependent on computer networks and information. The exponential growth of the Internet and its use by various emerging technologies such as social media, cloud computing, and smartphone technology has led to significant growth of cyber-attack incidents often with disastrous consequences. Common tools used by these attackers include malware, ransomware, phishing, SQL injection, cross-site scripting, service denial, MITM attacks, and session hijackings. Forbes magazine reported that global cyber security crime in 2017 cost an estimated 1 trillion US dollars which is expected to increase to 6 trillion US dollars by 2021. These global cyber-attacks are driven by financial and political motives.

The increasing threats in cyberspace have triggered discussions on the best strategies for combating these threats and safeguarding data and information stored in electronic platforms. This field is called Cyber Security. Individual countries' efforts to ensure cyber security have been in existence for many years. In the early days, individual country efforts to ensure cyber security were implemented in financial and health care institutions in some countries. A good example is the United States of America (USA). In the USA, The Health Insurance Portability and Accountability Act (HIPAA) of 1996 established national standards to protect individuals' medical records and other individually identifiable health information ("protected health information"). Similarly, in the USA, The Gramm-Leach-Bliley Act (1999) requires financial institutions to safeguard customer-sensitive financial data.

However, in recent times, the need to understand cyber security strategies at the international level has been recognized. Modern cyberspace involves multiple countries, making it difficult for national laws and policies, which differ by country, to address the problem sufficiently. Therefore, experts have recommended several strategies, including diplomacy, as a way of combating cyber threats. This field known as *Cyber Diplomacy* leads to cyber security agreements between two countries (bilateral) or multiple countries (multilateral). Diplomacy is the attempt to adjust conflicting interests of countries (referred to as "States" in international relations) by negotiation and compromise. Such negotiations result in understandings (such as Memorandum of Understandings or MOUs) and formal agreements. Cyber Diplomacy, therefore**,** is the evolution of diplomatic activities to tackle cyber security issues in the modern digital age.

In international relations and diplomacy, developing countries are sometimes referred to as "small

countries" or "small states". In this paper, we will use these three terms interchangeably. Small states are an integral and important part of the international order. About two-thirds of United Nations members fall into this category. They operate in the same broad political and economic environment as all other states. In their foreign policy, they pursue the same objectives of security, prosperity, and well-being of their citizens. Cyber security at the international level is a concern for small countries/states as well. Therefore, attention has been paid in recent times, to the importance of small states also engaging in cyber diplomacy.

There is a wide body of theories and knowledge on how foreign policy and relations, and diplomacy in general, apply to small states. It is generally assumed that because of the different international contexts in which small and large states operate, their foreign policies will reflect different sets of constraints. Therefore, it is reasonable to assume that the objectives and conduct of cyber diplomacy in developing or small states will be different from the general international level cyber diplomacy objectives and practices.

II. Materials and Methods

Research questions this paper will address are: (1) What is the current status of cyber diplomacy at the global level? (2) What is the current status of cyber diplomacy policies and practices in developing/small countries? (3) What is the relevance and importance of cyber diplomacy to developing/small countries, and what cyber diplomacy policies, models and practices should such countries adopt?

Our analysis of, and conclusion on, these research questions will be based on a comprehensive survey of the literature (journals articles, conference proceedings, and industry publications), industry and consultant white papers, expert opinion papers, bi-lateral and multilateral MOUs and agreements, and legal reviews related to cyber diplomacy.

III. Results and Discussion

Our Preliminary findings include the following:

(1) There is a strong understanding across the world that governments and industries must work together to tackle cyber security at the global level.

(2) There seems to be a consensus that early warning of new threats is vital, and that continuous monitoring has emerged as the principal viable approach for dealing with cyber security on a global scale. This shows the value in cyber diplomacy at the global level to build global coalitions.

(3) A handful of bilateral and multi-lateral cyber security agreements are in place. These include a cyber security treaty between China and Russia, an African Union treaty ("African Union Convention on Cyber Security and Personal Data Protection."), the Shanghai Cooperation Organization Security,", NATO's "Enhanced Cyber Defense Policy", and The United States and China MOU on timely responses to malicious cyber activities.

There is evidence that developing countries are also subject to international-level cyber security threats. This is due to a lack of surveillance capabilities, unsecured networks, a lack of cyber regulations, and a shortage of ICT security knowledge and capabilities.

(5) Cyber diplomacy is an inevitable tool for less-capable states in the twenty-first century.

(6) In cyber diplomacy, small states show a preference for engaging in dialogues among multilateral organizations because they reduce the power asymmetry between states, decrease the transaction costs of diplomacy, and impose constraints on large states. Small state security policies vary widely depending on domestic and international conditions.

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Track 5

Innovative Education

Student Perception on Online Flipped Classroom in Engineering: A Case Study of Thermodynamics

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Abstract – Flipped classroom pedagogical approach was adopted to teach the thermal sciences module in the second-year electrical engineering curriculum of the University of Moratuwa. All the core teaching materials for each topic were provided in video format. Formative assessments were conducted for each sub-topic, covered in a video, to assess the level of learning. Synchronous learning was facilitated via Zoom each week. Asynchronous learning of the self-learning material was facilitated through the University adapted standard Learning Management System (Moodle). Student perception of their learning experience was surveyed through a questionnaire distributed as a Google Form. The surveyed students were in good agreement on the positive impact of flipped classroom approach on their deep learning, mastering learning through self-paced learning, and lifelong learning. However, they have perceived the workload of the module as high due to weekly formative assessments. Nevertheless, their mean likelihood of recommending flipped classroom approach for other modules was 8.45, where the value of 10 reflects highly likely, and 0 reflects least likely.

Keywords: engineering education, mastery learning, deep-learning, lifelong-learning, flipped classroom

I. INTRODUCTION

The effectiveness of flipped classroom pedagogy has been researched in different subject domains. Karabulut-Ilgu, *et al* [1] present a comprehensive review of literature on these prior works. Due to a lack of research in the engineering/ technical domains, a key recommendation in this review is to research the suitability of flipped classrooms in engineering. This study attempted to fill this gap.

Basic Thermal Sciences and Applications is a three-credit module offered by the Department of Mechanical Engineering to Electrical Engineering undergraduates in their fourth semester. The module largely covers engineering thermodynamics and their applications with little exposure to heat transfer. The author is the sole examiner and the lecturer of the module. Due to social distancing restrictions imposed under the COVID19 pandemic, all synchronous lectures were conducted online via the Zoom platform. The following sections describe and discuss the methodology and the survey responses on student perception of their learning experience in a flipped classroom.

II. MATERIALS AND METHODS

A. Video Lesson Making

Video lessons were created for each topic of the module. Generally, the content of one video lesson covered the content that could typically be covered in a two-hour slot in conventional delivery. Thus, smaller topics required only one video and broader ones required a series of episodes of video lessons. For each broader topic, an introductory video was also created to provide an overview of the topic creating the big picture. The duration of an introductory video was between 5 to 10 minutes while a video covering a two-hour lecture content usually varied from 20 to 50 minutes.

The video creation phase was the most time-consuming stage mainly because the author, who did it alone, is not an expert in video editing. Nevertheless, the videos were in high quality as perceived by the students. Doodly software and Microsoft PowerPoint were used to create cartoon-animated videos and presentation slides. The lecturer does not appear on videos. A Nikon D32 DSLR camera was used to record voice because the sound quality of the laptop used was low. BOYA® BY-WM4 Mark II wireless microphone, connected to the camera, was used to record. This helped record the voice clearly without requiring the presenter to speak unusually loud. Flashback Express free screen recorder captured the screen when PowerPoint slides were presented. The free version of DaVinci Resolve 16 was the video editing software used. The free version of Flixpress, a web-based video creation tool, was used to create an animated title segment for each video lesson. Royalty-free music downloaded from the web was incorporated at 30% of the full volume to provide background music in each video. A script guided the presentation delivery to ensure it was smooth enough for a recorded video.

B. Flipped Classroom Design

The module had three hours of lectures per week on the timetable over the semester. Moodle was the Learning Management System (LMS) used to set up the module online. Video lessons relevant to a topic were added to LMS allowing approximately three days for students to complete their self-learning of the material. The three-day duration was a practical constraint because videos were prepared while the semester was going on, and it took nearly 13 hours to complete one video. Formative assessment was also provided, for each video lesson, in the form of a quiz on Moodle. The quizzes mostly contained a collection of multiple-choice questions (MCQ), gap-filling, and short answer types. They mainly aimed at judging the degree of the attainability of low-order learning, such as understanding and applying the concepts to simple problems. In addition, one essential question in each quiz was to list the three most confusing aspects of the content (if a student had such) or any other specific questions they have on the content. Participation in the formative assessment was compulsory and the deadline of completion was usually set several hours before the lecture slot allowing the lecturer to review the answers.

The lecturer (the author) scrutinized the responses giving high priority to any specific questions raised by students and on the indicated most confusing sections. The responses to this question were grouped based on their contextual similarity to improve response efficiency. Responses to MCQ and short answer questions were scrutinized to identify common gaps in understanding and application.

Every lecture (synchronous learning session) via Zoom was in the form of a discussion rather than a conventional lecture. The lecturer first focused rectify any poor performances identified in understanding and applications revealed through MCQ and short answer questions.

Then, the discussion led to responding to any questions students raised during the discussion as well as in the quiz. Finally, any common confusing sections, as indicated by students, were further clarified. Any unique issues that could

not be put into common groups in the grouping were dealt with individually at the end of the discussion. After completing all major issues, the discussions were then directed toward the high-order learning domain. The higher-order learning process consisted of an appropriate mixture of discussion of a complex problem, linking the learning to the industry standards and global developments such as SDG, climate change, etc. Usually, the discussions spanned over more than one lecture slot depending on the time allocated per topic in the lecture plan.

C. *Survey Method*

The survey had seven questions focused on different aspects where the first six questions were MCQ type containing six choices to select one from (i) Strongly Disagree, (ii) Disagree, (iii) Neutral, (iv) Agree, and (v) Strongly Agree. The last question asked about students' likelihood of recommending flipped classroom approach for other modules of their course. The response was collected on a point scale from 0 to 10 where the value of 10 reflects highly likely, and 0 reflects least likely.

The survey questions were set up on a Google Form as an anonymous survey. The target population was the final year electrical engineering undergraduates (N=100) who followed this module in their second year of study. The field representative (the group leader) distributed the questionnaire via their informal WhatsApp group. The field representative sent three reminders to students to participate in the survey. The lecturer made one request from students to participate in the survey via a Moodle message. No further attempts were made to increase the participation as that would yield distorted responses due to pressure.

III. Results and Disucssion

Out of the population of 100 students, 53 responded to the survey. Since the survey was done one academic year after the participants followed the module, the responses could be considered as deep-rooted perceptions which were not influenced by the excitement (positive or negative) of the new learning experience. The degrees of freedom of 53 participants could sufficiently converge the responses to a normal distribution. According to equation (1), a sample size of 53 for a population of 100 yields an approximate confidence interval of 91%.

$$n = \frac{NZ^2}{Z^2 + 4Ne^2} \qquad \cdots\cdots\cdots (1)$$

where n is the sample size, N is the population size, Z is the Z-score at the given confidence interval, and e is the margin of error[1].

As shown in Fig. 1, 96.2% of participants are in agreement (agree or strongly agree) with the fact that flipped classroom approach facilitated deep learning. Meanwhile, 98.1% confirm that video-recorded lessons facilitated self-paced learning. However, while 81.1% strongly agree with the facilitation of self-paced learning, only 50.9% strongly agree with its support for deep learning. Meanwhile, student performance records show that only 56.3% of students had scored over 65 marks for the module. According to the assessment design, to earn 65 or over, a student must have undergone some level of deep learning. Thus, the responses show that even if a student could not experience deep learning, the approach has facilitated their self-paced learning. In response to lifelong learning, 92.5% have, at least, agreed that flipped classroom approach facilitated it. Workload due to formative assessment appears to be the cost they had to pay for the advantages they gained, where 56.6% of them at least agreed that the workload had increased. However, compared to the higher agreement with the positive aspects, this proportion is relatively small. This may indicate that benefits may have outperformed the costs. Meanwhile, 28.3% of the students have not felt any difference in the module workload. Perhaps, the effort that would be put into last-minute exam preparation might have been reduced due to the smooth progression of the module. Students' response to their likelihood of recommending flipped classroom approach for their other modules has an average rating of 8.45 out of 10 where one student rated 5, 9 students rated 7 and 10 each, and 16 and 18 students rated 8 and 9, respectively. Despite the little concern about the workload, the students still prefer to experience flipped classroom approach for their other modules.

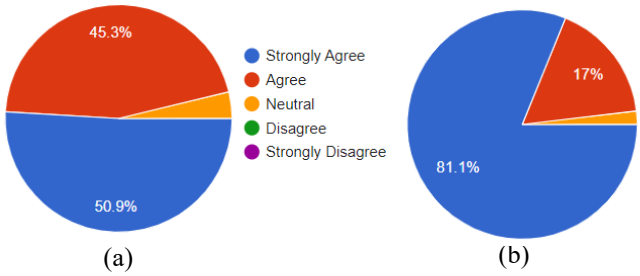

Fig. 1 (a) facilitation of deep-learning and (b) facilitation of self-paced learning

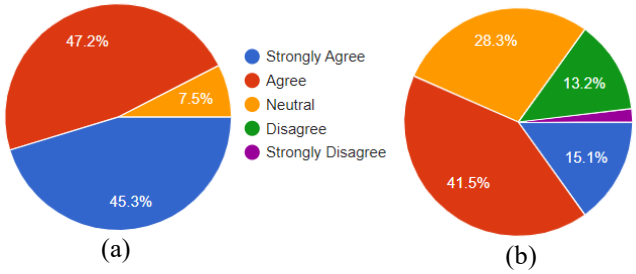

Fig. 2 (a) facilitation of lifelong-learning and (b) increase of overall workload of the module

IV. Conclusions

This study proves that the generic advantages of the flipped classroom approach are equally valid for highly technical and practical subjects like engineering thermodynamics. Also, the equal validity of the advantages in an online delivery setup is proven. The students were in very strongly agree that the approach facilitated their self-paced learning and a great agreement with its support for deep learning. Student agreement with the facilitation of lifelong learning is also very high. These aspects are essential attributes of a modern-day engineer as identified by the Washington Accord and other multinational bodies. Therefore, the wider adoption of modern pedagogical approaches like flipped classroom teaching should be seriously considered by faculties.

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Parents' and Students' Perceptions of the Education System of Sri Lanka

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Abstract - Twenty-first-century skills such as critical thinking, communication, collaboration, and creativity, are widely accepted as skills in high demand within modern working environments. National school curricula reforms in Sri Lanka attempt to propose pedagogies that disseminate content and design assessments to promote twenty-first-century skills. However, whether all stakeholders of the national school education agree to include such skills should be investigated before changes to curricula, policies and practices are implemented. The purpose of this study is to survey the perceptions of the main stakeholders of the national education system in Sri Lanka. The perceptions of parents, and students were investigated in this study. Seventeen (17) participants including nine (09) parents; three (03) school students, and five (05) vocational/degree level students) representing different social and educational backgrounds participated in the study. A standardized, semi-structured, open-ended questionnaire was conducted through virtual meeting mode. The 'Naturalized' transcription method was adopted in this study. Open coding of data revealed that more than 80% of the participants exhibited awareness of global 'good' practices and believed in the vital need for a change of policy and/or practice within the existing system. In addition, the participants expressed the need to improve students' emotional and attitudinal aspects within school setups. Interestingly some highlighted the need to consider external and control factors affecting policy/practice changes in education.

Keywords: Global 'good' practices, Stakeholder Perceptions, Education reform

I. Introduction

More than one-third of the institutions in the Sri Lankan labour market have mentioned team working, oral communication, and the ability to take initiative as essential skills to be improved [1]. Hence, it could be argued that there is a lack of attention to improving such skills within school setups. First jobseekers from higher educational setups have reportedly possessed poor attitudes, personalities, and motivation [1]. When considering the preparedness of the first job seekers, irrespective of them coming from secondary school, vocational/technical institutes, universities/any other higher education setup; very close to 50% from each category were found to be possessing either average/poor/very poor conditions in preparedness [1]. This is undoubtedly an alarming situation forcing the stakeholders, especially the policy-making institutions to rethink the entire education system of Sri Lanka. Many reports on Sri Lankan labour market and human capital formation suggest the requirement to address the gaps existing within education and skill training [1]. The Sri Lankan education system is reportedly facing a challenge to improve quality and real-world relevance [1]. The rapidly changing world economy demands skilled employees whereas the education system is not producing them which creates a mismatch that requires immediate attention. This mismatch makes finding employment difficult for the younger generation coming out of the education system. Although the overall unemployment rate has dropped from 4.7% in 2015 to 4.4% in 2016, the unemployment rate of young people had increased from 20.8% to 21.6%. Among those with educational qualifications equal to and above G. C. E. Advanced Levels have shown higher rates of unemployment (32.5%) compared to the ones with G. C. E. Ordinary Level qualification [2]. Sri Lanka has also reported providing poor quality education in Science and Mathematics fields [3]. Overburdening students with a massive content load with minimal utilization of student-centered activities is seen as the cause of low-quality education in Science and Mathematics [3]. Even though school curricula have been revised multiple times in the past few decades, little or no change can be observed in the quality of the school leavers [3]. Hence it could be argued that curriculum and policy changes targeted at enhancing educational outcomes have not yielded the expected results. The objective of this study is to understand the perceptions of all stakeholders of the national school education of Sri Lanka, prior to any reform recommendation. This is to ensure effective implementation avoiding the repetition of yet another reform.

II. Methodology

The interview guide was prepared considering the aim of the study. Standardized semi-structured open-ended questioning with 'probing' questions and 'interpreting questions' were used after obtaining approval from an ethical committee. It was conducted via ZOOM. Participants' written informed consent, sharing information about beneficence, do no harm, confidentiality, and anonymity were carefully thought out and implemented relating to all interviews. Before the study, strategies for organizing, storing, backup maintenance, and disposal of all data collected were planned. Positive dynamics such as encouraging gestures/words, reflecting remarks, probing, etc were maintained throughout the interviews. The same basic questions in the same order were asked. This phase rests in the interpretive paradigm with socially constructed ontology and epistemology recognizing multiple realities and agentic behaviours. Limitations such as the challenges of Covid, and the post-economic crisis in Sri Lanka, could have affected the design and the outcomes of the study. The context-bound and socially situated nature, researcher as the key instrument, data being descriptive, and respondent validated could have resulted in more validity [4]. Non-probable, purposive sampling method for 'fit-for-purpose' was employed for individual semi-structured interviews. They emphasized their uniqueness and intrinsic value. There were 17 participants representing parents and students from different social and educational backgrounds. Reflexive notes maintained were used during the interpretation of data and dissemination of findings. The 'Naturalized' transcribing-intelligent verbatim ' method was adopted as a fit-for-the-purpose. Transcripts and translations were shared with the participants for their confirmation after spot-checking and proofreading. Transcribed data are arranged in a tabular manner against the background information for each data set such as participant's background details including education level attained and social and demographic details. Reduced data was analysed repeatedly and then compared, conceptualized, and categorized using labels/codes derived from the transcribed data. Open coding was performed by adding a new text as a comment to describe and categorize the text of interest. That generated the

categories. The first level of individual analysis resulted in the coherence and integrity of that individual. The second level of analysis identified themes.

III. RESULTS

Some participants had dual roles which could have had an impact on their perceptions. Their education levels varied from O/L, A/L, first degrees, and above. Further, they represented social groups of the lower, middle, and upper-class families of Sri Lanka representing rural and urban demographic areas. Out of 9 parents, 5 were female participants and out of 8 students, 4 were female participants. All parents were from an age group of 30-45 years and adult students were from an age group of 20- 30 years. Transcripts are analysed to understand their perception of the existing education system of the country and their awareness of global practices. Their idea about adapting such attributes within our system was also encouraged to be discussed. Three main categories were identified. More than 80% of the participants had an 'unsatisfied' tone embedded in their discussion containing more than 90% of ideas criticizing or claiming for change regarding the current education system rating it 'Bad or needing to be changed. This group consisted mainly of parents and students with vocational/degrees and above educational statuses. All of them had awareness of global practices and believed in the requirement of integrating such into the Sri Lankan system. However, they hardly considered the need of considering the local conditions when commenting on the suitability of such practices. School students had either mixed or satisfied tones embedded within their discussions. However, at some points, they shared contradicting statements during their discussions. They had very limited knowledge about global practices and did not feel confident discussing their ideas related to that.

Table 1. Selected quotes -Perceptions of the existing education system and awareness of global practices

Unsatisfied Awareness of global practices	"Creativity is least encouraged in our education system. Kids are forced to follow instructions by exactly copying what their teachers would write with a piece of chalk on the board'-A parent with A/Ls 'We have learned a good deal of physics, chemistry, etc. But we have not applied the knowledge or used it in a way it creates an income."- A parent with a degree qualification "I believe our education system needs to change into a skill-based approach."-A parent with a PhD "In other countries, students work in groups connected with society and practice collaborative group work throughout their education. But in our country, it is limited to very young age and slowly it diminishes and students become more self-centered and individual target oriented. This needs to be changed for good."- A parent with a degree qualification
Satisfied Unaware of global practices	"Our teachers are teaching us well and all things are fine and we are very happy to go to school."-A/L Student "Our teachers are putting their maximum effort and doing us the favour of educating us. If we don't get the benefit out of it, it's our problem. Maybe we should try hard and study more and more."-O/L Student "I think I have heard…but I don't know much to talk about it…I am not sure."-O/L Student

IV. CONCLUSION

The trend of expressing more 'negative' comments about the existing education system alarms us about the requirement to understand the mindsets of the stakeholders holistically. Effects of decolonization could have played a role here. They also claim special attention to inculcating affective/emotional and attitudinal growth within students to shape them into holistic individuals. Hence, these could be a few areas where detailed expertise contributions are required before any educational reform. Few participants highlighted the importance of psychological stimulations to result in meaningful learning while motivating them intrinsically. It was depicted that stakeholders believed the Sri Lankan education system to be highly complex as it is affected by governing political bodies. Looking at factors such as parental influence, the impact of tuition, demand from the industry-private and state, students' preferences, administrative challenges, and resource inequalities as highlighted by some of the participants could indicate comparatively high stakeholder dependence across the system. Their ideas about its values and purpose and how financial, health, welfare, etc., could affect the policy of education could also be decisive factors within a wider context. The recent economic crisis and its influence could be a good example to look at. However, a wider study including other stakeholders such as teachers, industrialists, and academic administrators as well could provide a better insight into this. It is planned as future work. Sound analysis of the recognized problem using domestic and international research prior to determining and application of the solution is noted as mandatory in education reform. Several cycles of monitoring and implementation of improvement strategies are known to effectively end the 'Cycle of planned failure' in a reform. Therefore, a comprehensive analysis could be recommended to avoid rushing into premature actions. If not, the solution we propose could create opportunities for new problems due to a half-solved problem in the new context.

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Contextualizing and Infusing Gross National Happiness (GNH) Values Through Teaching Primary Schools Mathematics: Approaches and Relevancy

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Abstract-This paper presents approaches and relevancies of contextualizing and infusing GNH values through teaching primary schools Mathematics at Samtse, Bhutan. Teachers and principals of four primary schools were interviewed, classroom teachings were observed, and the relevant documents were studied. Findings confirmed contextualizing and infusion of core GNH values and higher degree GNH values are practiced depending on their suitability and feasibility; teachers` most persistent difficulties are how to contextualize GNH values in Mathematics lessons, and infuse the values through teachings; through teaching GNH values students` temptation towards unsocial activities and unreachable materials are reduced, on other hand their positive behaviours, openness, and being responsible are enhanced. This study is important for all because it provides significant insights: teaching GNH values promotes principles of GNH and holistic education and learners gain a deep understanding of common values and happiness. It also inculcates primarily required moral values and maintains peace and harmony in society. Although no demerits of teaching GNH values were reported, the resilience of practice of contextualizing and infusing GNH values through teaching Mathematics has been found weak.

Key words: GNH; contextualization; infusion; identify; approaches; relevancy

I. INTRODUCTION

In today`s world if we can balance materialistic developments and spiritual development then the coexistence of these developments in our life would provide us with more happiness. Education is one of the most powerful tools that helps people understand this "balance". Spirituality has positive effects on health, attitudes and behaviours in adolescent (Rew L and Wong YJ, 2006; Kub J and Solari-Twadell PA, 2013). Drukpa (2016) highlighted the review of Kesebir & Diener (2008) on Aristotle's quotation on happiness: happiness is the meaning and purpose of life, the whole aim and end of human existence. In a nation, it is unachievable to maintain happiness for every citizen, but it is possible to manage happiness for the majority of the population: Gross National Happiness (GNH).

The Gross National Product (GNP) is not for measuring the actual wellbeing (Gross National Happiness,2005) of people. The term `GNH` was first coined by the fourth King of Bhutan Jigme Singye Wangchuk in 1972 (Ura et al., 2012) for the happiness and well-being of Bhutanese people. Since then, in Bhutan, the concept of GNH has been followed as the main philosophy of socio-economic development. As this philosophy is flourishing in Bhutan, happiness is being realized promoted amongst Bhutanese people. As Ura et al.(2012a) maintained, `pursuit of happiness is collective effort`, happiness index of **GNH** concept is used to measure the collective happiness and well-being of people in Bhutan. Ura (2012) clearly states that GNH values are infused into different subjects including Mathematics. Thus, this study was conducted to explore approaches and relevancies of the practice of contextualizing and infusing GNH values in teaching Mathematics at PSs of Bhutan. This study was conducted in four primary schools located in Samtse district of Bhutan.

II. MATERIALS AND METHODS

We used interviews, lesson observations and the relevant documents to collect data on Mathematics contents, relevant GNH values, and appropriate approaches to contextualize and infuse the values in teachings Mathematics at the selected PSs. The randomly selected ten PS Mathematics teachers and three PS principals were interviewed, and eight PS Mathematics teachers teaching Mathematics lessons were observed. Since the PS students were not competent enough to face an interview, they were not interviewed. Consistency in the methods of data collection and the gender equity of the participants were maintained well.

Data collected from interviews were analyzed using the process of emerging themes. Data collected from lesson observations and the documents: textbooks, lesson plans and the GNH manual were analyzed using the content analysis approach.

Findings revealed from these sources were triangulated in order to get the most authenticated result.

III. Results and Discussion

Based on the theory of constructivism, this study was carried out successfully with an objective to explore approaches and relevancy in the practice of contextualizing and infusing GNH values through teaching Mathematics in the four selected PSs and also to see how resilient this practice was. Methods used were semi-structured interviews, lesson observations and documents analysis. Some distinguished findings as indicated from this study are:70% PS Mathematics curriculum are relevant for this practice; the types of GNH values reflected in the documents are 90% same as that revealed from interviews; PSs practice two categories of GNH values: Core GNH values and Higher degree GNH values; and there is a huge impact of infusion of GNH values in teaching at PSs if the practice is carried out properly. The impacts revealed are students` enhanced positive behaviours and openness, students being responsible and more interactive.

IV. Conclusion

This study was confined to only 4 PSs. The interviews were limited to the principals (3) and teachers (10), and 6 teachers` lessons observation since PS students were not competent enough to attend the interviews to perform the cross-sectional study. Since schools do not have standard tools to measure and assess the GNH values laden lessons, assessing students on teachings of GNH values is limited to observing and interviewing. Teachers need to be cautious that normally GNH values laden lessons take more time to complete, and also there is a danger of getting the lesson diluted and losing its original concept if more time is spent on GNH values. However, no demerits of infusion of GNH values in Mathematics lessons were reported.

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Transforming Indigenous Knowledge and Skills for Achieving Sustainable Business: Evidence from MSMEs in Nepal

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Abstract – This study aims to identify the factors responsible for the sustainability of the enterprise based on Indigenous Knowledge, Skills, and Resources (IKSaR). A questionnaire survey, Key Informant Interview, and case study method were used for this study. The findings show that adaptive enterprises that were based on the IKSaR were found to be more sustained in the ever-changing market and competitive business environment. The study also finds that family-based businesses passing through generations, being adaptive to improved technologies, having the courage and passion to bear risks, and avoiding quick returns were achieving sustainability in their business. The study also notes the urgency of integrating IKSaR with improved know-how and know-why to gain a sustained growth of enterprise in Nepal. The primary reason for such integration was the IKSaR-based strength of the Micro, Small, and Medium Enterprises (MSMEs). It is observed that the Government of Nepal's flagship programs such as the Micro Enterprise Development Programme (MEDEP), Micro Enterprise Development Program for Poverty Alleviation (MEDPA), and Youth and Small Entrepreneur Self Employment Fund (YSEF) also attempt to mobilize the IKSaR, promote an entrepreneurship culture, develop enterprises, generate employment, and alleviate poverty. However, the growth and sustainability of the enterprises based on IKSaR are still awaiting a major transformation.

Keywords: indigenous knowledge, skills, and resources; family-based business, business sustainability, improved technology

I. Introduction

Indigenous knowledge, skills, and resources (IKSaR) are considered as a driver of Micro, Small, and medium enterprises (MSMEs) in Nepal. Their use for enterprise development conserves the prevailing assets and paves way for the sustainability of enterprises. For the purpose of this study, sustainability refers to the growth, expansion, and continuation of existing business.

Since the formulation of the first national periodic plan in 1956, the Government of Nepal (GoN) has given priority to enterprise development, employment generation, poverty reduction, and the development of IKSaR. The priority of Nepal has always been on both the paths of developing indigenous skills and technology and the transfer of foreign technology as well [1]. The recent 15th five-year plan (2019/20-2023/24) also emphasizes the promotion, protection, and upgradation of IKSaR for increasing domestic production and promoting youth and women entrepreneurship [2]. In view of increasing employment, reducing poverty, and mobilization of local knowledge, skills, and resources, the GoN launched the Micro Enterprise Development Programme (MEDEP) in 1998. After implementing MEDEP for two decades, the GoN introduced Micro Enterprise Development Program for Poverty Alleviation (MEDPA) in 2018 as a flagship program under the Ministry of Industry, Commerce, and Supplies (MoICS) for sustainable micro-enterprise development. The program is being implemented at all 753 local levels across the country [3]. Similarly, the GoN has been implementing Youth and Small Entrepreneur Self Employment Fund (YSEF) and creating self-employment opportunities among youth through collateral-free business loans [4]. Eventually, the MoICS envisioned Growth Potential Enterprise Promotion Program (GPEPP) realizing the urgency of identifying and supporting growth potential enterprises.

Despite the deliberate and constant efforts of the government to promote IKSaR-based enterprises, substantial growth of the enterprises remains very limited. The study of the MEDEP/MEDPA evaluation report shows no significant growth of micro-enterprises [5]. This study aimed to uncover the factors responsible for the sustainability and growth of enterprises. It also attempted to explore the significance of technological adaptation for the sustainability of such enterprises.

II. Materials and Methods

The principal research method employed for this study was case studies. Out of nine case studies, three of them that were carried out with the enterprises that have been utilizing IKSaR and adapting contemporary technology for their business are presented in this study. Key Informant Interviews (KII) were conducted with concerned stakeholders working in the sector of entrepreneurship development. Besides, a questionnaire survey was carried out with those entrepreneurs who received support from the ISPs- MEDPA and YSEF, and with the entrepreneurs who did not receive support from any ISPs. In total, 384 entrepreneurs were surveyed. The sample size was calculated using the formula of W.G. Cochran (1977): *Sample size* $(n) = \frac{Z^2pq}{e^2} = 384.16$ where, z is 1.96 at 95% confidence level, p is the estimated proportion of the population, q is 1-p and e is margin of error.

III. Results and Discussion

The findings from the questionnaire survey of the study indicate that almost 69.6% of the enterprises are based on IKSaR. Almost half of them have been using more than 60% of such IKSaR in their enterprise, mainly in terms of raw materials and labor. The findings from interviews and case studies suggest that there is an upsurge of entrepreneurs who have been using IKSaR for enterprise development and income generation. As the government plans and programs are focused on promoting enterprises based on IKSaR, the number of such enterprises was eventually found to be increasing. However, the support from the government was very limited. The implementation of plans, policies and programs to promote such business were more limited to training and capacity-building programs for the entrepreneurs. The additional support required for the scaling up of the enterprise such as access to finance, market linkages, quality assurance mechanisms, intellectual property rights, and technology transfer was inadequate. Further, the case studies suggest that for the sustainability of an enterprise, transforming indigenous knowledge and skills with an adaptation of improved technology was pivotal. The following three cases reflect a few ground realities.

The first case study is about a couple from Rautahat District (Madhesh Province) who is engaged in livestock farming and selling milk to their local community, for generations. After receiving financial support from the ISP and ideas from the supply chain actors, the couple adopted a new technology- a Bulk Milk Cooler. The new technology adaptation integrated into their traditional skills and knowledge that has led to their business expansion, catering their milk supply even to the capital city. While, the similar livestock farming in that community, with no additional innovation in their business, is still limited to their local market.

The second case is a handicraft enterprise led by a lady from Kaski District (Gandaki Province) who acquired handicraft skills from her grandmother. The handicraft business was founded, based on intergenerational skills learned and extraordinary vision, and with an aim to employ and empower poor, vulnerable/marginalized women discriminated against in society. They use locally available resources and raw materials such as natural fiber and fruits to make their product. With the use and transfer of IKSaR, this enterprise has been able to transform the lives of hundreds of women while promoting locally hand-made products. Their handicrafts have made way not only to the domestic but also to the international market. The small organization that commenced with only three working women is now employing more than 600 women and has trained more than 18,000 girls and women. This case presents strong evidence of the transfer of technology and skills across and within generations, which has led to the sustainability of their business.

The third case is about a group of women from Banke District (Lumbini Province) who has utilized their indigenous skills and knowledge of making biodegradable leaf plates using Sal (Shorea Robusta) leaves and fine bamboo sticks for income generation. The women groups have been making such leaf plates for decades for different religious functions and ceremonies. With the formation of their group, they started catering to the nearby local market with their handmade leaf plates but the market was limited. Hence, with the support and idea from MEDPA, the women entrepreneurs procured an innovative technology – a leaf plate-making machine. With the introduction of this technology in their business, the use of products diversified from religious use to further expanding to the local restaurants and street vendors for serving food. The integration of modern technology into the indigenous skills and knowledge of the entrepreneurs acquired from their ancestors led to wide market linkages, business expansion, more income generation, and sustainability. Even with the socio-cultural challenges that women face in Nepal, these entrepreneurs have been able to transform their skills into a full-fledged growing business.

These case studies depict the evidence of IKSaR-based business sustainability and growth by making improvements on their product design and/or delivery with improved technology as needed in the current time and market. The entrepreneurs of those enterprises continued their business mobilizing the IKSaR learned through generations, but their learning by doing approach and appropriate technology adaptation led to sustainability of their business. Other factors such as access to finance, market access, availability of raw materials and labor, and the presence of encouraging policies were equally important. The passion and willingness of the entrepreneur, risk-bearing tendency, determination to utilize the indigenous skills and knowledge, integration and transfer of appropriate technology, and avoidance of quick return-seeking mentality were building the foundation for the sustainability and growth of an enterprise. Conversely, it was found that the enterprises utilizing IKSaR but without any innovation and adaptability in changing contexts, expecting high and quick returns, and those enterprises having a high dependency on borrowed knowledge and resources were doing business to some extent, but their growth and sustainability were largely restricted. The cases presented by this study, in fact, emphasize the importance of innovation in the business by being adaptive to the improved technology and changing market scenario and customers' demand without ignoring the IKSaR for sustainability and growth of MSMEs.

IV. CONCLUSION

With the in-depth case studies and extensive interviews with entrepreneurs, ISPs, government, and other concerned stakeholders, it is concluded that there is a need for innovation of IKSaR with improved technologies for the sustainability of MSMEs. There is an urgency of adaptiveness, continuous improvement in product design and delivery along with entrepreneurial willingness, passion, risk-bearing tendency, and unlearning of quick return/benefit-seeking mentality. The assumption of 'entrepreneurship as a way of life' ensures sustainability and invites growth in business. The study recognizes the importance of adaptability for sustainability and gives high emphasis on the mobilization of IKSaR with improved technology.

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Educational Pathways of Bhutan: Transition to Transformation

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Abstract - Bhutan, also known as the last Shangrila has evolved dramatically in the field of education from monastic to modern and is currently moving toward the realization of 21st-century requirements. The history of schooling in Bhutan started with Buddhist monastic education that was self-contained and inward-looking where learning happened at the spiritual and moral levels. It attempted to offer an appreciation of life and simple moments of being with a sense of self. The introduction of modern education in the 1960s altered the focus and ended in reductionism because the content of modern education differed vastly from monastic education; there were new disciplines of learning classified into humanities and sciences, with sub-categories branching into a wide range of subjects. The deviation from internal to external aspects was not without tension. In this context, the paper aims to analyse the effects of transition and the efforts taken in the form of a nationwide initiative called 'Educating for Gross National Happiness with the aim to reform the country's education system and the birth of the Green School concept for holistic development in the learners. However, the impacts of modern education are not different, the Bhutanese education system too mistook the ability to reproduce information as knowledge. As a result of which, Bhutan's current shift in focus toward technological-oriented and skill-based STEM-centered education will be examined to comprehend the nature and purpose of educational reforms in Bhutan from the past to the present. In the direction of life-long learning and for better future careers, the initiative is toward STEM topics.

Keywords: education system, initiatives, Green School, University College, pedagogical approach, futuristic vision.

I. Introduction

Education facilitates self-discovery which leads to realizing one's full potential. Good education also gives confidence, good judgment, and a virtuous disposition. Bhutan's unique development path under the leadership of its past and present kings is no different from Bhutan's approach to educational development. Buddhist monastic education used to be the main form of schooling in Bhutan and it existed for over a thousand years. Modern secular education began in the second half of the twentieth century and it is not based on Buddhism or monastic education but is viewed more as a means to an end that is for a better job and a better salary. This is mainly due to the need to enter the job market. This is in contrast to the traditional notion of education where education was more or less seen as an end in itself in the individual's quest to remove ignorance and attain greater knowledge for its own sake. However, the outlook and approach of modern education have created a lacuna, with a sense of moral vacuity, behavioral changes, different self-perceptions, and expectations often not matched by the opportunities that presently exist in the country like the lack of enough jobs for the graduates. But the divergent attribute of monastic and modern education is brought together to a meeting point in the Green School model as both values and skills define a Green School. But considering the model too idealistic and due to the lack of an in-depth understanding of the concept, the tertiary education system became market-driven and valued grades and paper degrees more than the productive value of education. With qualification inflation, there is an ever-increasing gulf between exam-centric pedagogical approaches and skill-centered learning practices. Therefore, the paper attempts to examine the past transitions and the present transformations in the Bhutanese education sector in order to unravel the nature and purpose of change.

II. Materials and Methods

Conceptual research allows one to conduct a study by observing and analyzing the existing information on the ground that it is a qualitative study. The topic did not involve a field survey to assess the practices or factors. Relevant books on education like *Educating for GNH: Nurturing Green School for Green Bhutan: A Guide to School Management, Sherubtse College: An epitome of Higher Education in Bhutan, The Pedagogy of the Oppressed by* Paulo Freire, and articles from *the newspaper Kuensel, The Druk Journal* and *Centre for Bhutan Studies* were also consulted. I have followed the search procedure from the articles included in the reference section.

III. Results and Discussion

The paper aims to critically analyze the varied dimensions of the Bhutanese education system to discover the inherent meaning and purpose of education and to emphasize the factors essential to empower the learners. *Holistic education* as a system takes into account the affective dimension of learning as much as the cognitive dimension. While cognitive learning takes care of knowledge and skills for workforce development, affective learning promotes socio-emotional skills, spirituality, and social-cultural values. In this direction, the end goal of both Green School and GNH is toward producing wholesome individuals in whom the affective and cognitive dimensions are fully developed. For instance, the petal arrangement in plants and flowers would be the means to study mathematical patterns and sequences popularly known as the Fibonacci sequence. By observing the arrangement pattern of leaves in a plant where the new leaves do not cover the older ones, children can learn about survival skills with the implied message that there is enough for everyone in the world. Philosophically, it shows one cannot obstruct another person's growth wherein, life skills are

not alienated from learning. But the 3Rs known as arithmetic reading and writing skills taught in the classroom focus only on the cognitive aspect of education and not on the whole person.

Modern education devotes its attention to preparing students to be competitively driven by personal success and ambition. The purpose of education is not only to prepare students to fit in the job market but also to nurture them as complete human beings with moral uprightness. According to educators, Dey and Sunar (2020), a 'Green School' is an alternative to teaching children wholesome values, it teaches children to be a true human being [1] and in this regard, Powdyel (2014) stresses that education has the privilege of being called the 'noble' sector due to its mission in cultivating the nobility of mind, heart, and hands thereby leading to the cultivation of the nobility of action [2]. Gyatsho (2019) who is a Buddhist teacher claims that today's education system requires reformation because "today's education system prepares learners only to use education as a tool to climb the social ladder and as a result, the growth of the other dimensions of human experience is totally ignored" (p. 6) [3]. However, the Bhutanese education system is geared toward teaching young boys and girls the ability to reproduce information as knowledge to compete in the examination resulting in mass production of graduates from tertiary educational institutions such as Sherubtse College, popularly known as the *peak of learning*.

The field of education is a noble sector, it is a powerful instrument for human development. But with the inflation in education there is reductionism as over time education has been reduced to the mere acquisition of knowledge and certificates. Paulo Freire refers to modern education as the 'banking concept of education that allows students only to receive and store information and be passive like money deposited in the bank. This misguided system prevents learners from discovering their talents and aesthetic sensibilities [4]. Today, education systems across the world are deficient in many respects. It prepares people for careers, factories, corporations, and the job market making education a means of accumulating information and reproducing the sense without developing an insightful understanding which will be irrelevant. With the introduction of several new programs with combinations such as English-Dzongkha, English-Media, and Eco-Evs, the vertical growth was affected and teaching-learning became mundane without purpose, leaving the graduates in a liminal state of interstice. As a result, in order to equip Bhutanese youth with twenty-first-century skills, the current reforms in the sector focus on the key subjects termed STEM by integrating the disciplines as a combination of major and allied modules to involve problem-solving and creative thinking to handle real-life situations. In the words of Dasho Zangley Dukpa, "All universities are now engaged in the creation of knowledge that is directly relevant to their societies." (p.151). [4].

IV. Conclusion

With more and more Bhutanese nationals leaving the country in search of greener pastures in countries like Australia, the government is initiating a reformative process in every sector wherein the field of education not being an exception in an attempt to enable the citizens in general and youth, in particular, to cope with the scientific and technological advancements through upskilling and reskilling measures. Thus, by applying the new style of learning, Bhutan is developing a 'growth mindset' in its adults through STEM-centered education.

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Track 6

Telecommunication Engineering

Path Planning for UAVs: A Survey

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***Abstract*—An Unmanned Aerial Vehicle (UAV) can be controlled remotely or fly autonomously by following a pre-planned flying route without an on-board pilot. UAVs have rapidly developed and been applied in many application domains, including civil security, terrain coverage, photogrammetry, and smart farming in recent decades. However, one of the major problems in such applications is path planning and view planning, which inform UAVs exactly where to go. UAV maneuver through the dynamic environments, UAV needs to avoid and pop-up threats and obstacles. Hence, one of the most critical aspects of UAVs is path planning. This paper aims to explore a recent state of the art of the algorithms for UAV path planning.**

Keywords—**UAV path planning, path planning algorithm, UAV, dijkstra algorithm, genetic algorithm.**

I. Introduction

In the real world unmanned aerial vehicles widely used in different contexts in recent years [1]– [5]. With the continuous the use of UAVs has been significantly expanded due to improvements in maneuverability, camouflage, violence, and intelligence [2,3]. The goal of UAVs is to effectively and safely conduct complex tasks autonomously, protect human lives and deliver economic benefits as UAVs collect data that can be used to enhance government and business decision making [2,4,5]. In that case, path planning is a critical component of the overall framework to ensure that UAVs complete their missions successfully. It primarily refers to determining the best UAV fighting route from a reference point to a destination that meets the UAV's performance expectations as well as the environment's requirements [5]. Different factors such as Energy consumption, maneuverability, time of arrival, flying range, and security situation must be considered for the trajectory planning to optimize the UAV's flight track between the starting point and the end point. Voronoi diagrams, A* algorithms, Generic Algorithms (GA), Virtual Potential Field (VPF), Particle Swarm Optimization (PSO), and Neural Networks have been proposed to optimize the trajectory.

II. Path Planning Algorithm

Path planning, also known as motion planning and is a computational problem that involves determining a set of valid configurations for moving an object from one location to another [5]. In the area of robotics, path planning issues have been extensively researched and using various methods and strategies, it has been discussed. Deterministic, heuristic-based algorithms and probabilistic, randomized algorithms are the most popular techniques.

A. Dijkstra algorithm

Dijkstra's algorithm is one of the earliest and most fundamental algorithms for finding the shortest route from one node in a graph to all other nodes in the same graph. The algorithm assigns a cost to all direct neighbors of the initial vertex, where the path should begin, starting at the initial vertex. It then moves from the lowest-cost vertex to all of its neighbors, labeling them with the cost of getting there alone if that cost is lower . The algorithm moves on to the vertex with the next lowest cost after checking all of a vertex's neighbors. When the algorithm hits the target vertex, the robot can then follow the edges that point to the lowest edge expense. Fig.1 illustrate method of finding the shortest distance between source vertex 'U' and remaining vertices using Dijkstra's Algorithm. The right side of the figure which represent the shortest path from the source vertex 'U' to all other vertices after the process of Dijkstra algorithm.

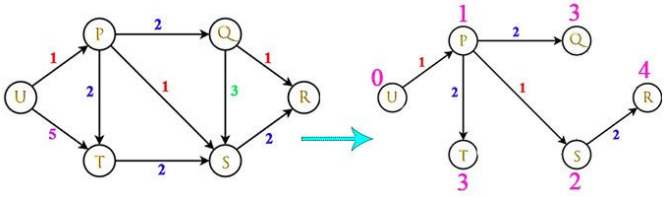

Fig. 1. Method of finding the shortest distance using Dijkstra's Algorithm

B. A* algorithm

The A-star algorithm is one of the most widely used path-finding and graph traversal techniques which is an extension of Dijkstra algorithm. Unlike other traversal methods, A* Search algorithms are equipped with "brains." This indicates that it is a clever algorithm that separates itself from others. It's also worth noting that this algorithm is used in a lot of games and web-based maps to find the shortest path (approximation). A*, on the other hand, generates sub-optimal solutions and unrealistic paths. In trajectory planning, A* with route smoothing and Linear Programming techniques is used.

$$f(n) = g(x) + h(x) \tag{1}$$

According to neighboring costs, each state's estimate $h(x)$ is usually similar to the true cost; therefore, A* has a faster rate of convergence.

C. D* algorithm

D-star, short for dynamic A*, is well-known in the DARPA unmanned ground vehicle programs for its widespread use. D* is a sensor-based algorithm that deals with dynamic obstacles by changing the weight of its edges in real time to create a temporary map, which then moves the robot from its current location to the shortest unblocked path to the target location. D *, such as A *, estimates costs by considering both post-calculations and future valuation factors. D * maintains a list of states used to distribute information about arc cost function changes. The evaluation function is,

$$f(n)' = g(x)' + h(x)' \tag{2}$$

In contrast to A*, $h(x)'$ is not always the shortest path length to the goal; additionally, $h(x)'$ computation assumes that the robot will move through obstacles. When it encounters new obstacles, it updates a minimum heuristic function and the entire graph, allowing for efficient searching in complex environments.

D. Voronoi Diagram

The Voronoi diagram was introduced into the field of computational geometry by Shamos and Hoey ; it was first used for finite points in the Euclidean plane and is now commonly used in the field of route planning with a series of improved forms. The distance between the edges and the surrounding barriers is the same in a Voronezh diagram that creates spatial relationships.

E. Genetic algorithm

J. Holland first proposed the genetic algorithm (GA) in 1975 and it is an intelligent search algorithm that simulates the process of biological evolution to find the optimal solution. GA begins with a population of genetically encoded individuals that is created at random or with a particular initial population. Collection, duplication, cross, and variation are all common operations used in GA. A genetic algorithm keeps track of a population of candidate solutions, each of which is normally encoded as a binary string known as a chromosome. Binary coding has been shown to be the safest choice of coding.

F. Particle Swarm Optimization

Particle swarm optimization (PSO) is a stochastic optimization algorithm that is based on a population. A swarm of particles is described by a PSO, which is a type of evolutionary algorithm. The study of real-life samples and social models led to the creation of particle swarm optimization. It is widely used in the field of robotic design due to its simple structure, rapid convergence, and few processing parameters. PSO is an evolutionary algorithm that involves random number generation.

III. Discussion and Future Direction

Many authors have solved the problem of route planning with UAV and discussed areas of interest in different shapes and complexities. To reduce energy consumption, some studies aim to reduce distance, flight time or maneuverability. During turning maneuvers, vehicles can decelerate, rotate, and accelerate, extending flight time and thus energy consumption. On the other hand, little research has been conducted on the subject of uncertainties and strength in general. In literature review, we found that most of the methods surveyed here do not involve much debate about their practical implementation. Thus, critical issues are likely to be overlooked by theoretical work. Many of the active implementations of UAV given in surveyed articles belonged to the hierarchical discontinued control type or in some cases focused solely on reactive readiness to overcome obstacles. In the case of digital transformation, we planned to focus on path planning for autonomous UAVs in an agricultural environment since the food demand became increasing. With the combination of automation and AI it introduces as a viable alternative for the agricultural industry. This brings agriculture towards a big leap.

IV. Conclusion

Path planning is critical in autonomous UAV navigation because it not only needs to integrate various data, such as environmental data and task objects, However, it also needs to provide accurate and stable planning to the lower layer of execution modules. The analysis of the path planning algorithm must be therefore be focused on the actual situation, and consideration should be given to the real-time and accuracy of the calculation. At the same time, the UAV efficiency constraint also poses further criteria for its algorithm for path planning, such as the restricted processing power of the UAV. The onboard computer, as well as the sensing modules' minimal precision. Although UAV motion planning research has advanced significantly, various methods still have weaknesses and vulnerabilities, and the prospect of UAV motion planning for future research remains exciting.

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Optimization of Secure Emergency Call Services in Asynchronous-NOMA D2D Network

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***Abstract*—This paper investigates the issue of improving secrecy capacity of device-to-device (D2D) communications in disaster scenarios under the presence of jammers in close proximity. Furthermore, an asynchronous-non orthogonal multiple access (A-NOMA) assisted transmission scheme is considered due to the resource limitations and the asynchrony in signal receptions in out-of-coverage D2D scenarios. A binary optimization problem is proposed to select the optimal data which enhances the sum secrecy capacity of the transmissions. The results show that the proposed optimized scheme outperforms the conventional secrecy capacity.**

Keywords—**Asynchronous-NOMA, binary optimization, D2D, secrecy capacity**

I. Introduction

Reliable emergency call services are required to save victims during catastrophes in a timely manner. The presence of jammers in a disaster areas can impact the reliability of the emergency call transmissions. Hence, enhancing the secrecy capacity of the wireless communication networks has become one of the research focuses in the B5G/6G networks [1]. Moreover, D2D assisted multi-hop emergency protocols have been proposed for emergency call transmissions [2]. In D2D networks, due to the distributed locations of the transmitters, signals arrive at the receiving terminal with varying time offsets and hence, time-synchronous data reception is not possible. In [3], an asynchronous NOMA (A-NOMA) scheme is proposed for enhancing spectral efficiency and reducing the bit error rate (BER) of the communication.

Hence, in this work a novel binary optimization problem is proposed for optimal data detection which will enhance the secrecy capacity of an A-NOMA assisted D2D communication under the presence of jamming users. Further, the secrecy capacity of the proposed optimized scheme is compared with the conventional secrecy capacity values.

II. System model and problem formulation

A. System overview

We assume a multi-hop emergency call forwarding system for a network area under a disaster, where device-to-device (D2D) uplink transmissions are occurring between a $k \leq K$ number of victim/relay nodes (e.g., Victim A, Victim B, etc), and $r \leq R$ number of receiving victim/relay nodes (e.g., Victim C, etc) as shown in Figure 1. However, such k transmitters can comprise of an equal number of both $m \leq K$ legitimate users, and $e \leq K$ jamming users, and $m + e = K$. It is assumed that such e nodes (e.g. Jammer A, etc) send a noisy data signal toward the receiver nodes to deteriorate its decoding ability. Moreover, all users are geographically distributed within a small local neighborhood. Hence, the total K users share a single subcarrier out of a total N subcarriers that are allocated to the D2D communication system. In addition, in the realistic channel conditions, we assume that the signals are affected through propagation delays, and hence, signals between transceivers are received asynchronously. Thus, an A-NOMA scheme is utilized to decode the received data signals.

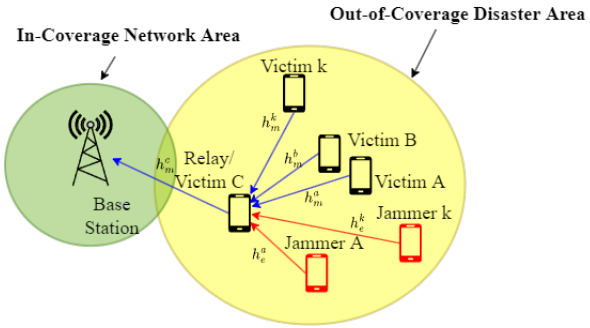

Figure 1: Asynchronous-NOMA uplink scheme for D2D Emergency Call Forwarding Services.

The received signal for the k^{th} user at sth symbol is given as,

$$y^k[s] = h^k.\sqrt{P^k}.x^k[s] + \eta^k_{k,i}[s] + n_0, \tag{1}$$

where $k \in \{\text{Victim } k, \text{Jammer } k\}$ and $x^k[s]$ denotes the sth symbol of the k^{th} user's data which is complex and generated by a higher modulation M-ary QAM symbol mapper. P^k denotes the transmission power of k^{th} user, h^k denotes the k^{th} user channel state information (CSI) and $\eta^k_{k,i}[s]$ denotes the interference from other ith users on the desired k^{th} user's sth symbol. Additionally, the received signal to noise ratio (SINR) of the k^{th} user, γ^k, is formed as,

$$\gamma^k = \frac{P^k g^k}{\text{Var}(\eta^k_{k,i}) + \sigma^2}, \tag{2}$$

where the channel gain of k^{th} user, thermal noise variance are given by g^k, σ^2 respectively. The γ^k_m of the m^{th} user

$\gamma_m^k = \frac{P_m^k g_m^k}{\text{Var}(\eta_{m,i}^k)+\sigma^2}$. It is assumed that the receiver detects the presence of a jammer e during the post processing stage and the γ_e^k of such an e user $\gamma_e^k = \frac{P_e^k g_e^k}{\text{Var}(\eta_{e,i}^k)+\sigma^2}$.

B. Optimization

The objective is to detect the optimal combination of s symbols of each k user which maximizes number of decoded symbols, n_{sym}, of the A-NOMA transmissions under the presence of e users. Further, a binary decision vector of the optimal data symbols to be decoded is introduced as $\boldsymbol{D} = [D_k]_{k\in\mathcal{K}}$, where D_k = 1 if the data symbols of the k^{th} user are selected to be decoded, and $n_{sym} = \sum_{k=1}^{K} D_k(K-k+1)$. The number of symbols decoded per each k^{th} user is $(K-k+1)$ under the T-SIC decoding scheme proposed in [3] for A-NOMA schemes. Hence, an optimization problem is formed as, ,

$$\underset{\boldsymbol{D}}{\text{maximize}} \quad \sum_{k=1}^{K} D_k(K-k+1) \tag{3a}$$

$$\text{subject to} \quad c_r \geq 0, \tag{3b}$$

where,

$$c_r = D_k \Bigg[\left\{ B\log_2\left(1+\gamma_m^k\right) - R_{\min} \right\} - \left\{ R_{\max} - B\log_2\left(1+\gamma_e^k\right) \right\} \Bigg]^+, \tag{4}$$

here $[]^+$ represents a positive quantity, which means that (4) is valid is positive or $\gamma_m^k \geq \gamma_e^k$ and $R_{max} \geq R_{\min}$. The solutions derived from such an optimization problem is used thereby to maximize the sum-secrecy capacity, C_s, of the communication system given as [1],

$$C_s = \sum_{k=1}^{K} D_k \log_2\left(\frac{1+\gamma_m^k}{1+\gamma_e^k}\right). \tag{5}$$

Further, k^{th} user data with $D_k = 1$ are decoded while the remaining users' data are decoded upon the reception of retransmissions from such users.

III. Performance Analysis

The performance of the proposed algorithm is evaluated for a D2D A-NOMA transmission with three m users and three e users. For simplicity, a unit total bandwidth of 1 Hz, equal P_m^k for each m user and equal P_e^k for each e user, and a channel with Rayleigh fading is considered. In addition, $R_{\min}$ and R_{max} are set to 1 Hz and 10 Hz respectively. The distance gap between the transmitters and its associated receiver is uniformly distributed in [0m, 100m]. Further, the noise level of the channel η_0 is set to 0.1W.

Figure 2 depicts the variation of C_s against the transmit SNR at the legitimate user, under different $\alpha_e = \frac{P_e^k}{P_m^k}$ values. Variation of C_s is considered under the proposed scheme and compared with the conventional C_s under $\alpha_e \in 0.01, 0.1, 0.5$. It is seen that as the α_e increases, the C_s decreases. The reason is that as jammer's γ_e^k increases, the $\log_2(1+\gamma_e^k)$ increases and hence C_s decreases. Moreover, it is seen that the proposed scheme achieves a higher C_S value compared to the conventional C_s when the transmit SNR of the legitimate m user is increased. The $D_k = 0$ for the k^{th} user data with $\gamma_e^k > \gamma_m^k$, and hence such data are omitted from decoding and only the reliable data with $\gamma_e^k \leq \gamma_m^k$ are decoded. Meanwhile, in the conventional C_s, the k^{th} user data with $\gamma_e^k > \gamma_m^k$ result in $C_{s_k} \leq 0$. In addition, the achievable C_s converges as the optimal D_k vector is reached under the constraint imposed by c_r. To sum up, the proposed scheme C_s becomes higher than the conventional C_s and it was observed that the proposed scheme achieves a C_s gain of 30.7%, 75.4%, 84.0% under α_e values of 0.01, 0.1, and 0.5, than the conventional C_s.

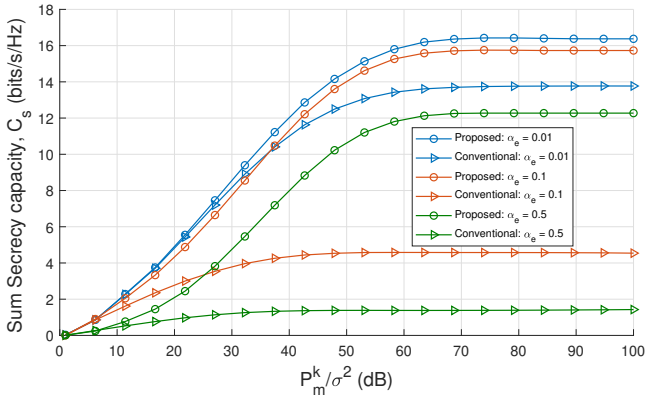

Figure 2: Sum secrecy capacity vs P_m^k/σ^2 in an A-NOMA assisted D2D uplink communication under different α_e values.

IV. Conclusion

The problem of improving the achievable C_s in an A-NOMA enabled D2D communication under the presence of jammers in a disaster scenario is studied in this paper. A binary optimization algorithm is proposed for reliable data detection at the receiver by taking the γ values of the legitimate users and jammers into account. It is observed that the proposed optimized scheme outperforms the conventional C_s with a gain of 30.7%, 75.4%, 84.0% under α_e values of 0.01, 0.1 and 0.5.

V. Acknowledgements

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SDMA Based Multi User VLC System for Indoor Office Environment

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Abstract - Visible light communication is an upcoming high speed wireless data transmission technique which uses a beam of light in the frequency range of 400-800 THz for signal transmission. Meanwhile, space division multiple access is an emerging multiple access technique in mobile communication systems which uses the same frequency. In this study we propose a space division multiple access based multi user visible light communication system for indoor office environment with the use of an array of light emitting diodes. Here, multiple users are assigned with light emitting diodes with spatial diversity which are placed with a specific distance from each other. The performance of the system is measured with the use of light source diversity.

Keywords: ***Space division multiple access, Visible light communication, Light emitting diodes***

I. INTRODUCTION

Visible light communication system (VLC) technology has emerged as a complementary alternative to current radio frequency (RF) techniques. Light emitting diodes (LEDs) are commonly used as light sources for an eco-friendly world due to their advantages over conventional wireless communication systems. In a general VLC system, an LED could be served as a transmitting element and a photodiode could be served as a receiving element. Thus a communication system can be proposed to be implemented with the placement of multiple LEDs as an array which can serve multiple users simultaneously.

Multiple access techniques are created to allow a large number of mobile users to share the allocated spectrum in the most efficient manner. Many studies have shown that conventional multiple access (MA) methods such as frequency division multiple access (FDMA), time division multiple access (TDMA), code division multiple access (CDMA), orthogonal frequency division multiple access (OFDMA), and the new multiple access method which is non-orthogonal multiple access (NOMA) can also be used for multi-user VLC systems. Frequency division multiple access uses different frequencies to transmit multiple data streams at the same time. In coinciding FDMA with a VLC system with LEDs, multiple LEDs with different colours have to be used to conduct such a simultaneous data transmission. In an indoor work environment, it is not very suited to use multi coulored LEDs blinking or transmitting data around the premises. Therefore, a multiple access system should be proposed to use the same frequency band without any hindrance for the users to be accessed by mitigating the inter user interference. Therefore, we propose a space division multiple access based indoor communication system by assigning different LEDs for different users. This technique uses the same frequency band throughout the process, where we need to use only one-colour LEDs for the transmission.

We proposed an interference free environment for the users. That is users cannot be placed too close. But we cannot consider our system like that. So we need to consider all the possible situation in this system. So we have to upgrade our LED allocating algorithm which is suitable for every possible ways that multiple users are to be accessed to the network. We can create a SDMA-based VLC system [1][2][3] to transmit data from server to multiple users simultaneously.

II. METHODOLOGY

There are two main phases in the proposed system for data transmission as selection of LEDs and transmission of data. Initially, the user sends a signal to the server that the user is ready to establish a communication. For that, we use a multiplexer, which has a connection with two users and the server. First, user send a request to the server with that user is ready for the transmission. Next, the server starts to “ON" the LEDs with certain time period. When the first LED is on, the receiver photodiode receives a power, then we feedback that power to the server. Then server store the power values. Same process is used to save the voltage values of eight LEDs and a maximum of n values within is selected and we allocate those corresponding three LEDs to user 1.

After the allocation of LEDs to user 1 the selected/allocated n LEDs want to send the specific data to user 1 by establishing a communication channel. Therefore, the connection with user 1 and the multiplexer is disconnected while a new connection is oriented with user 2. A similar process is conducted for user 2 for the selection of LEDs. After the allocation of LEDs, the system starts to send data from the server to two users simultaneously. This process doesn’t need a key code for the transmission. In any case if the photodiode did not detect any light beam from the transmitter, the system is reset until the receiver detects any light signal. Moreover, ‘T’ seconds are allocated for the initial LED selection for the users.

Here we proposed maximum power deliverable methods to allocate LEDs to users. But if there is an interference between 2 users, we need to add another algorithm method with LED accessibility. So even if 2 users are close, LEDs will be allocated for the 2 users morally. The data flow diagram of the system is presented in Fig,1.

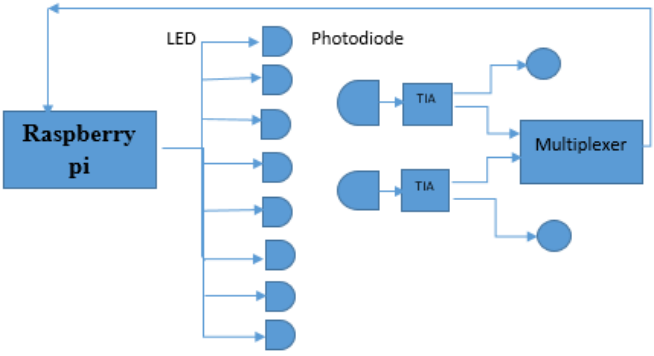

Fig. 1 Methodology data flow Diagram

The proposed methodology is illustrated further in the flow chart as in Fig. 2.

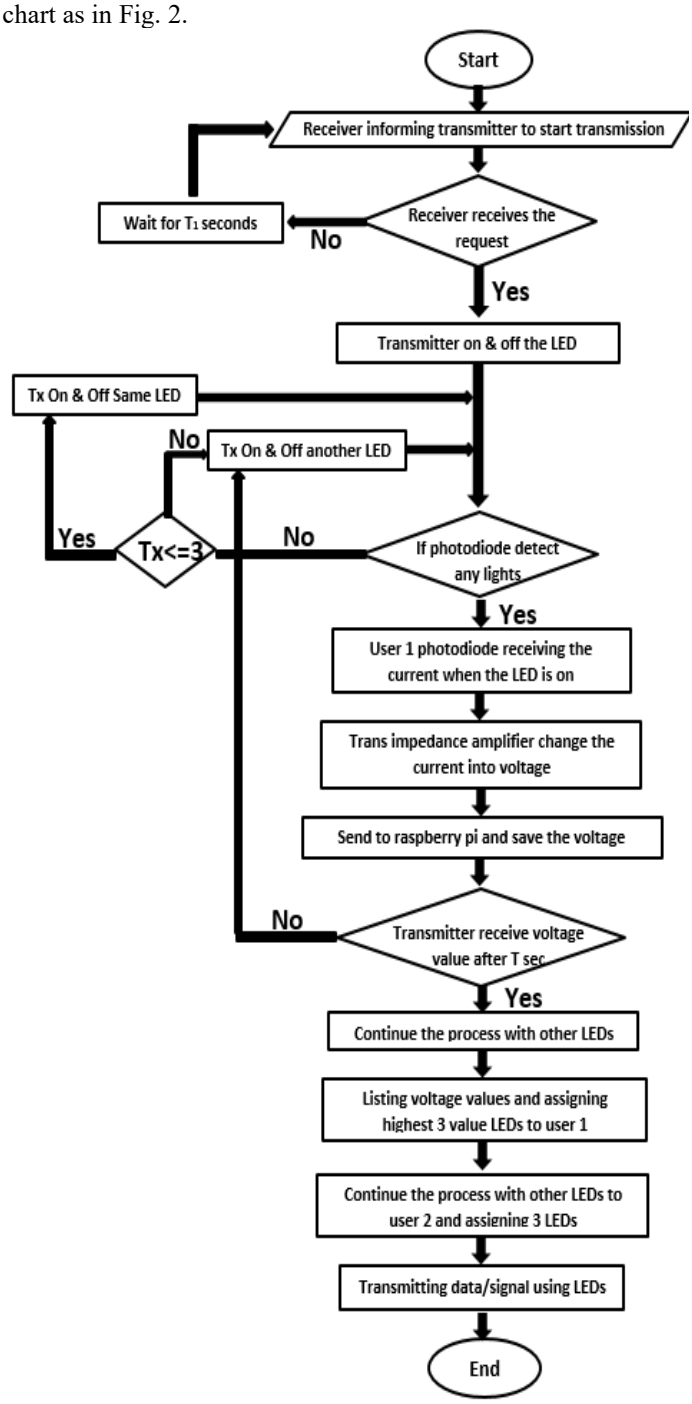

Fig. 2 Methodology Flowchart

III. RESULTS AND DISCUSSION

With the initial data analysis, a general comparison in between the proposed SDMA data transmission and CDMA data transmission is compared in Table 1. It is clearly observed that with the gathered data, the data transmission time for SDMA-VLC system is 9 seconds lower than CDMA-VLC system, where the proposed system could transmit a higher data capacity within an allocated time period. Additionally, the signal processing time is also much lesser in the proposed SDMA system where it could be an advantage in terms of latency of the data transmission. This SDMA-VLC processing time is calculated using the system which we have done until now. A comprehensive comparison of overall data transmission time (LED allocation time plus data transmission time) with TDMA and CDMA is to be done in future with the system implementation.

Table 1. Processing time comparison between CDMA & SDMA with visible light communication
D1 – Data for user 1 C1 – Code for user 1
D2 – Data for user 2 C2 – Code for user 2

Processing time for CDMA-VLC	**Processing time for SDMA-VLC**
D1 x C1 = 8 seconds	Assigning LEDs to receivers = 30 seconds
D2 x C2 = 8 seconds	Data transmission = 5 seconds
Tx Data addition = 8 seconds	-
Decode Rx1 signal = 10 seconds	-
Decode Rx2 signal = 10 seconds	-

IV. CONCLUSION

In this paper, a SDMA based VLC system is proposed for data transmission which is suitable for an indoor office environment. The maximum power deliverable methodology is used to allocate the LED to the specific users and multiple users are to be served simultaneously with the same frequency band. Though the initial system is proposed to transmit data among two neighbouring nodes the system can be adequately extended for multiple users with the limitation of the LED allocation processing time which is used prior to the data transmission. In our future works we hope design a (SDMA + CDMA) based multi user VLC system.

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Integration of SWIPT Enabled UAV Assisted NOMA in 5G and Beyond Wireless Network

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Abstract - Deploying unmanned aerial vehicles (UAVs) to establish wireless networks is expected to deliver wireless networks more efficiently and faultlessly to ground users in an area, which was affected by unexpected situations such as disasters circumstances while keeping their data demand at a relatively typical level. The flight time of UAVs can be extended by enabling the simultaneous wireless information and power transfer (SWIPT). By incorporating non-orthogonal multiple access (NOMA) for such networks, fifth generation and beyond (5GB) can provide high spectrum efficiency and a large number of connections to the wireless network than the orthogonal multiple access (OMA) techniques. In this work, we propose uplink and downlink NOMA enabled UAV assisted wireless powered cooperative communication system and investigate the rate change at the users.

Keywords: Simultaneous Wireless Information and Power Transfer (SWIPT), Non-Orthogonal Multiple Access (NOMA), Unmanned Aerial Vehicle (UAV)

I. INTRODUCTION

There has been considerable technological development in the field of wireless communication during the previous few decades. To satisfy the demands of 5th generation and beyond (5GB) wireless networks, new technological advancements are desperately needed. Non-orthogonal multiple access (NOMA) is a promising technology for deployment in 5GB wireless communications, can be allocated additional space for new users when they are attaching to the network, giving same resources to the users such as same frequency, time with differentiate by code domain and power domain. More flexibility and mobility of unmanned aerial vehicles (UAVs) give huge potential to be a powerful character in 5GB wireless networks. UAVs take advantage of line-of-sight (LoS) connections with ground users to provide effective coverage and throughput [1]. NOMA-enabled UAVs can be supported more devices, increasing network efficiency and reliability. UAVs can harvest energy from the received signals from base stations (BSs) while receiving the information in same signal using simultaneous wireless information and power transfer (SWIPT) [2]. This can be used to charge the battery of UAVs and it will increase the flying time of the UAVs.

II. SYSTEM MODEL AND PROBLEM FORMULATION

Consider a system model that a UAV flying over N ground users and deploying the NOMA to ground users backhauling with the BSs. The ground users are indexed by the set $\mathcal{N} = \{1, 2, \ldots, N\}$ and represent their individual location as $(U_n, 0)\ \forall\ n \in \mathcal{N}$, $U_n = [x_n, y_n] \in \mathbb{R}^{1\times2}$ that denoting places of 3D cartesian coordinates. The BSs are indexed by set $\boldsymbol{\mathcal{M}} = \{1, 2, \ldots, M\}$ and represent their individual location as $(B_m, z_m)\ \forall\ m \in \boldsymbol{\mathcal{M}}$, $B_m = [x_m, y_m] \in \mathbb{R}^{1\times2}$ and z_m represent the heigh of the m^{th} BS in 3D cartesian coordinates.

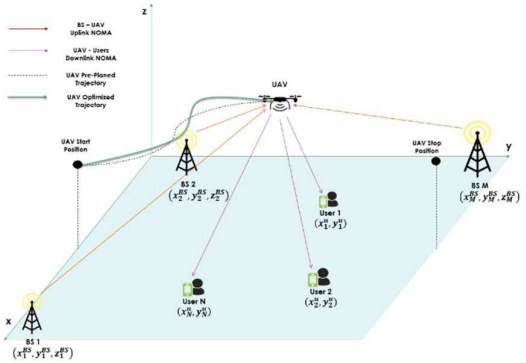

Fig. 1 System Model

As the above figure, data transmit from BSs to UAV consider as the uplink channels and data transmit from UAV to ground users consider as downlink channels. UAV will harvest the energy using SWIPT from uplink channel.

A. UAV Position

In the simulation, UAV will position randomly. The position of UAV can be represented in 3D cartesian coordinates as (q, z), that $q = (x, y)$ represents the position of the UAV in horizontal plane and z represent the vertical position such that height of the UAV from the ground level.

B. Channel Model

This work has two separate data paths. As the mentioned above, those are uplink data path and downlink data path. The channel between both downlink and uplink can be modelled as h_n and h_m respectively,

$$h_n = \sqrt{\beta_n} g_n, \quad (1)$$

$$h_m = \sqrt{\beta_m} g_m, \quad (2)$$

where β_n and β_m is the large-scale average power gain for both shadowing and pathloss for downlink and uplink respectively. The small-scale fading coefficient represented by g_n and g_m for downlink and uplink respectively.

$$\beta_n = \beta_0 d_n^{-\gamma}, \quad (3)$$

$$\beta_m = \beta_0 d_m^{-\gamma}, \quad (4)$$

where average power gain at reference distance of $d_0 = 1\ m$ is represented as β_0. The path loss exponent is represented by γ

and its value is between 2 and 6. The LoS distance from UAV to ground users and BSs denoted by d_n and d_m respectively,

$$d_n = \sqrt{\|q - U_n\|^2 + z^2}, \quad (5)$$

$$d_m = \sqrt{\|q - B_m\|^2 + z^2}, \quad (6)$$

due to the availability of LoS channel, for small fading, we consider the Rician fading. The Rician fading for ground users and BSs from UAV can be modelled as,

$$g_n = \sqrt{\frac{K_n}{K_n+1}}g + \sqrt{\frac{1}{K_n+1}}g, \quad (7)$$

$$g_m = \sqrt{\frac{K_m}{K_m+1}}g + \sqrt{\frac{1}{K_m+1}}g, \quad (8)$$

K_n and K_m represent the Rician factor of channels from UAV to ground users and BSs respectively. The g represent the zero-mean unit-variance circular symmetric complex Gaussian (CSCG) random variable [3].

C. Data Collection Model

This data transmits from BSs to UAV, then after UAV will forward data to ground users. From BSs to UAV, we consider uplink NOMA and from UAV to ground users, we consider downlink NOMA. The details of data collection model using uplink NOMA and downlink NOMA are described as follows,

1) Uplink NOMA

In uplink NOMA, each BS transmit information with same transmit power P_{BS}. According to the power level of received signal, UAV will identify the signal strength and perform the successive interference cancelation (SIC) for the received signal to decode each signal from BSs [4]. The achievable rate for each BS can be denoted by C_m in bits/second/Hertz (bps/Hz), is given as,

$$C_m = \log_2\left(1 + \frac{|h_m|^2 P_{BS}}{\sigma^2}\right), |h_m|^2 = \min_{1\le m\le M}(|h_m|^2), \quad (9)$$

$$C_m = \log_2\left(1 + \frac{|h_m|^2 P_{BS}}{\sigma^2 + \sum(|h_i|^2)P_{BS}}\right), |h_m|^2 > \min_{1\le m\le M}(|h_m|^2), \quad (10)$$

where σ^2 is the additive white Gaussian noise (AWGN) power at the receiver and $\sum(|h_i|^2)$ is summation of absolute square channel powers of channel powers that greater than the channel power of relevant channel.

2) Downlink NOMA

In downlink NOMA. According to the channel power of each ground users, UAV will allocate the power coefficient for each user. The total transmit power is P_{UAV} and achievable rate of each user is denoted by C_n in bps/Hz is given as,

$$C_n = \log_2\left(1 + \frac{|h_n|^2 P_{UAV}\alpha_{min}}{\sigma^2}\right), |h_n|^2 = \max_{1\le n\le N}(|h_n|^2), \quad (11)$$

$$C_n = \log_2\left(1 + \frac{|h_n|^2 P_{UAV}\alpha}{\sigma^2 + |h_n|^2 P_{UAV}\sum(\alpha_i)}\right), |h_n|^2 < \max_{1\le n\le N}(|h_n|^2), \quad (12)$$

where $\sum(\alpha_i)$ is summation of power coefficients of ground users who have less channel coefficient than the relevant user's channel coefficient.

III. Results and Discussion

As per our initial step of this work, we analyzed the result of data transmission of uplink and downlink by comparing NOMA and OMA conditions. We obtained the outage probability of the uplink channel that data transmit from BSs to UAV and the downlink channel that data transmit from UAV to ground users with considering the threshold value for achievable rate for each data transmission channel. *fig. 2* shows the simulation environment and *fig. 3* shows comparing the result of uplink and downlink channels between OMA and NOMA. These results indicate that NOMA will reduce the outage probability of the users than the OMA when increasing the transmit power.

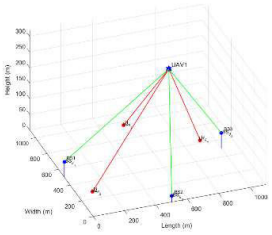

Fig. 2 Simulation (BSs, Ground Users, and UAV Randomly Positioned in Simulation Environment)

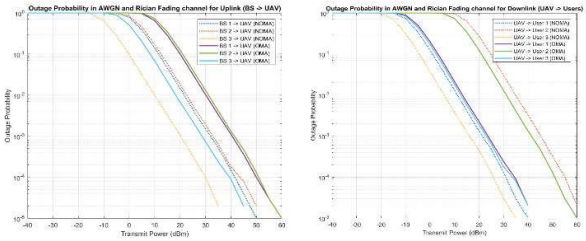

Fig. 3 Outage Probability of BSs to UAV (Uplink NOMA) Channels and UAV to Ground Users (Downlink NOMA) Channels

IV. Conclusion

This paper presented the data transition from BSs to ground users via a UAV assisted NOMA wireless communication network. We considered data transmission direction form BSs to UAV as uplink NOMA and data transmission direction from UAV to ground users as downlink NOMA. We modeled the equations for each channel and finally presented the initial result of uplink and downlink NOMA comparing with OMA.

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A Short Survey on Ultraviolet Communication Systems

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Abstract – The improvements made in the area of Optical Wireless Communication (OWC) has presented the new era of Ultra Violet Communication (UVC) which is used in both land and underwater arrangements. UVC has attracted extreme attention in providing more secure and reliable communication opportunities in the terrestrial environment and the same is been adapted in the underwater environment in order to increase the bit rate and efficiency of the present available systems. This short survey studies the specific uses of UVC in the terrestrial and underwater applications and identifies the future applications of UVC.

Keywords: Optical Wireless Communication, Terrestrial Communication, Underwater Communication, Ultraviolet Communication.

I. INTRODUCTION

Optical wireless communication systems (OWC), as one of the fastest growing industries in the world, has gained major importance in the field of research. Visible communication (VLC) has gained most attention as a popular OWC mechanism, yet development of VLC brought forth an important segment known as ultraviolet communication (UVC) [1]. Faster communication links were unachievable during the times where Xenon flashtubes and mercury lamps were the only UV light source available, and various advances occurred in the OWC and UVC fields within the past, with China and USA being pioneers [2].

The interaction of UV signals with atmosphere allows UVC a low-cost mode of communication and a less interception technology. The strong scattering and reflection ability of the UV signals enable them to bypass obstacles and the since the UV band has a solar-blind radiation, the system is capable to achieve higher performance through a low-transmitted power [1]. Application of UVC increased with its adaptability in the radio-silent scenarios as an alternative for wireless technologies, and thus, have become an advantage towards military grade communicational activities.

However, though UV channels show strong performance against meteorological conditions, it has strong channel attenuation which reduce the maximum achievable data rate and the rage of transmission of the signal. Thus, UVC has been characterized as requiring dense network configurations in its applications in non-line-of-sight (NLOS) optical transmission. Channel modeling through avoidance of atmospheric turbulence which can result in fluctuations of receiving power as well as scintillation attenuation effects has become a main issue and the single and multiple scattering models has been proposed on short range and middle to long range UVC respectively [3].

II. APPLICATION OF UVC

The initial studies on adaptation of UV-C spectrum to wireless communications dates back to the World War II, yet with complicated requirements being made in order to present an actual implementation, the applications have not been developed until much later. At present, UVC has been identified as applicable in both terrestrial and underwater environments.

A. Applications in the Terrestrial Environment

Terrestrial communication was mainly integrated with VLC in the past, yet the basic disadvantages that VLC showcased due to the strong influence that solar radiation had on its accuracy has created space for the development of UVC as a more suitable replacement. The current research studies on UV mainly focuses on its adaptability in the terrestrial links which assumes that both the transmitter and the receiver and locate on ground. The adaptability of FSO and UVC in military and civilian applications with lesser impact being curated through less noise generation has made its importance more higher and studies have focused on the development of more secure communication links between satellites due to the strong scattering of deep UV light in the air, especially with the strong absorption in the ozone layer [2].

Among the UVC systems that have been developed for use within terrestrial environments, mostly have been designed for short range distances and the limitations imposed by the transportation media as well as scattering effects such as Rayleigh has been identified in long-range communication channels [1].

The development in the UVC application in the terrestrial environment has been higher and performance enhancement mechanisms based on a number of techniques have been adapted, and the most studies mechanisms are presented in the table 1 below.

Table 1. Performance enhancement techniques in terrestrial UVC [1]

Technique	Advantages
Combination of MRC and ECG	Improve system BER Compensate for channel differences
Spatial diversity	Improved information rate within the system
Selective MRC	Captures mobility effect Ideal for typical transmission distances in indoor-environments
Beam reshaping	Improve intensity of received signal
Multiple input multiple output	Increase received signal power Reduce BER Reduce ISI

Present developments in the terrestrial UVC sector are focused on improving the distance and improving the quality of Tx and Rx signals. A most fundamental issue that terrestrial UVC faces is included with the noise associated in the entire transmission process [2].

B. *Applications in Underwater Environment*

Underwater communication has been mainly integrated with acoustic communication in the very beginning, and with further development underwater transmissions ranging through tens of kilometers with transmission rates of kilobits per second have been identified at the very beginning while at present it is capable to present a range of several kilometers at relatively low bit-rates. However, the limitedness of acoustic communication in presenting the required high-bandwidth has created a demand for better mechanisms with improved data capacities and RF technology emerged as a better solution [4]. With the recent developments undertaken in proposing wireless sensor networks underwater, with focus being based on unconventional factors such as soil properties. Yet, RF communications have also shown remarkable disadvantages since the higher attenuation within the underwater environments have required sacrificing of the transmission distance in the studies that were capable of maintaining higher data rates [4].

The propagation delays encountered in large transmission ranges due to the speed of sound underwater, alongside with Doppler effects and the hazards being caused to the marine environment has restricted the transmission levels and power levels [5]. The limited signal bandwidths achieved have considerable proven the systems to be much less effective and the attenuation has been shown to be higher within the water medium. Thus, the drawbacks of both acoustic and RF communication methods attracted UWC as a more suitable proposition, and the harsh environments have lesser effect.

When considering underwater FSO, it has been identified that it is capable to provide higher bandwidths with lower latency with a reduction in multipath effects [4].

III. Future Scope Of UVC

With the recent research work in the field of UVC, it is inevitably an advantageous addition towards the performance of the terrestrial communication and futuristic communication models can be expected via UVC-models. The requirements that are directly associated with the implementation of a standardized communication method. However, in the transmission and receiver-based channels still holds a number of significant issues which arises with the limited source power and the path loss as well [1]. More optimized pulse shaping is required to match the channel frequency and more improvements in beam shaping would provide considerable efficiency in energy transmission towards the receiver.

The nature of scattering needs to be considered and these improvements will provide much better opportunity to completely understand the transmission channel. With further improvements being made in the receiving end, UVC would provide an ability to extract a signal with less-noise. The optical background noise, device dark noise and the circuit thermal noises are to be considered when developing the Rx towards advanced demodulation [2].

However, the theoretical aspects of the study have been presented by various scholars yet the experimental studies are limited and the most accurate and practical models on UVC still remain unidentified [1]. Thus, the future scope of UVC needs to be more related towards experimental validation of the various models proposed and to gain comprehensive measurement analyses in the validation of the models in different environments and determining a solid model for practical use.

IV. Conclusion

When considering the future of communication, it is undeniable that further developments are essential in order to establish towards the future requirements in the social and industrial segments. The recent work in the UVC field has become an advantageous addition towards terrestrial communication but with the adaptions being made towards underwater communication, it has become an important segment in this area as well. Thus, the provision of a proper practical mechanism to further improve the transmission and receiving process in underwater transmission, it would be an important value-addition towards communicational sector.

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Indoor Air Quality Monitoring and IoT Platform for Smart Building Management

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Abstract - Indoor air quality is rapidly becoming a global issue. On the one hand, public health experts, environmental entities, and industry experts are working to enhance the overall health, comfort, and well-being of building occupants. Smart city projects promote the use of real-time monitoring systems to acknowledge unfavorable scenarios for enhanced living environments. The primary purpose of this work is to present and describe an indoor air quality monitoring system based on the Internet of Things for smart building management purposes. This paper highlights the design aspects of the platform, including sensor types, the microcontroller, the overall architecture, and connectivity. Moreover, preliminary results are presented, considering a minimal implementation to demonstrate the feasibility and reliability of the proposed platform.

Keywords: Air Quality, Data Analytics, Internet of Things, Monitoring, and Wireless Sensor Networks

I. Introduction

The indoor air quality level is a significant concern for most developing countries as it can be correlated to building users' health, comfort, and well-being. Moreover, people generally spend around 85% of their daily time indoors, so buildings' indoor air quality directly impacts their users' overall health and workplace productivity [1]. In that sense, smart city projects nowadays promote using real-time monitoring systems to detect adverse scenarios for enhanced living conditions. While energy efficiency or thermal comfort would be paramount in the recent past, more and more emphasis is being given to monitoring variables such as CO2 or the level of volatile particles. In that sense, the technological advancements for sustainability in smart city projects nowadays promote using real-time monitoring systems to detect adverse scenarios for enhanced living conditions. While energy efficiency or thermal comfort would be paramount in the recent past, more and more emphasis is being given to monitoring variables such as CO2 or the level of volatile particles [2].

From a technological point of view, the Internet of Things (IoT) and the expansion of new low-power, miniaturized, and cheaper processors and peripherals allow for the development of new platforms. Those have increased capabilities, as further communication means such as long-range LoRa networks and Bluetooth Low Energy, but also increased computational power [3]-[5]. While low-cost sensor technology retains a significant challenge in the lack of data reliability, the increased computing power permits correction algorithms through artificial intelligence (AI) for trend analysis and prediction [6]-[8].

While platforms that rely on the features mentioned above are quite standardized, the full integration of all the components is not usual. It poses a challenge regarding its global architecture, communication protocols, software services, and middleware algorithms that may or even should support machine learning strategies [9]-[11].

To that end, the current work proposes a new software/hardware model architecture. It collects data from different sources (air quality, building occupation, etc.), processes all building data analytics, triggers actions and feedback to actuators, and supplies information to its users. One of the most pertinent novelty considered is the total distribution of the "intelligence" of the system, where the sensor nodes can also contribute to low-level AI algorithms.

II. Proposed Solution

The architecture under development undergoes a standard distributed design, comprising sensor nodes with actuation capabilities, some communication means, and cloud services to provide the necessary information for building users and administration. Also, the required infrastructure for database storage, web support, data analytics services, and algorithm deployment are considered. Figure 1 resumes the global architecture and its components.

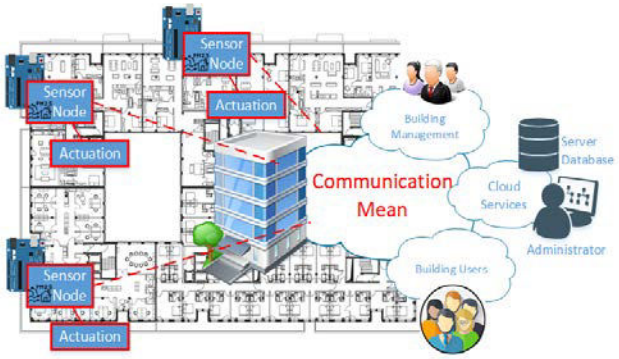

Fig. 1 - Global architecture

When considering the use cases, one can see two groups of actors: building management staff and the users of the building space. Also, the embedded sensor nodes can be seen as pseudo-actors, since they perform some actions on the overall system, and are the target of activities of the same.

The communication channel here is considered as a wireless sensor network that can exchange messages from simple sensor value packets to an extended ones, such as transferring data for or from an AI engine. Due to easy integration purposes, Wi-Fi with WPA2 Enterprise security is initially considered, although extending it to LoRa, 6LoWPAN, or ZigBee would be straightforward as updates of the IoT ecosystem. Also, MQTT through a JSON scheme is considered for data and command transmission, as a simple way to transfer simple to high complexity and length data frames.

The information gathered is stored and processed using cloud services. It is in the form of microservices that facilitates the management and availability of all distributed software implementation. Featuring a time-series database providing fast writing and reading through a web server, several tools such as administration, back-office, and AI data analytics services are

available in a rich interface. From this point on, all the necessary infrastructure is available for implementing features such as air quality information, occupation maps, alerts triggering regarding fatigue, evacuation, windows opening, etc.

A. Preliminary Results

For validation purposes, a simple setup was implemented to collect initial data from a set of air quality sensors. The sensors employed are listed in table 1, with the goal of covering the most common metrics to accommodate those who are more critical for human health [12].

Table 1. List of the all sensors used and their main features

Measured Parameter	Sensor Model Manufacturer	Measuring Range	Accuracy (Repeatability)
$PM_{1/2.5}$	SEN54 [Sensirion]	0 to 100 µg/m^3	±5 µg/m^3 AND 5% m.v.
		100 to 1000 µg/m^3	± 10% m.v.
$PM_{4/10}$		0 to 100 µg/m^3	± 25 µg/m3
		100 to 1000 µg/m^3	± 25% m.v.
RHT		-10 °C-50 °C; 0% to 100%	0,1 °C; ±1%
VOC		0-1000 ppm	± 25
CO_2	SCD30 [Sensirion}	400-10000 ppm	± 10 ppm
RHT		-10 °C-70 °C; 0% to 95%	0,1 °C; ±0,1%
eCO_2	ams iAQcore [ScioSense]	450-2000 ppm	NA
eTVOC		125-600ppb	NA
CO	MQ-9 [Seeed]	20-2000 ppm	NA
NO_2	SEN0441 [DFRobot]	0.05-1000 ppm	NA
Baromeric Pressure	BMP280 [Bosh]	300-1100 hPa	± 1 hPa
T		-40 °C-85 °C	± 1°C

The setup consists of one sensor node constituted by a Tensilica Xtensa dual-core 32 bits LX7 microprocessor featuring 240 MHz, 520 KB SRAM, and a Wi-Fi: 802.11 b/g/n transceiver. The sensor list (Table I) is connected through the I2C interface or the analog input channels. On the cloud side, there are Docker containers featuring an MQTT broker, an InfluxDB time series database, and Grafana for monitoring and analytics. Figure 2 shows the carbon dioxide level acquired by the two corresponding sensors, used here to demonstrate the feasibility and reliability of the preliminary deployed platform, and considering a person getting nearby the sensors, and thus producing the increased level.

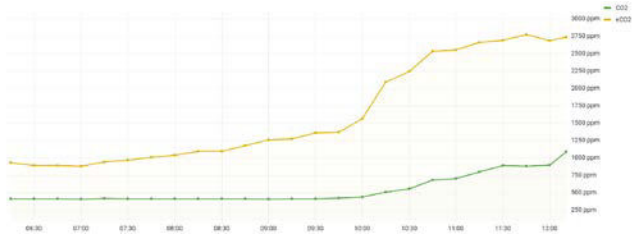

Fig. 2 Carbon dioxide in parts per million vs time

B. Conclusions

The current work describes an architecture for indoor air quality monitoring considering the possibility of acting on the environment's surroundings. This feature was possible by applying the IoT paradigm and using the most recent microcontroller design and programming advances. The preliminary results were presented to demonstrate the feasibility and reliability of the platform. Future developments will include deploying all the described features for the building users and the building administration, as well as powerful human-machine interfaces for monitoring and management. Implementing a distributed AI architecture, allowing the sensor/actuator nodes to be "intelligent" is also being considered, using a description language to transfer the AI knowledge.

C. Acknowledgements

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On the Competitiveness of LDPC Codes in Wireless

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***Abstract*—As 5G networks begin to be deploy commercially on a large scale, more and more research and industries are beginning to investigate next-generation communication systems. LDPC code is identified as a candidate channel code for 5G due to its design flexibility and high performance in medium and long code blocks. The question of how LDPC codes will perform in the 6G generation and how to maintain their advantages is a question worthy of consideration. In this paper, we briefly discussing the 6G vision and requirements and combining the characteristics of LDPC codes, analyzing how the development potential of LDPC codes in the 6G and maintaining their competitiveness, and providing directional guidance for the subsequent optimization of LDPC codes development.**

***Keywords*—LDPC codes, 6G, requirements, competitiveness**

I. Introduction

Recently, more and more organizations or individuals are involved in Beyond-5G (B5G) or 6G concepts, including academia, industry, government and even the public. Channel code is the foundation of wireless communication, and the next-generation channel code mechanism needs to be researched and broken through first to lay the foundation for future 6G wireless communication systems. In this paper, we will focus on the vision and requirements of 6G and combine the characteristics of LDPC codes, and try to outline the application and optimization scheme of LDPC codes in 6G generation, and provide directional guidance for the subsequent development of LDPC codes optimization. The following sections of this paper are organized as follows: Section 2, which discusses main possible future scenarios of 6G; Section 3, which discusses main directions of future LDPC codes development; Section 4, which makes a competitiveness analysis of LDPC codes; Section 5, which provides a summary of the whole paper.

II. 6G VISION

There is no doubt that compared to 5G, 6G will have wider coverage, higher data transmission rate, higher reliability, lower latency.

Each communication technology update, communication content will be more and more towards the real. Extended reality (XR) services (encompassing augmented, mixed, and virtual reality (AR/MR/VR)) can greatly improve people's sensory experience, which are the most promising evolutionary direction for future mobile communication, entertainment, and office equipment. In recent years, XR devices and XR technology have been fully developed, and there are more and more application scenarios. There is no doubt that many companies have taken XR devices as the future research direction [1] [2]. With the arrival of 6G, which will provide peak rates of Tb/s and lower latency, this will greatly improve the network environment for XR devices, and with the continued maturation of XR technology and the enrichment of XR content. With the arrival of 6G, XR devices will be at the breaking point.

In the future, when IoT devices are more and more functional, complex and targeted, the IoT clusters will be formed as show in Fig 1, while IoT central devices for different scenarios will be determined. The center of the IoT clusters will gradually turn from people to devices. IoT devices will also be combined with cloud computing, distributed, and blockchain technologies to achieve decentralization in order to build device-centric IoT clusters. The ideal system will be one that is completely free of human intervention [3].

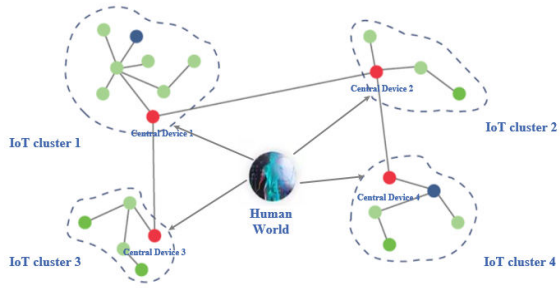

Fig. 1: IoTs clusters communication model.

III. FUTURE DIRECTIONS OF LDPC CODES IN 6G

From the 6G vision analysis, it is clear that the peak rate of 6G in 2030 will reach Tb/s and should also have extremely low latency and can support the simultaneous linking of large-scale IoT devices. Therefore, the optimization direction of LDPC codes should be relevant to the needs of the 6G vision. In general, LDPC codes optimization direction can be divided into two categories, one is the new combination with 6G popular technologies, such as Thz, optical communication, etc, and the other is the optimization of LDPC codes system itself, such as in structure, encoder, and decoder algorithm.

THz as a new frequency band between microwave and light wave has not been fully developed. THz band, spectrum resources are very rich, with high transmission rate and easy to achieve the integration of communication detection, etc, focusing on meeting the needs of the Tb/s level of high-capacity, ultra-high transmission rate systems, so THz communication is an advantageous broadband wireless access technology in future mobile communication [4]. LDPC codes can reduce the signal fading of Thz, improve Thz communication distance and data bit rate [5], and the combination of LDPC codes and

Thz can now reach 352Gb/s data throughput [6], which is a significant progress towards Tb/s level data throughput.

VLC has been proposed as an emerging solution for the next generation wireless network [7]. Compared with radio communication, VLC has many attractive advantages [8]. Firstly, VLC technology can provide a large amount of potentially available spectrum (THz-level bandwidth), and the use of spectrum is not limited and does not require the authorization of spectrum regulators. Secondly, VLC does not generate electromagnetic radiation, and is not easily affected by external electromagnetic interference, widely used in the electromagnetic interference sensitive, and even must eliminate electromagnetic interference of special occasions. Thirdly, the network built by VLC technology can effectively avoid the transmission of information by external malicious interception, to ensure the security of information. Finally, VLC technology supports the rapid establishment of wireless networks, which can easily and flexibly set up temporary networks and communication links, reducing Low network usage and maintenance costs. LDPC codes can reduce the BER and energy consumption of VLC, and improve the communication distance of VLC [9].

The research of AI technology in wireless communication also gives a new optimization tool for channel code research. The optimization of AI technology for LDPC codes mainly focuses on the optimization of LDPC codes decoding algorithms. Among many machine learning methods, neural networks and deep learning are the most commonly used means for channel decoding algorithm optimization. The min-sum decoding algorithm of LDPC codes is well suited to be unfolded with deep learning, which can optimize the excessive parameters of the min-sum algorithm and reduce the computational complexity, and the min-sum algorithm optimized by deep learning has better BER performance [10]. The correct and efficient usage of AI techniques to optimize LDPC codes can exploit the value of LDPC codes even more.

IV. Competitiveness of LDPC Codes in 6G

TABLE I: Comparison of LDPC,Polar,Turbo.

Channel code	**LDPC**	**Polar**	**Turbo**
Advantages	Suitable for parallel decoding	Theoretical performance is optimal	Good anti-fading and anti-interference ability
Disadvantages	Short code performance is inferior to Polar	Not enough industrial support	Large decoding delay

From Tab 1, we can see that Turbo codes do not meet the requirement of low latency of 6G vision, the existing channel code only LDPC, Polar can achieve the 6G corresponding performance requirements, so the biggest competitor of LDPC codes is Polar codes, which is the only code scheme that can be mathematically and rigorously proven to reach the Shannon limit [11].

In terms of throughput and latency performances, LDPC codes have a natural advantage because LDPC codes use the sparsity of the checksum matrix, which makes the decoding complexity linear with the code length, so that decoding can still be performed efficiently w ith l ong c ode l engths and LDPC can use an efficient p arallel d ecoding a rchitecture to ensure decoding accuracy and low latency at high throughput rates. The mainstream decoding algorithm of Polar codes is considered as successive cancellation list (SCL) decoding [11], and the mechanism of SCL is bit-by-bit decoding, which is not easy to implement with high parallelism, resulting in relatively large latency.

In terms of BER performance, the channel polarization characteristic of Polar codes and SCL decoding algorithm ensure that Polar codes are theoretically the best among all channel codes. In practice, the short code BER performance of Polar code is better than LDPC code, and the long code BER performance is comparable to LDPC code, but LDPC code BER performce is better under high SNR [12] [13].

In terms of industry support level, LDPC codes have been developed for nearly 60 years and has been widely used in WIFI, WIMAX and DVB-S2, etc [14]. LDPC codes have a strong industrial base, and the practical application is extremely competitiveness. Polar codes development years are too short, many things need to be implemented from theory to hardware design, system design, so the potential of Polar codes has not been fully exploited.

V. Conclusion

LDPC codes are not the best channel codes in any aspect of performance, but on the whole, they are the most competitiveness codes. LDPC codes' long code position is almost unshakable at present, and with the increase of 6G data throughput, the advantages of LDPC codes will be further strengthened, and LDPC codes will also play an important role in 6G communication system.

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5G Key Technologies Adopted in South Asian Countries

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Abstract - Due to rapid changes in the wireless communication world, we discussed the adaptation of 5th Generation (5G) key technologies in South Asian countries. There are eight South Asian countries and only four countries have taken the steps to deploy 5G technology while only two countries could be deployed commercially at present. These four countries deployed Non-Standalone (NSA) 5G network while Sri Lanka deployed a Standalone (SA) 5G network as a pilot project. This work is extended to describe the challenges faced in south Asian countries when deploying the 5G network and finally discussed future trends.

Keywords: Non-Standalone (NSA), Standalone (SA), massive Multiple Input Multiple Output (mMIMO), 5th Generation (5G), Ultra-Reliable Low Latency Communication (ULLRC).

I. INTRODUCTION

In 1980, the launch of analog cellular systems in the world created a revolution in wireless communication systems. The continuous evolution of wireless communication is experienced day to day in the telecommunication world. The 5G of mobile broadband technology is the latest which gives greater speed data and connectivity with low latency [1]. This 5G is a major milestone in wireless technology and will be replaced the existing 4th Generation Long Term Evolution (4G LTE) technology [2]. 5G could be implemented in non-standalone (NSA) which uses existing 4G network infrastructure or standalone (SA) modes when deploying according to the requirement of the mobile network operators (MNOs) There are key technologies introduced in 5G technology such as new spectrum bandwidth, mMIMO and beamforming, lean design, network slicing, CUPS and multi-access edge computing. Further, 5G Network Radio (NR) will make better with technologies of flexible slot base framework, scalable Orthogonal Frequency Division Multiple Access (OFDM) numerology, advanced Low-Density Parity Check codes (LDPC), mMIMO and mobile mm-wave [3].

There are eight countries in South Asia namely Sri Lanka, India, Pakistan, Nepal, Afghanistan, Bhutan, Bangladesh and Maldives. The Indian Institute of Technology launched the 5G testbeds at 5 locations in May 2022. Also, Reliance Jio and Airtel plan to launch the 5G in 13 cities namely Ahmedabad, Bengaluru, Chandigarh, Chennai, Delhi, Gandhinagar, Gurugram, Hyderabad, Jamnagar, Kolkata, Lucknow, Mumbai, Pune on 29th of September 2022 [4].

Before Afgan was fallen to Thalaibhan, the 5G foundation was laid in March 2021 through a parallel wireless project while the Open Radio Access Network (ORAN) with Etisalat. Bangladesh is planning to have a 5G network in the country in 2024. It will be covered selected cities as well as government facilities [5]. In the Maldives, 5G is presently commercially available the greater Male' area. The Ooredoo service provider implemented the 5G network and it has above 1Gbps peak speed and average speed is 400 Mbps- 600 Mbps. Nepal is expected to launch 5G by the end of 2022. However, Nepal is not a country that demands 5G since the 4G network was introduced with a delay. It is a plan to launch 5G services in Pakistan in 2023. They have decided to allocate a 700 MHz band. However, it is maybe delayed to launch due to political instability in the country [6]. Dialog Axiata, Mobitel, Airtel and Hutch service providers successfully tested 5G in Sri Lanka in 2019. Hence, Sri Lanka became the first ever country which tested a 5G facility in South Asia. There are 3 service providers namely Dialog Axiata, Mobitel and Sri Lanka Telecom which operate pre-commercially 5G networks in selected areas. However, Dialog Axiata operates it separately Stand Alone network of 5G. Airtel Lanka tested its 5G trials with the Non-Stand Alone network technology with the highest ever speed record of 1.9 Gbps. Hutch also has done its 5G trials recording a speed of 1.8 Gbps. The 5G facility was launched in Bhutan on 27th December 2021 for commercial use in its 3 major cities [7].

A. Contribution

The main contributions of this work are listed as follows:

- Identified the countries which deployed 5G technology in South Asia.
- Briefly explained the reasons that the remaining South Asian countries could not deploy the 5G.
- Explored the technologies used for deployment.
- Identified the challenges and explored future trends.

B. Paper Organization

The remainder of the paper is organized as follows: Section II presents the 5G key technologies adopted in South Asian countries and challenges faced in South Asian countries during the transition from 4G to 5G in Section III. Section IV, future trends and Section V conclude the whole paperwork.

II. THE 5G KEY TECHNOLOGIES ADOPTED IN SOUTH ASIAN COUNTRIES

The four countries in South Asia introduced 5G technology. Further than Bhutan and Maldives 5G is commercially available for selected cities while India and Sri Lanka already conducted trials and awaiting launch.

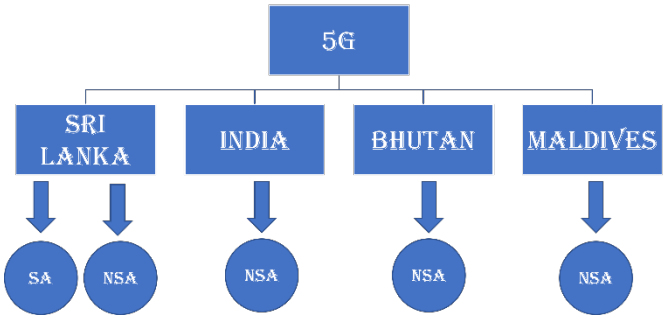

Fig. 1 5G deployment modes in South Asian countries.

Fig. 1 shows the 5G deployment modes in south Asian countries. There are two basic deployment modes such as Non-Standalone (NSA) and Standalone (SA) [9]. NSA mode is 5G technology implemented with 4G LTE existing architecture and

SA mode is the separate architecture used with 5G Radio Access Network (RAN). In Sri Lanka, Dialog Axiata service providers used SA deployment mode and the other three service providers used NSA deployment modes. We identified several benefits use NSA 5G over SA 5G. These are low-cost, easy and fast deployments and they will give a pathway to develop the SA 5G network [8]. However, NSA 5G have major drawbacks it uses more energy as both 5G and 4G infrastructure are powered.

Table 1. Adoption of key technologies to 5G deployments in South Asia.

Technologies	NSA	SA
New spectrum and bandwidth	✓	✓
mMIMO and beamforming	✓	✓
Lean design	✓	✓
Network slicing	×	✓
CUPS	✓ (Limited)	✓
Multi-access edge computing	✓ (Limited)	✓

Table 1 shows the details of the adoption of co-technologies for 5G deployments in South Asia. NSA 5G could use CUPS and multi-access edge computing only up to a limited level. Also, network slicing is unable to use in NSA deployment mode. Therefore, NSA does not have the capability of low latency and high speed which improve the 5G network performance.

Table 2. Adoption of 5G NR to 5G deployments in South Asia.

5G NR Technologies	NSA	SA
Flexible slot base framework	✓	✓
Scalable OFDM numerology	✓	✓
Advanced LDPC	✓	✓
mMIMO	✓	✓
Mobile mm-wave	✓	✓
eMBB	✓	✓
ULLRC	×	✓
mMTC	×	✓

Table 2 shows the details of the adoption of 5G NR to 5G deployments in South Asia. The SA 5G network was deployed to complete the new architecture with 5G RAN and NR. The NSA 5G network is developed over an existing 4G network architecture. NSA only supports enhanced Mobile Broadband (eMBB) and Ultra-Reliable Low Latency Communication (ULLRC) and massive Machine Type Communication (mMTC) services cannot be deployed on NSA.

III. CHALLENGES FACED IN SOUTH ASIAN COUNTRIES DURING THE TRANSITION FROM 4G TO 5G

All eight South Asian countries are considered developing countries. Further, the Covid-19 situation and world economic crisis badly affected their economy during the past few years. Hence, Afghanistan, Bangladesh, Nepal and Pakistan had compelled to delay 4G implementation due to high-cost involvement. However, Bhutan, India, Maldives and Sri Lanka managed to launch 5G as they had their 5G road map in place before the crisis. However, Dialog Axiata could not implement SA 5G transition by investing approx. USD 250 million as they expected due to the dollar crisis in Sri Lanka. For 5G implementation, it is required to deploy more 5G stations investing very huge cost which will provide industries and users facilitating with very high network speed connectivity and up to 1 million devices connect seamlessly among them while ensuring a highly reliable network with low latency. In current trends industries are not ready to face this evolution as they have very less knowledge about 5G capabilities [8]-[10]. Hence, service providers have a big challenge in getting their Return of Investment (ROI) as expected.

IV. FUTURE TRENDS

There will be an industry evolution due to the 5G deployment based on the data and connectivity. The South Asian countries' economies are based on agricultural backgrounds. Therefore, 5G implementation could be used in most areas in the agriculture field to obtain details and track and monitor in real-time. Sri Lanka and Bangladesh are more in the apparel industries and both countries can utilise 5G for the concept of smart factories with automation. Further, tourism in Soth Asian countries is very popular in the world. Hence, Augmented Reality (AR) or Virtual Reality (VR) helps to promote tourism. There are hundreds of applications that could be developed to use 5G technology [6]-[8].

V. CONCLUSIONS

In this paper, we have discussed the adaptation of 5G key technologies with 5G deployments in South Asian countries. We observed that NSA 5G technology is vastly used during the 4G to 5G transformation mainly due to cost-effectiveness, easy deployment and the least roll-out time. However, no any South Asian country is still ready to use all benefits.

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Track 7

Chemical Process Technology

Enlargement of Interlayer Spacing of Molybdenum Disulfide on Graphene Oxide for the Hydrogen Evolution Reaction

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Abstract- Molybdenum disulfide is a prominent substance in experiments on hydrogen evolution reaction (HER) due to the lower binding energy of the material. It has been recently considered as a promising non-precious metal alternative to platinum with high HER activity. The most stable form of molybdenum disulfide among three specific phases is 2-H MoS_2, and it has a hexagonal phase structure but only edge-sites are activated across the basal plane. Here, we have hypothesized that the concentration of GO will influence the interlayer spacing of MoS_2 on the GO. In this work, we studied the formation of MoS_2 using various concentrations of GO (6 mg, 12 mg, and 18mg) along with other precursors. (Ammonium Molybdate, Thioacetamide, and Urea). The impact of the mass ratio of MoS_2 to rGO during the synthesis process was then extensively examined, utilizing a variety of analytical methods such as SEM, PXRD,and Raman. The intercalation of rGO nanosheets into the MoS_2 nanosheets results in a 3D hierarchical floral architecture in the MoS_2/rGO nanocomposite. Moreover, the sharp, uniformly distributed MoS2 nanostructures observed at the higher amount of GO (18mg) and also the X-ray diffraction pattern show that a polycrystalline, hexagonal structure with a larger interlayer spacing of 9.39 A^0 for the same sample. Raman results of the material confirmed the structure and GO-3 sample has a less number of defects Additionally, GO-3 had the lowest onset over potential for HER, according to the electrochemical analysis.. Finally Interlayer space enlargement happened due to the intercalation of GO into the MoS_2 layers during the hydrothermal process, which led to the creation of a 3D hierarchical floral structure of MoS2 with a greater activity for HER.

Keywords: Hydrogen Evolution, Molybdenum Disulfide, Interlayerspace

I. Introduction

Global warming has been identified as the huge environmental problem that people have to face in next two decades and it refers to the gradual rise in the overall temperature of the atmosphere of the Earth. Carbon dioxide is one of the main gas components contributing to the daily increment of global warming and the Rate of the carbon dioxide emission has been increased due to the higher usage of fossil fuels. In that case numerous researchers have concentrated on the production of alternative energy sources such as Hydrogen. In that purpose renewable energy sources like solar are used for the formation of hydrogen through the electrochemical or photochemical water splitting reaction. But the electrochemical water splitting reaction should be catalysed due to their kinetic and thermodynamic barriers of the reaction. Platinum is the most appropriate catalyst could be used for the Hydrogen Evolution Reaction (HER) because it can easily override the both barriers of kinetics and thermodynamics. But, Platinum cannot be used in the industrial scale due to the low cost and low availability. That is the main reason for focusing on the Alternative catalysts for HER.

Molybdenum disulfide is a commonly used material in research related to electrochemical hydrogen production. Because it has a lower binding energy value, it is more near to zero as compared to the platinum metal. We hypothesized in this study that changing the ratio of GO to MoS_2 would have a significant impact on interlayer spacing and the HER catalytic performance of the MoS_2/rGO nanocomposites. MoS_2 has three major structures, which are identified as 1T-MoS_2, 2H-MoS_2 and 3R-MoS2. But 2-H MoS_2 is the most stable form that has activated edge-sites and an inactive basal plane. Therefore, enhancing and opening edge-sites into the reaction site is important for the synthesis of reactive materials. Here we have investigated the influence of rGO on the interlayer spacing of MoS_2 to form the best material for the hydrogen evolution reaction. 3R-MoS2.But 2H-MoS2 is the most stable form and only the edge sites are activated here.

II. Materials And Methods

A. Synthesis of Molybdenum Disulfide-Graphene Oxide Nanocomposites

GO was synthesized from natural graphite powder by a modified Hummers' method [1]The MoS_2/Graphene Oxide nanostructures are synthesized by a hydrothermal method using Graphene Oxide, Ammonium molybdate tetrahydrate $(NH_4)_6Mo_7O_{24}.4H_2O$, thioacetamide and urea as starting precursors under 6-7 PH of conditions. GO (10, 15, 20 mg) powder was added into deionized water Under ultrasonic dispersion for 60 min to get the dispersion solution at room temperature After being dissolved in graphene mixture under continuous stirring for 2 hours. The resulting solution is then put in a 25 mL Teflon-lined stainless-steel autoclave at a temperature of 180 ˚C for 24 hours. Then it is allowed to cool

down to room temperature. The finally obtained product is collected by centrifugation and washed several times using water and ethanol Finally, The precipitates are then vacuum dried for 2 hours. The reactions which occur during above procedure are written as follows

III. Results And Discussion

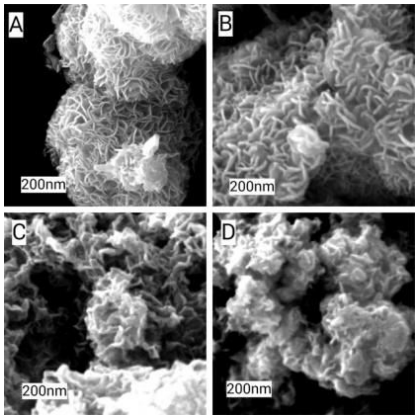

Figure 01: SEM images of MoS_2 nanoparticles on graphene ,(A,B,C) Samples prepared by using 18mg, 12mg, 6mg of graphene oxide respectively (D)Pure MoS_2

The morphology and nanostructure of the as-prepared samples were examined using scanning electron microscopy (SEM). SEM (FESEM-LEO 1525) was used to evaluate the morphology and structure of the samples in order to verify the sharpness and extent of MoS_2 development on the different amounts of graphene oxide. According to the figure:01 the stark morphological contrast emphasizes the key role of GO as a support material for mediating the formation of nanomaterials. To begin with, as shown in Figure 01 (D): MoS_2 has a diameter of between 100 - 150 nm and the structure is like 3D flowers. However, the edge sites were not cleaned and have a staggered structure with no discernible strata. However, when GO got involved, these layers began to diverge, and at 18 mg of GO, they were properly divided equally and dispersed as intended.

The MoS_2/rGO hybrid was characterized by X-ray diffraction (XRD), and the set of diffraction peaks indicated the Nano sized MoS_2 crystal with hexagonal structure. For pure MoS_2, the diffraction peaks are well matched with the JCPDS Card No. 37-1492[2]. The peaks appear at 14.2 º, 33.5 º, and 59.3º corresponding to (002), (100), and (110) planes, respectively. For MoS_2/rGO only the GO peak has disappeared and all the other characteristic peaks of MoS_2 are present. Enlargement of the interlayer spacing of the MoS_2 has been proved by XRD patterns of MoS_2/rGO. In comparison to the pure MoS_2, Peak value corresponding to the (002) plane in MoS_2/rGO3 has shifted from 14.2˚ to 9.411˚ and interlayer spacing values has risen from 6.22A˚ to 9.39A°. Furthermore, the interlayer space has also increased with an increment of GO ratio as a result of GO intercalation into the layers of MoS_2[3]. The layed-like structure of MoS_2/rGO, which possesses a hexagonal phase, was confirmed by the Raman spectra of three different materials. E2g1 and A1g peaks representing in-plane and out-of-plane vibrations were seen At 181 cm^{-1} and 320 cm^{-1}, respectively, The number of defects in the material is correlated with the intensity ratio between the G peak and D peak. They claim that the sample made with 6 mg of graphene oxide had the highest number of defects. Additionally, the peak at 786 cm^{-1} is related to the Mo- C bonding.

Linear sweep voltammetry was used to test the hydrogen evolution capabilities of nanocomposites in an acidic environment. The results were confirmed that the activity of the materials is able to increase by increasing the number of edge sites by enlarging the interlayer space value of MoS_2. According to the LSV the sample with the largest interlayer space also had the lowest onset over potential (0.276 V) at a current density of 4.4 mA/cm^{-2}.

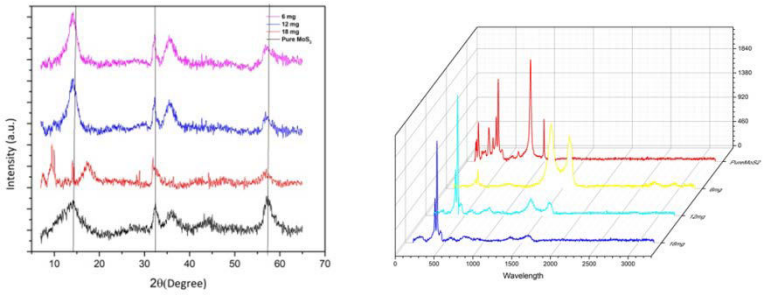

Figure 01: XRD and Raman patterns of pure MoS_2 and MoS_2/rGO hybrids

IV. Conclusion

In conclusion 3D hierarchical MoS_2.rGO nanocomposites have successfully synthesized by the one pot hydrothermal method exhibits the interlayer spacing of 9.39 A^0. The addition of GO increased the interlayer space of MoS_2/rGO. It has been wider with more clear, sharped active edge sites which have contributed to the hydrogen evolution activity.

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Effect of Graphite Oxide Loading on Tensile Properties of Natural Rubber Composites

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Abstract - Graphite-based fillers have garnered global attention in the industry and academia due to their outstanding mechanical properties such as mechanical stiffness, strength, and elasticity. In this study, a series of natural rubber (NR) composites were prepared by varying the graphite oxide (Gro) loading from 0 to 10 phr (parts per hundred rubber) at 2 phr intervals. Gro showed a significant enhancement in tensile properties and hence reinforcement of the NR composites as evident from the comparison of the results with those of the composite prepared without Gro (control). The composite prepared with 10 phr loading of Gro indicated high mechanical performance in terms of tensile strength and elongation at break. Therefore, this composite could be used in high elastic rubber-based applications. In addition, this composite shows an enhancement in tensile performance and hence, it could be economically advantageous for low volume NR based applications. Moreover, the stress-strain performance of 10 phr Gro loaded composite showed greater improvement due to representation of the largest area under the stress-strain curve and could be related to enhancement of elastic energy of the composite. Finally, the composite prepared with 10 phr loading of Gro showed about 10% increase in tensile strength compared to the control. Also, a 22% increase in elongation at break was observed in the former composite in comparison to the latter composite. Hence, the NR composite prepared with 10 phr loading of Gro could be suitable for high elastic polymeric applications requiring good modulus and tensile strength.

Keywords: Natural rubber, graphite oxide, tensile strength

I. INTRODUCTION

Graphite oxide (Gro) is generally the intermediate compound for obtaining separated graphene sheets. Further, graphite lattice has been exfoliated via chemical oxidation to disrupt the weak van der Waals forces, allowing for easy penetration with molecules. This process results in the formation of Gro, of which the interlayer space is occupied by epoxy, hydroxyl, and carbonyl functionalities [1]. Hence, Gro represents better functionality than natural graphite and this would be advantageous in improving compatibility with polymeric materials. In addition, Gro is widely used in different fields such as modern chemistry, physics, materials science, engineering, etc. [1]. Natural rubber (NR) possesses good mechanical and chemical properties, which enable NR as one of the most important raw materials used widely in the tire industry and other product manufacturing industries. NR is usually reinforced with mineral fillers in order to get substantial improvements in strength and stiffness [2]. However, the traditional reinforcing materials are not so effective in NR composites as high loadings should be incorporated to get the required properties. The most widely used filler in the rubber industry is carbon black. The incorporation of graphite-based materials such as Gro, graphene, surface-modified graphite has a potential to improve the overall performance of NR and lower loadings could be sufficient to enhance the performance of the end composite [3]. Hence Gro was used in this study, and it interacts well with the rubber when they are mixed together. In order to achieve an enhancement in properties of NR composites, fillers need to be well dispersed and homogenized with the rubber.

II. MATERIALS AND METHODS

A. Materials

RSS-2 (Ribber Smoked Sheet rubber) was supplied by the Rubber Research Institute of Sri Lanka. Graphite having a mean particle size of 14 micron was obtained from Bogala Graphite Lanka PLC., Sri Lanka. All rubber compounding ingredients were purchased from local suppliers. Potassium permanganate ($KMnO_4$), ethanol (C_2H_5OH), hydrochloric acid (HCl), sulfuric acid (H_2SO_4), and hydrogen peroxide (H_2O_2) were purchased from Organic Trading (Pvt.) Ltd., Sri Lanka.

B. Methodology

Preparation of NR composites filled with Gro

A series of NR composites was formulated by varying the Gro loading from 2 to 10 phr at 2 phr intervals. The NR composite prepared without Gro was considered as the control. The formulation of the composites is given in **Table 1**. The composites were prepared by melt mixing using a Brabender Plasticorder operated at room temperature, at a rotor speed of 60 rpm. Total mixing time was kept constant at 10 min.

Table 1. Formulation of NR composites filled with Gro

Ingredient	Function	Phr
NR	Rubber	100
ZnO	Inorganic activator	5.0
Stearic acid	Organic activator	2.0
TMQ	Antioxidant	1.0
Gro	Filler	0 2 4 6 8 10
ZDC	Accelerator	1.5
Sulphur	Vulcanizing agent	2.0

Determination of tensile properties

Tensile properties of Gro/NR composites were determined using Instron tensile testing machine according to BS ISO 37:2017. Dumb-bell shaped tensile test specimens were used. Cross-head speed was maintained at 500 mm/min with three replicates per treatment.

III. RESULTS AND DISCUSSION

Stress-strain curves provide an extremely important graphical measure of mechanical properties of a material such as modulus, tensile strength and elongation at break. These parameters are highly important to explain the elastic behavior of a polymeric material and special rubber-based materials. **Fig. 1** shows the stress-strain behaviour of NR composites prepared with and without Gro. The composite prepared with

10 phr loading of Gro shows higher stress-strain properties compared to the other Gro filled composites and the control. Generally, toughness of rubber composites increases with filler loading [4]. The 10 phr Gro loaded composite shows the highest toughness, which is indicated by the highest area under the stress-strain curve. In addition, area under this curve represents the elastic potential energy of polymeric materials. Hence, the composite prepared with 10 phr loading of Gro shows a higher elastic potential energy than the other composites. Tensile strength of most of the Gro loaded composites is higher than that of the control. The composite prepared with 10 phr loading of Gro shows the highest tensile strength (28.6 MPa) and it could be attributed to greater toughness. In contrast, the composite prepared with 6 phr loading of Gro shows the lowest tensile strength (24.3 MPa) and the reason might be due to agglomeration of graphite-based materials at lower loading levels [5]. All the composites exhibit similar tangents at 100% elongation and hence, modulus at 100% elongation of NR composites has not shown a significant variation with the increase of Gro loading (Figure 1). Further, modulus at 100% elongation indicates hardness of a rubber material. Hence, the composite prepared with 10 phr loading of Gro indicates the highest hardness out of all the composites. However, all the Gro-filled NR composites show a higher modulus at 100% elongation compared to the control. The factors that affect reinforcing potential of fillers include filler dispersion, surface reactivity, bonding strength between the rubber and the filler, etc. Variation of modulus at 300% elongation of NR composites with Gro loading is also shown in Figure 1. Modulus at 300% elongation of all six composites is observed in the range 2.04 – 2.48 MPa. Modulus at 300% elongation of most of the composites prepared with Gro is higher than that of the control. The composite prepared with 10 phr loading of Gro shows the highest modulus at 300% elongation and it can be attributed to the highest crosslinking density. Elongation at break of all composites is higher than 500% (Figure 1) and it is a good indication of elastic performance. Elongation at break of all Gro filled NR composites is higher than that of the control and this can be attributed to better dispersion of Gro in the NR matrix and further, better reactivity of Gro with NR via the hydroxyl group. The composite prepared with 10 phr loading of Gro shows the highest elastic properties, and the reason may be better adhesion between the NR phase and the functionalized Gro. Moreover, the composite prepared with 12 phr loading of Gro illustrates poor surface morphology (Fig. 1) compared to 10 phr loading Gro. Hence, 10 phr loading of Gro would be used as optimum loading to enhance the tensile properties of NR composites.

IV. Conclusions

The composite prepared with 10 phr loading of Gro showed 10.4 % increase in tensile strength compared to the control. Further, the Gro filled NR composites showed a remarkable improvement in elongation at break in comparison to the control. Hence, it can be concluded that the NR composite prepared with 10 phr loading of Gro could be suitable for high elastic polymeric applications requiring good modulus and tensile strength.

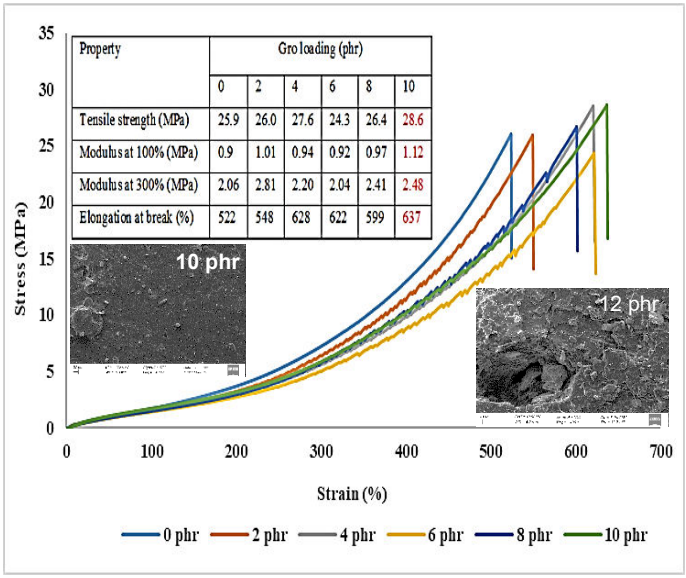

Fig. 1 SEQ Figure * ARABIC 2. Variation of stress-strain properties of NR composites with Gro loading

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Investigation of Environment-Friendly Skin Whitening Agents from the Plant *Polyscias balfouriana* L.H. Bailey

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Abstract - Skin is the most visible organ in the body. The use of whitening agents can help skin to glow and lighten the colour by reducing the melanin concentration. Despite using synthetic whitening agents which contain heavy metals like mercury that are toxic and not environment-friendly, it is always better to consume environment-friendly whitening agents which are produced using natural products and to achieve sustainable development goals. The *Polyscias balfouriana* L.H.Bailey belonging to family Araliaceae, leaves were used to find activities which inhibit the melanin synthesis that leads to whitening the skin. The leaves were extracted using hexane, ethanol, methanol and ethyl acetate. The obtained extracts were used to determine the antityrosinase activity. Inhibitory activity of the mushroom tyrosinase method was used to determine the antityrosinase activity. The most effective activity (48% inhibition) was observed for the ethanol extract with the concentration of 0.25 mg/mL. The standard (kojic acid) showed only 22% inhibition at the same concentration. However, when the ethanol extract concentration was raised the antityrosinase activity declined. This observation was opposite to the behaviour of standard. The other two extracts followed a similar trend to that of ethanol. Therefore, according to the results *Polyscias balfouriana* L.H.Bailey leaves show some positive antityrosinase activity.

Keywords: Melanin, Tyrosinase, Antityrosinaes, Enzyme, Polyscias balfouriana L.H.Bailey

I. INTRODUCTION

Skin is the most visible organ in the human body. So, most of the individuals including the youth are interested in improving their skin complexion by applying commercially available cream/lotions which contain harmful chemical substances. These products may help to lighten the skin or to provide an even skin colour mainly by reducing the melanin concentration in the skin. These agents can be synthetic or non – synthetic. But most of the skin whitening agents found today are synthetic which contain heavy metals like nickel, mercury and zinc [1]. They are toxic and not environment-friendly, and they can cause health issues such as neurological problems and kidney problems. Therefore, in the view of sustainable development goals, the development of nontoxic and environment-friendly whitening agents is desirable.

Tyrosinase enzyme can be found in plants and animal tissues. It is an enzyme which contains copper. The enzyme functions as a catalyst in the melanin synthesis during melanogenesis. This biological reaction converts tyrosine into a polymer of melanin. Tyrosinase enzyme limits the rate of the melanogenesis stage [2]. In fact, the first step of the melanin synthesis is controlled by the tyrosinase enzyme. *Polyscias balfouriana* L.H.Bailey is native to Australia and Papua New Guinea. It belongs to the family Araliaceae and it is commonly cultivated in South-eastern Asia. This plant is not famous in Sri Lanka however, it is widely available in urban areas. It is a small tree with many branches and has broad leaves. Reported data shows that plants belonging to the Araliaceae family have bioactivities including antitoxin, antibacterial, and anti-inflammatory effects which are helpful in the treatment of asthma [3]. Parts of this plant are used as anti-dysentery, febrifuge, diuretic and for neuralgia and rheumatic pains. Therefore, as a part of an ongoing effort to develop environment-friendly skin lightening agents, it is interesting to investigate the potential antityrosinase activity of *Polyscias balfouriana* L.H.Bailey.

II. MATERIALS AND METHODS

Polyscias balfouriana L.H.Bailey leaves were collected from Gampaha district. They were first dried and homogenized using a blender. Powdered leaves (50 g) were soaked in 350 mL of hexane and it was kept on a shaker for 8 hours at room temperature at a speed of 200 rpm. Then it was kept it in a refrigerator for 2-3 days. The residue was soaked in 350 mL of 100% ethanol and kept on a shaker for 4 hours at room temperature at a speed of 200 rpm. Then it was kept in a refrigerator for a day. Ethanol solution was then filtered using a cheese cloth and the solvent was removed by rotary evaporation. Finally, it was collected into an evaporating dish and purged nitrogen to obtain the final crude product. A similar procedure was followed to get methanol and ethyl acetate extracts.

A. Tyrosinase inhibition assay

A weight of 1.70 g of KH_2PO_4 was dissolved in 250 mL of deionized water to prepare a phosphate buffer solution (50 mM, pH 6.5). A weight of 61.2 mg of the L-DOPA solid was dissolved in 25 mL of the phosphate buffer to prepare L-DOPA solution (12 mM). Extraction of the tyrosinase enzyme was done by torning and squeezing 200 g of fresh oyster mushrooms and filtering it using a cheesecloth into a beaker which was kept in an ice bath. The standard/sample was dissolved in the phosphate buffer (50 mM) to a final concentration of 4 mg/mL. For the solution preparation, 0.6 mL of tyrosinase enzyme was mixed with 1.2 mL of each standard/sample of different concentration (2.0-0.12 mg/mL). The control was prepared in a similar way by adding 1.2 mL of phosphate buffer (50 mM) in the place of standard/sample. First, samples were incubated at room temperature for 5 min and 2.2 mL of 12 mM L-DOPA

solutions was added. Then the mixture was incubated at 15 ^{0}C for 30 min. In this procedure, Kojic acid was used as the standard. Absorbance of the samples was measured at 475 nm [4] using UV-VIS spectrometer and plate reader.

III. RESULTS AND DISCUSSION

Percentage tyrosinase inhibition was calculated using the formula given below.

$$\%\, Tyrosinase\ inhibition = \left[\frac{(A_{control} - A_{standard/sample})}{A_{control}} \times\right] 100 \qquad (1)$$

Polyscias balfouriana L.H.Bailey leaves were extracted using ethanol, methanol and ethyl acetate solvents. First, the extracts at 0.25 mg/mL concentration were analyzed for the antityrosinase activity. All the extracts showed some antityrosinase activity and the most effective activity of 48% inhibition was observed for the ethanol extract. At this concentration, the standard (kojic acid) only showed 22% inhibition.

On the basis of these results, different concentrations of the extracted solutions were analyzed. When the concentration was lowered to 0.125 mg/mL, ethanol extract continued to show the best activity among the other extract. However, the effective activity was low compared to the activity at 0.25 mg/mL due to the low concentration. Thus, the extract concentration was increased to 0.5 mg/mL and ethanol extract showed an effective activity of 42 %. The standard (kojic acid) showed only 27 % inhibition at that same concentrations. This shows that the inhibitory activity of ethanol extract concentrations at 0.125 mg/mL and 0.5 mg/mL was lower than that at 0.25 mg/mL concentration. However, it is still greater than the inhibitory activity of the standard at the same respective concentrations. Later, the extract concentration was increased to 1.00 mg/mL. At this concentration the inhibitory activity of ethanol extract decreased compared to that of the standard. The variations of the % tyrosinase inhibitions with the different extracts are shown in Figure 1.

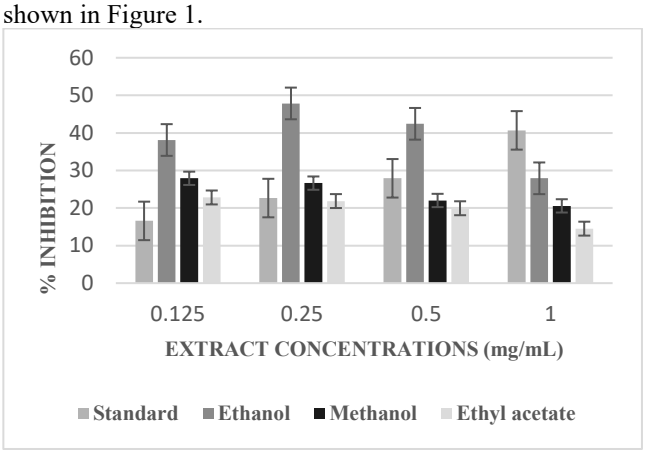

Fig. 1. Tyrosinase Inhibition % Vs Extract Concentrations

Therefore, the ethanol extracts showed better tyrosinase inhibitory activity at low concentrations and the activity declined at high concentrations. Both methanol and ethyl acetate extracts showed some inhibitory activity at all concentrations, but it was always low compared to the ethanol extract activity till 1.00 mg/mL concentration. After 0.5 mg/mL inhibition activity of the ethanol extract started to declined. But when the concentration was further increased ethanol extract had no inhibitory activity compared to other two extracts.

IV. CONCLUSION

Polyscias balfouriana L.H.Bailey leaves were extracted using ethanol, methanol and ethyl acetate and all the extracts showed some positivity towards the inhibitory activity. Ethanol extract showed the most effective tyrosinase inhibition activity at 0.25 mg/mL concentration which was greater than the standard's inhibition activity at the same concentration. Even at 0.125 mg/mL and 0.5 mg/mL concentrations the highest inhibitory activity was shown in the ethanol extract. But when the concertation was increased, the highest inhibition percentage was shown in the standard. Therefore, according to these results *Polyscias balfouriana* L.H.Bailey leaves show some positive antityrosinase activity and better inhibition at lower concentrations. Therefore, it is believed that these inhibitory activities can be further improved by purifying these ethanol extracts. Future studies will focus on isolating the active compounds responsible for the inhibitory activity and using them in making potential skin whitening agents which are environmentally friendly.

Acknowledgement

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A Low Cost Air Purifier for Killing Harmful Airborne Microorganisms with a Combination of an Electric-field and an Ultra Violet Light

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Abstract- This work describes the design of a low cost air purifier. The device can suck up the air in a room, kill the microorganisms via an ultraviolet light and an electric field and let clean air flow out. Three electric field types (radial, parallel, perpendicular) were used for an efficient cleaning. Stainless steel meshes were used to increase the density of the electric fields. The instrument was tested against an evaporated bacterial solution. The results showed the instrument is extremely effective when tested against high bacterial concentrations. The instrument is extremely useful to clean air in closed rooms and prevent the spread of airborne diseases.

Keywords: **Air purifier, High electric field, Ultra violet lamp, Microorganisms, Bacteria**

I INTRODUCTION

Harmful microorganisms can be found in air as well as attached to surfaces and are a major threat to human health. The deadly out-break of the corona virus (COVID-19) in 2020 [1] raised the concerns of humans to look at similar cases happened in the past. Several such cases were reported in the past such as, the "severe acute respiratory syndrome" (SARS) in 2003 and H1N1 in 2010. The COVID-19 virus was the deadliest due to several reasons. It could spread from a human or an animal to another when they are in close range (< 2m) by respiratory droplets. Also these respiratory droplets can stay on surfaces and air for several hours and could get in contact with an uninfected person and enter via moth/nose/eye soon as they touch them.

The most common method used to eliminate harmful microorganisms is the chemical method. Several issues related with this method is that, chemicals kill microorganisms selectively; they take time to kill microorganisms completely. As a result, researchers keep on looking for alternative methods.

Effective and low cost air purifiers have the potential to reduce the exposure of humans to virus-laden aerosols in any type of indoor environments. Most air purifiers have filters installed and need to be replaced and disposed as medical waste to prevent any secondary contamination. Most currently available air purifiers have high-efficiency particulate air filters (HEPA) for particles filtration. Using an electric field to clean air have been a known topic in the past, yet has been mostly focused on removing particles [3]. Most of such systems use fibrous filtration although, there is an intrinsic conflict between filtration efficiency, low air resistance, and long service life. Scientists have been struggling to come up with new filter materials to overcome such issues.

As a solution for above mentioned issues, we have designed a simple low cost air purifier which use a combination of an ultra violet (UV) light with a direct high voltage electric field to remove microorganisms in air. The strong multi directional electric field is used to kill microorganisms more effectively. The instrument has been proven to be highly effective against high bacterial concentrations.

II MATERIALS AND METHODS

Two methods were used (UV, High electric field ~ 2000 kV m^{-1}) to kill microorganisms present in air. The high electric field and the UV light. The electric field was divided in to three main parts. A blower was used to suck the air from the environment. The incoming air flows through each chamber in the following order: parallel electric field, UV chamber, perpendicular electric field, and the radial electric field (Figure 1 a). The parallel and perpendicular electric fields were created using two mesh networks (Figure 1-b, c). The radial electric field was created using two cylindrical type mesh networks inside a polyvinyl chloride (PVC) tube (Figure 1-d). The many wire crossing points in the mesh creates a high charge density. The distance between two meshes was maintained at a level which make sure there are no sparks created.
The air flow rate of the instrument was calculated to be 0.188 $m^3\ s^{-1}$. An anemometer (AM 4201) was used to measure the air speed when calculating above parameters.

III RESULTS AND DISCUSSION

The device substantially reduced the bacteria in the airflow. The aerobic plate count of the neat was 6.64 x 108 colony-forming unit (CFU) per milliliter. The two conditions; the control and the activity of UV radiation only, yielded CFU that are impractical to count. The results convinced that the activity

of UV radiation used in this device itself was inadequate for air cleaning. The application of the electric field only made an obvious reduction in CFU was observed compared to that of the control or treatment with UV radiation only. The activity of UV radiation and electric field together significantly (P = 0.04) reduced CFU compared to that of the activity of the electric field only (Table 1).

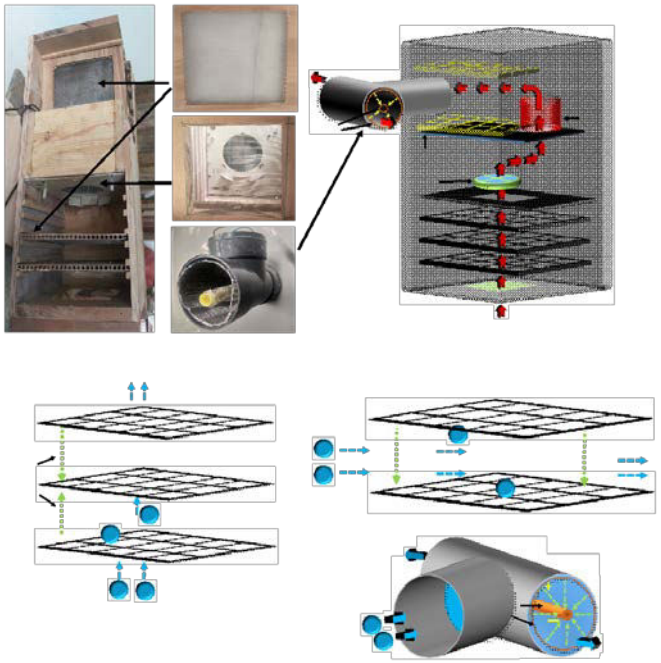

Fig. 1. a) The main components of the E-Field/ UV air purifier with the flow diagram. The three air cleaning electric chambers. b) The parallel electric field (The air flow is parallel to the electric field), c) The perpendicular electric field (The air flow is perpendicular to the electric field), d) The radial electric field (The air flow is radial to the electric field).

The species of bacteria chosen for this experiment, Staphylococcus aureus, is usually found in air as a contaminant. [4].

According to the experimental results the instrument is successful in removing bacterial microorganisms in air. We believe it will be successful against killing viruses such as COVID-19 as well. According to the results the usage of the multidirectional electric field has proven to be effective than a normal unidirectional electric field. The design of the instrument is simple low in cost. l. The instrument can also use as a research instrument to study how microorganisms behave in various types of electric fields.

Table 1 Mean bacterial colony counts observed at the end of incubation at 37 °C for 18 hrs.

Dilution	Mean bacterial colony counts			
	without purification	with UV only	with electric field only	with UV and electric field
Neat	TNC*	TNC	224	210
10^{-1}	TNC	TNC	161	140
10^{-2}	TNC	TNC	90	75
10^{-3}	TNC	TNC	7810	

*TNC: Too numerous to count

IV CONCLUSION

We were able to use a combination of a high electric field and a UV light to kill microorganisms in air efficiently. The combination of three electric fields is proved to be useful in killing and trapping microorganisms efficiently. The low-cost (100 $) of the instrument has increase the attraction of the instrument in commercial applications compared to the available commercial products in the market (1700 $). The development process is extremely simple and can be achieved under minimum lab facilities.

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Track 8

Waste Management

Potential Reuse of Greywater using constructed wetland:Design and Implementation of Vertical Constructed wetland System: A Case Study

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Abstract- In this study, greywater characteristics and treatment possibilities were reviewed using vertical constructed wetlands (VCW) to come up with a schematic of a greywater recycling system designed specifically for non-potable uses. Vertical flow constructed wetland units were designed according to the calculation of Kicked equation, which has been widely used in the research literature. Three types of plants, Canna (*Canna indica*), Ferns (*Matteuccia struthiopteris*) and Cattail (*Typha latifolia*) were used. Retention tank constructed for retaining solid particles in greywater as primary treatment. The experiment was conducted in a Completely Randomized Design (CRD) with three replicates conducted during two months period by using a hydraulic retention time of the system of 24 hours. The quality of the influent and effluent was monitored in two weeks intervals by analyzing water quality parameters namely PO_4^{-3}, NO_3^-, and SO_4^{3}. It can be concluded that the pilot scale VCW's are feasible for greywater treatment at the domestic level with Cattail as the wetland plant since Cattail dense fibrous root system cause to remove more pollutants from the influent compared to that with this other two types of plants.

Keywords: Constructed wetlands, Greywater treatment, Wetland plants, Pollutant removal, Recycled-water, Waste-Water

I. INTRODUCTION

As the world's freshwater supply becomes increasingly scarce, increased attention toward alternative water resources has become necessary. In this context, water reuse has gained significant momentum in discussions about sustainable water resource management, green economies, urban planning and agricultural and landscaping. Greywater filtration and reuse has already been recognized as a promising alternative water source particularly for non-potable uses. Moreover, greywater reuse has become an essential component of local and national efforts to adapt to climate change, enhance food security, extend potable water supply, and reduce pollutants in the environment and helps to maintain groundwater level effectively.Greywater treatment by constructed wetlands involves chemical, biological, and physical processes like precipitation, sedimentation, absorption, adsorption, biological degradation, etc. The processes mainly work under the force of gravity without the consumption of energy [1]

The purpose of this research project is to investigate and compare the performance of plants in vertical constructed wetland and investigate the possibility of greywater treatment using vertical constructed wetland. For that Canna plant (*Canna indica*), Ferns plant *(Matteuccia struthiopteris)* and Cattail plant (*Typha latifolia*) used as wetland plants.

II. MATERIALS AND METHODS

Three experimental setups were designed and constructed using canna, ferns, and cattail plants planted in the same density as shown in Fig. 2. Data collection was performed in two phases. Firstly, the greywater quality was tested for a range of physicochemical parameters in the septic tank. Secondly, the water quality of the water passed through each of the wetlands was tested for a range of physiochemical water quality parameters. Fig.1 shows the summary of the methodology.

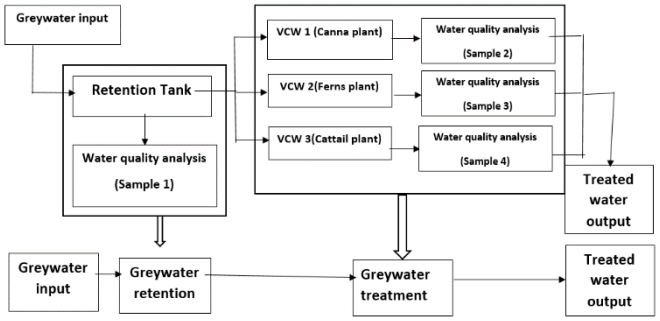

Fig 1.Methodology

The wetland size calculated based on the equation proposed by Kicked [2], 150 cm in length, 66 cm in width, and 70 cm in height. Wetlands were constructed using cement sand blocks and surface was waterproofed using cement mortars. Then wetland was filled with different size of aggregates and materials as shown in Table 1. This study designed for domestic wastewater at a flow rate of 1.2 m^3/d. The Hydraulic Retention Time of the system was 24 hours.

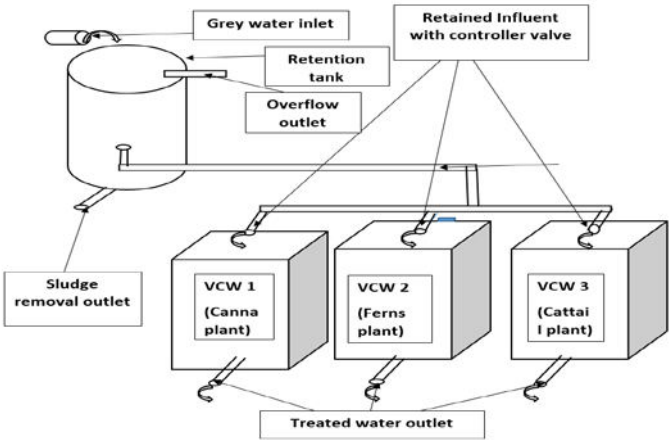

Fig 2.VCW setup

Table 1 : Layer Details

Layer	depth	purpose
64 mm-100 mm(cabals)	10 cm	provide more time and surface for microbiological activities
16 mm- 64 mm(Coarse gravel layer)	10 cm	provide more time and surface for microbiological activities
plastic mesh layered	-	prevent aggregates block below coarse gravel and corbels layers
8 mm-16 mm (Medium gravel layer)	10 cm	provide more time and surface for microbiological activities
Charcoal layer	10 cm	remove toxins from the water
Sand layer	10 cm	facilitate oxidation of reduced toxic metals, support a large rhizosphere as well as filtration purpose

Vegetation layer	10 cm	dominating macrophyte species, deep root penetration, strong rhizomes and massive fibrous root
plants	-	-

III. Results and Discussions

Data analysis was primarily conducted to understand the variation of water quality after passing through each of the VCW. Table 2, Table 3, and Table 4 show the results obtained through the laboratory testing for NO_3^-, PO_4^{3-} and SO_4^{2-} respectively whereas Fig.3, Fig.4, and Fig.5 show the performance of each plant graphically for each of these parameters.

A.Removal of Nitrite (NO_3^-)

As can be seen in Table 2 and fig 3, NO_3^- reduction efficiency of the cattail plant showed a higher performance of 95.45%. NO_3^- reduction efficiency in ferns plants 93.18% is comparatively higher than and canna plants 74.43%.

Table 2: NO_3^- Variation

Week	Retention Tank	Canna plant	ferns plant	Cattail plant
0	0.62	0.35	0.03	0.01
2	0.62	0.01	0.01	0.01
4	0.18	0.01	0.01	0.01
6	0.34	0.08	0.07	0.05
Average No^-_3	0.44	0.11	0.03	0.02
No^-_3Reduction efficacy		74.43%	93.18%	95.45%

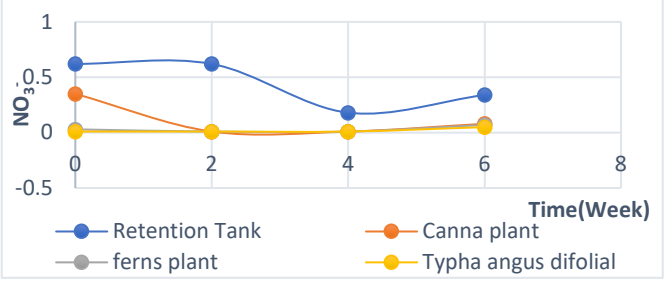

Fig.3. Nitrate Removal

B. Removal of phosphate (PO_4^{3-})

As can be seen in Table 3 and fig.4 PO_4^{3-} reduction efficiency of the canna plant showed a higher performance 86.11%. PO_4^{3-} reduction efficiency in ferns plants 83.33%is comparatively higher than and cattail plants 69.44%.

Table 3. Removal of phosphate

Week	Retention Tank	Canna plant	ferns plant	Cattail plant
0	0.07	0.03	0.06	0.02
2	0.26	0.01	0.02	0.1
4	0.35	0.09	0.03	0.01
6	0.4	0.02	0.07	0.2
Average Po4	0.27	0.0375	0.045	0.0825
PO43- Reduction efficiency		86.11%	83.33%	69.44%

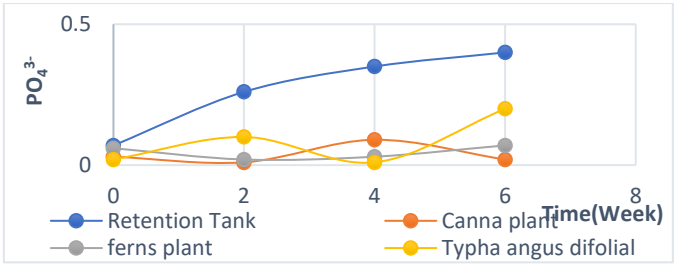

Fig.4 : Phosphate Variation

C. Removal of Sulphate (NO_3^-)

Table 4: Sulphate variation

Week	Retention Tank	Canna plant	ferns plant	Cattail plant
0	17.2	10.6	4.5	3.9
2	4.2	3.3	3.7	2.5
4	32.12	8.22	5.3	25.1
6	21.25	15.35	9.5	1.45
Average SO42-	18.69	9.37	5.75	8.24
Sulphate reduction efficiency		49.89%	69.24%	55.93%

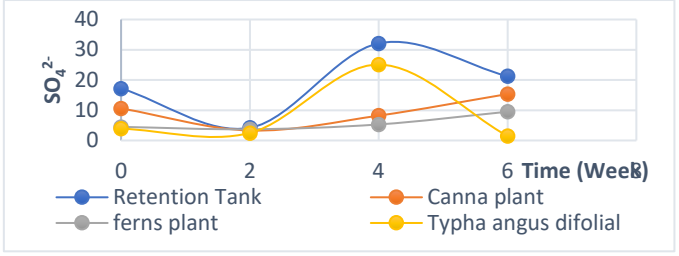

Fig. 5 : Sulphate variation

As can be seen in Table 4 and F.ig.5 SO_4^{2-} reduction efficiency of the ferns plant showed a higher performance 69.24%. SO_4^{2-} reduction efficiency in cattail plants 55.93% is comparatively higher than and canna plants 49.89%.

IV. CONCLUSION

Three plants; Canna, Ferns, and Cattail were tested for their performance in Greywater treatment using small-scale vertical constructed wetland units. Over a two months period, the Cattail plant showed higher performance in, NO_3^- removing by 95.45% compared to Ferns (93.18%) and Canna plants (74.43%). PO_4^{3-} removal efficiency also increased (86.11%) during the treatment process with the Canna plant compared to ferns (83.33%) and cattail plants (69.44%). Ferns plants showed significantly higher performance on the removal of SO_4^{3-} by 69.25% respectively compared to canna (49.89%) and cattail plants (55.93%). Overall, it can be concluded that small-scale VCW units are a viable technology for greywater treatment at the domestic level with the Cattail plant (*Typha latifolia*) plant since its' dense fibrous root system leads to removing more pollutants from the domestic wastewater. This study only investigate the performance of each plant separately. Composite VCW is recommended for further studies.

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Disparity among Urban, Rural and Estate Sector Communities in Solid Waste Management

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Abstract – The legislative framework in Sri Lanka has given the mandate and responsibility of waste management to Local Authorities where the Local Authorities are supposed to deliver waste collection service to all citizens. However, all communities in the country are not equally served by waste collection service due to various issues in administrative structure and infrastructure facilitation. This research was conducted to assess the waste management practice of Urban, rural, and estate communities in different income groups. The results revealed that the urban poor has equal access to waste collection services (>98%) as of other communities in urban cities. However, a disparity exists between urban and rural communities in receiving the waste collection service. Rural communities in Pradeshiya Sabha areas have very limited access to Local Authority waste collection (<60%) and rural households tend to practice onsite disposal. The most marginalized community is the estate sector household having very limited access to formal waste collection service (<24%); thus, opted to use inappropriate waste disposal practices such as onsite burring, disposal on water bodies and illegal disposal that pose a great risk on health and environment sanitation. Introduction of onsite waste management systems for degradable and recyclable waste has identified the feasible solution; however, intervene solution is required to manage the non-recyclable waste disposal.

Keywords: Low-income, Access to services, Estate

I. INTRODUCTION

Population in developing countries are rapidly growing while governors are struggling to supply adequate basic infrastructures like water supply, sanitation, transport, and Municipal Solid Waste (MSW) management services. The MSW has been traditionally recognized as an urban issue with the economic reforms in 80's; however, rising evidence suggest that the demand for a quality and reliable waste management service is increased from rapidly urbanizing semi urban cities and townships [1]. The expansion of middle-income population in semi-urban and rural areas brought up new challenges for rural Local Authorities (LAs) because many agricultural lands were converted to residential areas and new townships appeared leaving no room for open disposal of household waste in rural communities [2].

There are three types of LA in Sri-Lanka namely Municipal Councils (MC), Urban Councils (UC) and Pradeshiya Sabha (PS) responsible for providing a variety of local public services including roads, sanitation, drains, waste collection, housing, libraries, public parks and recreational facilities in provincial level. There are 341 LAs comprise of 24 MCs, 41, UCs, 276 PSs in Sri Lanka. Waste generation rates are directly related to urbanization and economic development. Waste collection rates also correlate to the income level. Waste collection rate of low-income countries is 41% whereas high-income countries have 98% coverage of waste collection services. [3]. This study is geared towards evaluating and understanding the availability, efficiency of solid waste collection service and waste disposal practices of three different social segments, plantation rural and urban communities.

II. MATERIAL AND METHODS

As this study focused on three social segments namely urban, rural and estate communities it identifies 4 MC areas, 2 PS areas and six major tea plantations in Sri Lanka as study locations. Urban populations were identified from four MC areas including Kurunegala MC (KMC), Nuwara Eliya MC (NMC), Jaffna MC (JMC) and Moratuwa MC (MMC). Rural population was identified from two PS areas, including Thamankaduwa PS (TPS) and Kathragama PS (KPS). Plantation communities were identified from 6 major tea estates from Ambagamuwa (2) and Nuwara Eliya (4) areas in the Central Province. Study locations (LAs and tea estates) were randomly selected for the research.

A structured questionnaire was used to collect primary data from all the communities. Stratified random sampling was used in each estate to represent all the divisions in estates that comprises of several worker communities. The study sample size for urban areas were 606 and 309 for rural areas, which represent high, middle, and low-income categories. There were 104 low-income households were identified from rural households. Share of household monthly income quintiles described in household income and expenditure survey 2019 was used to define income levels for this study.

III. RESULTS AND DISCUSSION

The waste composition of the three different segments clearly shows the differences in consumption patterns. Table 1 reveals the data on solid waste composition in different segments. Kitchen waste is the major type of waste among all communities. Even though the line houses are compacted, the garden waste is higher (29%) among the estate communities as the arable lands are high. According to Table 1, polythene, and plastic content (12%), paper (14%), and textile (2%) content is comparatively higher among urban communities. Waste composition is more important in determining the solid waste management process.

Table 1 Waste Composition

Sector	Kitchen waste (%)	Paper (%)	Textile (%)	Plastic & Polythene (%)	Metal (%)	Garden waste (%)	Other (%)
Urban	48	14	2	12	1	6	17
Estate	38.2	3. 7	0.8	2.6	2.4	29	23.4
Rural	57.5	11.6	1.6	7	0.9	17	4.5

The results of the study reveal that Nuwara Eliya, Moratuwa, and Kurunegala MCs cover waste collection in more than 90% of its population irrespective of income status. Among these municipalities, MMC area has the highest population density (7317 persons/sq.km) and waste collection coverage is 100% in MMC. Low-income population in NMC and JMC areas receive lesser extent (10% reduction) of waste collection coverage compared to high and middle-income communities in the same area. Poor access roads to households are a major reason to have less availability of waste collection services. In rural areas waste collection services mainly cover high and middle-income

segments. Low-income categories of the rural areas receive lesser waste collection coverage (Thamankaduwa PS 9.8%, Katharagama PS 25%) than the high and middle-income in the same group. Majority of the urban people are satisfied about the waste collection services provided by the local authorities. Lack of waste disposal sites and facilities of the LAs hinder its performance in service deliveries.

According to the study findings there were more than three fourth (76%) of the estate community have no access to garbage collection service. However, a few estate communities (24%) those who reside close in roadsides used to dispose garbage into the Local Authority collection vehicles though the LAs did not serve them. So, it is rather than the availability of the service, the estate Community residing near the service coverage areas put their garbage into the collection vehicles. Estates are demarked as privet properties in the PS and there are no provisions to extend the public services to the estate sector.

This research also focused on waste collection frequency in addition to the availability of the collection service. There were 22% of the urban population receive daily waste collection service and 47% receives waste collection at least 2-4 times per week. Rural communities (40%) receive less frequent waste collection service (irregular/less than once a week or once a week) compared to the urban community. Estate sector community receive less frequent or no service from the local authorities.

Table 2 Waste Disposal Methods

Sector	Method	High (%)	Middle (%)	Low (%)
MC	Curbside	7.7	9.5	13.6
	Open dump	5.1	2.8	2.8
	Onsite burning	9.4	7.9	7.7
	Recycling	3.2	3.6	3.4
	Composting	3.8	5.8	2.3
	Waste collection service LA	70.7	70.3	70.3
PS	Curbside	9.2	2.3	1.5
	Open dump	11.7	19.1	27.1
	onsite burning	36.0	42.2	49.1
	Recycling	0.0	0.0	0.0
	Composting	2.3	6.9	5.6
	Waste collection service LA	40.8	29.5	16.6
Estate Sector	Curbside			0
	Open dump			8.5
	Onsite burning			47.5
	Recycling			30
	Composting			10
	Waste collection service LA			4

Table 2 illustrates the waste disposal methods by three different groups. In contrast to the urban low-income groups, there is only 4% of the plantation community access garbage collection services. There are more than two third of the urban population use waste collection services provided to them. Fever usage of waste collection service was observed as a waste disposal practice by the low and middle-income groups of the rural community than the same income groups of the urban communities. Less frequent service, distance to the collection point and arable land to go for other disposal methods are some of the reasons for the fewer usage of waste collection s by the rural sector.

Burning of waste is the most popular waste management practice among the plantation and rural communities, which are underserved or excluded by the LA collection system. The burning of waste creates enormous health and environmental problems. As urban people receive a satisfactory waste collection system, inappropriate waste disposal practices such as open dumping and burning remain low compared to the people who do not receive proper waste collection service.

IV. Conclusions

The comparative study between urban, rural and plantation communities revealed that plantation community practice primitive waste disposal methods such as onsite burning and illegal disposal of water resources due to the absence of proper waste collection service. Availability and Frequency of the waste collection service are also inversely proportionate to the usage of inappropriate waste management practices. Rural communities also tend to use inappropriate waste management practices due to less access to the waste collection service. Traditionally plantation administration was given the responsibility to provide waste management service but gradually decline over the time due to changes in administrative structure in the plantation sector. Continuation of inappropriate waste management practices by estate communities pose a great risk on pristine water resources. Decentralize waste resource recovery (composting, recycling etc.), non-degradable waste collection service by the local authority and small landfill and bailing of non-recyclable waste for a less frequent collection seem feasible solutions to the issue.

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Removal of Spilled Engine Oil Using Dendro Biochar as an Adsorbent

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Abstract – Oil spills have become a severe concern in recent years due to their complexity and massive cost of cleaning. Among different cleanup methods such as mechanical, chemical, and biological, adsorption is a promising physico-chemical method for cleaning up spilled oil. Biochar is often used as an adsorbent in oil adsorption however, a waste output from dendro power plants has not been tested for the adsorption of engine oil. Hence, the purpose of this study was to determine the adsorption potential of biochar obtained from the Embilipitya dendro power plant. The experiment used varying amounts of biochar, ranging from 0.1 to 1 g, with a fixed initial oil amount (1.5 g). The maximum engine oil adsorption capacity and removal efficiency was shown by dendro biochar when the dose of biochar was 4 g/L. The removal rate slightly increased with the dosage though, the optimum adsorption capacity (1220 g/kg) when the dosage was 10 g/L. Intensities of peaks observed at ~1500 - 1640, ~2850 - 2900, and 3450 cm^{-1} of Fourier transform infrared (FTIR) spectrum for oil adsorbed biochar increased due to the formation of new bonds with hydrocarbons which indicates interactions between oil and biochar.

Keywords: Oil spill, Dendro Biochar, Adsorption

I. Introduction

Releasing petroleum hydrocarbons (PHCs) has become a serious problem worldwide, and scientific communities have focused on them. The Exxon Valdez incident, Hebei Spirit spill, Prestige spill, and the Deepwater Horizon are some examples of oil spills occurred so far which left long-term impacts on ecology, economy, public health, and wildlife [1]. Being a country adjacent to the silk route, Sri Lanka has a risk of oil spills from distressed ships. The most reason spill incident happened in Sri Lanka is X-press pearl cargo ship which caught on fire on 20th May 2021, leaving a huge ecological footprint that Sri Lanka would likely suffer for decades due to its risk [2]. Furthermore, hundreds of automobile service stations are distributed with the expansion of transportation, and the effluents from these stations may contaminate the water sources. These oily effluents may contain a variety of pollutants, such as gasoline, detergents, shampoo, and engine oils which are adjacent to water sources or wetlands.

Many cleanup techniques for oil spills have been developed for years which can be categorized into chemical, mechanical, and biological methods [3]. Among these methods, sorption-based methods have become more popular especially because of their nonflammability, chemical inertness, cost-effectiveness, and availability. In recent years, biochar was utilized broadly for remediation approaches due to its great sorption characteristics including large surface area, porous structure, hydrophobic properties, etc. Dendro biochar is a by-product of dendro power plants and is woody biochar made from *Gliricidia sepium* [4], however, no studies conducted using dendro biochar for oil removal. Hence, this might encourage researchers to look into the use of dendro biochar which is a waste byproduct of the dendro power industry to be used in oil pollution mitigation.

II. Materials And Methods

Embilipitya Biochar (EBC) originated from dendro power plant in Embilipitya, gasified at around 700 °C was collected and samples were washed several times to remove impurities and dried at 60 °C for overnight to remove absorbed water. Crushed EBC was sieved through 1 mm and 0.5 mm sieves and collected the retained particles on the 0.5 mm mesh for the study. An artificial oil spill was simulated by adding 25 ml of ultrapure water and 1.5 g (60 g/L) of engine oil into a 50 ml glass beaker and then collected by filtration onto a filter paper.

The effect of adsorbent dose on adsorption of engine oil was investigated by varying the EBC dose from 4 g/L (0.1 g) to 40 g/L (1 g) of dosage and holding the pH, oil concentration, and temperature constant at 7, 60 g/L, and 25 °C respectively. Blanks were run as controls to determine the weight of the filter paper. The filter paper was dried in an oven at 60 °C to remove adsorbed water. Mass balancing determined the adsorption capacity of engine oil. The sorption kinetics for EBC were conducted by varying the contact times from 0 to 360 min while the other conditions remained constant, including pH (7), added oil amount (1.5 g), temperature (25 °C), and dosage (10 g/L). The experimental data were analyzed using fractional power, Elovich, pseudo-first-order, and pseudo-second-order kinetic models.

Proximate analysis was conducted for EBC to observe the moisture, volatile, ash, and resident matter. Fourier transform infrared (FTIR) analysis was done to identify the functional groups present in the EBC as well as the change in the material composition of the pristine EBC and the EBC after the oil was adsorbed.

III. Results And Discussion

Adsorption capacities were determined for the dosages (4, 10, 16, 24, 32, 40 g/L) of EBC as aforementioned, and the highest adsorption capacity (2465 g/kg) was observed when the dosage was 4 g/L (0.1 g). The best degree of removal efficiency with its adsorption capacity (1220 g/kg) was obtained when the mass of the adsorbent was 0.25 g (10 g/L) (Table 1). When the dosage exceeded 10 g/L, even though the removal rate of

engine oil started to slightly increase, adsorption capacities started to decrease, as was previously reported [5].

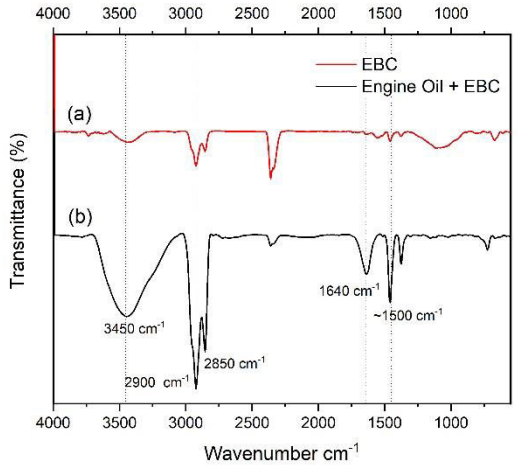
$$q_e = \frac{m_e}{m_0} \quad (1)$$

$$R\% = \frac{m_e}{m_{oil}} \times 100 \quad (2)$$

The adsorption capacity, q_e (1) and removal efficiency, $R\%$ (2) were calculated using the above equations, where m_0, m_e , m_{oil} are initial EBC amount (g) and adsorbed oil amount (g) and initial oil amount (g) respectively.

Table 1. Adsorption capacity and removal efficiency data for EBC dosages

Dosage (g/L)	Adsorption Capacity (g/kg)	Removal Efficiency (%)
4	2465	16.66
10	1220	20.44
16	752	20.30
24	555	22.48
32	465	24.66
40	376	25.14



The moisture content (7.84%), volatile matter (39.74%), ash content (10.24%), and resident matter (42.18%) of EBC were measured as proximate analysis. The FTIR spectra of pristine EBC and oil adsorbed EBC are illustrated (Figure 1). The appearance of a strong, broad peak at 3450 cm^{-1} corresponds to the stretching vibration of an O-H bond and a sharp, narrow peak at ~1500-1640 cm^{-1} corresponds to the sp2 C=C stretching vibration of an unsaturated ketone [(O=CR)−Cα=Cβ -R] functional group present additionally in oil adsorbed EBC other than pristine EBC. Spectra of oil-absorbed EBC display some sp3 C−H stretching for -CH2 (~2900−2850 cm^{-1}). According to Figure 1, the increase of intensity of the peaks in (b) confirms the adsorption of organic components including C and H, which are commonly present in the hydrocarbons (engine oil).

The sorption kinetics of EBC with engine oil was found to be fast. It was observed that oil uptake reached equilibrium in less than 60 min. Kinetic data well fitted with the Elovich kinetic model at 25 °C with high (>0.99) correlation coefficients.

IV. Conclusions

Biochar derived from dendro power plants was successfully used as a promising adsorbent for the removal of engine oil from oil-contaminated water. As per the sorption experiments carried out for adsorbent dosage, the dosage of biochar has shown a great influence on the adsorption performance of dendro biochar which shows the optimum removal efficiency when the adsorbent dosage was 10 g/L. Therefore, dendro biochar can be considered a cost-effective and efficient material that shows great potential to uptake oil pollutants from water.

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Microplastics-Assisted Hexavalent Chromium Transportation in Soapy Water Environments

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Abstract - The sorption medium plays a vital role in vector transport of microplastics bound metal ions. The influence of soapy water on transportation of microplastics bound Cr(VI) and sorption mechanisms are still not clear. Therefore, in the present study the performance of pristine and aged polyethylene (PE) microplastics to adsorb Cr(VI) in soapy water was compared with $NaNO_3$ and humic acid (HA) mixed water. The influence of pH, contact time, and concentration of Cr(VI) on the sorption performances of PE microplastics have also been tested. Soapy water exhibited a greater adsorption performance than $NaNO_3$ and HA mediums. The highest adsorption of Cr(VI) occurred at an acidic pH range from 2.0 to 2.5 without depending on the sorption medium. Hydrophobic and electrostatic interactions predominantly played a vital role in binding of Cr(VI) in soapy water onto PE microplastics through surface complexation. Adsorption kinetic data for pristine PE microplastics was well fitted with the non-linear pseudo-second-order kinetic model, thereby indicating that the chemisorption-based surface adsorption is the rate-limiting process. Sorption kinetic data of aged PE microplastics were fitted well for fractional power and intra-particle-diffusion models suggesting that the adsorption was assisted through diffusion-controlled adsorption that depends on sorption time. Isotherm data fitted with Hill model implicit a cooperative adsorption process. Microplastics bound Cr(VI) largely released from the surface at basic pH conditions implying the sorption of Cr(VI) is influenced primarily by the pH. Hence, soapy water could be a potential sorption medium for microplastics bound Cr(VI) ions influencing the migration of Cr(VI).

Keywords: Polyethylene microplastics, sorption medium, vector transport, chemisorption, cooperative adsorption

I. INTRODUCTION

Chromium (Cr) can be introduced as one of the major potentially toxic elements which can commonly exist in the environment. Industrial metallurgy, coal combustion, and pesticides are the major anthropogenic sources of the environmental existence of Cr(VI) in groundwater [1]. Hydrophobicity, surface area, and charge of the microplastic surfaces greatly influence the adsorption of pollutants in water through hydrophobic and electrostatic interactions [2]. Domestic wastewater is mixed with soap, shampoo, and other detergents and ends up in surface water systems. Microplastics bound the vector transportation of Cr(VI) in the presence of soap water have not been studied yet. Nevertheless, polyethylene (PE) microplastics showed a notable adsorption performance for Cr(VI) in surfactant rich water indicating the role of surfactants in the vector transport of Cr(VI) [3]. Hence, it is important to reveal the interactions and mechanisms behind the Cr(VI) adsorption onto microplastics with soap-enriched sorption medium. The present study investigates the adsorption behaviour of Cr(VI) onto PE microplastics in soap water comparing to organic and ionic species-rich water. Further, implications for the soap water boosted adsorption of Cr(VI) onto both pristine and naturally aged PE microplastics are revealed concerning the sorption isotherm and kinetic profiles.

II. MATERIALS AND METHODS

A 1 g L^{-1} of pristine microplastic dosage was used in the entire experiment. All samples were shaken at a speed of 150 rpm at 25 °C. The samples were filtered through 0.22 µm PTFE filters. The pH edge experiment was conducted with an initial concentration of 5 mg L^{-1} of Cr(VI) in water and the solution pH was adjusted to a range of 2.0–9.0. The effect of $NaNO_3$ (0.1 M), humic acid (HA) (1.5 mg L^{-1}), and soapy water (commercial dish wash in water 0.4% V/V) on Cr(VI) adsorption were examined by repeating the pH edge experiment at the same range (i.e., pH 2.0–9.0). By calculating the adsorption capacity of each batch, the best pH and the solution medium for Cr(VI) adsorption were selected. Both kinetic and isotherm experiments were performed at pH 2.0-2.5 in the presence of soapy water (0.4% V/V). The kinetic experiment was conducted for 7 days and the initial concentration for Cr(VI) was 5 mg L^{-1}. First sample was withdrawn after 12 h and then each vial was withdrawn at 24 h of time interval. Adsorption isotherm experiments were carried out with Cr(VI) concentrations ranging from 1 to 25 mg L^{-1} for 168 h. The same procedure was performed for the aged PE microplastics. The control experiment was conducted only without microplastics. The kinetic data were modelled with pseudo-second-order, Elovich, fractional power, and intra-particle diffusion kinetic models while isotherm data were modelled with Hill, Freundlich, and Langmuir isotherm models. The optimized parameters for the adsorption were determined using Origin statistical computer software (version 8.0).

III. Results And Discussion

The adsorption of Cr(VI) showed a gradual increase with decreasing pH, reaching the maximum adsorption at pH 2.0–2.5. In the lower pH range Cr(VI) ions are present in the forms of $HCrO_4^-$, H_2CrO_4, and $Cr_2O_7^{2-}$whereas the $HCrO_4^-$ is the predominant ionic form. Since pHpzc of microplastics are around pH 4.0, at the pH range of 2.0-2.5, the surface of microplastics is positively charged. The protonated surface of microplastics enriches the affinity of $HCrO_4^-$ ions towards itself and binds through electrostatic interactions. The decreased adsorption efficiencies with further increase in the pH from 2.0 might be due to the drop of H^+ ions in the sorption medium and thereby increased negative charge density at the surfaces of microplastics. Repulsive effects between $HCrO_4^-$ and negatively charged adsorbent surface and competitive effects between $HCrO_4^-$ and adding OH^- ions for occupying available adsorption cites cooperatively decrease the adsorption of Cr(VI). Due to the remarkable adsorption performances of both pristine and aged PE microplastics at acidic pH (pH 2.0- 2.5) without depending on the sorption medium, pH 2.0 was chosen as the optimum pH condition.

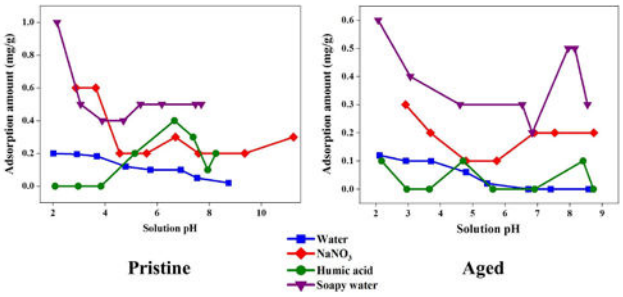

Fig. 1. Adsorption performances of pristine and aged PE microplastics in the presence of different sorption mediums

Adsorption performance of Cr(VI) onto both pristine and aged PE microplastics in the presence of soap water was more notable than the performance in the presence of $NaNO_3$ or HA likely indicating soap water medium accelerates the adsorption of Cr(VI) than the sorption mediums consist of ionic and organic species (Figure 1). Sorption performance in the presence of 0.1 M $NaNO_3$ was second highest whereas the microplastics in an aqueous solution mixed with HA showed the least Cr(VI) adsorption. Presence of NO_3^- ions affects the binding affinity of $HCrO_4^-$ towards protonated microplastics surface making competency to each other. Besides, Na^+ and HA reduce the mobility of $HCrO_4^-$ in the sorption medium hindering sorption sites. Anionic surfactant (Sodium dodecyl sulfate) can influence the adsorption process of Cr(VI) onto PE microplastics [3]. Hence, surfactants consisting of the sorption medium might be supported the adsorption of Cr(VI) onto the surfaces of PE microplastics. Consequently, hydrophobic and electrostatic interactions predominately play a vital role in the binding mechanism of Cr(VI) onto PE microplastics through surface complexation. Chromium ion sorption onto pristine PE microplastics reached equilibrium slightly within 168 h (7 days). Adsorption kinetic data for pristine PE microplastics was well fitted with the non-linear pseudo-second-order kinetic model indicating that surface adsorption is the rate-limiting process that involves monolayer chemisorption (Table 1). Nevertheless, Cr(VI) onto aged microplastics did not reach a sorption equilibrium. Sorption kinetics for aged microplastics was well described by the fractional power and intra-particle-diffusion models (Table 1). Accordingly, Cr(VI) adsorption onto aged PE microplastics was assisted through diffusion-controlled adsorption which depends on sorption time (Table 1). Adsorption processes were well fitted with the Hill isotherm model. Resultant Hill cooperativity coefficients (n_H) for pristine and aged PE microplastics for the present study indicate the positively cooperative binding of Cr(VI). Consequently, once one Cr(VI) ion occupies a site and adsorbs onto the surface of microplastics, the binding affinity to occupy more Cr(VI) ions enhances spontaneously.

Table 1: Modeling data for kinetic and isotherm experiments

Kinetic data				
Pseudo-second order $q_t=(k_1tq_e^2)/(1+(k_1q_et))$	k_1	q_e	R^2	
Pristine PE + Surfactant	0.003	1.595	0.989	
Fractional power $q_t=Kt^v$	K (mg g^{-1})		v (h^{-1})	R^2
Aged PE + Surfactant	0.089		0.462	0.963
Intra-particle diffusion $q_t=k\,t^{1/2}$	R^2		k (mg g^{-1} $s^{-1/2}$)	
Aged PE + Surfactant	0.959		0.076	
Isotherm data				
Hill $Q_e=(Q_H(k_HC_e)^{n}_H)/(1+(k_H C_e)^{n}_H)$	Q_H (mg g^{-1})	k_H (L mg^{-1})	n_H	R^2
Pristine PE + Surfactant	1.296	0.142	4.564	0.988
Aged PE + Surfactant	1.541	0.092	5.081	0.973

IV. Conclusions

Influence of the sorption medium for adsorption of Cr(VI) ions onto pristine and aged PE microplastics was studied. Soapy water was the most potential sorption medium at acidic pH range from 2.0 to 2.5 compared to water, $NaNO_3$, and HA mediums. Pristine PE microplastics underwent monolayer chemisorption whereas aged PE microplastics underwent diffusion-controlled cooperative adsorption which depended on sorption time. Hydrophobic and electrostatic interactions predominately play a vital role in the binding mechanism of Cr(VI) in soapy water onto PE microplastics through surface complexation.

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Life Cycle Energy Utilization, Economic Feasibility, and Climate Change Impact Assessment for End-Use Options of Waste Plastic Pyrolysis Oil in Sri Lanka

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Abstract - Plastic pollution is a major environmental issue in developing countries like Sri Lanka due to the increasing plastic use and lack of proper implementation of waste management techniques. Nearly 1.6 million tonnes of non-recyclable plastic waste are generated in Sri Lanka annually, and the majority is disposed in landfill sites. Micro-plastics leaching from these landfills into freshwater could cause ocean deposition and threaten marine life leading to serious environmental impacts. A waste-to-energy technique like pyrolysis can be an attractive solution for non-recyclable plastic waste management in the country. This study analyzes the energy, economic, and environmental feasibility through the aspects of net energy gain, net profit, and climate change impact for five possible end-use scenarios of waste plastic pyrolysis oil. The entire life cycle of the waste plastic pyrolysis process is analyzed that consisting of plastic waste collection and transportation stage, pyrolysis processing stage, and end-use stage of produced pyrolysis oil. Results show that the use of crude pyrolysis oil for electricity generation is not desirable as an end-use option in all aspects. Refining crude pyrolysis oil at a unit basis of 1 m^3 and blending with diesel as commercial fuel reported the highest net energy gain at 24,532 MJ/m^3 with a net profit of Rs. 188,185/m^3 and environmental impact of 6,408 kg CO_2 eq/m^3, implying feasible end-use options of waste plastic pyrolysis oil in practical implementation at commercial scale. Findings in this study could facilitate policy development and decision-making for plastic pollution prevention and management in the country.

Keywords: Life cycle assessment, Waste plastics, Pyrolysis oil, Feasibility assessment

I. INTRODUCTION

Waste plastics have a significant share of Municipal Solid Waste (MSW) in Sri Lanka. The total plastic waste generation is approximately 539,667 tonnes per annum in Sri Lanka where nearly 33% of that plastic waste is collected and largely disposed in landfills [1]. Such landfills can leach micro-plastics into freshwater, causing ocean deposition and threatening the marine life as the ultimate impacts. Currently, the recycling rate is about 3% [1]. Hence, proper management of non-recyclable plastic waste is essential. Pyrolysis technology is an attractive waste to energy technique for non-recyclable plastic waste, which can convert waste plastics into pyrolysis oil, gas, and solid residue.

Thermal degradation of waste plastics in the pyrolysis process can be occurred at 700-900°C temperature. With the involvement of different kind of catalysts, the operating temperature can be reduced to 450-500°C range. Published studies show that catalysts such as zeolite, Y-zeolite, FCC, and MCM-41 can improve the quality of the final product [2]. In addition, parameters like heating rate, retention time, and plastic type also affect the quantity and quality of waste plastic pyrolysis products [2]. Studies report that catalyst involvement at 450°C is optimum for polystyrene (PS), polypropylene (PP) individually and for mixtures with different ratios of PS, PP, PET, and PE where the major product is pyrolysis oil [3]. Under these conditions, the low quantity of generated pyrolysis gas can be used as the heating source for a pyrolysis reactor or for generation of heat and electricity in gas turbine combined system [2]. Produced char content can be sold as an adsorbent for heavy metals from municipal and industrial wastewater and toxic gases [2]. For a country like Sri Lanka, implementation of a commercial scale waste plastic pyrolysis plant would require a proper assessment of energy utilization, economic feasibility, and environmental impacts.

Selection of the most feasible end-use options for the pyrolysis products is also important for successful practical implementation. Studies have reported that pyrolysis can be used for electricity generation by combustion in a diesel engine [4]. Further, pyrolysis oil can be used as an alternative for furnace oil in an industrial boiler or as a fuel for heavy transportation vehicles after blending with conventional diesel at different ratios [5]. Nevertheless, there is no proper comparison among the end-use options reported in the current literature, especially for the context of Sri Lanka. Therefore, this study focuses on an evaluation of energy utilization, economic feasibility, and environmental impacts from possible end use options of waste plastic pyrolysis oil. In this study, establishment of a waste plastic pyrolysis plant in Sri Lanka with five possible end-use options of pyrolysis oil is considered. In terms of environmental impacts, the life cycle greenhouse gas (GHG) emissions are evaluated. Analysis of mass flows and energy flows of various life cycle process stages in this study could support future studies with a dataset for commercial scale implementation of waste plastic pyrolysis plants in the country.

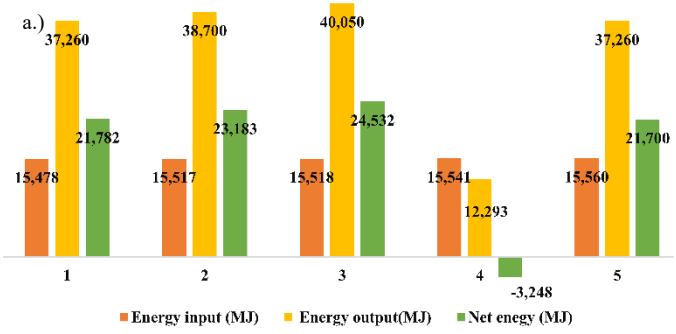
II. MATERIAL AND METHODS

This study adopts ISO 14040-14044:2015 standard Life Cycle Assessment (LCA) methodology to analyze the GHG emissions and global warming impact from each end-use option. The system boundary defined for the study consists with three stages such as plastic waste collection and transportation

stage, pyrolysis processing stage and end-use stage of produced pyrolysis oil stage. The end use stage is further divides into five different scenarios and comparison was done for these five scenarios at the end of the LCA. The five end-use scenarios are,
Scenario 01: Use of crude pyrolysis oil for thermal energy generation
Scenario 02: Refine crude pyrolysis oil at commercial fuel quality
Scenario 03: Refine crude pyrolysis oil at commercial fuel quality and blend with convectional diesel
Scenario 04: Use crude pyrolysis oil for electricity generation
Scenario 05: Use crude pyrolysis oil for refinery mixed with petroleum crude oil.

The functional unit (FU) is taken as 1 m^3 of crude pyrolysis oil production for all inventory calculations. Pyrolysis plant with 10 tonnes per day batch size reactor was considered for the study. The catalytic pyrolysis process is considered that provides an increased quantity of pyrolysis oil at low temperature process condition of 450°C and at a pressure slightly higher than 1 atm. Mixed plastic waste that consists of PS/PP/PE in a ratio 50/25/25% is considered as the feedstock for the plant and the selected catalyst is Natural Zeolite after thermal modification [3]. The pyrolysis product yields were taken as 44% of oil yield, 37% of gas yield, and 19% of ash in weight basis. Batch retention time is considered as 10 hours and heating rate is at 10°C/min for the considered commercial scale plant. For collection and transportation stage, energy requirement was calculated by considering diesel consumption in tractors. For the pyrolysis process stage, calculations were made for pyrolysis plant with and without a refinery stage to purify the crude pyrolysis oil. Through energy input-output analysis and economic calculations, the net energy utilization and net profit were evaluated for the five end-use scenarios and compared.

a.)



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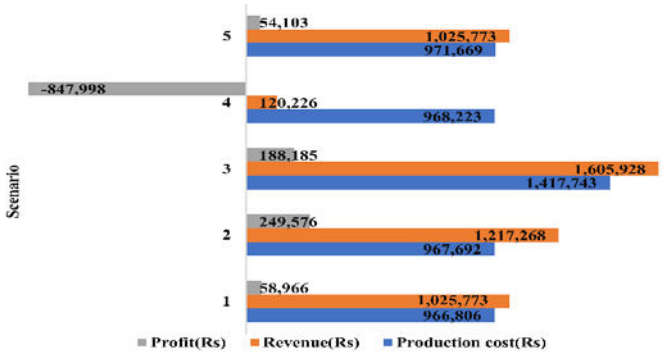

Fig. 1 Energy utilization and Economic analysis for five scenarios (a.) Energy utilization vs scenario (b.) Scenario vs Profit, Production cost, and Revenue (in Rs)

III. RESULTS AND DISCUSSION

Figure 1 shows the scenario comparison of net energy utilization and net profit for the five end-use scenarios. According to the net energy utilization results, scenarios 1, 2, 3, and 5 provide positive net energy gain while only scenario 4 shows a negative net energy gain. It implies that the use of crude pyrolysis oil for electricity generation is energy-wise not desirable as an end-use option. The highest energy gain is showed by the scenario 3, which indicates that the most energy efficient end-use option would be refining crude pyrolysis oil and blending with diesel as commercial fuel. In terms of economic feasibility results, scenario 4 reports an economic loss due to the low selling price of 1 kWh of generated electricity and low efficiency of electricity generating system. The results point out that refining crude pyrolysis oil at commercial fuel quality shows the most economically feasible end-use option for waste plastic pyrolysis oil.

Table 1: GHG emissions in kg CO_2 eq at basis of 1 m^3 of pyrolysis oil

Scenario	1	2	3	4	5
Stage 01	5,108	5,108	5,108	5,108	5,108
Stage 02	1,093	1,298	1,298	1,093	1,093
Stage 03	0	0	2	3,390	11
Total	6,201	6,406	6,408	9,590	6,212

Table 1 lists the stagewise GHG emissions (kg CO_2, eq) in each scenario of waste plastic pyrolysis oil end-use options. The highest total GHG emissions are reported for scenario 04 and 03, respectively. Accordingly, the lowest GHG emission corresponds to the scenario 01, illustrating the most feasible end-use option in terms of environmental emission would be the use of crude pyrolysis oil for thermal energy generation.

IV. CONCLUSION

This study performed a comparative assessment of five end-use scenarios of waste plastic pyrolysis oil in the aspects of net energy gain, net profit, and climate change impact. According to the findings, electricity generation from the produced waste plastic pyrolysis oil is not a desirable end-use option in terms of all aspects. Nevertheless, refining crude pyrolysis oil and blending with diesel as commercial fuel showed more feasibility as an end-use option for waste plastic pyrolysis oil. The Findings can support future implementation of waste plastic pyrolysis at commercial scale in the country.

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Kinetics Modeling of Hydrolysis in Anaerobic Digestion of Food Waste

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Abstract - Solid-State Anaerobic Digestion (SS-AD) is one of the most promising methods for producing biogas from various kinds of organic wastes. SS-AD has gained much more attention recently than Liquid State Anaerobic Digestion (L-AD) due to higher organic loading capacity and lower energy consumption. However, hydrolysis is the rate-limiting stage in SS-AD and it determines the overall rate of the process. Most of the kinetic studies for the hydrolysis process were conducted for the L-AD and this is to determine the most appropriate kinetic model for SS-AD with food waste. This study evaluated the performance of the hydrolysis stage in SS-AD of food waste in laboratory-scale experiments using 5-liter benchtop bioreactors operated at mesophilic temperature condition. They were operated in a batch mode at a mesophilic temperature under a Total Solid (TS) content of 15%. The Volatile Solid (VS) reduction was used to investigate the hydrolysis performance. Mathematical modeling is one of the most essential tools for studying and investigating the behavior of the hydrolysis process in AD and the kinetics of hydrolysis have been predicted using three different models (first-order kinetic model, first-order modified model, and surface-based kinetic model). The kinetic study showed that the first-order modified model has fine goodness of fit and root mean square error (RMSE) with the other two models. Moreover, the hydrolysis rate constant was evaluated from these three models in the range of 0.02–0.07 day^{-1}.

Keywords: Solid State Anaerobic Digestion; Food waste; Kinetics models; Hydrolysis

I. INTRODUCTION

Anaerobic Digestion (AD) is a biochemical degradation process that degrades various organic compounds into end-products including methane and carbon dioxide, collectively called biogas by a series of sequential processes including hydrolysis, fermentation, acetogenesis, and methanogenesis. This technology is widely used for treating various kinds of biomass, and food waste is a highly desirable substrate due to its high biodegradability and methane yield.

However, due to the substrate complexity, the first step of the process, hydrolysis has received more attention. Hydrolysis is an extra-cellular enzymatic activity and considered as the rate-limiting step in SS-AD process. Therefore, studying on hydrolysis kinetics in detail is essential to understand the process. Moreover, simulated mathematical models of hydrolysis processes are important in monitoring, predicting and optimizing, the process performance under various conditions.

Historically, most AD process has been applied to waste treatment sludge and perform hydrolysis kinetics. Therefore, most of the hydrolysis mathematical models are introduced for wet basis (TS< 15%). Nevertheless, there are very limited studies on the kinetics models in hydrolysis for SS-AD (TS>15%). The current investigation evaluates the hydrolysis process under SS-AD at TS content of 15% on a batch anaerobic digestion of food waste through experimental and kinetic studies. Three mathematical models; first-order, modified first-order and surface-based model were used to predict the behaviour of hydrolysis performance in SS-AD.

II. MATERIALS AND METHODS

A laboratory scale single stage batch anaerobic digester was made of plastic bottles with total volume of 5 liter and working volume of 3 liter. The substrate (food waste) was collected from the canteen of the Faculty of Engineering, University of Peradeniya. The inoculum (cattle dung) was collected from the Faculty of Agriculture, University of Peradeniya. The wastes were mixed and shredded to a particle size of 2 mm and kept in a refrigerator until it use for the experiment. The TS of each feedstock were measured individually and samples were prepared to get its TS content to 15%. Initial Total Solid (TS) and total Volatile Solid (VS) of the substrate were calculated according to the standard methods [1]. The samples were collected once in two days for two weeks of time for analysing VS content.

First-order kinetic model, modified first-order kinetic model and surface-based model were selected to determine the best-fitted kinetic model for obtained experimental data. The equation 1, 2 and 3 follows the models of first-order, modified first-order and surface-based respectively [2]–[4].

$$\frac{dS}{dt} = -kS \tag{1}$$

$$\frac{dS}{dt} = -k(S - \beta S_0) \tag{2}$$

$$\frac{dS}{dt} = -k_{sbk}\left(\frac{6S}{\rho d_0 \exp(-kt)}\right) \tag{3}$$

Where S is the concentration of dissolved substrates, t is the time, k is the hydrolysis rate constant, β is the non-degradable fraction, S_0 is the initial substrate concentration, k_{sbk} is the initial surface disintegration kinetic constant, d_0 is the initial substrate diameter, and ρ is the density of substrate.

The kinetic parameters for the experiment was evaluated by best fitting the experimental data on VS(%) in equations (1), (2) and, (3) using nonlinear curve fitting toolbox available in MATLAB (R2016b). For statistical indicators, Root Mean Square Error (RMSE) and coefficient of determination (R^2) were obtained.

III. Results and Discussion

The results obtained with the experiment and the calculated values from the models are shown in Figure 01. Table 01 presents the hydrolysis rate constant (k), coefficient of determination (R^2), and RMSE of the three models. As shown in table 01, the first-order and the modified first order kinetic model fit the experimental data quite well. But, it revealed that those two models have two different k values as 0.02052 day^{-1} and 0.06122 day^{-1} respectively. However, it could contain a significant number of slowly degradable and non-biodegradable substrates in the organic material in SS-AD [2]. Hence, a long-term batch digestion is required to determine the complete biodegradability of a given substrate. Therefore, deriving the biodegradable fraction is difficult and the kinetic value given by the first order model is not accurate [2]. In that context, using modified first order model with biodegradable fraction is reasonable and results accurate values. Table 01 shows that the k (0.06122 day^{-1}) of the modified first-order model was higher than that of the first-order model with the non-biodegradable fraction constant, the modified model was more flexible than the first-order kinetic model. Moreover, under the surface-related kinetic model, the observed k value was 0.02346 day^{-1}.

Comparing the performance of the models, the best fit was obtained from the modified first-order model with the highest coefficient of determination in all cases (0.8449). However, the surface-based kinetic model shows a weak correlation compared with the other two models. This could have happened due to the assumptions made by the authors during the investigation of the surface-based model. The authors assumed that the substrates present in the digester were spherical particles. Moreover, during the hydrolysis process, particles were believed to be peeled layer by layer and there were no breakages of the substrate during the hydrolysis process. Therefore, the less compatibility with the assumptions in the surface-based kinetic model may be the reason for the weak correlation between the experimental data. Moreover, all three models were developed with the assumption of enough inoculum amount are presented around the substrates. Therefore, it could be a reason for the low correlation of the models with experimental data. Nevertheless, these models were mainly developed in L-AD. Therefore, using these three models to predict the hydrolysis process is not at a significant subscription level.

However, all three models showed a lower hydrolysis rate constant. Slow mass transfer between inoculum and feedstock could be a reason for the low hydrolysis rate at SS-AD. Water content highly facilitates better mass transfer between the inoculum and feedstock. The high solid content in SS-AD may lead to slow mass transfer between microbes and the feed. Additionally, the high solid content can be affected by diffusion limitations [5].

IV. Conclusion

The main objective of this study was to select the best fitted kinetic model, which suits for SS-AD. From the selected kinetic models, the first-order modified model showed a good fit (R^2=0.8449, RMSE=0.04606) among the other models. Nevertheless, the obtained R^2 for the three models are not close to unity above 0.7 would generally be seen as showing a high level of correlation. Moreover, it was observed that the obtained k values for the first-order, first-order modified and surface-based models are 0.02052 day^{-1}, 0.06122 day^{-1}, and 0.02346 day^{-1} respectively. However, the obtained k values have a lower value, when compared with the hydrolysis rate constant, which were investigated by other authors in L-AD. From that, it can be concluded that high solid concentration may be affected by a lower hydrolysis rate constant.

Table 01: Summary of kinetic analysis using different models

Model	Parameter		
	R^2	RMSE	k (day^{-1})
First-order model	0.8325	0.04431	0.02052
First-order modified model	0.8449	0.04606	0.06122
Surface-based model	0.8114	0.04702	0.02346

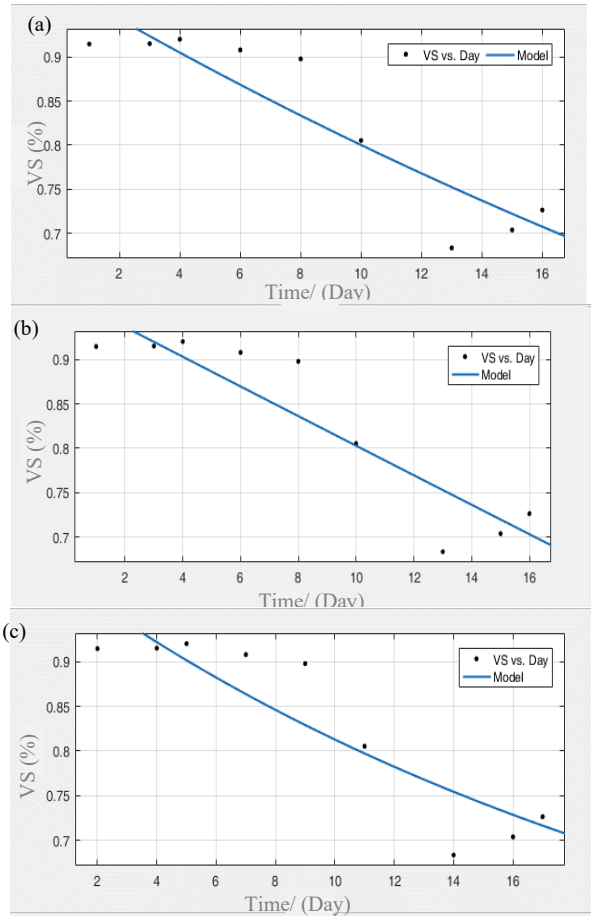

Figure 01: Comparison between the experimental values and model of VS (%) vs time. (a) First-order model. (b) First-order modified model. (c) Surface-based kinetic model

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Performance Evaluation of an Up-Flow Anaerobic Sludge Blanket Reactor with a Bio-Filter Liner System

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Abstract - The Up-flow Anaerobic Sludge Blanket Reactor (UASBR) is widely used due to its high potential in converting food waste to bio-gas. Long start-up periods and inhibitions due to high ion concentrations are common issues of UASBRs. Therefore, a prototype UASBR was designed and developed by incorporating biofilter liner system to address these issues. This study was conducted for 40 days to evaluate the performance of UASBR with the modifications in the feeding system, recirculation system, and newly established sludge removal port. Reactor performance was evaluated daily by analysing the physical and bio-chemical parameters. According to the results, several interventions were done to enhance the anaerobic digestion and to accelerate the start-up process. All the parameters fluctuated responding to the interventions. The overall mean pH of the bottom, middle, top, and permeate of the reactor throughout the study period was 3.83 ± 0.61, 4.47 ± 1.94, 4.16 ± 0.48, and 6.69 ± 1.42 respectively. Even though there was a low pH inside the reactor, the percentage of methane gas produced was observed to be in an increasing manner because methanogenic bacteria have started to adapt and acclimatize in the low pH range. Also towards the end, total nitrogen, nitrate-nitrogen, available phosphorous, and total potassium were detected in permeate. Thus, the composite liner system acts as a live biofilter providing optimum conditions in the anaerobic digestion process via reducing the inhibitions and to accelerate the start-up process.

Keywords: Food Waste, Biogas, Bio-Filter Liner System, Up-Flow Anaerobic Sludge Blanket Reactor

I. INTRODUCTION

According to the Food and Agriculture Organization of the United Nations, 2019, 1.3 billion tonnes of food production are wasted every year and it is one-third of world food production. Daily, a large quantity of food waste is generated at different stages along the food supply chain due to several reasons. Anaerobic digestion of food waste is a promising approach for managing biodegradable organic waste materials and biogas is one of the alternative energy sources [1]. The Up-flow Anaerobic Sludge Blanket Reactor (UASBR) is widely used due to its high potential to be applied in households and industries because it is a simple design, easy to construct, convenient to operate and maintain, low operating cost, and cost-effective. The main problem reported of USAB reactors is that a long-time period is needed to start-up process of the reactor due to the time required for the anaerobic granulation [2]. As well as the overload of minerals existing in USAB leads to reducing the efficiency of gas production. Based on all these past studies, a prototype UASBR was established by Bandara, 2018 and it was modified by Senevirathna, 2019. Observations made from those two studies were short performance evaluation period, recirculation frequency was not adequate, mass and energy balances, gas analysis and biochemical transformation kinetic analysis were not done. Hence, it is necessary to evaluate the performance of UASBR for a long period, in order to develop a pilot scale UASB reactor and to commercialize the UASBR.

II. MATERIALS AND METHODS

The prototype UASBR which was established by Bandara, 2018 and modified by Senevirathna, 2019 was re-modified and used as the experimental setup of the study. The modifications that had to be done to the experimental setup was drawn by using AutoCAD 2018. Mainly three modifications such as restoration of the feeding system, modification of the recirculation system and establishment of the sludge removal port were done to the experimental setup as shown in Fig. 1.

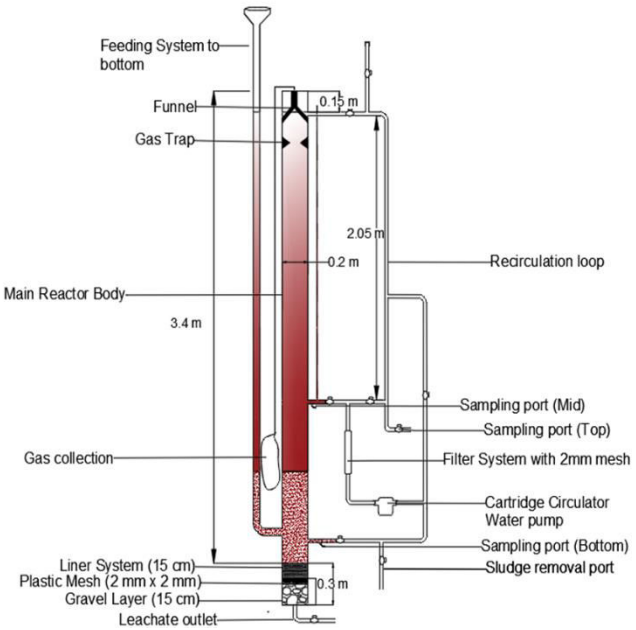

Fig. 1 A schematic diagram of the modified UASB reactor

In this study, food waste was prepared rather than collecting the food waste so as to ensure the optimum elemental composition of the feed required for anaerobic digestion and to formulate mass and energy balances. Initially, ingredients which are needed to be cooked were weighed according to the calculations done by using MS Excel Solver. The cooked food mixture weighed 24 kg. The cooked food mixture was blended by using an electric blender. Then it was mixed with 90 L of river water and fed to the reactor. 52 g of Triple super phosphate (TSP) was also added to the slurry in order to balance the C: N: P: S ratio. Before feeding, the feed characteristics were analysed for pH, conductivity, salinity, total dissolved solids (TDS), total solids (TS), volatile solids (VS), total nitrogen, available phosphorous, and total potassium by using standard methods and instruments. Samples were collected daily at 8.00 am from permeate, bottom, middle, and top of the reactor and stored in sampling bottles. Interventions such as recirculation, addition of water, 1M KOH, and triple super phosphate (TSP) and inoculum were done to accelerate the start-up process, based on daily evaluation results. Continuous feeding was initiated when the start-up process was observed to reach stable conditions. On 34th and 35th days and on 39th and 40th days 500 g (wb) food waste mixed with 3 L water was fed to the reactor from the bottom port. Performance evaluation was done for 40 days by analysing the samples which were collected from bottom, top, mid, and permeate in triplicates from the established UASBR by using the standard analytical procedure.

III. RESULTS AND DISCUSSION

The study was conducted only for 40 days. According to the results, the reactor has not completed the start-up process and stabilization during the experimental period. Even though there was a low pH value inside the reactor, the percentage of methane gas produced was observed to be increasing manner. On the 39th day, the percentage of produced methane gas out of the total percentage of gas composition was 1.55. So, it can be deduced that methanogenic bacteria have started to adapt and acclimatize in the low pH range. Some other interventions could be used in addition to the interventions that were used in this study, in order to accelerate the start-up process of the reactor and to increase the efficiency of the reactor. In this study, food waste which is 6 % of the total volume of the reactor was fed to the reactor but a continuous pH drop inside the reactor due to extreme hydrolysis and acidogenesis was observed. Thus, it is also necessary to study the pattern of organic loading rate in order to optimize the reactor performance. Beer addition also can be done to enhance the anaerobic condition inside the reactor and to accelerate the start-up process [3]. Inoculum with pH 6.98 was used in this study which was not within the desired pH range so inoculation with good quality can be used to enhance the methanogenic activities and to enhance the anaerobic digestion process. The top to middle recirculation is not possible with the existing recirculation system. In this study, top to bottom recirculation was done along with the addition of inoculum, which could led to the disturbance of the stratification process inside the reactor. Hence, top to middle recirculation has to be installed to overcome this consequence and to improve the efficient start-up process. Modified recirculation system, prepared slurry with a proper C:N:P elemental composition of 100:4.4:0.8 which was needed for anaerobic digestion, biofilter liner system with the permeability fluctuated between 2.0 x 10^{-6} - 5.2 x 10^{-6} cm/s and the established sludge removal port were the strengths for the performance of the UASB reactor.

IV. CONCLUSION

Performance evaluation of UASBR with biofilter liner system portrayed that the food waste used as feeding material was successfully converted to useful products. The pH particularly was an influential parameter which was intervened to increase the low pH values after the phases such as hydrolysis and acidogenesis of anaerobic digestion. In this experiment, establishment of the sludge removal port, modification of the recirculation system, and the feeding system did considerable influence to accelerate the start-up process. Towards the end, total nitrogen, nitrate-nitrogen, available phosphorous, and total potassium were detected in permeate and also, the permeability of the composite liner system was within the desired range. Thus, the composite liner acts as a live biofilter to make anaerobic system biologically stable, providing optimum conditions for anaerobic digestion via reducing the inhibitions. The study was terminated on 40th day due to the outbreak of COVID-19. Hence, the reactor had not completed the start-up and reached stabilization during the study period. It is recommended to continue the evaluation process with more interventions such as beer addition, the addition of good quality inoculum, installation of top to middle recirculation system, etc. to accelerate and stabilize the start-up process of the UASBR.

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Development of Silica Gel from Rice Husk and Evaluation of its Applications

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Abstract - Rice husk was used to extract silicon since it has a very high silicon content. Therefore, this research was conducted to convert rice husk into silica gel by developing a process. Cleaned rice husk was burned in a muffle furnace at 600°C for 6 hours to get ash. Ash was dissolved by potassium hydroxide (1.425 M, 150 mL) and heated for 20 minutes at 100°C. The solution was filtered and 5 mL of phosphoric acid was added to the filtrate to get the silica gel. Rice husk ash and the silica gel were analyzed for biological and biochemical parameters. Prepared silica gel showed an alkali pH of 9.59. Germination percentage of control treatment and treatment with 1% silica gel was 68% and 43%, respectively in bioassay. Organic solution was prepared using CO-3 grass. It was used to adjust the parameters of the silica gel. A mixture of silica gel and the organic solution was analyzed for different parameters for 7 days. The initial parameters of the mixture changed and reached static values. After 7 days, pH, electrical conductivity, salinity, and total dissolved solids (TDS) of the mixture were 9.59 to 8.56, 14.68 to 5.28 mS/cm, 8.4 to 2.7 ‰, and 8,230 to 2,710 mg/L, respectively. Adsorption kinetics was applied to the mixture and 12.97 times transformation of TDS took place in the mixture. A huge portion of TDS transformed into available form. Different organic solutions can be used to check the TDS transformations and concentrated organic acid could replace phosphoric acid.

Keywords: Rice husk, Silica gel, Phosphoric acid

I. INTRODUCTION

Rice husk is a by-product of rice processing industry. Very large amount of rice husk is produced annually in Sri Lanka. This produced rice husk is mainly used as an energy source in Sri Lanka in many industries where they need high amount of heat. Silicon (Si) is the second richest element on the earth's surface which can provide substantial benefits for many crops, particularly greenhouse crops since our soils have less substrate and do not contain much available silicon. It is very common to use silicon fertilizers in soil less culture (hydroponics) as foliar or root application, but there are significant benefits to the crops if it is used in soil cultures too. It can act as a reinforcement of cell walls by deposition of solid silica. In addition to naturally occurring soluble Si in soil, many crops respond positively to additions of supplemental Si. Plants especially grasses, can up take large amount of Si which it contributes to their mechanical strength [1]. However, an effective method of application of Si is one of the problems for the farmers, whether to apply as a foliar application or root application because of the uncontrollable factors. Rice husk ash is a good silicon pool. So, developing a process to convert the Silicon in the rice husk ash into an available form for the plants will be the best option to solve environmental pollution while harnessing the economic benefits.

II. MATERIALS AND METHODS

The process was started using the rice husk as the raw material. Fresh rice husk was collected from a rice processing centre. The research was conducted in the Soil and Water Engineering Laboratory of Department of Agricultural Engineering, Faculty of Agriculture, University of Peradeniya. Collected rice husk was cleaned to remove the inert materials soon after collection. Cleaned rice husk was burned in a muffle furnace at 600°C for 6 hours to get ash. 10 g of rice husk ash was measured and put into a conical flask. 150 mL of prepared potassium hydroxide (1.425 M) solution was poured into the conical flask and stirred using a magnetic stirrer. The solution was gently heated in the water bath (100°C) for 20 minutes. The heated solution was filtered using a Whatman No 1 filter paper. 5 mL of pure Phosphoric acid was added to the filtrate soon after filtering. The solution was shaken well by hand. The gel was obtained while shaking. Rice husk ash and the silica gel were analysed for the parameters of pH, electrical conductivity, salinity, total dissolved solids (TDS), total suspended solids (TSS) and volatile solids (VS). Organic solution was prepared using CO-3 grass. It was used to adjust the parameters of the silica gel. The surface of the silica gel was fully covered with the organic solution in the parameter adjustment test mentioned above. Adsorption kinetics was applied to the mixture as the process more likely to an adsorption process. Eq. 1 (Elements of Chemical Kinetics, 1970) was used for the calculation.

$$v = k\frac{\lambda_A \times P_A}{1+\lambda_A \times P_A} \qquad \text{Eq. 1}$$

Where, v = Rate of reaction, λ = Inverse of the ratio of available TDS, absolute TDS (B/A), P = Specificity, and k = constant. Absolute TDS of the solution and the available TDS of the solution were calculated with the collected data. The inverse value of the ratio of available TDS and absolute TDS was calculated which was given the λ value. The value for v was calculated using those λ values. Bioassay studies with

Table 1: Measured Parameters of Silica jel

Parameters	Replicate 1	Replicate 2	Replicate 3	Average
pH	9.59	9.53	9.66	9.59±0.05
Electrical conductivity (mS/cm)	15.72	14.04	14.28	14.68±0.74
Salinity (‰)	9.1	8.0	8.1	8.4±0.49
TDS (mg/L)	8,980	7,890	7,820	8,230±531.09
TSS (mg/L)	214	144	178	178.67±28.58
VS (mg/L)	160	96	136	130.67±26.39

different silica gel percentages were conducted to check the phytotoxicity of the silica gel. Lettuce seeds and Tomato seeds. Germination percentages of each treatment were measured after seven days.

III. RESULTS AND DISCUSSION

The measured quality parameter values of the prepared rice husk ash and silica gel showed some variations from the literature. Rice husk was selected to prepare the silica gel because the available quantity of rice husk is very high in Sri Lanka [2]. Si is available in a readily available form of rice husk ash too. The mass conversion ratio of rice husk to rice husk ash is about 20% according to the literature [3]. But in this experiment, it was around 14.93± 0.9%. There could have been an instrumental error and the Replicate 3 could be considered as an outlier or simply the new varieties may have low ash contents since the thickness of the husk is very small. KOH is used to prepare the silica gel instead of NaOH as KOH is having many advantages over NaOH. The use of KOH is good to incorporate K^+ ions into the soil which is an essential nutrient for the plants. The exchangeable Na^+ adversely affects the physical and nutritional properties and the growth of the plants.

Prepared silica gel has an alkali pH of 9.59 (Table 1). The TDS value of the prepared silica gel is comparatively high and it is due to the high availability of ions. The average mass conversion value is 82.3% which is higher than the reported value of 73.1% [4]. The first bioassay failed and germination percentage of control treatment and treatment with 1% silica gel was 68% and 43%, respectively in the second bioassay. Bioassay studies show the concentration of the silica gel has an effect on germination. A high concentration of the silica gel made a negative impact on the germination of the seed. 0 – 1 % of the gel is better than at higher concentrations to be used as a soil application. parameters of silica gel, particularly the pH is high in terms of it as a fertilizer. So, the parameters must be adjusted using the organic solution to a certain preferable level. The amount of nutrients present in CO-3 is high compared to other types of biomasses. pH, electrical conductivity, salinity, and TDS values of the sap were 6.12, 5.32 mS/cm, 2.8 ‰ and 2790 mg/L respectively. A mixture of silica gel and the organic solution was analysed for different parameters for 7 days. The initial parameters of the mixture changed and reached static values. After 7 days, pH, electrical conductivity, salinity, and TDS of the mixture were 9.59 to 8.56, 14.68 to 5.28 mS/cm, 8.4 to 2.7 ‰, and 8,230 to 2,710 mg/L, respectively. At the same time, the organic solution adsorbed into the gel surface had a high portion of TDS transformed into the solution. Adsorption kinetics was applied to the mixture and 12.97 times transformation of TDS took place in the mixture. The available portion of the TDS relates with the available number of ions. So, the ions for the uptake of the plant are increased once the gel is treated with the organic solution.

IV. CONCLUSIONS

Mass conversion of the silica gel from rice husk ash is much higher. Very high amount of Silica was converted using rice husk ash and KOH with an average of 13.33 litres per kg of rice husk ash. Important parameters of pH and ionic strength of the silica gel were adjusted using the prepared organic solution from CO-3 grass. An extremely high quantity of TDS was made available from the gel when it was incorporated with an organic solution. Adsorption kinetics indicates rapid transformations with available active sites. Further studies should be undertaken with different organic solutions to check the quality changes of the silica gel. Phosphoric acid can be replaced with organic acids with the required concentration to make use of conversions to TDS. Bioassay should be undertaken with the organic solution treated silica gel and also with the diluted silica gel. Silica gel can be incorporated to biofertilizer granules.

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Track 9

Food and Food Security

Obstacles Faced by Women in Urbanized Areas in Kandy District Related to Food Crop Cultivation

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Abstract - In general, women play an important part in urban agricultural output. Regardless of their roles, women farmers confront many obstacles that impede their greater productivity in metropolitan settings. With a focus on Kandy, Sri Lanka, this study examined the issues faced by women farmers in metropolitan locations. A total of 70 women farmers were surveyed across the district's urban areas. Lack of land facilities was identified as one of the most significant barriers to greater production by women, according to the matrix ranking, lack of credit facilities is another issue that have been noted among others. Appropriate recommendations were made, including hosting agricultural extension programs by authorities, particularly for women farmers, and the inclusion of women in agricultural decision-making.

Keywords: Agricultural issues, Food security, Urban farming, women's participation

I. INTRODUCTION

Women's kitchen gardens or homestead plots are frequently overlooked when it comes to agriculture, yet they play a significant role, particularly in terms of dietary diversity. In certain cases, women also raise a significant portion of the household's main cereals or root crops (1).

Their economic empowerment, which allows them to produce more and participate in policy development, is crucial to tackling poverty and food insecurity. Women's contribution to subsistence production (farm/income generating activities) is counted as unpaid family work. It is estimated that over 56% of the women work as unpaid family workers (2) with women's participation in planting, weeding and post-harvest work high.

For instance, Olaoye (1999) discovered that Nigeria's capacity to increase crop output is constrained by the recurring occurrence of drought caused by uneven rainfall distribution and/or rain cessation throughout the growing season (3). Population migration to urban areas is another issue. Urban population growth in Sri Lanka is 1.9% in the past year, which has been rising for the last couple of years after the steady decline from the 1960s (4).

And as almost half of this population is women, it is important to look at their potential in urban farming to help the uprising in the food crisis among many other issues.

II. MATERIALS AND METHODS

The focus of this study is the Kandy district in March and April 2022. Using a random selection approach, households in the sampled urban settlements were selected to receive the questionnaire. The target population consisted of one-woman farmer per household, and samples were only taken from those households. A randomized sampling method was used in the process.
The percentage contribution of these difficulties faced by women farmers in the study area was calculated using a matrix 15x7 ranking system. Ordering things in this manner entails going from best to worst, smallest to largest, etc. The scoring process entailed the women farmers giving numerical scores to each group of issues. This was carried out following the most urgent issue limiting women's participation in agricultural production in the research area.

III. RESULTS AND DISCUSSION

After filtering the 70 responses 66 of them were suited to analyze the data. According to the survey conducted, 80.3% of them were single young adults, with an average of 4 people living in each home. Additionally, 43.9% of the studied women farmers have sat for the G.C.E Advanced Level Examination, while 28.8% had a degree. In addition, practically all farming activities, including planting, weeding, transplanting, fertilizer application, and harvesting, were carried out by women farmers. In addition, they cultivate a variety of crops, including cereals, herbs, spices, fruits, and vegetables.
Lack of sufficient land was likewise listed as the top issue facing them by 32 (48.5%) respondents, while 9 (13.6%), and 3 (4.5%), ranked it as the second, and third issues, respectively.
In the research area, the productivity of the staple food crops is often low, mostly because the quality of the seeds and the fertilizers tend to be low; this was ranked as the fourth most pressing issue overall. Additionally, since farm inputs are required to raise productivity, this is significant. The level of income, the size of land holdings, or the potential level of agricultural production—in which women may be at a disadvantage—could all affect access to inputs. overall it was ranked as the seventh most pressing problem.
The following table showcases the parameters taken for the survey and the results.

Table 1 : Ranking of problems in urban farming

Problem	Rank						
	1st	2nd	3rd	4th	5th	6th	7th
Credit facilities	8	6	5	4	1	2	9
lack of land	32	9	3	2	4	2	1
Lack of farm input	1	7	5	5	3	4	4
Seasonal rainfall	1	3	7	11	8	6	4
Lack of knowledge	3	7	5	7	4	2	5
Lack of storage	-	3	-	6	4	8	2
Animal disturbance	16	7	9	3	6	3	3
Poor road facilities	-	3	1	2	-	1	1
inadequate agri. services	-	1	4	3	12	4	6
Pests and diseases	2	11	12	8	9	3	2
Marketing problems	1	-	2	3	-	2	3
Low productivity	-	3	8	7	7	11	4

Inability to access necessities goods	2	5	2	-	3	7	5
Inadequate labor force	-	-	1	4	1	4	5
Policy changes	-	1	2	1	4	7	12

As per the above table, recent policy changes were identified as the most pressing seventh issue among many women farmers. In addition, women farmers in Kandy identified access to credit as one of the least concerning problems to their ability to produce agricultural products. This was majorly based on the fact that they are utilizing household scraps, and leftover vegetables to grow new crops.

From the aforementioned findings, it can be seen that women farmers in the sampled small towns confront a variety of issues, the most important of which are limited access to land, animal disturbances, pests and diseases, and low productivity.

Another pressing challenge could be noted as the lack of agricultural knowledge. This could be solved by conducting agricultural programs for women engaging in household gardening.

This study supports Tunde's (2011) observation that most women farmers maintain small plots of land because they lack access to financing that would allow them to buy larger plots and farm supplies to boost production. A strong institutional framework should be created through initiatives that cater to the training requirements of women farmers for them to be more relevant and productive in the agricultural sector.

Zoning designated agricultural areas next to roads, power lines, or waterways (buffer zones) would be a significant step in increasing the legitimacy and sustainability of urban agriculture.

IV. CONCLUSION

It was identified that lack of land is the most pressing issue. This was major because almost all of these women were living in urban settings. It could be identified that many of these farmers use seasonal rainfall as a method of watering their crops. Introducing new technology like hydroponics, wastewater filtering, and drip irrigation could help to illuminate this issue. Issues like pests and diseases, the inability to access necessary goods for farming, and low productivity could be linked to the recent policy changes of avoiding the import of fertilizers, vegetable seeds, and agrochemicals.

Before the food crisis, the houses were designed as spaces to live, disregarding the environmental elements and sometimes even regulations. Imposing strict restrictions and making the architects, designers and necessary authorities aware of the situation may help to eliminate this problem.

Women contribute significantly to the growth of the national economy. They make up more than half of a country's human capital and have a major impact on agricultural output. It is important to recognize their importance in overcoming the obstacles to agricultural development and productivity. Farmers are typically seen as "males" by policymakers, development planners, and providers of agricultural services, despite this tendency in most descriptions of agricultural development planning. It is important to have the input of female farmers when making policies related to agriculture.

Acknowledgements

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Potentials and Future Prospects of Major Fruit Exports in Sri Lanka

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Abstract - Tropical fruits from Sri Lanka are highly rated worldwide due to their unique characteristics such as flavour, aroma, and colour. In terms of the fresh and processed fruit export industry, Sri Lanka has not tapped its full potential but only a speck of the total production reaches off-shore markets. Despite the significant evidence available on the fruit export industry in Sri Lanka, scant attention has been paid to its potential. Therefore, the overall objective of the study is to identify the export potential of Sri Lankan major fruit exports. Both primary and secondary data were used. Purposive sampling technique was employed in sample selection. According to weighted average score analysis pineapple has the most potential for export. The Gravity model found that the American region was the preferred destination for Sri Lanka's major fresh and processed fruit exports followed by Middle East and South Asia.

Keywords: Export Potential, Major Fruits, Gravity Model, Weighted Average Score Analysis

I. INTRODUCTION

In Sri Lanka there is high potential for cultivating fruit crops for domestic and export markets. Compared to certain other countries in the region, given the favourable climatic and soil conditions, Sri Lanka has high prospects in the fruits. Moreover, specialties associated with Sri Lankan products such as superior flavours and vicinity and organic yield have elevated the industry's prospects. For instance, tropical fruits in Sri Lanka such as pineapple, rambutan, mangosteen and passion fruit are very popular around the world for their unique flavour, aroma and colour [1]. At present, the government of Sri Lanka hails export promotion as a key strategy to capture the international market. Further, the current local agricultural policy framework is aimed at modernizing Sri Lankan agriculture to draw a lucrative income from export crops. In this context identifying and addressing the issues that caused uncertainty in the fruit export subsector in Sri Lanka despite the growing world demand is a step in the right direction. With the recognition of proper niche markets, Sri Lanka may have the potential to develop exports of fresh and processed fruits. Therefore, scientific research directed at revealing the underlying reasons for market changes and potential niche markets is needed [2]. Therefore, this study was designed to analyze the export potential of major Sri Lankan fresh and processed fruits.

II. MATERIALS AND METHODS

Both primary and secondary data were used for this study. Export data (from 2010 to 2020) collected from the Sri Lanka Customs was used. The primary data was gathered by using questionnaire surveys, key informant interviews, and case studies. A purposive sampling technique was applied to select the sample from fresh and processed fruit exporters. Weighted Average Score Analysis was used to identify the most potential fruit crop for exporting. The Augmented Gravity Model was employed to estimate the export potential of Sri Lankan major fruits for the study period.

III. RESULTS AND DISCUSSION

A. Export Potential of Major Fruits in Sri Lanka

1. Potential Commodities in Major Fruits in Sri Lanka: Weighted Average Score Analysis

Based on the methodology and the weightage given, the researchers have analyzed major fruits produced in Sri Lanka and calculated their individual scores. The individual scores of the major fruits are exhibited in Table 1.

Table 1: Individual Scores of Major Fruits

Fruit Crop	Individual Score Calculated	Rank
Pineapple	7.72	1
Banana	8.12	2
Papaya	9.82	3
Mango	10.02	4
Avocado	10.32	5
Lemon	10.35	6

Source: Authors' Own Calculation Based on Agricultural Statistics, Department of Census and Statistics and Sri Lanka Customs

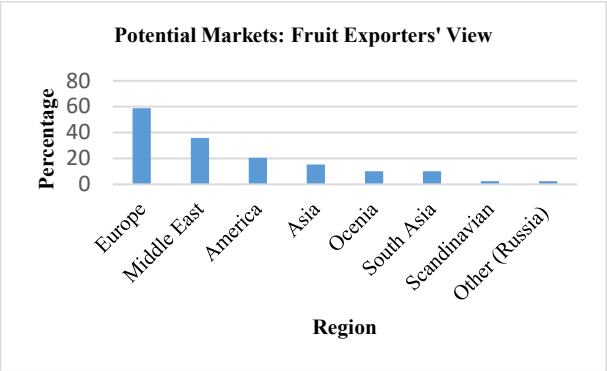
The scores depicted above are calculated on a ranking basis, therefore lower the score more the export potential of the crop is. The results revealed that pineapple has topped based on the scores above. Further, this is in accordance with the results shown in [3].

2. Potential Markets for Sri Lankan Fruit Exports

As stated by key informants, China, Jordan, Singapore, Korea, Japan, and Russia are the potential new markets for Sri Lankan fruit exports. Figure 1 depicts the export regions that are believed to have export potential in the future for Sri Lankan fresh and processed fruits.

According to the majority (58.97%) of the surveyed fruit exporters, Europe has the highest potential for Sri Lankan fresh

and processed fruit exports, followed by the Middle East (35.90%), America (20.51%), and Asia (15.8%). A similar percentage (10.26%) of fruit exporters mentioned that Oceania and South Asia are potential regions as well. However, five percent of exporters indicated that Scandinavian countries and Russia can also be potential markets for Sri Lankan fresh and processed fruits in the future.



Source: Authors' Compilation based on Survey Data, (2021)
Fig. 1. Potential Regions according to Fruit Exporters

3. *Estimation of Export Potential through Gravity Model*

Table 2. Estimation Results for Exports

Predictors	Coefficient	Standard Error	P value
Log (GDPit)	-1.855*	1.085	0.087
Log (GDPjt)	0.311	0.426	0.465
Log (POPit)	12.108**	5.229	0.021
Log (POPjt)	0.381	0.382	0.318
Log (PCGDPDijt)	1.788***	0.462	0.000
Log (DISTij)	-3.117***	0.403	0.000
Log (REERijt)	0.234*	0.132	0.075
Log (COLij)	-1.391***	0.513	0.007
No of Observations	165		
eta	0.113***	0.021	0.000
Gamma	0.628	0.430	

Note: ***Variables significant at 1% **Variables significant at 5.0%
* Variables significant at 10.0%
Source: Authors' Estimates

Importing country's GDP(GDPjt) and population (POPjt) have positive impact on Sri Lanka's fruit exports whereas distance (DISTij) has negative and significant impact on Sri Lanka's fruit exports. However, GDP of Sri Lanka (GDPit) shows a negative sign and is statistically significant while population (POPit) parameter is positive and significant. In addition, the difference between the factor endowments (PCGDPDijt) has a positive and significant impact on Sri Lanka's major fruit exports, which is in accordance with the Heckscher-Ohlin theory. However, real exchange rate (REERijt) has a positive and significant impact on Sri Lanka's fruit exports, implying that the exchange rate policy did not play a significant role in Sri Lanka's fruit exports. Therefore, the growth in Sri Lanka's fruit exports can be credited to effective export promotion programs and improvements in the production base. Coefficient for COLij has a negative sign and it is statistically significant. Further, this depicts that Sri Lanka's fruit export performance is not supported by colonial relationships (COLij). Accordingly, most of the estimation results are in line with the existing literature even though some variables were found to be statistically not significant.

Maximum Likelihood Estimates of gravity stochastic frontier model was used to estimate the destination-wise potential of the fresh and processed fruit exports of Sri Lanka. Table 3 presents the region-wise results.

Table 3. Region-wise Export Results: 2010-2020 Average (Rs)

Region	Actual Exports	Potential Exports	Ratio of Actual to Potential	Unused potential (%)
European	45103993.04	196375842.6	22.97	77.03
American	161368319	186889959.8	86.34	13.66
Oceania	25318532.27	122639462.1	20.64	79.36
Middle East	660469137.2	1164703305	56.71	43.29
Asian	39362308.27	123320699.4	31.92	68.08
South Asia	33867801.6	59793556.34	56.64	43.36

Source: Authors' Estimates

IV. CONCLUSION

The results depict that Sri Lanka has not tapped more than 50 percent of its potential in Oceania (79.36%), Europe (77.03%) and the Asian region (68.08%). Therefore, Sri Lanka can enhance fresh and processed fruit trade with above regions in place of the countries which have exceeded the trade potential. Weighted Average Score Analysis was used to identify the highest potential fruit crop for export from Sri Lanka. Pineapple has the highest potential for export. Therefore, government should encourage and facilitate commercial-level cultivation of pineapples.

Acknowledgement

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Use of Sound Waves in Increasing Shelf Life of Banana

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Abstract - Banana is one of the most widely produced and consumed fruits in the world, but their short ripening period is a major disadvantage. Many chemical and physical method are currently being used to delay ripening of bananas, which are hazardous and expensive. Sound wave treatment has applied successfully to various commodities to control their ripening. The present study analyzed the effectiveness of using soundwave treatment for controlling ripening of Kolikuttu banana. The treatment was applied for same aged bananas in their mature green stage inside a soundproof box with three sound waves frequencies (600Hz, 1000Hz, 1500Hz) for continuous 06 hours. As the control, a sample without soundwave treatment was analysed. After the sound wave treatment ripening levels were measured using banana ripening chart, starch breakdown patterns, pulp to peel ratio, titratable acidity, pH value and total soluble solids on 1st, 3rd, 5th, 7th and 9th day and the results were statistically analyzed. Controlled banana sample reached their fully ripened level by 5 days while 600 Hz sample took 11 days and 1000 Hz and 1500 Hz samples took 13 days. According to the results there was a significant effect from sound wave treatment for the ripening of bananas (ANOVA, P = 0.000). When conferring the time series analysis of tested parameters, the1000 Hz treated banana samples showed the best increase in shelf life. Therefore, this frequency can be used to develop ecofriendly, cost-effective sound wave treated system to delay ripening of banana and reduce post-harvest loss.

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Keywords: Banana, Ripening, Post-harvest loss, Sound waves

I. INTRODUCTION

Banana is one of the most widely produced and consumed fruits in the world. Normally, bananas are harvested when they are young and consumed when they have fully ripened. An immature banana usually takes three to four days to ripen [1]. When compared to other fruits, the main disadvantage of bananas is their fast ripening due to ethylene. Ethylene is a colourless gaseous plant hormone that regulates a variety of processes [2]. To minimize the post-harvest loss of bananas, their ripening period has to be extended. Researchers have tried a variety of scientific approaches to delay the ripening of bananas such as use of salicylic acid [1], use of 1-MCP microbubbles [3] and use of light triggered release of nitric oxide [3]. However, these methods could be hazardous, expensive and not environmentally friendly. The utilization of sound waves as a factor in ripening delay is a revolutionary concept that has been used previously for vegetables such as tomatoes [4]. Using sound waves to delay the banana ripening has advantages as this is an environmentally friendly method. Also, this is a better way of avoiding hazardous chemicals and other agents. Further sound stimulation may improve disease resistance while reducing the need for chemical fertilizers and biocides [2].

The present study analysed the use of sound waves in extending shelf life of Kolikuttu bananas {Musa spp. (Kollikuttu)} considering its wide usage around the country.

II. MATERIALS AND METHODS

A. Collection of bananas

Kolikuttu variety of banana fruits were purchased from a cultivation land in Badulla through a local buyer. All the bananas were of the same bunch, and were free of any chemical agents.

B. Preparation of soundproof box

First, two different sized wooden boxes {(Large-25*25*25 inches) (Small-20*20*20 inches)} were prepared. Then, sound insulation foam was glued to each side of the large wooden box and a small box was placed inside the large box. Six speakers were placed on each side of small box to distribute the sound waves.

C. Programming the frequency generating software

Software was coded by python programming language using sound devices, NumPy and math libraries. The software resulted two dialog boxes which was inserted with the required frequency for specific time.

D. Treatment of banana with sound waves

Bananas were treated with sound waves of 600 Hz, 1000 Hz and 1500 Hz respectively for continuous six (6) hours inside the sound proof box. Sixteen banana fingers were treated with one soundwave treatment and three replicates were carried out for each frequency. As the control the same amount of banana fingers were kept in the same environment without soundwave treatment. Finally, the bananas were stored under room temperature for further monitoring.

E. Experiments to detect the ripening level

Both sound-treated and controlled banana samples were analyzed using several tests to detect their ripened level on 1st, 3rd, 5th, 7th and 9th day after the sound wave treatment. As the tests, detection of the ripening level using banana ripening chart, study of the starch breakdown patterns, analysis of pulp to peel ratio, and measurement of titratable acidity, pH value and total soluble solids were carried out.

F. Data analysis

The experiment was carried out in a Completely Randomized Design (CRD) with three replicates. The data were subjected to analysis of variance (ANOVA)using the Minitab 19 statistical software. The results showing significant differences were then subjected to mean separation using Tukey Pairwise Comparison Test.

III. Results and Discussion

A. Results according to banana ripening chart

Controlled banana sample reached their fully ripened level (according to the chart) by 5 days while 600 Hz sample took 11 days and 1000 Hz and 1500 Hz samples took 13 days. These findings conclude that, not all the sound wave frequencies but some frequency ranges may delay the ripening of banana (Fig. 1).

B. Results from laboratory experiments

According to the results there is a significant difference among sound wave treated samples and controlled samples in Pulp to peel ratio, Titratable acidity, pH value and Total soluble solids (ANOVA, P= 0.000).

Furthermore, Tukey pairwise comparison was used to group the information at 95% confidence. The results also revealed that there is a significant difference between controlled and treated samples proving that sound wave treatment has affected the ripening of the banana.

Time series analysis was performed for variations in pulp to peel ratio, titratable acidity, pH value and total soluble solids with time. From these, Pulp to peel ratio, pH value and Total soluble solid values had increased with time showing a similar pattern. On the other hand, titratable acidity values had decreased with time. The results revealed that controlled banana samples always showed fast ripening compared to the sound treated samples. A study done for tomatoes to increase shelf life using sound waves, revealed that the expression level of several ethylene biosynthetic and ripening-regulated genes was affected by sound wave treatment [4]. The same mechanism must be the reason for delaying of the ripening of the banana when they were treated with sound wave frequencies.

Further time series analysis revealed that 1000 Hz was the best frequency, which increased the shelf life of banana. Consequently, this frequency can be used to develop ecofriendly, cost-effective sound wave treated system to delay ripening of banana and reduce post-harvest loss.

Fig. 1 ripening of banana Day 05. a) 1000 Hz treated sample b) control sample.

IV. Conclusion

The utilization of sound waves as a method of delaying banana ripening is a revolutionary concept. Our results revealed that sound wave treatment on bananas can be used in increasing the shelf life of banana. From the frequencies studied, 1000 Hz frequency gave the best result in delaying the ripening of banana. This ecofriendly, cost effective and healthy method can be further developed to reduce post-harvest loss in banana industry. This study paved the way for additional research on the effects of sound waves on plant responses. The results of this study suggest that acoustic biology can be useful in agriculture and may aid in improving product quality and decreasing losses. This study also offers the first proof that sound treatment can increase the shelf life of banana fruit. Future research must include more in-depth analysis because this field is still in its infancy.

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Sauerkraut as a Probiotic Food

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Abstract - Sauerkraut is a naturally fermented cabbage which is a nutritious fermented vegetable product highly appreciated for its particular sensory characteristics. It is considered as a probiotic food as it contains live microorganisms which actively enhance health of consumers. It is said to improve the balance of gut microflora and confer resistance against pathogenic microorganisms. The preparation of sauerkraut does not require a starter culture. The first stage of sauerkraut fermentation involves anaerobic bacteria which is why the shredded cabbage and salt need to be packed in an airtight container. This process was found to be lactic acid fermentation. The microorganisms responsible for the characteristic change in the sauerkraut were isolated and identified. At the initial stage, the bacterium which was found to be *Leuconostoc mesenteroides* produces lactic acid and CO_2 due to which the conditions within the container becomes too acidic for the particular bacteria to survive. This was followed by yeast mainly *Saccharomyces cerevisiaea* after 3days of fermentation. After 5 days, *Lactobacillus* sp namely *L. plantarum* and *L.brevis* appeared in sauerkraut. The fermentation was studied for seven days. Though bacteria and yeast were prevalent in this microbial succession in sauerkraut fermentation process, the overall microbial load was dominated by bacteria. The lactic acid bacteria involved in fermentation are considered as probiotic source of the food process. Probiotics in foods provides several health benefits in human such as reduction of serum cholesterol, enhanced immune system and others. Thus developing probiotic foods from cheap sources is an emerging trend nowadays.

Keywords: Leuconostoc, Lactobacillus, sauerkraut, yeast

I. INTRODUCTION

People have been fermenting vegetables for centuries to increase the stability of fresh foods to make the foods safe to eat in the absence of refrigeration and to enhance their flavor. Fermentation also increases the nutritional content by producing vitamin B and improves the digestibility. Today vegetable fermentation is done on a large-scale in factories as well as in households throughout the world. Cabbage has been fermented in various fashions by different cultures throughout history. The simplest product in which no additional seasonings are added is generally referred to as sauerkraut. It is very popular in America and European countries. Sauerkraut is not very popular in Asian countries like India and Sri Lanka. The taste should be enhanced to suit the Indian consumers. In India in fact cabbage is cultivated in most parts of the country. However due to its perishable nature the cabbage is available only for a short period. A higher percentage of the total production is destroyed due to lack of processing. People consume cabbage as cooked vegetable curry or raw salad. Usually during cooking, vitamin C which is an essential component of cabbage is destroyed if the processing is not done properly [1]. Therefore vitamin C and other nutrients can be preserved through fermentation and availability of cabbage can easily be increased throughout the year. Sauerkraut is made by shredding cabbage and allowing it to ferment with the addition of 2.2-2.8% salt (NaCl). Lactic acid is the major contributing factor to the taste and shelf life of sauerkraut [2]. The objective of the present study is to isolate and identify the beneficial microorganisms which are naturally involved in sauerkraut fermentation. Sauerkraut can be introduced as a cheap and important probiotic food other than the conventional dairy products such as yoghurt, cheese etc.

II. MATERIALS AND METHODS

A. Preparation of Sauerkraut

White cabbage was bought in the local market in Jaffna. It was washed and dried. Shredded cabbage was taken in a plastic bag and weighed. 2.5% NaCl was added and mixed well. Cabbage was pressed down firmly with the base of an Erlenmeyer flask to force out any trapped air bubbles. A thin film of juice should accumulate at the top. The beaker was covered with a polythene paper and maintained under anaerobic conditions. It was allowed to ferment for seven days. The pH, percentage of acidity and microbial count were studied at 24 hrs interval for seven days.

B. Preparation of inocula

10ml of sauerkraut sample was taken and dissolved in 90ml sterile water. Then 1ml of sample was transferred into 10ml sterile water. It is called the initial inoculum. Samples were taken 24hrs interval to determine the pH, acidity, plate counts and type of microorganisms involved in the fermentation.

C. Standard plate counts

The initial inoculum was serially diluted and 10^{-5} and 10^{-6} dilutions were plated on MRS broth (Man Rogosa and Sharp agar) and nutrient agar (for bacteria) and yeast extract malt extract agar (for yeasts) to determine the number of different types of microorganisms in the sauerkraut at various time intervals. The plates were incubated at 37 °C and 28 °C for 48 hrs respectively. The colonies were taken and sub cultured for identification of bacteria and yeasts. The biochemical tests were done on the isolates for identification of bacterial species based on the key designed by [3] and Key designed by [4] for identification of yeasts. The biochemical tests used were Growth in nutrient broth with 3% NaCl, Catalase test, Growth in nutrient broth with 6.5% NaCl, Growth in nutrient broth at pH 4.8, sugar fermentation (acid and gas production), nitrate reduction test, tryptone glucose yeast extract broth test and gelatin test. The biochemical test done for yeasts was sugar

fermentation (acid and gas production). The yeasts were identified from the shape of the cells and change in color of the colonies as well.

III. Results and Discussion

The production of sauerkraut involves succession of bacteria and yeast. At the start of fermentation, the bacterium *Leuconostoc mesenteroides* caused the acidification which was followed by the yeast *Saccharomyces cerevisiae* that improved the nutritional quality in terms of flavor. The presence of bacteria and yeast in microbial succession has been reported in sauerkraut by [5]. The salt added to sauerkraut extracts liquid from the vegetable serving as a substrate for the growth of lactic acid bacteria [6]. During this fermentation study, when the acidity increased (2%) it favored the development of some other bacteria namely *Lactobacillus plantarum* and *Lactobacillus brevis* after five to seven days. The viable count of the bacterial population ranged from 10^5 to 10^6 from 3 days to 7 days of fermentation. The viable count of yeast was found to be 10^5 on the third day. The increase in microbial count was accompanied by an increase in acidity from 0.35% to 2% and decrease in pH from 5.74 and 3.2 respectively. Bacteria and yeasts are responsible for the production of acid and gas from simple sugars in the sauerkraut juice. This produced the particular flavor in sauerkraut. Thus the beneficial microorganisms in sauerkraut, bacteria and yeast were identified and the viable count was determined. The series of microorganisms during the production of sauerkraut found in this research was also supported by a study made by [7]. The present study also suggests the value of consumption of non dairy products as a source of probiotic foods.

IV. Conclusion

Probiotics are essential to promote health in human. It is a very good source of probiotic bacteria (mainly lactic acid bacteria) other than the dairy products. The conditions of fermentation should be optimized to enhance the growth of lactic acid bacteria in sauerkraut. The influence of seasonal variation on the growth of lactic acid bacteria in sauerkraut should be studied. The nutritional quality is increased in sauerkraut by avoiding the loss of vitamins which usually occurs during cooking.

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Conceptualizing a Mobile Application Aimed at Enhancing Food Security

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Abstract - Sri Lanka is currently facing an economic crisis that has severely affected the availability and accessibility of food and beverages. Therefore, it is now vital to come up with technological innovations to enhance the food security within the country. This study was aimed at formulating a feasible solution for addressing severe food insecurity via reducing the food wastage that occurs at the domestic level. At the same time, it was expected to find means to provide an additional mean of income for the households to relieve the economic burden through this study. Understanding food wastage as one of the most contributing factors towards the food scarcity laid out the foundation of designing this application. It was also observed that only very few or no measures have been taken to reduce the domestic food wastage. Therefore, the application was designed in such a way that a virtual marketplace is been created for the household units to sell the food items that are prepared in excess to potential buyers who require to buy their meals. The application will act as the platform that brings the households producing excess foods and the potential buys together for the selling and purchasing activities. The application is now has completed the conceptualization phase and require further evaluation on efficiency and technical build-up before being introduced to the community.

Keywords: domestic food wastage, application, food security, virtual marketplace

I. INTRODUCTION

According to recent reports the Sri Lanka's food inflation in June has increased up to 75.8% from 58% in May 2022 [1]. This condition is a result of the forex crisis the country is facing currently. However, with increasing prices of the food commodities, most people have been deprived of the access to safe and nutritious food. Food wastage has always been a problem in the Sri Lankan food supply chain, happening not only in domestic level, yet throughout all the levels of the supply chain. Reference [2] indicates household food waste generation as one of the key categories in food waste generation in the country. Given the current situation it is important to come up with strategies to reduce the food wastage at all the levels of the food supply chain.

Behavioral changes that are influenced by the mobile technology can assist the reduction of domestic food waste generation [3]. There seems to be more enthusiasm among the community in adopting technological solutions in the present day, hence that can be effectively utilized in establishing sound strategies that ensures the food security.

II. MATERIALS AND METHODS

The first step was to identify the nature and extent of the household food waste generation. This was studied covering all the districts of the country and was focused on understanding the frequency, quantity, composition and quality of the domestic food waste. The information was gathered via informal dyadic communication and group discussions. Accordingly, it was concluded that there is a potential of developing a mobile application which provides a platform for connecting households with excess food and individuals who are seeking to buy meals.

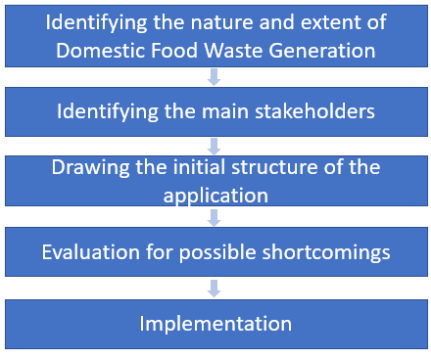

Fig 1: Steps of developing the application

Next step was to identify the major stakeholders. The households who are willing to join this venture should possess the ability of preparing food safely and hygienically and should have access to the mobile application. Households that fulfill these requirements can register on the platform. The next main group are the individuals or family units who are willing to buy meals. They also should register on to the platform to obtain the service. The other associated groups are delivery personnel, administrative officers, and the quality checkers. The application should consist of two separate interfaces which will be accessed separately by the groups depending on their roles.

The next important stage was the conceptualizing and drawing the initial structure of the application. Household registration should be done via the registration portal of the application and the details of a contact person and location details should be necessarily collected. The registration of the customers should also be done via the same portal under a different category along with personal details. The next main section of the application is the platform created to present the relevant menu of the food available by the household. Purchasing activities are organized into 3 sessions for breakfast, lunch, and dinner. Each household can sell up to maximum of 3 meals per each session. They need to input the menu details. The data will then be displayed in a map along with their location. The consumer who is willing to buy food can refer to the map and select the household from which they need to buy the meal. Once selected he/she can connect with the household and arrange the way of receiving the meal either through own transportation or through the delivery service offered by the application.

Pricing and money transactions were identified and considered as one of the major concerns in this application. The price of the meal will be decided by the application upon entering the menu details of the household. This will be done by an automated system into which the price levels are included and will be constantly updated and regulated by the administrative officials. The money for the purchases can either be given

through cash payments or online transactions and the application provides the opportunity to the household and consumer to decide the method. However, the payment record should be updated in the system.

The quality checking and regulation will be constantly done by our quality checkers. This group can consist of individuals that have prior understanding on the health regulations and guidelines related to food preparation. Before accepting a household to the system, a quality check will be done in the preparation place, packaging methods and will be accepted only if acceptable. The application will also have a complement and complain section where the claims of the consumers will be immediately investigated. A system of guidelines and regulations that include critical information such as portion amounts, packaging guidelines etc. will be prepared before the implementation of the application and will be periodically updated and regulated. The registering households will require to accept these guidelines as terms and conditions.

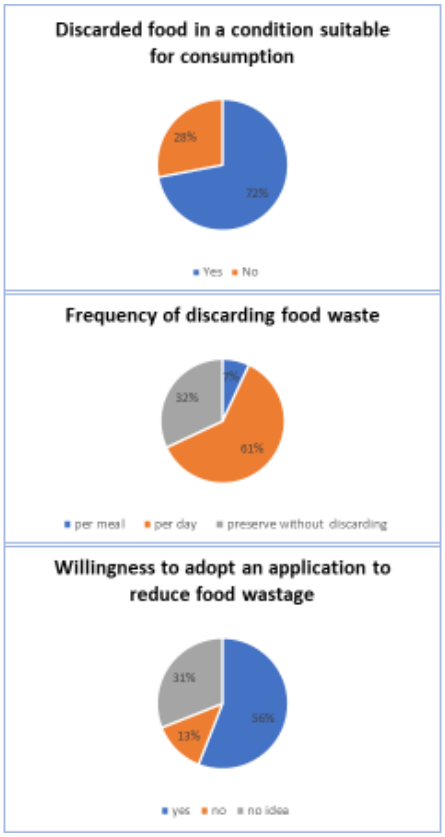

Fig 2: Results of the study conducted based on several households

The revenue for the application management will be obtained as a predetermined portion of each transaction.

Accordingly, the conceptualization stage was completed. Currently the system is being evaluated for possible shortcomings.

III. Results and Discussion

The conceptualization stage has been successful, and a technologically feasible structure has been developed for the application. The application can cover almost all the accepts that are involved during the buying and selling process of food items.

The system will eventually add a commercial value to the excess food, providing an opportunity for the households to make it an extra income. This will reduce the food wastage and implement sustainable usage of food commodities. This will affect positively in the mission of ensuring food security among the Sri Lankan community.

IV. Conclusion

Integrating technological advancements with creative concepts is a timely need of the country given that we need to find solutions for ongoing economic crisis. Different mobile applications and software can function as a major key player in implementing these sorts of positive change. This application can also be considered as such an attempt to come up with an innovative solution to solve the food crisis and enhance food security. Further assistance in developing this into a sound system is needed.

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The Awareness of Traffic Light Labeling System and Nutrition Information on Packed Food Labels Among Young Generation in Sri Lanka.

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Abstract - A Traffic-light labeling system is a labeling system that uses a color code in front-of-package to immediately express the nutritional quality of the food to the consumer. Nutrient levels and the proportion of products are classified in main three colors "Red" (High), "Amber" (Medium), and "Green" (Low) to indicate sugar, salt, and fat content in food. In Sri Lanka, this labeling system was initiated on the 1st of June 2019. This survey-based study was focused on the consumer knowledge of nutritional food label information among the young generation (Age in between 15 – 29 years) in Sri Lanka. A questionnaire with 12 questions was used to collect information (including Kano model questions) from 230 consumers. The obtained data were computed and statistically analyzed using STATA 14.2 software to determine relationships and associations between various factors and the effectiveness of the Traffic-light labeling system. Findings showed that amongst 230 respondents 74.8% are aware of the color light labeling system and 25.2% are not aware. Awareness and use of pre-packaged food labeling information were significantly associated with the age and education level of the respondents and there is good knowledge about the labeling system among the young generation and can conclude that this has been successfully communicating the information to the young generation.

Keywords: Consumers, Traffic-light Food Labeling, Respondents

I. INTRODUCTION

Many consumers struggle to resist unhealthy food temptations. A nutritious and balanced diet is mandatory for the existence of human daily life and the prevention of many diseases. However, 39% of adults in the world population are overweight or obese and therefore more at risk for developing cardiovascular diseases, diabetes, and certain types of cancer [1]. With the intention of avoiding non-communicable diseases in Sri Lanka, the Ministry of Health had introduced a traffic light labeling system and nutrition information on packaged food labels. The traffic light labeling system indicates, whether a food has high, medium or low amounts of fat, saturated fat, sugars and salt. It also represents the number of calories and kilojoules in that particular product. Red, Amber and Green colors are used to give an illustration of the meaning: the red color indicates the higher level of nutrition, amber color indicates the medium level and green signifies the low level of nutrition [2]. Investigating whether the traffic light labeling system affects the food choice of the young generation was one of the objectives in this research. In addition, another objective was to examine if young people are aware of the ingredients on food labels. Moreover, finding out how that awareness varies according to their gender, age group, and educational level and realizing what are the reasons that people tend to read food labels are the expected outcomes of this research.

II. MATERIALS AND METHODS

The survey for "The Awareness of Traffic Light Labeling System and Nutrition Information on Packed Food Labels among Young Generation in Sri Lanka" was conducted among the population of young generation in Sri Lanka by designing the questionnaire to gather the necessary data. Primary data was collected by a set of questionnaire. There were 230 respondents both male and female included in this survey who were in 15- 29 years aged and certain levels of education. Secondary data was gathered by using several sources such as published journal articles and books. Stata 14.2 software was used to statistically analyze the data and a quantitative comparison of data was done using Microsoft Excel. In order to identify if there is any relationship between the awareness and these independent variables (gender, age group, education level and academic discipline), Pearson's Chi-square Test for Independence was conducted.

III. RESULTS AND DISCUSSION

From the survey it was found that amongst 230 respondents 44% are male and 55% are female. There were 7.8% respondents in age group of 25-29, 18.7% respondents in age group of 15-19 and 73.5% respondents in age group of 20-24. The highest number of respondents was in the age group of 20-24. Moreover, results illustrated that, amongst 230 respondents 20.9% were school students and 70% were undergraduates. There were few numbers of respondents at certificate/diploma level,

technical/vocational level and graduated level. It was found that 57.4% respondents represent health, food or nutrition related discipline and 42.6% are representing other disciplines. According to the results, 70% of the respondents buy packed food items 1-3 times per week, 15.2% of the respondents buy packed food items 4-6 times per week and 10% of the respondents buy packed food items more times per week. It was found that amongst 230 respondents 74.8% were aware of the color light labeling system and 25.2% were not aware of the color light labeling system.

Table 1 represent the percentages of respondents ranked (1-5) how important is it or would it be of the label information such as price, manufacture date, quantity, ingredients, expiry date, country and brand when they buy packaged foods. The highest percentage of respondents (65.36%) agreed that the expiry date on the label is the most important. Furthermore, the highest percentage of respondents feels that country is the least important. That percentage is 18.18%.

Table 1. Summary of the chart, ranked 1-5 according to the importance of various factors from the responses received

	Price	Quantity	Mfd Date	Exp Date	Ingredients	Country	Brand
Rank 1	4.33 %	4.76%	7.36%	7.79%	7.79%	18.18%	6.92 %
Rank 2	9.95 %	9.95%	11.25%	1.29%	8.65%	28.57%	22.94 %
Rank 3	28.57%	26.40 %	19.04%	7.79%	26.83%	31.60%	29.87 %
Rank 4	25.54%	32.46 %	24.24%	17.74 %	26.40%	13.41%	27.27 %
Rank 5	31.60%	26.40 %	38.09%	65.36 %	30.30%	8.22%	12.98 %

Most of respondents, as a percentage wise 55.2% like if traffic color code is available in the label when they are buying packaged foods. But 18.7% of respondents feel the traffic color code must be there. 20.9% of respondents feel that they are neutral that the code should be or not there.

As a percentage, 27.4% of respondents feel like moderately important about effectiveness of this color code system for consumers' buying perceptions. 26.1% of respondents feel that it is extremely important and 19.1% of respondents feel it is important very much. But 13% of respondents feel that it is slightly important.

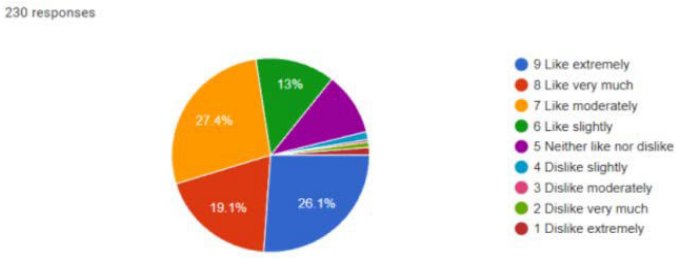

Figure 1. Summary chart to importance of effectiveness of the color code system for consumer's buying perception

According to the customer survey can be concluded that there is no statistically significant relationship between independent variables (gender, age group, education level and academic discipline) and awareness of traffic light labeling system and nutrition information on packed food labels among young generation in Sri Lanka (P value > 0.05).

IV. Conclusion

Traffic light labeling system and other information on packed food labels such as price, quantity, manufacture date, expiry date, ingredients, country and brand on packaged foods are very important because people can get a brief knowledge about the food. The survey investigated the awareness of traffic light labeling system and nutrition information on packed food labels, among young adults who are from 15 - 29 years of age in Sri Lanka. It can be concluded that there is no statistically significant relationship between independent variables (gender, age group, education level, academic discipline) and awareness of traffic light labelling system and nutrition information on packed food labels among the young generation in Sri Lanka. The highest percentages (74.8%) of respondents are aware of the color light labeling system. There is good awareness among the youth (age group between15-29) in Sri Lanka and this system needs to be developed to the older generation as well.

Acknowledgement

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Awareness and Perception of Functional Foods Among Undergraduate Students in Sri Lanka

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Abstract – Recently, 'Asian diet' has transferred to the 'Western diet' leading high occurrence of Non-Communicable Diseases (NCDs) which is a major issue in the younger generation as well. Mainly, 18.8% of undergraduates are overweight, and 18.2 % of undergraduates are obese in Sri Lanka. This could be due to poor dietary habits with the consumption of high fat or sugar-containing foods and lack of Functional Foods (FFs) in the diets. The present study aimed to investigate the awareness and perception of FFs among undergraduate students in Sri Lanka. The survey was conducted using a google questionnaire on 541 undergraduates aged between 20-27 years. The questionnaire consisted of four sections in order to check their knowledge on FFs. Quantitative data were analyzed by using frequencies and percentages. Most (60.44%) undergraduates were unaware of the term FFs. Interestingly there is a significant effect of gender on the knowledge about FFs (Chi-Square test, $P \leq 0.05$), 56.69% of female undergraduates were aware of the term FFs while only 32.99% of male undergraduates were aware of the term FFs. There is a significant effect from the academic year for the knowledge about Functional Food Products ($P \leq 0.05$), and the 4th year students had the highest knowledge compared to other academic years (77.84%). These results suggest that gender and academic year affect to knowledge of FFs. Further, most undergraduates (83.48%) are still interested to learn about FFs. Therefore, in this study, we have identified the potential of undergraduate students to add FFs in their diet.

Keywords: Functional Foods, Undergraduates, Non-Communicable Diseases, Awareness

I. Introduction

Functional foods (FFs) are foods that beneficially affect body functions beyond the basic nutrients. Bioactive compounds found in FFs can increase physical and mental health and reduce the risk of many chronic diseases. They not only satisfy hunger but also provide necessary nutrients to humans by enhancing the health and personal well-being [1]. The modern concept of FF was built by the Japanese by linking the food with traditional Asian philosophy [2]. FFs are beneficial to all human beings in various life stages. However, awareness about the FFs among the society is still lacking and "functional food" concept is novel to the consumers. Especially the younger generation should be well aware of the FFs since many chronic diseases have started to appear in the younger generation recently [3].

Undergraduates represent the major segment of the younger generation who are the future of our society. Thus, their health can be considered crucial in the development of the country. According to some previous studies, 18.8% and 18.2% of undergraduates are overweight and obese in Sri Lanka due to poor dietary habits and consumption of high fat or sugar-containing foods [4].

Lack of knowledge regarding FFs minimizes purchasing FFs in the market as consumers' knowledge interacts with the good purchasing process. Therefore, awareness of the younger generation regarding FFs can be a key to promote FFs among the younger generation as the first step in the motivation of the younger generation towards in eating more FFs [5].

Globally many research studies have been done to assess knowledge about FFs in the younger generation. However, the information is still lacking. Therefore, the present the study focusses on gathering and assessing the awareness and perception of functional foods among undergraduate students in Sri Lanka.

II. Materials and Methods

A. Development of questionnaire and Data Collection

The survey was conducted using the google questionnaire administered age 20–27 years old 541 Sri Lankan undergraduates between December 2021 and January 2022. The questionnaire was conducted in English. It was distributed via emails. The questionnaire was consisted of four sections. The first part was about the demographic characteristics of the undergraduates. The second part was general question about FFs without using the term FFs. End of the 2nd section students had to select 3rd or 4th part based on their awareness of the term FFs. If the student who were aware of the term FFs could access to 3rd part. If the students who were not aware of the term FF was assessed in 4th part. One participant could participate in only three sections of the questionnaire.

B. Statistical analysis

The results were statistically analyzed by the Minitab 19 statistical software. Quantitative data was analyzed by calculating summary statistics including frequencies and percentages. Determination between categorical data was statistically analyzed using Chi-square analysis.

III. Results and Discussion

Most (63.59%) undergraduates were females, and 36.41% of undergraduates were males. Most (42.14%) of the undergraduates were aged between 24 and 25, while 31.61% had been educated in the 1st year, 14.79% had been educated in the 2nd year, 22.74% had been educated in the 3rd year, and 30.87% had been educated to the 4th year. Most undergraduates (60.44%) were unaware of the term 'FFs', and 39.56% of

undergraduates were aware of the term 'FFs'. Female undergraduates had more knowledge of FFs than male undergraduate students. According to the results, only 43.31% of female undergraduates have not become familiar with the term "Functional Food," while 32.99% of male undergraduates have become familiar with the term "Functional Food". Further, most male undergraduates (67.01%) were unaware of the term 'FFs' than females (56.69%). Interestingly there is a significant effect of gender on the knowledge about FFs (Chi Square test, $P \leq 0.05$). 4th year undergraduates had more knowledge of Functional Food Products [(FFPs) (54.49%)], while 1st year students had lower knowledge of FFPs (32.92%). According to the results, 4th year students had more knowledge about FFs than other years. Further, undergraduates had lower knowledge of FFPs; therefore, need to improve and become familiar with FFPs.

Most (65.42%) undergraduates had knowledge about FFs, while 34.58% of undergraduates hadn't knowledge of FFs. The results show that most undergraduates (73.36%) agree that FFs have compounds that help to prevent chronic diseases. Most undergraduates (68.22%) agree that FFs are biologically active and healthy foods (64.02%). But, only 20.09% of undergraduates agreed that FFs are part of our diet. So, most do not have a big idea as FFs are part of our diet. Therefore, the responsibility should be on improving knowledge about FFs so far. Most (74.29%) female undergraduates had knowledge about FFs, while 25.71% of male undergraduates had knowledge of FFs. Most (55%) rural area living undergraduates had knowledge about FFs, while 45% of urban area living undergraduates had knowledge of FFs. 39.29% of 4th year, 22.86% of 3rd year, 15% of 2nd year and 22.86% of 1st year undergraduates had knowledge of FFs.

Only 43.71% of 4th year undergraduates have become familiar with the term "Functional Food," while 33.92% 1st year undergraduates have become familiar with the term "Functional Food". Further, most 1st year undergraduates (66.08%) were more unaware of the term 'FFs' than 4th year students. According to the results, the need to improve knowledge of FFs and to be familiar with the term 'FFs' of 1st year students and male students. The academic year has a significant effect on the awareness of FFPs (Chi-Square test, $P \leq 0.05$).

When considering the knowledge of prevention of chronic diseases, most undergraduates had knowledge of the prevention of chronic diseases (73.13%). Female students (74.84%) had more knowledge of preventing chronic diseases than males (64.29%). Most undergraduates had knowledge of the prevention of chronic diseases (73.13%). 4th year students (77.85%) had more knowledge of preventing chronic diseases than another year. 1st year students had little knowledge of the prevention of chronic diseases (66.67%). According to the results, need to improve knowledge of chronic diseases of 1st year undergraduate students and male students. There is a significant effect of awareness about the prevention of chronic diseases on gender. At the same time, there is no significant effect of awareness about the prevention of chronic diseases on the academic year and awareness of the term 'FFs' [(Chi-Square test, $P \leq 0.05$).

33.6% of undergraduates who had knowledge about FFs consumed fruits once a week, while 28.46% of undergraduates consumed daily compared to undergraduates who hadn't knowledge about FFs (14.41%). 50.09% of undergraduates consumed condiments daily. And knowledgeable students of FFs consumed FFs and FFP more than undergraduates who hadn't knowledge about FFs. Among undergraduates who were unaware of the term 'FFs', 71.25% ginger, 64.22% garlic, 49.54% carrot, 55.35% Mango, 50.76% vitamin C added yogurt, 58.40% Omega 3 rich fish, 45.25% probiotic yoghurt, 5.2% bread, 9.7% pizza and 9.7% noodles considered as being a FFs. According to the results, most undergraduates who were unaware of the term 'FFs' were able to select FFs after understanding the provided definition in the survey. 70.09% of the undergraduates reported that they came to know about the FFs via the internet, while 83.48% of undergraduates like to learn more about FFs via the internet. Therefore, the most suitable media is the internet to distribute the knowledge about FFs among the younger generation. And after the finishing survey, 80.12% of undergraduates who were unaware of the term 'FFs' have improved their knowledge about FFs. Today, the Internet is the best and easy way to learn about various subjects.

Conclusions

This study has shown that undergraduate students' socio-demographic characteristics (age, academic year, and gender) are important indicators that influence awareness and perception of FFs. Survey results concluded that undergraduate students have enough knowledge about FFs in this context, although they were unaware of the term 'FFs.' The most important thing for researchers should be to distribute knowledge to undergraduate students about the term 'FFs'. The survey results suggest that knowledge of FFs could affect undergraduates' interest in FFs; the internet might be necessary to distribute the knowledge of FFs. Further, there is a need to be the familiar term 'FFs' among undergraduate students.

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Track 10

Nanotechnology

Multi Responsive, Anisotropic Colloidal Mixture Using 2D α-ZrP Nanoparticles

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Abstract- The electric field-assisted orientation of colloidal nanoparticles has attracted significant attention in recent years, mostly due to its operational simplicity. However, this alignment is only temporary and gradually disappears after the removal of the electric field. Essentially, polymer-hybrid nano systems make it easier to achieve well-ordered permanent structures even under termination conditions. However, reversible stabilization of the structure is still a challenging goal for energy-saving stand-alone devices with structural switching capability. To begin with, we synthesized a dual responsive anisotropic hydrogel by dispersing an aqueous solution of exfoliated α-ZrP nanosheets with Pluronic F-127. The temperature-dependent sol–gel-sol phase transition behavior of Pluronic provided an excellent thermosensitive characteristic to the composite hydrogel mixture. Moreover, the embedded ZrP nanosheets endow the hydrogels with electrical responsiveness at their sol state, which could be aligned under high-frequency electric fields. Stabilization of nanoparticles with proper alignment was achieved at a non-flowable gel state, by increasing the temperature above the sol-gel transition temperature. Upon increasing and/or decreasing the temperature from the gel state, the electric alignment completely disappeared in a reversible manner due to the gel-sol transition

Keywords: liquid crystals, Polymer colloid, multi stimuli responsive

I. Introduction

Two-dimensional (2D) materials have been drawing immense attention for the fabrication of electronics and optoelectronics devices in the field of academic research due to their extraordinary and unique properties. [1,2] In nature they exist in bulk layered phase, where the monolayers are hold together by the van der Waals forces, and single layer flakes can be obtained by mechanical exfoliation. The exfoliated nanosheets are usually obtained as colloidally dispersed particles and due to this particular 2D shape specifically they can exhibit lyotropic liquid crystal (LC) phase behavior. Unlike the conventional LCs, colloidal LC can be selectively and easily mixed with polymer colloidal mixtures when they have a common solvent. The α- zirconium phosphate (α-ZrP) is an inorganic 2D material which can exhibit the lyotropic liquid crystalline properties in aqueous solution, owing to their anisotropic shape. Similar to the conventional LC, orientational direction of these nano particles can manipulate using AC electric fields. However, lack of multi responsive nature of colloidal mixtures have produce several restrictions on industrial applications of colloidal-based opto-electronic devices. In this study, we introduce a novel method to enhanced the intrinsic electro optical properties of α-ZrP nano colloidal mixture by simply mixing with PF-127; hereafter simply referred to as ZPF colloid. Aqueous Pluronic F-127 (PF-127) is a well-known triblock copolymer which can exhibit reversible sol-gel-sol phase transition characteristics in response to external temperature variations. Interestingly, we were able to graft the unique thermal properties of polymer colloids into nano colloidal LC in order to obtain multi responsive nature. Moreover, we supposed to control the nanosheets orientation of ZPF colloids (at their sol state) by electric fields over a tunable range of temperature as one of the most significant features of our technique.

II. Materials and Methods

Two dimensional, layered α-zirconium phosphate (α-ZrP, [Zr(HPO4)2·H2O)] nanoparticles were synthesized via a hydrothermal method. The nanoparticles were functionalized using tetrabutylammonium hydroxide (TBAOH), and a stable colloidal was obtained by mixing with deionized (DI) water. The top image (TEM) of fig. 1(a) revealed the stratified nature of the obtained α-ZrP nano particles with an irregular hexagonal shape. This particular shape induced the LC properties to the α-ZrP colloidal mixture (in DI water) which can easily observe through two cross polarizers as shown in the bottom image of fig.1(a). A set of thermo-sensible ZPF colloidal mixtures were prepared using different concentrations of PF-127 (10–25 wt %.) at a fixed total formulation concentration of α-ZrP (0.44 wt%.) by simply mixing the exfoliated α-ZrP and PF-127 powders in an aqueous medium at 0 °C. [3] The thermo-responsive behavior of pure PF-127 colloidal mixture and ZPF colloidal mixtures were studied by means of the tube inversion method. The temperature-dependent sol-gel-sol transition phase diagrams for both colloidal mixtures at various polymer concentrations are shown in Fig. 1(b).

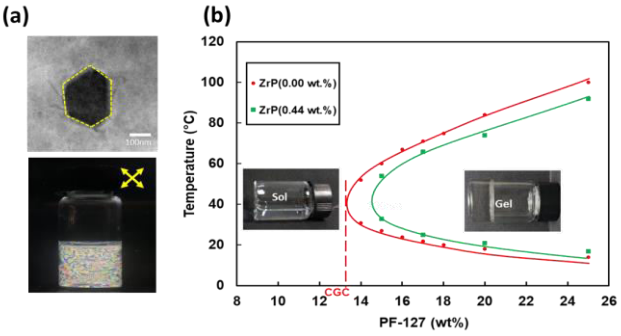

Fig. 1 Material characterization (a) TEM image of ZrP monolayer platelets after exfoliation (top) and LC phase behavior under cross polarizers (bottom) (b) Sol-gel-sol phase diagrams of prepared hydrogels at given α- ZrP concentrations

II. Results and Discusssion

In general, Pluronic in aqueous solution is undergoes a sol-gel-sol transition, that occurs via construction and destruction of small sets of micellar structure that correspond to the temperature increment. Essentially, for the composite ZPF hydrogel mixtures, while adding the α-ZrP nano particles, exhibited slightly different phase transition curves with a shift to the right along with a narrowing of the gelation temperature range, compared to the PF-127 only hydrogel. The critical gelation concentration (CGC) values of the ZPF colloidal mixtures with α-ZrP concentrations of 0.44 wt %. were ~15 wt %, which numbers are slightly higher than for the PF-127 hydrogel (~13 wt%%., labeled in red dash-dotted line.). The presence of α-ZrP nanoparticles in the medium possibly perturbs both the packing density and integrity of the well-ordered micellar networks of the ZPF hydrogel mixtures. The right shift of the phase transition curves indicates that the addition of α-ZrP nanoparticles effectively increases the CGC values as it requires a higher polymer concentration to complete the gelation process. Consequently, the CGC and the gelation temperature range were significantly altered depending upon the α- ZrP concentration.

The orientation of the nano sheets in both ZPF composite (at sol state) and pure α-ZrP samples can highly and facilely control by utilizing square wave AC electric fields. A cell with patterned electrodes was prepared by assembling two indium tin oxide (ITO) electrodes with a 5 mm inter-electrode gap and 1mm cell gap was utilized to control the nano particle orientation (fig. 2(a)). Under the application of 10 kHz; 100V square wave electric field, long axis of the α-ZrP nano particles tend to align parallel to the electric field and it can be easily observed by placing the cells between two crossed polarizers. However, as can be seen in the fig. 2(b), the electrically induced alignment of the nano sheets is gradually disappeared after removal of the electric filed within a few second in the cells filled with α-ZrP samples and the ZPF samples which have a low polymer concentration (below their CGC).

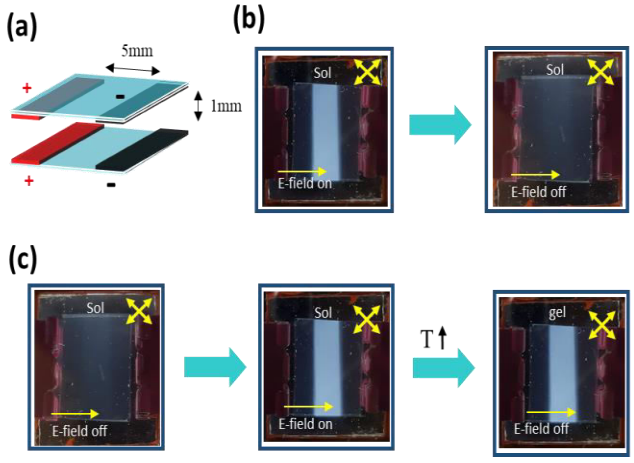

Fig. 2. Multi responsive nature (a) Electrode configuration of ITO cell (b). Electrically induced alignment of α-ZrP nano colloid (c) Electrically induced alignment of ZPF nano colloidal mixture at their sol and gel states.

In addition, the samples at a higher polymer concentration (above the CGC) still follow a relaxation of the induced alignment with the termination of electric field, especially at their sol state. Nevertheless, the ZPF hybrid mixtures at a higher polymer concentration (above their CGC) facilitate to maintain the obtained alignment in between the sol-gel phase transition temperature (T_{sg}) and ge-sol phase transition temperature (T_{gs}). Accordingly, we examined the stabilization of α-ZrP nano sheets by using a polymerizable mixture of ZPF hydrogel, prepared by mixing 0.44 wt%. of α-ZrP with 17wt%. of PF-127. As illustrated in the fig. 2 (c) alignment of the composite mixture was able to maintained under retention of the electric filed by using the self-assemble temperature-induced gelation mechanism in between 35°C and 80°C. Interestingly, this temperature region can easily control by altering the PF 127 concentration according to the phase diagram which illustrate in fig.1(b)

IV. Conclusion

In conclusion, we have introduced a new type of dual responsive anisotropic hydrogel from an aqueous solution mixture of exfoliated α-ZrP nanosheets and Pluronic F127. The vial inversion tests were carried out for PF-127 only and the ZPF hydrogel was examined for its thermo-reversible gelation behavior. High (10 kHz) frequency alternating electric fields were used to control the α-ZrP nanoparticles in the ZPF hydrogels. Stabilization of alignment was achieved through the sol-gel phase transition of PF-127 copolymer. The nanosheet alignment was retained for more than two weeks between the T_{sg} and T_{gs} even after the termination of the electric field. Our study further confirms that PF-127 concentrations is vital factors for controlling the T_{sg} and T_{gs} values.

Acknowledgements

This work was supported by National Research Foundation of Korea (NRF) grants (NRF-2019R1A2C2008359) and the ICT Creative Consilience program (IITP-2020-0-01821) funded by the Ministry of Science and ICT of Korea.

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Electrically Tunable Liquid Crystal Lens based on Zirconium Phosphate Nano Colloid

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Abstract- The nematic liquid crystals (LCs) have risen as a promising material for tunable lenses with high potentiality in the field of electro-optical applications, including display devices for augmented reality and virtual reality. However, several characteristic limitations of conventional LC materials such as polarization-dependency and short beam path length have brought about critical restrictions on actual applications of LC-based tunable lenses. Here, we report that concentration-controllable nano-colloidal dispersion can be a good candidate for functional materials for tunable lenses. Unlike usual LCs, the refractive index of colloids depends on the particle concentration in colloids, and using dielectrophoresis, we could manipulate the density distribution and consequently the refractive index profile, as well. Besides, the colloidal lens system can be devised to have a polarization-independent lens effect and a wide tuning range of positive to negative focal length using negative dielectrophoresis (n-DEP) and a two-dimensional (2D) α-ZrP nano colloid.

Keywords: Liquid crystals lens, 2d materials, Dielectrophoresis, Nano-colloid, Lyotropic liquid crystals

I. Introduction

An electrically tunable lens is a fascinating research topic having a high potentiality in display applications including virtual reality (VR) display and augmented reality (AR) displays, because they can directly control the focus or depth of displays without any mechanical motion or bulky system. Many researchers have developed lenses with tunable focal length in the last decades by utilizing various functional materials such as tunable plasmonic crystals, stimuli responsive hydrogels, and nematic liquid crystals (LCs) [1]. Among those lens materials, nematic LC has been regarded as the most promising candidate for the tunable lens, because it is simply achieved to electrically control the refractive index in nematic LC medium. However, LCs are optically anisotropic materials and are sensitive to the polarization of incident light [2]. As a result, only one direction of polarization works properly within LC medium, which results in the loss of one-half of the incident light. Several approaches to avoid the polarization-sensitive issues in LC lens have been proposed, but each of the avoidance techniques has its own limitation. Nonetheless, it is hard to find alternative materials to replace the polarization-sensitive nematic LCs in the tunable lens system.

In this study, we introduce a new material for the tunable lens, that is, a 2D nano colloid using exfoliated α-ZrP nanoparticles. Using the new material and system, we could successfully implement a polarization insensitive tunable lens. The refractive index profile in the colloidal medium is electrically controlled by manipulating the density distribution of ZrP particles by using negative dielectrophoresis (DEP). In the colloidal-based lens, the focal length can be continuously and reversibly controlled in a wide range from negative to positive values.

II. Materials And Methods

Two dimensional, layered α-zirconium phosphate (α-ZrP, [Zr(HPO4)2·H2O)] nanoparticles were synthesized via a hydrothermal method. The nanoparticles were functionalized using a commercial polyoxyalkylene amine (Jeffamine ® M1000), and we obtained a good colloidal α-ZrP colloidal mixture in N, N-dimethylformamide (DMF) solvent. The FESEM image (left image in fig. 1a) revealed that the stratified nature of the obtained α-ZrP nano particles with an irregular hexagonal shape. Then, another α-ZrP colloidal mixture was prepared by introducing an intensive exfoliation process to the functionalized α-ZrP mixture using ultrasonication within the Jeffamine M1000 mixture. Although the FESEM images in the right of fig. 1a does not clearly identify the monolayered particles due to the extremely thin thickness, it is well discernible that the exfoliation process diminishes the particle thickness dramatically. The exfoliated samples also exhibit a clear LC phase under the cross polarizers, as shown in fig. 1b.

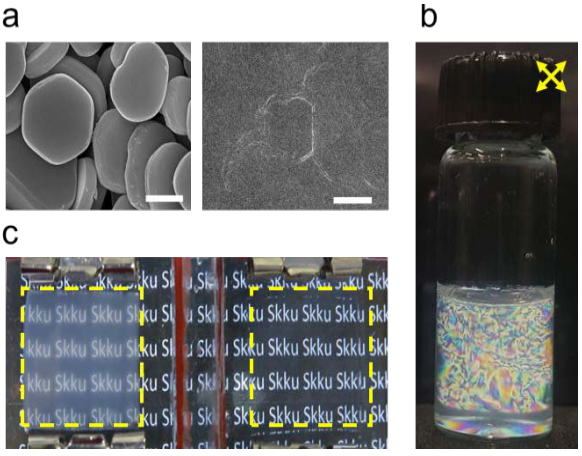

Fig. 1 (a) The field emission scanning electron microscopy images (FESEM) of 2D, α-ZrP nano particles before (left) and after the exfoliation (right), Scale bars, 1μm. (b) Liquid crystalline phase behavior of the exfoliated colloid. (c) Visual representation of the optical transparency of the non-exfoliated (left) and exfoliated(right) nano colloids; Yellow dotted line indicates the boundary of the cell.

III. Results And Discussion

Optical transparency of a material is a fundamental requirement to allow the optical usage in optoelectronic devices. Transparency of the synthesized two α-ZrP colloidal mixtures were investigated by direct observing 2-mm-thick cells containing each colloidal mixture. Fig. 1c shows the comparison of the optical transparency of the non-exfoliated and exfoliated α-ZrP nano colloids. Here we performed the tunable lens experiment using the exfoliated α-ZrP colloidal mixture in order to obtain a clear lens. The cells were made by utilizing two patterned indium tin oxide (ITO) electrodes. For the positive lens, a circular hole (diameter of 6 mm) was etched from the middle of the ITO substrate and a reversed shaped electrode was utilized for the negative lens as illustrated in top and bottom images in fig. 2a, respectively. A PDMS spacer was used to maintain the gap of 2 mm between the top and bottom substrates and α-ZrP sample of 1.18 wt.% was injected to the fabricated cells, and 10 kHz square wave electric field was applied. Both lens effects were visually observed placing each cell in between a printed paper with text pattern and a camera (as shown in fig. 2b) as the input voltage increases from 0 to 150V. Based on the electrode design, prepared cells exhibit positive and negative lens effect as well discernible in the photographs in Fig. 2c

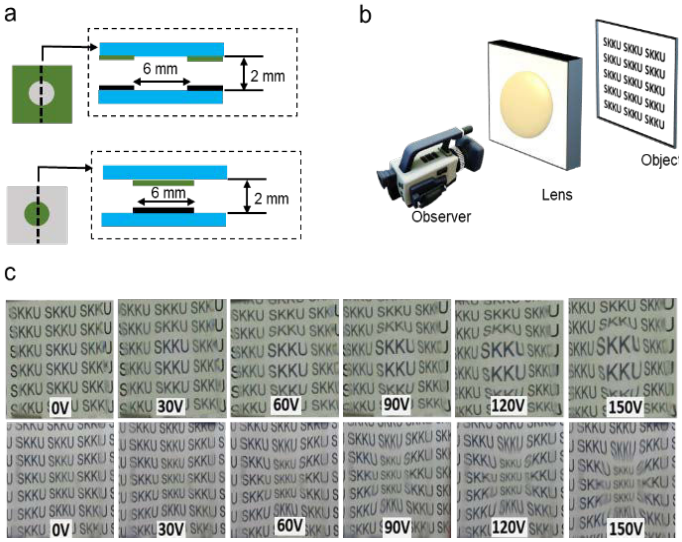

Fig. 2 (a) Cross-sectional view of the lens cell structures with (top) positive and (bottom) negative focal lengths, respectively. (b) Schematic diagram of the experimental setup for the tunable lens experiment. (c) Positive (top set of images) and negative (bottom set of images) lens effect obtained in the nano colloidal tunable lens, at various applied voltages.

DEP is an excellent tool for manipulating electrically neutral and charged particles when subjected to a non-uniform electric field. Ignoring higher-order effects of polarization, the DEP force exerts on a spherical particle with volume V, under an electric field E, can be approximated as,

$$\vec{F}_{DEP} = \frac{1}{2}\varepsilon_m V \cdot \mathrm{Re}[K] \cdot \nabla(\vec{E} \bullet \vec{E})$$

Here, K is the polarization factor which can be further simplify by using the complex permittivity of particle (εp) and suspended medium (εm) according to the Equation 2,

$$K = \frac{3(\varepsilon_p^* - \varepsilon_m^*)}{\varepsilon_p^* + 2\varepsilon_m^*} \quad (2)$$

It can be seen from Eq. 1, depending on the sign of the Re[k] factor, the DEP force propels particles either towards the E-field maxima (positive DEP) or minima (negative DEP). The polarization factor was measured to be negative in the operating frequency range by utilizing a mixture of 1.2 wt.% α-ZrP colloid in DMF. The E-field distributions inside the both cells are highly non-uniform (essentially edge of the electrodes) and as consequence nano particles experience a DEP force, in which they either migrate toward (positive lens) or away (negative lens) from the center. This particle movement leads to modify the nanoparticles concentration in the medium and modify the refractive index distribution accordingly. The corresponding focal lengths of the positive and negative lens was further measured as 7.5 cm and -11.2 cm at 150V, respectively. In addition, field induced birefringence (Δn) of the α-ZrP nano colloid exhibits a relatively low value ($\sim 4.0 \times 10^{-5}$) referring to the nematic LC's (0.05−0.2) and therefore it can simply ignore the polarization dependence property, which is one of the merits in our system.

IV. Conclusions

We have demonstrated a polarization independent and electrically tunable lenses with positive and negative focal lengths by incorporating 2D α-ZrP nano-colloidal liquid crystals. The effective refractive index profile was altered without any mechanical movements. The advantage of the devices is a wide focal-length tuning range, a simple cell and electrode structures, no use of polarizer, and rather thick cell thickness. These types of systems can be highly useful in the lens systems of AR and VR display.

Acknowledgements

This work was supported by National Research Foundation of Korea (NRF) grants (NRF-2019R1A2C2008359) and the ICT Creative Consilience program (IITP-2020-0-01821) funded by the Ministry of Science and ICT of Korea.

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pH-Induced Structural Changes in mRNA Lipid Nanoparticles

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Abstract - The SARS-CoV2 virus has had an enormous adverse global impact. With great efforts from scientists around the world, mRNA vaccines have been developed to effectively reduce morbidity and death due to the virus. mRNA vaccines use a nanoparticle lipid-based formulation (LBF) to deliver the mRNA to the cell interior. This LBF is a mixture of an ionizable lipid, a PEGylated lipid, a phospholipid and cholesterol. Importantly, the chemical behavior of the ionizable lipid changes with the pH conditions. The mRNA formulation process is initially carried out at acidic pH and the formulation is then raised to physiological pH. The change in charge of the ionizable lipid due to pH conditions affects the molecular arrangement of the LNPs. Therefore, understanding pH-induced structural changes of lipid nanoparticles (LNPs) in mRNA formulations will greatly assist the development of new mRNA delivery systems. Molecular dynamics (MD) is a powerful tool for exploring complex systems at the atomic level. In this study, we carried out long MD simulations of pre-assembled LNPs using the coarse-grain MARTINI force field. Our simulations provide insight into molecular packing within the LNP at acidic and physiological pH and how water molecules aggregate inside the LNP. The simulations further show that LNPs at acidic pH have ordered molecular arrangements and LNPs at physiological pH have less ordered molecular arrangements. The simulation results agree with SAXS measurements reported in the literature. The results of our study will help us understand LNP systems at different pHs and explore efficient mRNA delivery systems.

Keywords: lipid nanoparticles, mRNA, pH

I. INTRODUCTION

Starting in November 2019 the spread of the SARS-CoV2 virus has had an enormous effect on global events. To date, millions of people worldwide have died from the respiratory disease caused by this virus. However, with great efforts from scientists around the world, vaccination has become the most suitable approach fight this viral disease.

Among the various vaccine types, mRNA vaccines have been the most versatile platform so far. Formulation is an important aspect of the mRNA platform to ensure that the mRNA is delivered to the cell without degradation. The frontline COVID-19 vaccines developed by Moderna, and Pfizer use a lipid-based formulation (LBF) to surround the mRNA and deliver it to the target cells efficiently. This LBF is a mixture of ionizable or cationic lipid (pKa < 7), PEGylated lipid, phospholipid and cholesterol. Together, these lipid materials self-assemble to form a nano sized particle with spherical morphology known as lipid nanoparticles (LNPs).

The ionizable lipids within the LNPs play a critical role; they are positively charged at acidic pH and are neutral at physiological conditions (pH 7.4). The mRNA formulation process is carried out initially at pH 4 and then raised to pH 7.4. During this procedure chemical nature of the ionizable lipid influences the molecular structure of the LNPs and these structural arrangements are still not fully understood.

To explore new avenues of the LNP-based drug delivery systems, understanding the structure of mRNA-encapsulated LNP and its microenvironment is essential. However, the atomic details of such colloidal systems are difficult to obtain from experimental methods such as small-angle X-ray scattering (SAXS) or NMR spectroscopy due to the heterogeneous composition of the LNP formulations. In contrast, molecular dynamics (MD) has become an important emerging technique for exploring complex colloidal systems at the atomic level [1-2]. MD simulations model the movement of atoms and molecules by solving the Newton's equations of motion to model the dynamic evolution of a molecular system over time. To date, few experimental studies have investigated how the molecular structure of LNP systems change as the pH is varied [3-4]. Similarly, few MD studies have investigated this [5]. Thus, we are still lacking detailed atomic information on the molecular arrangement of each lipid component within LNP and the extent that water molecules are trapped inside the LNPs. Thus, the aims of the current study are, to investigate the structural changes of LNPs at acidic and physiological pHs and to study the how water is dispersed inside the LNPs. For this purpose, we modeled pre-assembled LNPs using MD simulations with the MARTINI force field for 1.5 microseconds (μs). The resulting structural features were then compared with existing experimental data in the literature.

II. MATERIALS AND METHODS

A. Topologies

Topologies for DSPC and cholesterol were obtained from the MARTINI website. The parameterization of the ionizable lipid; DLin-MC3-DMA (both protonated and neutral form), RNA (with 13 bases), and the DMG-PEG2000 was carried out following the processes given on the MARTINI website.

B. Construction of computational model systems

LNPs were constructed using 50: 38.5: 10: 1.5 molar ratios of ionizable lipid, cholesterol, DPSC and DMG-PEG2000 along with the molar ratio of ionizable lipid to nucleotide (i.e., N to phosphate) as 5. All systems were modeled as containing 20% formulation and 80% water (w/w). Changes in pH were modelled by changing the fractions of ionized lipid (DLin-MC3-DMA). At pH 4, 100% of the lipid was ionized. At pH 7.4 and 10% of the lipid was ionized. All RNA and lipid molecules except DMG-PEG2000 were placed in a random orientation in a sphere with 25 nm radius. The water content inside the LNP was varied as 1% (less water) and 10% (more water) as some literature models [6] have proposed that LNPs contain water. The PEGylated lipid (DMG-PEG200) was placed randomly on the surface of the sphere.

C. *MD simulations*

All simulations used GROMACS version 2018.4 with the isothermal-isobaric ensemble (NPT). Systems were simulated at 310 K with a reference pressure of 1 bar. Before the production run, systems were energy minimized using the steepest descent method to remove steric clashes and then the systems were subjected to an equilibration run (4 ns). The production was run for 1.5 µs with a time step of 10 femtoseconds.

D. *MD analysis*

All structures were visually inspected using VMD software and the structural details were compared with the available experiment data.

III. RESULTS AND DISCUSSION

To investigate the pH-induced structural changes of the LNPs and to study the distribution of water inside the LNPs, we carried out MD simulations for pre-assembled LNP structures. In these pre-assembled NLPs as starting configurations, lipids, RNA and water were randomly distributed in spherical morphology and particularly PEGylated lipid was placed on the surface of the morphology. The water content inside LNPs was changed to 1% and 10%. Acidic and physiological pH conditions were modeled considering 100% and 10% ionization of DLin-MC3-DMA.

We observed that randomly placed lipid molecules were re-arranged according to the hydrophobicity and lipophilicity nature of the molecular components and assembled structure stayed in the spherical morphology for 1.5 µs without any deformation. Visual inspection further revealed that DMG-PEG2000 molecules dispersed on the surface fully interacted with water irrespective to the pH condition. For LNPs simulated at acidic pH showed ordered bilayer-like arrangement composed of cholesterol, DSPC and positively charged DLin-MC3-DMA. However, the molecular arrangement of LNPs simulated at physiological pH is amorphous. Interestingly, this behavior matches with SAXS data in the literature [3-4]. The ordered and amorphous molecular arrangements inside the LNPs (with 10% water inside the LNP) at pH 4 and 7.4 are shown in Fig. 1.

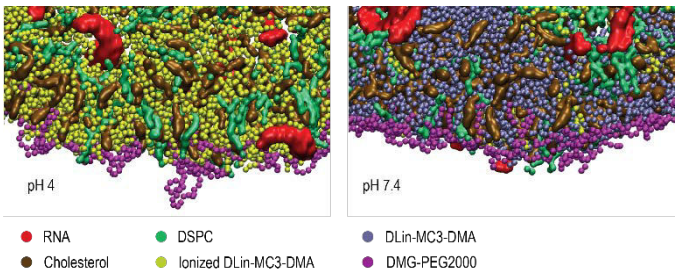

Fig.1 – Molecular arrangements inside the LNPs (at the edge) at pH 4 and pH 7.4.

LNPs simulated with 10% water inside the LNP at physiological pH formed separate water aggregates inside the LNP, while the same systems simulated at acidic pH resulted in interconnected water clusters. This behavior is the same for the systems simulated at two pH conditions with 1% water inside LNPs.

IV. CONCLUSION

Our simulations show that LNPs at acidic pH are ordered structures while LNPs at physiological pH are amorphous, which matches with the experimental observations. This result highlights that MD can be used as a tool to predict the structural features of complex colloidal systems successfully. Furthermore, our simulations reveal that the chemistry of the ionizable lipid influences the distribution of water within the LNP. Currently, we are working to find whether the chemistry of ionizable affects the distribution of RNAs within the LNP.

ACKNOWLEDGEMENTS

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Chemical Bath Deposited ZnO Nanowires for H_2 Gas Sensors: Optimisation of Deposition Time

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Abstract - The metal oxide semiconductor-based gas sensors play a vital role in detecting toxic, explosive and combustible gases in the environment. ZnO is an n-type metal oxide used as a promising material in gas sensing applications. Recently, ZnO-based one-dimensional nanowires have been taken much attention in gas sensors due to their high surface-to-volume ratio. In this study, ZnO nanowires were grown through chemical bath deposition (CBD) at different deposition times (2, 4, 6 and 8 h) and investigated the response change of the gas sensors towards H_2 gas at 100 °C. ZnO nanowires were grown on a borosilicate glass substrate pretreated with a seed layer. The seed layer was deposited using the Jet Nebulizer Spray Pyrolysis (JNSP) method. ZnO nanowires were grown using $Zn(NO_3)_2$ and hexamethylene tetraamine (HMTA) during the CBD process. The obtained nanowires at different deposition times were investigated for their structural (XRD), morphological (SEM), and optical (UV-Visible spectroscopy) properties. According to the SEM analysis, the nanowires grown for 6 hours had the highest aspect ratio of 30, with a diameter of 90 nm and the highest length of 3 µm. XRD analysis revealed that the synthesized hexagonal ZnO nanowires were preferentially oriented in the (002) plane. Deposited nanowires were later used to fabricate H_2-sensitive gas sensors. Gas sensing results showed the highest response change of 9.36 to 100 ppm H_2 at 100 °C for the nanowires grown for 6 hours. Obtained results concluded that the optimum ZnO nanowires deposition time is 6 hours for the deposition method used.

Keywords: Chemical bath deposition, Deposition time, Gas sensors, Spray-coated seed layer, ZnO nanowires

I. INTRODUCTION

Numerous factors have been the source of the releasing of a vast amount of toxic, explosive, and flammable gases to the environment. Therefore, it is essential to identify toxic gases like H_2S, NH_3, CO, H_2, and LPG to safeguard humankind. Hence, scientists have been working on various types of gas sensors to detect mentioned chemical gases. Among these types, metal oxide (MOx) semiconductor-based gas sensors stand out due to their high sensitivity, fast recovery, low working temperature, and low cost. ZnO and SnO_2 are the most studied martials so far as MOx gas sensors, and further investigations are been carried out to inent superior gas sensing devices. The sensitivity of the gas sensor enhances by the nano-sized MOx by increasing the surface-to-volume ratio. This research thoroughly focused on synthesising ZnO nanowire-based gas sensor through the chemical bath deposition (CBD) technique, which is one of the most scalable, low-cost wet chemical techniques. Special attention was paid to optimize the CBD deposition time of the ZnO nanowires to fabricate highly sensitive H_2 gas sensors.

II. MATERIALS AND METHOD

Firstly, borosilicate substrates were cut into 2.5 cm × 2.0 cm pieces and thoroughly cleaned with detergent. Then, they were washed with DI water and dried. Then substrates were sonicated in dilute HCl solution, and the previous step was repeated. Then, the glass plates were cleaned by immersing in the order of acetone, methanol, and isopropanol just below their respective boiling points. Chemically cleaned substrates were then washed with DI water and dried with Nitrogen before being stored in a desiccator. The substrates were plasma cleaned for 5 minutes to obtain a better hydrophilic surface.

ZnO seed solution was prepared with 0.1 M solutions of Zinc acetate dehydrate [$Zn(CH_3COO)_2.2H_2O$ – 99.5%] with monoethanolamine (MEA) [$NH_2CH_2CH_2OH$] [1]. The molar ratio between zinc acetate and MEA was 1. The solution was sonicated for 15 minutes and stirred for 2 hours at 300 rpm and 70 °C. The resulting milky solution was aged for 24 hours at room temperature. The solution was then spray-coated on the cleaned glass substrate 10 times. Throughout the process, the substrate was placed on a hot plate at 120 °C.

ZnO NWs were grown with an equimolar (0.1 M) aqueous solution of zinc nitrate hexahydrate [$Zn(NO_3)_2.6H_2O$ – 99.5%] and hexamethylenetetramine [$C_6H_{12}N_4$ – 99.5%]. The prepared substrates with seed layers were used for CBD at 90 °C and a rate of 700 rpm. The deposition time was varied as2 h, 4 h, 6 h, and 8 h. After the CBD process, samples were rinsed with DI water and dried in air. Finally, the samples were annealed in air at 300 °C for half an hour.

III. RESULTS AND DISCUSSION

A. Morphological characterization

The ZnO nanowires were grown at different deposition times. The deposited nanowires were morphologically analysed using FESEM imaging. The length, morphology, diameter, and surface density of nanowires were examined.

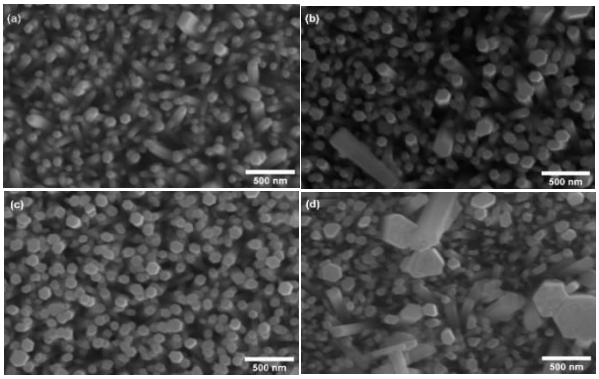

Fig. 1. The FESEM images of ZnO nanowires grown for (a) 2 h (b) 4 h (c) 6 h and (d) 8 h

Fig. 1 illustrates the FESEM images of nanowires grown seeded borosilicate substrates at different CBD deposition

times. Nanowire diameter and lengths were measured using ImageJ software. The diameter of the NWs increased from 70-150 nm with the deposition time [1]. But the length of the nanowires increased up to the nanowires grown for 6 h. Nanowires grown for 8 h possess the highest diameter and the lowest length of 740 nm. According to the Fig. 1 (d) image, the diameter of the nanowires increased due to the coalescence of smaller nanowires with nearby nanowires and formed the outer ZnO layer. The length of the nanowires was fallen due to the pH of the medium. CBD process governs the HMTA concentration, which creates OH^- ions in the medium. With time, the OH^- concentration of the medium began to decrease. After that, two factors become dominant. One is the pH of the medium is reduced. In the low pH conditions, which create extreme acidic mediums, it is hard to form ZnO due to the dissolution of ZnO [2]. Besides that, due to the lack of OH^- in the solution, the ZnO forming reaction rate becomes slower. Therefore, the length of the nanowires is reduced with time. Therefore, according to the results, the length reduction after 6 h may be due to the above facts.

Also, the density of NWs per unit area increases as the deposition time increases to 6 h. Nanowires deposited for 8 h has the lowest surface density of 60 μm^{-1}. As seen in the SEM images, with the increment of the time duration of the deposition vertical alignment of the nanowires increases [1]. Even though the nanowires grown for 2 h have the lowest diameter, they are poor in vertical orientation compared to the Fig. 1 (c). Therefore, the surface density is lower than nanowires grown for 6 h.

B. H_2 gas sensing results

In this study sensing response of the prepared gas sensors was investigated using 100 ppm H_2 gas at the operating temperature of 100 °C. Fig. 2 shows the sensing response of the sensors fabricated by varying the deposition time of the ZnO nanowire.

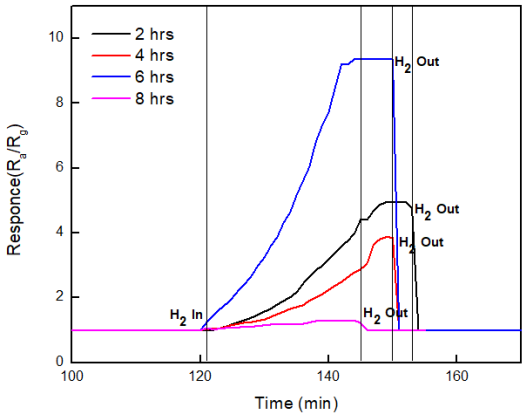

Fig. 2. Response change of the ZnO nanowire sensors grown for different deposition times when exposed to H2 with concentration levels of 100 ppm at 100 °C

It was observed that the deposition time dramatically influences the gas sensing property of the sensor since it enhances the NW density of the sensor. As shown in Fig. 2, the response of the sensor increased with increasing seed layer thickness and obtained the highest response for NWs grown for 6 h at 100 °C. That is maybe because the surface density of the NWs influenced by the increasing deposition time. With the increase of NW density, the reaction sites of the sensor increase [3]. Since gas sensing is a surface reaction, the sensor response increases with the number of reaction sites. Therefore, with the increment of surface density, the response of the sensors towards H_2 gas increased.

IV. Conclusion

To summarize, Nanowires of ZnO semiconductor MOx can be effectively synthesize through the chemical bath deposition method. Deposited ZnO nanowires can be used to fabricate highly sensitive H_2 gas sensors. The CBD deposition time has a significant impact on the morphology as well as the gas sensing behaviour of the ZnO nanowires. The seed layer was deposited using JNSP method. Nanowires grown for 6 h have the highest aspect ratio and are properly vertical oriented. Also, it has the highest surface density, which is an essential factor as a gas sensor. It has shown the highest response change to H_2 gas compared with the nanowires grown for 2 h, 4 h, and 8 h.

Acknowledgement

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Automated Instrument to Measure Specific Surface Area of Powders using the Brunauer–Emmett–Teller Method

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Abstract - An automated instrument was designed to measure Specific Surface Area (SSA) of a powder material using the Brunauer–Emmett–Teller (BET) isotherm method. A material with a known SSA was introduced to make the method simpler, accurate and fast. The cost was reduced by operating the instrument at a fixed partial pressure. A piezoelectric sensor was introduced to increase the sensivity of changes in gas flow rates. The SSA analyzer is used to analyze the SSA of an unknown sample, to compare the SSA of two samples and to identify unknown samples using the SSA. The error of the instrument was found to be less than 0.1%.

Keywords: Specific surface area, Partial pressure, Piezoelectric sensor, Brunauer–Emmett–Teller (BET) isotherm method.

I. INTRODUCTION

The surface area of a material is often mutually related to rates of dissolution and other rate-related phenomena such as catalyst activity, electrostatic properties of powders, etc. Various methods were suggested in the past to measure it [1]. As the particle size decreases, surface area per unit mass increases. In powder solid materials the surface area is calculated per unit mass and called the specific surface area (SSA). In some porous materials SSA is reported high as several thousands of square meters per gram [2]. The surface area of a powder effects the intensity of interaction between two materials. SSA depends on the size of particles and surface texture [2].

In general, three types of SSA are known. First definition is the area that can be completely covered by an adsorbed monolayer of individual molecules of a reference gas adsorbate. The well-known Brunauer–Emmett–Teller method (BET method) is based on this phenomenon. The second definition is called the "geometric specific surface area" [3]. The related measurements are obtained by measuring the particle size using an optical microscopy. The third definition is the "wet surface area" [4]. This definition considers the microscopic surface texture. Wetting of particles by a liquid having a negligible angle of wetting results in creating a real phase interface between the granules and their environment. The surface area is determined on the amount of liquid needed to create an interface. The "wet surface area" is important in studies related to chemical reactions between solids and liquids. The BET method is commonly used for evaluating the surface area of powder materials [2]. However due to conditions need to be controlled and accuracy the related devices are expensive.

This work describes the design of a low cost, fully automated instrument to analyze SSA of a solid powder (SSA- analyzer). The instrument was designed using the BET principle. To make the analysis simpler and accurate a known sample was introduced.

II. THEORY

The SSA of a powder material can be determined using the following equation,

$$S = \frac{V_m}{m \times 22400} Na \qquad (1)$$

where,
S – Specific surface area ($m^2\ g^{-1}$)
Vm – Volume of gas adsorbed at constant temperature and pressure (ml)
N – Avogadro constant ($6.022 \times 10^{23}\ mol^{-1}$)
a – Effective cross sectional area of one adsorbate molecule (m^2)
m – Mass of test powder (g)
22400 – Volume (in ml) occupied by 1 mol of the adsorbate gas (Nitrogen) at standard pressure and temperature allowing for minor departures from the ideal.
By measuring the adsorbed gas volume of a SSA known sample and an unknown sample the following equation was obtained,

$$\frac{S_T}{S_R} = \frac{V_{mT}}{V_{mR}} \frac{m_R}{m_T} \qquad (2)$$

where,
S_T, S_R – SSA of test and reference samples ($g\ m^{-2}$).
m_T, m_R – Mass of powders of test and reference samples (g).
The SSA analyzer calculates the VmT/VmR ratio using equation (2) at partial pressure 0.3 and temperature -193 ^{0}C using the two signals it gets from the two sensors.

III. MATERIALS AND METHODS

A block diagram of the SSA-Analyzer is shown in Figure 01. The mass of the reference and test samples were measured using the chemical balance. Next the two sample tubes were filled with the powder samples and installed in the machine.

Then the samples were degassed in a flowing Nitrogen gas environment and were left to cool down to room temperature in the nitrogen environment. Next the partial pressure was set to 0.3 as follows, $P_{He}/(P_{HE}+P_{N2}) = 0.3$ (P_{He} - Pressure of Helium, P_{N2} - Pressure of Nitrogen). After that the gas mixture was let to flow through the samples by opening valves V_1 and V_2 for about five minutes. At this point the data processing system in the software was started to collect the data. Next the valve V_2 was closed while V_1 is still open and only the reference sample was immersed in liquid Nitrogen to cool down to -193 ˚C in order to start the adsorption process. After the adsorption process is completed it is successfully identified by the software. After the adsorption was completed the V_1 was closed and V_2 was opened and the test sample was immersed in liquid N_2. Finally, the software processes the sensor signals and determined the SSA of the unknown sample.

IV. RESULTS AND DISCUSSION

To optimize the adsorption and to keep the system within the linear range of the partial pressure (0.05-0.35) the partial pressure was fixed at 0.3. According to the BET theory when partial pressure is at 0.3 the error is minimized. With the support of two valves (V_1 and V_2) gas mixture was flown through one sample at a time. As soon as the adsorption starts the out coming flow rate (detected by sensor 2) drops for some time due to the adsorption of N_2 molecules and comes back to the initial value which indicates that the sample is saturated by adsorbing nitrogen molecules. As a result of the drop in flowrate a drop in pressure occurs in the outflowing gas. This variation was detected by the pressure sensors 1 and 2. The sensor signals were analyzed and used to plot the graph of "arbitrary adsorbed gas volume" vs time. The curve increased with time when the adsorption started and came back to the initial value after a period of time, which indicated the completion of the adsorption process. Therefore, the area of the graph is proportional to the adsorbed gas volume by the sample.

When the valve V_1 closed and V_2 opened the gas flows only through the test sample. Same as the process described above with the reference sample. The software again calculates the area under the curve which is proportional to the adsorbed gas volume by the test sample. Using the data, the ratio VmT/VmR was calculated. The weights of the test and reference samples were already measured and the SSA of the reference sample was known and hence the SSA of the test sample was calculated using equation-2.

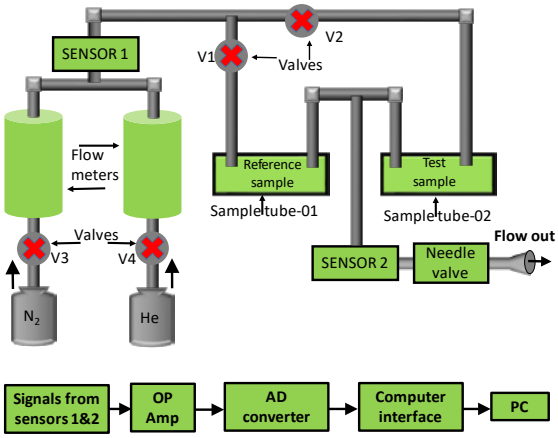

Figure 01: Basic block diagram of the SSA analyser

Four samples of activated charcoal (A, B, C, D) with different SSA values were used to calibrate the instrument and their SSA values are shown in Table 1. The measured values were highly accurate (error 0.1 %).

Table 1. SSA values of known samples.

Reference	Given Specific surface area (m^2/g)
A	1743.0
B	1663.0
C	1734.0
D	1527.0

V. CONCLUSION

Designed analyzer is capable to find the SSA of an unknown sample, to compare the SSA of two samples and identify unknown samples using the SSA. The introduction of a SSA known sample simplifies the method and reduces the cost. The error of the instrument was found to be less than 0.1%.

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Track 11

Forestry and Land Use

Deforestation Monitoring System (DMT) to Reduce Deforestation and Protect the Environment in Sri Lanka

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Abstract - Sri Lanka has a rich biodiversity distributed in a wide range of ecosystems such as forests, rivers, wetlands, coastal and marine ecosystems. Forest density in Sri Lanka was 82% in 1882 and has decreased by 65.5% over 137 years. It causes to climate changes, humidity, and CO2 emissions in the areas. The main reason is deforestation, which happens due to farming, wood cutting, and natural causes. Other reasons behind this are the lack of properly enforced laws and having lots of ways to mislead authorities due to the unavailability of a mechanism to monitor all the cases in one picture. Hence, the relevant authorities require the system to monitor this deforestation and identify law-breaking people to take proper legal action against them. To overcome these issues, Deforestation Monitoring System (DMS) has been proposed, which has Sawmills and Timber Depot owners, Grama Niladhari, Divisional Secretariat, Range Forest officer, and Legal Enforcement Officers. The Global Forest Watch online platform, location updates of system registered, and uploaded images are the main inputs of the proposed system. DMS is proposed to reduce law violators and increase responsibility, efficiency, transparency, and effectiveness among citizens. Further, the relevant laws and regulations should be revised to get the maximum benefits of this system for the advancement of the Sri Lanka's environment and society.

Keywords: Deforestation, Global Forest watch, Range Forest officer, Sawmills and Timber Depot owners

I. INTRODUCTION

Sri Lanka is a land of 65,610 km2 and it has a rich biodiversity. Its main ecological factor is the forests. Forests have different types, and we have highly protected forests and primary forests. In ancient times, people used to cut down trees for their crops, which caused minimal damage to the environment. The forest has been cut down 65.5% in a span of the last 137 years and depicts that the forest density in 1882 was 82% and in 2019 it was 16.5%. The factors may be the growth in population, construction of mega dams & highways and urbanization. Furthermore, World Food and Agriculture Organization rated Sri Lanka as the 4th country with the highest amount deforestation in 2010 and still Sri Lanka holds the same position even now [1].

Global Forest Watch, the powerful tool for mapping recent tree cover loss indicates the Primary Forest in Sri Lanka which is the most diverse form of forest lost 10.5kha of humid primary forest, making up 5.3% of its total tree cover loss in the same period (2002 to 2021) (Fig.1). In this period, the total area of humid primary forest in Sri Lanka decreased by 1.8%. Further, 9.0% of tree cover loss occurred in areas where the dominant drivers of loss resulted in deforestation. Further to that, tree cover lost 202kha of tree cover from 2001 to 2021, which is equivalent to a 5.1% decrease in tree cover since 2000, and 3.3Mt of CO_2e emissions to the environment. According to the above fact, we observed that deforestation is the critical factor that affects the environment, and it is getting worse in the coming years [6].

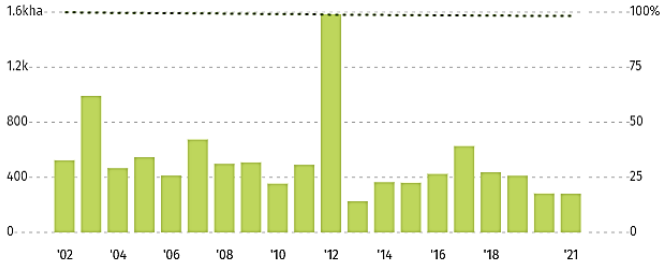

Fig. 1. Total loss of humid primary forest from 2002 to 2021.
Source: Global Forest Watch

In Sri Lanka, we should have a permit to cut and transport timber. This information is in Gazette No. 1548/29 of 09.05.2008 and No.1762/1 of 11 June 2012 and in Chapter V of the control of timber and forest produce in transit under Forest-Ordinance-No-16-of-1907. There is a current remote sensing approach to monitor forest degradation in support of countries measurement, reporting and verification (MRV) systems for Reducing Emissions from Deforestation and Forest Degradation (REDD+) [3]. Also, Norway's Ministry of Climate and Environment and the satellite monitoring group planet developed a system to anyone with an internet connection can now view monthly updates of high-resolution satellite imagery of tropical forests for free [2]. Further, Canada's National Deforestation Monitoring System (NDMS) was created and introduced to provide the information needed by Canada to meet its obligation under the United Nations Framework Convention on Climate Change (UNFCCC) to report the areas affected annually by deforestation [4]. Another one is IJATSCE (A Smart Deforestation Monitoring and Control System Model) system. It is a design of an intelligent framework created for deforestation detection and control systems. It is using machine learning algorithm and wireless sensor network for proactive and reactive measure [5].

All existing monitoring systems can identify deforestation, but there is no proper mechanism to involve all relevant stakeholders in the monitoring and decision-making process.

Therefore, it is very difficult to act against such violators. Sri Lanka still uses outdated laws & regulations and manual procedures to restrict deforestation. Hence, Sawmills and Timber Depot owners (SATD) can easily violate the laws and regulations they have agreed to carry out through the process of felling trees. The proposed system is introduced to streamline the existing outdated manual system.

II. Materials And Methods

This proposed system will get all the relevant authorities to monitor, evaluate, and take decisions efficiently and effectively. This increases transparency, responsibility, and relationships among members. Also, all actions are recorded in the system which creates some reluctance for users to violate applicable laws and regulations.

A. User requirement

The system has different users who are divided into Administrator (System Owner), Monitoring Officers I (RFO and Law Enforcement Officer), Monitoring Officers II (Divisional Secretariat officer and Grama Niladhari) and other users (SATD and guest users). They have different levels of responsibilities and authority. SATD owners must register their timber transport vehicles with the system. SATD requests will be sent to the other members after mentioning the recommendation in the system. Grama Niladari (GN) should update the geolocation (Depending on the Mobile data coverage) and images of the locations requested and number of trees planned to be felled. Once this approval is received from an authorized officer, SATD owners are notified to proceed with the request. After they finish the felling of trees, GN should take images of the location and update the system with number of trees being felled. Also, the system has the facility to refer violations to the Law Enforcement Officer. Furthermore, they can check log transport vehicles on the spot at checkpoints with the help of this system.

Range Forest officers have details of protected forest and other information to consideration requests. Furthermore, they have access to the Global Forest Watch website view and get updates on tree coverage in the relevant area. Then they have peer observations of the locations and can make decisions about the forest cover. Also, this system has guest user access and users, those who want to protect the environment can be part of the system. They can upload deforestation cases to the system with the geotagged images. This can be considered when making decisions by the RFO. Therefore, this will minimize the escape points of the law violators.

B. System requirement

Existing deforestation monitoring systems are focused only on monitoring of deforestation and there is no mechanism to reduce deforestation. Therefore, the system is proposed to bring simultaneous decision-making as well. This application has mainly three parts (Web portal, Database, Mobile Application) (Fig.2).

Web portal has registration, login, request, view, and recommendation pages for different users. All these activities can be done by this web portal. Also, mobile application was developed for easy access to the system users.

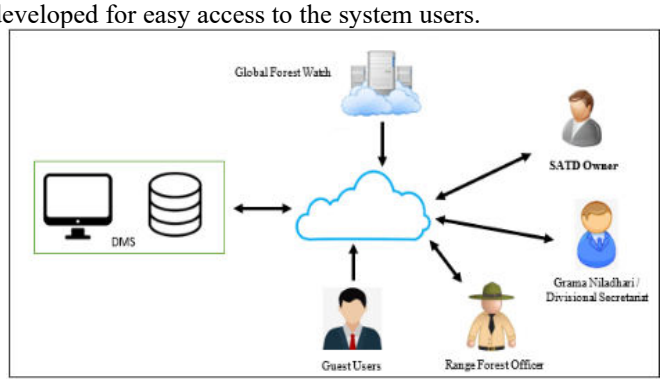

Fig 2: Top Level Diagram of proposed System

III. Results and Discussion

The proposed DMS is developed using HTML, PHP, MySQL, CSS, JavaScript, JQuery and WSDL. GN is the key role of the system, and they must upload location images in the initial and final stages of requests to the system. This image can be uploaded to the system online or offline with a geotags and date stamp. Then RFO can then refer to global forest watch and related satellite images to analyze the specific location. All the activities and decisions will be displayed and will reduce the possibility of misleading the relevant authorities. We can provide a Global Positioning System (GPS) for the timber transport vehicles, which will help track their location. This is not easily implemented due to financial limitations. Furthermore, we suggest that providing system access to the public (citizens) will increase system efficiency. Because they can upload deforestation cases and these cases can be taken to the decision-making. Also, if any cases are illegal, they can be referred to the law enforcement officer for legal action. Further, it is proposed to enact rules for SATD holders to plant large number of saplings in selected areas for forest felled trees to maintain tree cover in Sri Lanka. It will improve air quality, mitigate climate changes, enhance biodiversity, maintain water quality, enrich soil fertility.

IV Conclusions

Implementation of this system is the involvement of good citizens and authorities to change the existing outdated mechanism related to felling of trees for business purposes. The system is cost-effective and uses minimum technical and maximum user involvement to operate. All the users/activities can be monitored and it creates transparency, efficiency, and effectiveness among the relevant stakeholders. Further, the laws and regulations relevant to deforestation, felling of trees, and issuance of permits for SATD should be updated to get the maximum benefits of the system. This approach can be used to streamline similar public services and systems. The ultimate goal is to create a law-abiding society and protect the environment in Sri Lanka for a better future.

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Fluoride Release from the Weathered Rocks in Chronic Kidney Disease of Unknown Etiology Endemic Regions in Sri Lanka

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Abstract - Fluoride is recognized as one of the risk factors for Chronic Kidney Disease of unknown etiology (CKDu) due to its high prevalence. Studies regarding the leaching behaviour of fluoride from rocks in CKDu prevalent areas is scarce. Therefore, this study is focused on identifying the behaviour of fluoride release from a weathered rock commonly found in CKDu endemic area (Girandurukotte) and compare with a CKDu non-endemic area (Sewanagala). Weathered rocks were collected at 5 m depth from freshly excavated subsurface wells. Mineralogy of the rocks was analysed using X-ray diffraction method. Alkaline digestion using KOH been carried out to determine the total fluoride content in rocks. Fluoride leaching experiments were conducted to determine the kinetics of the fluoride release into groundwater and a sequential extraction to determine the fluoride fractions in rocks. Quartz, biotite, carbonate fluorapatite and gypsum were found as primary minerals in the rock from Girandurukotte while quartz, biotite, albite and feldspar were found in the rock from Sewanagala. Total fluoride content found using alkaline digestion was higher in the rock from Girandurukotte (994.8 mg/kg) compared to Sewanagala (788.1 mg/kg). According to fluoride leaching, a higher concentration of fluoride being leached from the rock from Sewanagala (6.81%) compared to Girandurukotte (2.60%) with HCO_3^- rich water. Based on the sequential extraction data, the rock from Sewanagala (10.19 mg/kg) found to have more fluoride in the exchangeable fraction compared to Girandurukotte (4.40 mg/kg) concluding that the rock from CKDu non-endemic area got more ability to release fluoride into groundwater.

Keywords: Fluoride, Weathered rock, Groundwater, Kidney disease

I. Introduction

Hofmeister series is a classification of cations and anions which Franz Hofmeister ranked based on their capacity to denature proteins [1]. The ranking is protein specific, but a typical Hofmeister series is: Cations: $NH_4^+ > K^+ > Na^+ > Mg^{2+} > Ca^{2+}$; Anions: $F^- > H_2PO_4^- \geq SO_4^{2-} > HCO_3^- > Cl^- > NO_3^-$. The strong protein denaturing ability of fluoride makes it one of the most active ions in this Hofmeister series. The prolonged exposure of the kidney to many Hofmeister ionic species, all below maximum allowed limits (MALs), but adding to a high ionicity which is termed 'chronic exposure' may have led to an emergence of a new form of chronic kidney disease (CKD) of unknown. Due to impaired kidney function of an unknown reason; this was named 'chronic kidney disease of unknown etiology (CKDu) by the World Health Organization [2]. CKDu is responsible for tens of thousands of deaths every year in Sri Lanka, and it has become a significant burden on public health and health care systems.

The Hofmeister ions occur naturally in rocks and the water-rock interaction plays a major role in their release into groundwater. When rocks are exposed to the weather agents, a series of chemical processes start and these chemical processes lead to the alteration of the rock minerals and the release of fluoride and other Hofmeister ions. Intense weathering of rocks, and minerals, and passage of some chemical species into the aqueous medium enhance the entry of these ions making long residence the main cause of enhanced ionicity in groundwater [2]. Accumulation of Hofmeister ions including fluoride in drinking water sources, and prolonged use of subsurface groundwater with high ionicity may contribute to CKDu by a protein denaturing mechanism in the kidney [1]. According to the World Health Organization (WHO), the permissible fluoride content in water is 1.5 mg/L. However, the optimal concentration of fluoride can vary according to climatic conditions. Recommended limits for fluorides in drinking-water ranged from 0.6–0.8 mg/L for tropical regions having daily air temperatures between 26.3–32.6°C. A recent study carried out in Girandurukotte found that 0.02-2.14 mg/L of fluoride with an average of 0.64 mg/L in groundwater [3]. Prolong exposure to high fluoride concentrations through drinking groundwater gained a lot of attention with regard to the incidents of CKDu in Sri Lanka. Therefore, this study is focused on identifying the release of fluoride from weathered rocks in the CKDu endemic region and compare with the same in CKDu non-endemic region.

II. Materials And Methods

A. Methods

Study area description. This study was carried out in Girandurukotte, a CKDu endemic area, and Sewanagala, a CKDu non-endemic area both belonging to the dry zone low country region. Annual rainfall is around 1,800 mm, mainly from October to December, and the average temperature is about 30°C (29°C–30°C).

Sample Collection. A total of two partially weathered rock samples were collected from a depth of 5 m from two fresh

excavated wells from CKDu endemic (Girandurukotte) and CKDu non-endemic (Sewanagala) regions.

Characterization of rock samples. X-ray diffraction (XRD) analysis was done using Seimens D-5000 Diffractometer for the rock samples to understand the mineral composition. The XRD data was obtained in the 2θ range from 3 to 60° (Step width: 0.02°; scan speed/duration time: 4.000°/min) for samples.

Total' fluoride in the rock samples. A total of 0.5 g of prepared rock sample was weighed accurately up to 4 decimal places into nickel crucibles and 2 ml of 50% (w/v) potassium hydroxide solution was added. Thorough mixing was achieved by gently shaking the crucibles, followed by heating on a hotplate calibrated to 100°C for 30 min. The crucibles were heated in a muffle furnace until reaching 600°C and then holding for a further 30 min. Cooled samples were filtered through 0.45 µm cellulose nitrate filters. Samples were analysed by ion chromatography (IC) (Metrohm-930 Compact IC Flex).

Leaching kinetics with HCO_3^- rich water. A volume of 20 ml of prepared 150 mg/l $NaHCO_3$ solution was transferred into each 5 g of the rock sample and mixed well. A sample volume of 2.5 ml was collected at 60 min, 120 min, 240 min, and 480 min, 1 day, 2 days, 4 days, and 8 days and analysed the dissolved fluoride in the leach liquor using IC method.

Sequential Extraction experiments of the weathered rock samples. Step-wise sequential extraction was carried out to assess exchangeable, carbonate bound, Fe-Mn oxide bound, organic matter bound and residual fractions of fluoride [4].

III. Results And Discussion

Rocks from both CKDu endemic and non-endemic areas were biotite gneiss in type. According to XRD data, quartz, biotite, carbonate fluorapatite and gypsum were found as primary minerals in the rock from CKDu endemic area while quartz, biotite, albite and feldspar were found in the rock from CKDu non-endemic area. Total fluoride content found using alkaline digestion was higher in the rocks from CKDu endemic area (994.8 mg/kg) compared to CKDu non-endemic area (788.1 mg/kg). According to the fluoride leaching kinetic experiments carried out for 8 days in HCO_3^- rich water, a higher concentration of fluoride being leached from the rock from CKDu non-endemic area (6.81%) compared to CKDu endemic area (2.60%) with HCO_3^- rich water (Fig. 1). Higher amount of exchangeable fluoride in the rock from CKDu non-endemic region could be a reason for this variation.

Furthermore, based on the sequential extraction data (Table 1), higher fluoride content was found in the residual phase in both rocks collected from CKDu endemic (88.63%) and non-endemic (92.41%) areas. The rock from CKDu non-endemic area (10.19 mg/kg) found to have more fluoride in the exchangeable fraction compared to the rock from endemic area (4.40 mg/kg). Fraction of fluoride bound to organic matter as well as to Fe-Mn oxide were remained higher in CKDu endemic area (6.45 and 4.28% respectively) compared to non-endemic area (4.21 and 1.94% respectively) while the fraction of fluoride bound to carbonates was higher in CKDu nonendemic area (0.22%) compared to endemic area (0.15%).

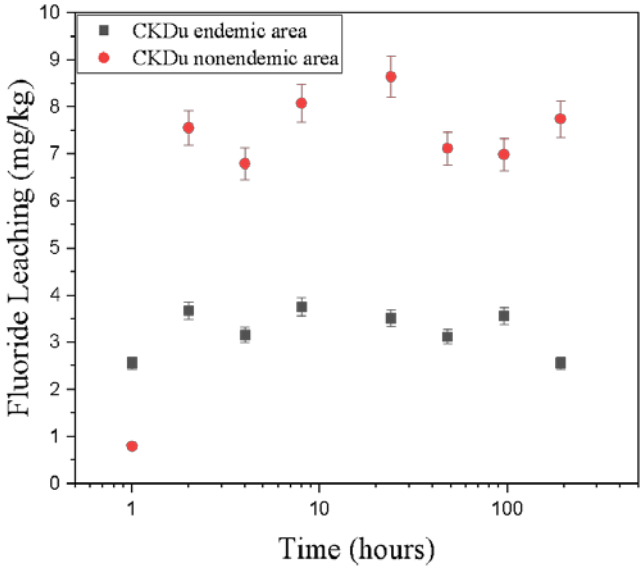

Fig. 1 Fluoride leaching kinetics of powdered rock samples collected from CKDu endemic and non-endemic areas with HCO_3^- rich water

Table 1: Amount of fluoride bound in different phases of the two rock samples collected from CKDu endemic and non-endemic areas

Phases	Fluoride content of the rock samples	
	CKDu endemic area (mg/kg)	CKDu non-endemic area (mg/kg)
Exchangeable	4.403	10.20
Bound to carbonates	1.514	1.776
Bound to Fe-Mn oxide	42.63	15.29
Bound to organic matter	64.55	32.53
Residual	881.7	728.3
Total fluoride	**994.8**	**788.1**

IV. Conclusion

This study demonstrates that the rock from CKDu non-endemic area (Sewanagala), contain high amount of fluoride in the exchangeable phase compared to the rock from CKDu endemic area (Girandurukotte) proving the fluoride leaching behaviour of the rock from CKDu non-endemic area having higher capacity in releasing fluoride into water.

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Factors Affecting the Soil Conservation Practices of Upcountry vegetable farmers in Sri Lanka

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Abstract This study mainly focuses on identifying the factors instrumental in soil conservation and investigating farmers' pro-environmental behaviours related to their soil conservation practices in upcountry vegetable cultivation. The majority of the vegetable growers are small-scale, intensive vegetable farmers. When considering the problems faced by vegetable farmers, nearly 90% of the vegetable lands in Nuwara Eliya district and 45% in Kandy are under the steep slope category. In this category 46% in Kandy and 34 % from Nuwara Eliya district. It was, observed, the soil texture is clay. These characteristics can have a weighty influence on cultivating lands resulting in reduced crop production and difficult land management. Varied soil conservation techniques are practiced in the study area: biological, cultural, and structural conservation techniques. Structural techniques and incorporating organic manure as amendments are popular among the farmers in the study area. With regard to soil moisture conservation practices, half of the population does not perform soil moisture conservation practices. It is highlighted the need for awareness programs on soil and water conservation. In both districts, the need for land improvements for farming activities was highlighted. Nearly half of the farming population follows an average level of soil conservation. A number of farmers who practice soil conservation at a poor level is lower than those who practice soil conservation at a good level. Factor analysis was applied separately to each sustainable land management practice (SLM) and erosion category with a unit cost of production. It is highlighted from the findings that land slope directly effect the cost of soil conservation practices and the cost of production. This study also aimed to pro-environmentally analyze farmers' concerns and behaviors towards soil conservation.

Keywords: Intensive vegetable cultivation, land degradation, soil erosion, soil conservation practices, pro-environmental behaviours

I. INTRODUCTION

Vegetable cultivation is a key sector in agriculture in terms of frugality and employment generation. The rapid growth experienced in the agricultural sector has led to resource degradation with an adverse impact on sustainability [1]. A major form of environmental damage associated with agriculture is land degradation; particularly intensive vegetable cultivation practices have caused soil erosion on the steeply sloping lands of Central Hills [2]. Policies and legislations protecting the land resources in the country were introduced following Independence. The existing institutional set-up lack vigour at the field level; hence the capacity building of the institutions with strong policies can be effective in preventing further degradation of land and water resources. This study mainly focuses on identifying the factors instrumental in soil conservation, and investigating farmers' pro-environmental behaviours related to their soil conservation practices, in order to suggest policy measures to enhance the upcountry intensive vegetable cultivation in Sri LankaMaterials and Methods

Both primary and secondary data were used. This study was conducted in the Central Province of Sri Lanka in 2021, and a sample of 384 farmers was surveyed. The primary data collection tool was a questionnaire survey. A multistage sampling technique was applied to derive the sample. Descriptive and inferential statistics identified the factors that influence the farmers' soil conservation practices the logistic regression analysis was applied for the above purpose. Factor analysis was applied separately to each SLM practice and erosion category with profit. The farmers' pro-environmental behaviours related to their soil conservation practices were investigated by examining the relationship between variables. The effect of two variables "attitude" and "social pressure" on the variable "soil conservation concern", and analysing the effect of the variable "soil conservation concern" on "soil conservation behaviour" was investigated. The reliability of the questionnaire relevant to the objective was calculated using Cronbach's alpha test for the variables measured by the Likert scale. To examine the relationship between variables, Pearson correlation was primarily used. The path analysis was used to determine the explanatory power of the variables.

II. RESULTS AND DISCUSSION

A. Present Status of the Soil Conservation Practices

The majority of farmers who cultivated interestingly in three sessions, this pattern of cultivation is significant in Nuwara Eliya. Farmers in Kandy (28%) and Nuwara Eliya (32%) districts cultivated vegetables in both Yala and Maha seasons. Among farmers who practised soil conservation practices, organic manure application and terracing are the most popular methods. More than 50% of the vegetable plots are suitable for agricultural activities (Considering the soil texture, proportion of sand, silt and the clay content).

Descriptive statistics are used to identify the factors affecting the soil conservation practices of the farmers. All practices come under sustainable land management practices (agronomic practices, vegetative methods, structural methods and cropping systems). Most of the farmers in the sample are following at least one method of soil conservation. Farmers used different techniques to conserve their soil (table 1). Structural techniques and incorporating organic manure as amendments are popular among the farmers in the study area. Adding organic amendments improves soil health. Most of the farmers Nuwara Eliya district constructing stone bunds and terracing are the most popular conservation methods.

Table 1: SLM Practices Followed by Upcountry Vegetable Farmers and their Adaptability

Management Practices	Kandy				Nuwara Eliya			
	Highly adopted	Moderately adopted	Poorly adopted	Not adopted	Highly adopted	Moderately adopted	Poorly adopted	Not adopted
Mulching	0.90	8.11	43.24	47.7	10.00	20.00	20.00	50.00
Biological hedges	0.00	13.16	14.04	72.8	27.59	31.03	20.69	20.69
Lock and spill drains	2.48	26.45	29.75	41.3	29.63	40.74	25.93	3.70
Contour planting	14.05	23.14	11.57	51.2	63.33	30.00	3.33	3.33
Grass hedges	2.61	12.17	14.78	70.4	25.71	51.43	14.29	8.57
Stone bunds	1.72	11.21	10.34	76.7	54.24	33.90	6.78	5.08
Zero tillage	0.00	4.59	5.50	89.9	9.52	19.05	4.76	66.67
Cover crops	3.85	28.46	21.54	46.1	30.43	39.13	21.74	8.70
Soil bunds and drains	13.25	30.46	12.58	43.7	48.89	48.89	2.22	0.00
Application of organic fertilizer	1.68	14.29	26.89	57.1	15.00	25.00	30.00	30.00
Fallowing period	0	2.1		86.6	0	1.88		89.1
SALT technique	4.35	6.96	3.48	85.2	5.88	29.41	0.00	64.71

Source: Author's survey data, 2021

Each SLM practice was rated as highly adopted, moderately adopted, and poorly adopted and not adopted based on the Department of Agriculture (DOA) recommendations that consist of different levels and sublevels.

Accordingly, gender, number of family members, land ownership and nature of slope were significant predictors for the production of vegetables at 95% CI. None of the other variables considered for the model was significant predictors according to the sample analyzed.

B. Different Soil Erosion Control Techniques used to conserve the Water Flowing out of the Farm Land

Soil erosion control techniques used to minimize the water flowing out of the farmland (off-farm) is a very important activity in topsoil conservation. This is a very important aspect we have observed during our data collection. Because a significant amount of soil eroded from the farmland due to the mismanagement of a proper drain water system out of the farm field to the main waterway. More than 70% of farmers in both districts used those methods. However, still, more than 25 % of farmers in both districts are not adopting these methods. This accelerates the topsoil erosion.

C. Constraints in Soil Conservation and Awareness of Soil and Water Conservation Practices

Further, sloping lands accelerate topsoil erosion. Poorly drained fields or those within lowlying areas can become waterlogged during periods of excessive rains. Such conditions cause diseases, reduce plant health and yield, and under extreme situations can cause plant death.

Cultivation on extremely high eroded lands according to the erosion category. In Nuwara Eliya District all the land area under this category is occupied for intensive vegetable cultivation. As per the soil texture, 46% in Kandy and 34 % from Nuwara Eliya, we have observed the clay soil on extremely highly eroded lands. When irrigation water or rainfall slowly penetrates through the soil it is evident the area is not well-drained. According to the United States Department of Agriculture (USDA) water drainage classification in well-drained soil, water is removed from the soil readily but not rapidly). Poorly drained soils (water is removed so slowly that the soil is wet at shallow depths periodically during the growing season or remains wet for long periods) are often high in clay, in low-lying areas, or compacted. Soils have poor drainage when rainfall or irrigation water cannot easily enter (infiltrate) or move downward through the soil (percolation).

According to the results reviewed about the Extension services received, more than half of the study population has not received any extension service granted by the government during the last two years. Most farmers are not satisfied with the advisory service from 2020 to 2021 while a great majority has not received any state guidance within the last two years.

D. Effects of existing SLM practices and erosion category on profit

Two-way factorial ANOVA was applied separately to each SLM practice with profit. According to the analysis profit proportionately increases with the soil conservation adaptability. High eroded areas with soil conservation practices offered a significant profit. It is highlighted from the findings land slope directly effect the cost of soil conservation practices and the cost of production. The cost of production proportionately increases with the increasing land slope. According to the analysis profit proportionately increases with the soil conservation adaptability.

E. Pro-Environmental Analysis Farmers' Concerns and Behaviours towards Soil Conservation

The results of the analysis regarding the effects of independent variables on the variables "soil conservation behaviour" and "soil conservation concern" indicated that, among the variables affecting these two variables, the variable "attitude towards soil conservation "was the most powerful predictor of "soil conservation concerns" and the variable "social pressures on soil conservation" predicted farmers' "soil conservation behaviours" enhanced. Similarly, the independent variables used in this research could predict 30% of the variance in terms of soil conservation concern and 20% of the variance in terms of soil conservation behaviour. These outcomes can be applicable for executive officials since, instead of making efforts to directly change the behaviour, they can first focus on conceptual changes and persuasive changes like changing attitudes towards soil conservation.

III. CONCLUSION

The use of descriptive and inferential statistics helps identify the factors affecting the soil conservation practices used by farmers. The farming population (42%) follows an average level of soil conservation. The land slope has a direct effect on the cost of soil conservation practices and the cost of production. Observed soil erosion control techniques used to conserve the water flowing out of the farmland (off-farm) is a very important activity in topsoil conservation. A silt trap is a very important method to collect nutrient-rich topsoil, but farmers do not practice these methods. In the upcountry region farmers did not apply modern technology for tilling, watering, cultivating, and harvesting, which makes the processes time-consuming. A wide range of technologies is available for soil and water conservation in cultivation activities. Farmers are unable to use the high machinery system due to land elevation. Therefore, the constraints in technology application have limited their land productivity to a great extent and highlighted the need for strong extension activities. It is highlighted from the findings land slope directly effect the cost of soil conservation practices and the cost of production. The results of the analysis identify the farmers' pro-environmental behaviours can be related to their soil conservation practices.

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Greater Reduction of Soil Erosion Rates after the Introduction of Simple Conservation Measures to a Small Tank Cascade System in Palugaswewa, Sri Lanka

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Abstract - Agriculture in the dry zone of Sri Lanka has been sustained for over two millennia by harvesting rainwater using manmade village tanks, which are arranged in a cascade system. Induced soil erosion threats the Tank Cascade Systems (TCS) by causing a high level of sedimentation of tanks. There are no studies conducted in the country on spatial soil loss in TCS. Therefore, this study aims to study the spatial distribution of potential soil erosion rates in six selected sub-catchments in Palugaswewa TCS under various land uses. The revised Universal Soil Loss Equation (RUSLE) model was used with ArcGIS 10.8 to assess soil erosion. Erosion rates were estimated for the present conditions under each land use, assuming simple conservation practices to assess the effect of the introduction of conservation measures on soil erosion rates. The spatial distribution of soil erosion of the sub-catchments of Palugaswewa TCS was created by multiplying all factor layers of annual rainfall erosivity factor (R), soil erodibility factor (K), slope length and steepness factor (LS), vegetation cover and management factor (C) and support/conservation practice factor (P) with a raster calculator using map algebra in ArcGIS 10.8. Erosion values of the sub-catchments of Palugaswewa TCS vary between 19 t/ha/yr to 44 t/ ha/yr at the present conditions, and it is reduced between 8.9 t/ha/yr to 14.5 t/ha/yr after the conservation measures such as cover cropping and soil bunds were applied. The finding of this study suggests that adopting simple conservation measures such as soil bunds and cover crops can reduce soil erosion to a great extent.

Keywords: sedimentation, RUSLE, tank cascades, land use

I. INTRODUCTION

Tank chains or tank cascades are one of the traditional land and water management systems developed based on catchment ecosystems. Erosion rates rise with increased population, rapid development, human modifications and climate change [1]. Soil erosion and sediment accumulation in tanks are one of the serious issues of TCS [2]. Sediment accumulation gradually reduces the tank storage capacity, including the dead storage which is vital to meet the community and environmental needs during the dry periods Soil erosion in the catchments is the cause of tank sedimentation. Watersheds comprise many land uses. Land use is a major variable of soil erosion. Further, land slope, soil type, rainfall, and soil management influence soil erosion and these factors have a spatial distribution in the watersheds. Therefore, there is a spatial distribution of soil erosion in the TCS. Adopting supporting conservation practices such as terracing, contour farming, strip/ cover cropping and soil bunding will effectively reduce soil erosion by influencing drainage patterns, runoff concentration, runoff velocity and hydraulic forces exerted by the runoff on the soil surface [3]. A proper understanding of the spatial distribution of soil erosion in the watersheds is essential for the control of sedimentation of the tanks in the TCS. There are no studies conducted on the spatial soil loss in tank cascade systems in the country. Therefore, this study aims to study the spatial distribution of potential soil erosion rates in six selected sub-catchments in Palugaswewa TCS under various land uses in the present context and with some selected conservation methods.

II. METHODOLOGY

The study was conducted in the Palugaswewa TCS comprising of six tanks, namely a) Maha wewa, b) Alapath wewa, c) Yakandagas wewa, d) David wewa, e) Kundalugas wewa and f) Udakadawala wewa. The sub-catchments of the Palugaswewa TCS were delineated using ArcGIS 10.8. Extents of different land use in the catchment were assessed using the land use map of the year 2018 of the Palugaswewa DS division, prepared by the Land Use Policy Planning Department, Anuradhapura.

The mean annual rainfall was calculated using thirty years of daily rainfall data (1988 - 2018) for six rain-gauge stations around the study area, namely Anuradhapura, Diyabeduma, Giritale, Hingurakgoda, Mahagalkadawala and Mahaillupallama. R factor layer was calculated using the inverse distance weighted interpolation technique and a regression model proposed for the Sri Lankan conditions [4].

$$R = \frac{972.5+(9.95* P)}{100} \quad (1)$$

where R is the annual rainfall erosivity (MJ mm ha^{-1} h^{-1}yr^{-1}) and P is the mean annual rainfall (mm).

Palugaswewa TCS consists of Reddish-Brown Earths soils on upper land and Low Humic Glay soils in the valley bottoms. Their soil erodibility factors were used to create K factor layer. Slope length and steepness were calculated using 30 m × 30 m resolution Digital Elevation Model (DEM). The slope length factor was computed using equation (2), and "m" in this equation was taken as 0.2 as the slope of the sub-catchments of the study area is less than 1% [5]. According to equation (3), the slope steepness was determined [6].

$$L = (\lambda/22.1)^m \quad (2)$$

where L is the slope length factor, λ is the horizontal projected slope length (m), and m is the slope length exponent.

$$S = 10.8sin\theta + 0.03 \; for \; slope \; percent < 9\% \quad (3)$$

where S is the slope steepness factor and θ is the slope angle in degree.

The C factor was estimated by using Wishmeirs graph, which explains the combined effect of mulch and canopy on soil erosion. The canopy cover was determined by looking at the Google image, and the surface cover was determined by ground observations and judgment. At present, conservation measures are used only in paddy lands which are terraced. The conservation techniques introduced in this study were cover cropping for the open forest and forest plantation and soil bunds for homesteads and *chena* lands. The spatial distribution of soil erosion of the sub-catchments of Palugaswewa TCS was created

by multiplying all factor layers of R, K, LS, C, P (determined as explained above) with the raster calculator using map algebra in ArcGIS 10.8.

III. RESULTS AND DISCUSSION

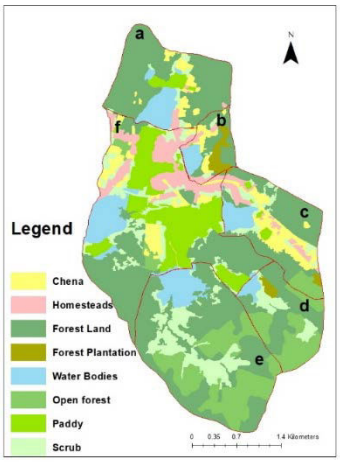

Figure 1. Land use map of sub catchments of Palugaswewa TCS in 2018

The drainage area of sub-catchments of Palugaswewa TCS vary only from 0.5 km^2 to 5 km^2, the R (168 MJ mm ha^{-1} $h^{-1}yr^{-1}$) and K (0.27 t h MJ^{-1} mm^{-1}) factors of the study area does not show any variation, LS factor only shows a very less variation of 3.7 to 4. The support or conservation practice represented by P factor adopted is only terracing of paddy at present. Therefore, the land use or vegetation (C) is the most important factor influencing soil erosion in this study. This is supported by reference [7] as when other factors are similar and if vegetation cover on a plot falls from 100% to 0%, erosion goes from 1 to over 1000 tons. The experimental cascade system, sub-catchments and land uses are given in Fig. 1. The land use distribution and soil erosion rates under the sub-catchments are given in Table 1. High erosive land use types are *chena*, homesteads, forest plantation and open forest and the least erosive land uses are scrub, forest and paddy. Some catchments, including Alapath wewa, David wewa, and Yakandagas wewa have a high percentage of high erosive land uses compared to other catchments. In present conditions, the Maha wewa sub-catchment has the lowest erosion as it has the lowest percentage of high erosive land uses and the highest percentage of dense forest cover. Alapath wewa sub-catchment has the highest erosion rate as it has the highest percentage of highly erosive land uses, namely forest plantation, homestead and *chena*. Yakandagas wewa sub watershed has the second highest erosion rate. It has the third highest percentage of highly erosive lands but has the highest percentage of *chena* lands which cause high erosion. When comparing the remaining watersheds, David wewa shows high erosion as it has a high percentage of open forest. In Udakadawala wewa sub-catchment, almost 75% of the land use includes forest, scrub and paddy, which are low erosive land uses. Kundalugas wewa sub-catchment shows the lowest erosion rate next to the Maha wewa sub-catchment and has the lowest percentage of highly erosive land uses. The data show very high potential for soil erosion under the present land management system in the cascade. The potential erosion rates varied between 18.8 to 44.3 t/ha/yr. Simple conservation measures such as cover cropping and soil bunds adopted in this study are respectively biological and mechanical techniques. Reference [8] reports that the effects of biological and mechanical practices in soil conservation are around 85% according to a global analysis. In this study, soil erosion reduced between 62 % to 68% in all the tanks other than Maha wewa after the introduction of these conservation practices. In Maha wewa, soil erosion was reduced by only about 43 %, as it already had the least erosion even before applying conservation measures.

IV. CONCLUSION

Potential soil erosion rates of the sub-catchments of Palugaswewa TCS vary with lamd use type and are reduced in the range of 43 % to 68% after the introduction of simple conservation methods such as soil bunds and cover crops to the present land use systems.

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Table 1. Comparison of soil erosion of sub-catchments in Palugaswewa TCS under present conditions and with the introduction of conservation practices

Name of the sub-watershed	Land uses in sub-catchments (%)							Soil erosion at present condition (t/ha/yr)	Soil erosion with the introduction of conservation practices (t/ha/yr)	Reduction of soil erosion after the introduction of conservation practice (%)
	Scrub	forest	paddy	Open forest	Forest plantation	homesteads	*Chena*			
Alapath wewa	5.10	44.30	-	-	22.60	11.50	16.50	44.3	14.5	67.3
David wewa	13.64	41.82	-	41.00	3.54	-	-	30.0	9.6	68.0
Yakandagas wewa	10.06	47.58	2.34	8.10	1.43	9.19	21.30	39.9	14.5	63.7
Kudalugas wewa	18.88	49.16	-	31.96	-	-	-	23.1	8.9	61.5
Udakadawala wewa	13.33	32.64	30.19	2.32	-	13.84	7.68	27.4	10.5	61.7
Maha wewa	4.97	78.35	5.66	-	-	2.46	8.56	18.8	10.7	43.1

The Abundance of Rare Earth Elements in Tropical Montane Forest Soils in Sri Lanka

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Abstract - Lanthanide series that consists of 14 elements (from La to Lu) is the major portion of the rare earth elements (REE). There is an increasing interest to study lanthanides in pedology as their role in nature is still poorly understood. The objective was to present the role of REEs in nature by determining REE content within the soil in montane forests (MFs) of Sri Lanka. The study presents the content of lanthanides in the soils of MFs in Sri Lanka. Seventeen near-surface representative soil samples were collected (up to 25 cm) in 1 ha sized plots at Horton-Plains (HP) and Piduruthalagala (PDG) forests. The REE contents were quantified by using ICP-MS. Total average content of lanthanides in HP and PDG soils were 62.1 and 127 mg kg^{-1}, respectively, whereas the mean content varied in order of Ce>La>Nd>Pr>Gd>Sm>Dy>Er>Tb>Ho>Eu>Lu>Tm. Higher content of Light REE (La-Nd) with depleted Eu content is a significant feature in both forest soils. The upper continental crust-normalized patterns were comparable in both sites with positive Tb and Er anomaly, indicating a similar nature in soil genesis. The higher content of lanthanides in PDG site is probably due to enriched clay content. It is well-known that clay minerals can incorporate lanthanides in their structure. The average organic matter content was determined using the loss on ignition method which showed 14.94 and 22.58 % for HP and PDG, respectively. A higher amount of lanthanides in the PDG soils is thus supported by greater organic matter content. In conclusion, both forests showed similar nature in soil genesis and lanthanide distribution may be a result of clay mineral and organic matter that adsorb REEs in soils.

Keywords: Rare earth elements; Tropical montane forests; ICP-MS; upper continental crust-normalized REE patterns

I. INTRODUCTION

Rare earth elements (REE) include all elements of the lanthanide series from lanthanum (La) to lutetium (Lu) of which fourteen elements (except Pm) are relatively abundant in the earth's crust. These elements are typically subdivided into two groups known as light-REEs (LREEs; La-Eu) and heavy-REEs (HREEs; Gd-Lu) [1]. The abundances of REEs in soils are influenced by their parent materials, weathering history, texture, pedogenic processes, anthropogenic disturbances, organic matter contents and reactivity. The Sri Lankan upper montane forests are characterized by natural vegetation ranging in altitude from 1,500 to 2,500 m. Among these, the Horton-Plains (HP) and Piduruthalagala (PDG) forests are two of the most crucial natural ecosystems in the country. Major and trace elements in plants and soils in MFs in Sri Lanka have been studied by several researchers [2] but there are no previous studies related to REEs in soil. Therefore, the objective of this study was to present the role of REEs in nature by determining REEs content within the soil in MFs of Sri Lanka.

II. MATERIALS AND METHOD

Soil samples were collected in selected forest plots of one hectare in size at Piduruthalagala and Horton Plains Systematic sampling was carried out in each plot and 17 near-surface representative soil samples were collected up to 25 cm in depth. Samples were microwave digested using 3:2 HNO_3: HCl and element contents were quantified by using inductively coupled plasma mass spectrometry (ICP-MS). In addition, the organic matter contents were determined using the loss on ignition method.

III. RESULTS AND DISCUSSION

The REE concentrations in the soils from HP and PDG are summarized in Table 1 which allows easy comparison of the REE contents of the different MFs. The total content of REEs (ΣREE) in these HP and PDG soils were 62.1 and 127 $mgkg^{-1}$ respectively. The mean content of REE varies in the order Ce>La>Nd>Pr>Gd>Sm>Dy>Er>Tb>Ho>Eu>Lu>Tm in both HP and PDG sites (Table 1). Higher content of light-REE (LREE; La to Eu) with depleted Eu content was a significant feature of the element distribution pattern in both HP and PDG soils. In addition, both LREEs and heavy REEs (HREEs; Gd to Lu) concentrations were higher in PDG soils than in HP soils. The upper continental crust normalization is a widely used and accepted method for the comparison of REE abundances in the soil environment. In this study, the REEs concentrations in the upper continental crust proposed by Rudnick and Gao [3] were used for normalization. The upper continental crust normalized REE distribution patterns (Fig. 1) were similar in both HP and PDG sites, with positive Tb and Er anomalies, indicating a similar nature in soil genesis in both plots. The normalized plots also confirmed that REE concentrations are higher in PDG soils than in HP soils.

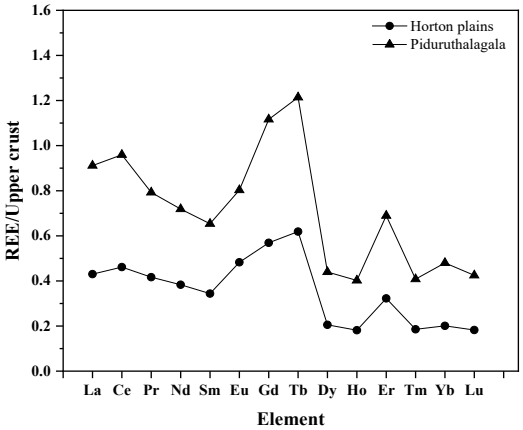

Fig. 1 Upper continental crust-normalized REE distribution patterns in soils from HP and PDG sites (Upper continental crust normalized values from Rudnick and Gao, 2003)

The breakdown of primary minerals that are inherited from bedrock during weathering releases a variety of chemical substances, including REEs, which is beneficial for the accumulation of soil REEs. The soil samples were collected from similar geological terrain, the upper continental crust–normalized REE distribution patterns suggest similarities between the two MFs. However, the influence of parent material on REE content in soil cannot be determined without geochemical data on the REE content of the underlying rock types. In addition to that, secondary processes such as clay

mineralogy, organic matter content, soil type and agricultural practices can also influence REE content of the soils [4]. Generally, REEs are the least soluble trace elements and remain mostly immobile even in the most deeply leached environments. Some researchers were noted that REEs are adsorbed more readily onto kaolinite than other clay minerals [5]. Formation of complexes between Al and humic compounds that speed up the dissolution of kaolinite under acid condition [6]. Some previous studies reported that the behavior of REEs in environments where there are enough humic compounds to form a coating on the surface of inorganic particles is most strongly affected humate formation [7]. The amount of dissolved REEs (especially LREE) would decrease as a result of adsorption on the solid surface as humate complexes in an acidic environment [7]. These factors may have an impact on the soils' REE geochemistry. However, the higher content of REE in the PDG site is probably due to enriched clay content. It is well-known that clay minerals can incorporate REE in their structure. The average organic matter content was 14.94 and 22.58% for HP and PDG sites, respectively. This is relatively a higher amount compared to other soils of the country and a higher amount of REE in PDG soils is thus supported by greater organic matter content as well.

IV. CONCLUSION

The REE content of PDG soils may be explained by the greater dominance of clay content and organic matter. Both MFs showed similar nature in soil genesis and REE distribution may be a result of clay mineral and organic matter that adsorb REEs in soils. Further studies are required to elucidate the clay mineral adsorption of REE in MFs soils in Sri Lanka.

Acknowledgements

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Table 1. The REE content in soils from Horton Plains, and Piduruthalagala montane forests.

REE (mg/kg)	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Horton Plains														
Mean	13.33	29.07	2.96	10.35	1.62	0.48	2.28	0.43	0.80	0.15	0.74	0.06	0.39	0.06
median	11.95	23.92	2.59	9.11	1.46	0.45	1.95	0.38	0.74	0.14	0.69	0.05	0.36	0.05
SD	6.28	12.99	1.50	5.29	0.69	0.21	1.21	0.21	0.31	0.06	0.33	0.02	0.14	0.02
Minimum	5.95	12.91	1.30	4.66	0.82	0.24	0.97	0.20	0.45	0.08	0.37	0.03	0.21	0.03
Maximum	26.43	61.55	6.27	23.32	3.42	1.04	5.09	0.99	1.73	0.32	1.60	0.10	0.76	0.10
Piduruthalagala														
Mean	28.26	60.45	5.63	19.41	3.07	0.80	4.47	0.85	1.71	0.33	1.59	0.12	0.94	0.13
median	27.21	58.23	5.48	18.59	2.93	0.79	4.20	0.78	1.63	0.30	1.48	0.11	0.87	0.12
SD	6.24	10.73	1.29	4.79	0.89	0.23	1.06	0.25	0.74	0.16	0.55	0.06	0.40	0.06
Minimum	19.56	44.62	3.79	12.76	1.89	0.42	3.04	0.55	0.89	0.14	0.99	0.06	0.50	0.06
Maximum	38.32	78.01	7.81	29.06	4.93	1.36	6.87	1.43	3.51	0.70	2.79	0.28	1.94	0.29
REEs content in the upper continental crust proposed by Rudnick and Gao (2003)														
Mean	31	63	7.1	27	4.7	1	4	0.7	3.9	0.83	2.3	0.3	1.96	0.31

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Variation of Soil Physical Properties of Kanneliya and Sinharaja Tropical Lowland Rainforests of Sri Lanka Along an Altitudinal Gradient

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Abstract - Increasing deforestation leads to reduce climate change mitigation capacity of tropical lowland rainforests (TLRFs) in Sri Lanka. For efficient forest conservation, knowledge of both above- and below-ground characteristics of TLRFS is required. Up to date, above-ground information sufficiently available but below-ground details are scarce. Therefore, this study was carried out to investigate soil physical properties by selecting two important TLRFs: Kanneliya (KDN) and, Sinharaja-Pitadeniya (PTD). Four permanent sampling plots (PSPs) of one ha (KDN_1, KDN_2, PTD_1 and PTD_2) were established. Five composite soil samples from each PSP up to 25 cm were collected. Bulk density, porosity, volumetric water content (VWC), field capacity (FC), permanent wilting point (PWP) and available water content (AWC) were determined. Soil aggregate stability was measured by using Le Bissonnais method following (i) fast wetting (FW), (ii) slow wetting (SW) and (iii) mechanical breakdown (MB). Data were statistically analysed. Measured parameters were significantly (P<0.05) different among PSPs except bulk density, porosity, FC and AW. Bulk density, porosity and VWC ranged between 1.03-1.39 Mg m^{-3}, 0.48-0.61% and 8.93-16.11%, respectively, while FC and PWP were between 34.16-48.75% and 10.26-14.75%, respectively. Aggregate stability ranged between 0.89-1.38 (FW), 0.78-1.43 (SW) and 0.75-1.34 (MB). The size of major aggregate fraction was >2 mm for FW and SW while MB was >0.25 mm. Most stable and least stable soil aggregates were found in PTD_2 and KDN_2, respectively. Overall, with increasing altitude, soil porosity and VWC increased while bulk density, FC and PWP decreased. A clear relationship was not observed between altitude and aggregate stability.

Keywords: Tropical lowland rainforest; soil below-ground properties; soil physical properties; forest conservation

I. Introduction

Tropical rainforests (TRFs) are one of the warmest, wettest and oldest woodland Biomes on the earth and are demarcated by high precipitation (>2,500 mm), dense biodiversity and continuous canopies of evergreen trees [1]. In Sri Lanka, the majority of TRFs belong to tropical lowland rainforests (TLRFs), for example Kanneliya (KDN) complex and Sinharaja Biosphere Reserve [2]. During photosynthesis, the rainforest vegetation captures a considerable amount of CO_2 and store it in forest soils and biomass [3]. The reduction of atmospheric CO_2 is directly involved in climate change mitigation. Importantly, below-ground soil physical properties exert a significant influence to ensure the ecosystem roles of above-ground vegetation [4]. Currently, Sri Lankan TLRFs ecosystem is under serious threat due to rapid deforestation, thus reducing the efficiency and effectivity of their ecosystem services. Conservation and restoration of TLRFs are essential, but are constrained by a scarcity of information on above-ground forest and below-ground soil properties of TLRFs and their dynamics. In comparison to above-ground information, availability of information on below-ground properties is particularly scarce. In order to fill this gap, researching is needed elucidating the variation of below-ground soil properties of TLRFs. Therefore, the objective of this study was to investigate soil physical properties, selecting two important TLRFs, Kanneliya and Sinharaja-Pitadeniya (PTD), Sri Lanka as an initial step to expand the level of understanding about them.

II. Materials And Methods

A. Sample collection and preparation

Soil samples were collected from four permanent sampling plots (PSPs): two from the KDN complex (KDN_1 - 117, KDN_2 - 174 m asl) and two from PTD (PTD_1 - 509, PTD_2 - 618 m asl). Each PSP was one ha in size and soil samples were collected from five representative places of a PSP up to 25 cm.

B. Analysis of soil physical properties

Soil physical properties were measured by conducting field-level measurements and a series of laboratory analyses. Soil bulk density, porosity, volumetric water content (VWC), field capacity (FC), permanent wilting point (PWP) and available water content (AWC) were measured using standard methods. Soil aggregate stability was determined according to the Le Bissonnais method [5] following three treatments: (i) fast wetting (FW), (ii) slow wetting (SW) and (iii) mechanical breakdown (MB). The following equation was used to determine aggregate stability based on the mean weight diameter (MWD) of soil particles.

$$\text{MWD} = \sum_{i=1}^{n} XiWi \qquad (1)$$

where Xi is the mean weight diameter (mm) of each size fraction and Wi is the proportion of the total sample mass in the corresponding size fraction

C. Data analysis

All measured data were subjected to analysis of variance (ANOVA) using the General Linear Model and mean separation was conducted using Duncan's New Test.

III. Results And Discussion

A. Soil physical properties

Measured parameters were significantly (P<0.05) different among PSPs except for bulk density, porosity, FC and AWC. Except for soil aggregate stability, variations of all other physical parameters are presented in Table 1.

Table 1: Variation of soil bulk density, porosity, VWC, FC, PWP and AWC values of measured PSPs.

Location	Bulk density (Mg m^{-3})	Porosity (%)	VWC (%)	FC (%)	PWP (%)	AWC (%)
KDN 1	1.39± 0.17^{a}	47.65± 6.46^{b}	8.93± 1.91^{c}	48.75± 5.04^{a}	14.75± 1.72^{a}	33.99± 3.37^{a}
KDN 2	1.25± 0.19^{ab}	53.01± 7.21^{ab}	14.02± 2.16^{ab}	39.24± 10.79^{a}	11.15± 1.23^{bc}	28.08± 6.76^{a}
PTD 1	1.22± 0.27^{ab}	54.07± 5.01^{ab}	11.13± 2.98^{ab}	41.17± 10.79^{a}	13.04± 1.35^{ab}	28.13± 10.75^{a}
PTD 2	1.03± 0.23^{b}	61.25± 8.62^{a}	16.11± 5.82^{a}	34.16± 6.38^{a}	10.26± 0.88^{c}	21.31± 4.49^{a}

The highest bulk density values were recorded in KDN_1 whereas the lowest was determined in PTD_2 (Table 1). Even though bulk density was not significantly (P>0.05) different, a gradual decrease was observed with increasing altitude. The bulk density value higher than 1.75 Mg m^{-3} could restrict root penetration [6] but none of the measured values exceeded this limit in all PSPs. Soil porosity gradually increased with increasing altitude. The highest soil porosity was shown in PTD_2 whereas the lowest was in KDN_1 (Table 1). In the rainforest ecosystem, around 50% of average soil porosity is needed for proper soil oxygen circulation and also for ensuring potential plant growth [4]. All calculated soil porosities of the above PSPs were close to this value, except in PTD_2 (Table 2). Thus, in these TLRFs vegetation is expected to be in its potential growth status. Both bulk density and porosity values are influenced by soil texture, clay content, water and aeration status of the particular soil [6]. VWC was significantly (P<0.05) different among different PSPs and a gradual increase was observed with the increase in altitude. The highest VWC was recorded for PTD_2 and the lowest was observed in KDN_1 (Table 2). VWC is affected by soil porosity and highly porous soils have more capacity to store water than compacted soils [4].

PWP was significantly (P<0.05) different among different PSPs whereas FC and AWC content did not show a significant (P>0.05) difference. The highest FC, PWP and AW content values were recorded in KDN_1: 48.75±5.04, 14.75±1.72 and 33.99±3.37%, respectively, whereas the lowest values were in PTD_2: 34.16±6.38, 10.26±0.88 and 21.31±4.49%, respectively. The observed variation of FC, PWP and AWC might be due to the differences in soil texture, organic matter decomposition and wettability of soil materials [7] of each PSP. Wider knowledge of soil FC, PWP and AWC content of TLRFs soil is essential as these parameters indicate soil water availability of TLRFs soils for the growth and development of vegetation.

B. Soil aggregate stability

Variation of aggregate stability of selected PSPs, as measured following Le Bisonnais method [5] is presented as the mean weight diameter (MWD) of the soil aggregates in Figure 1.

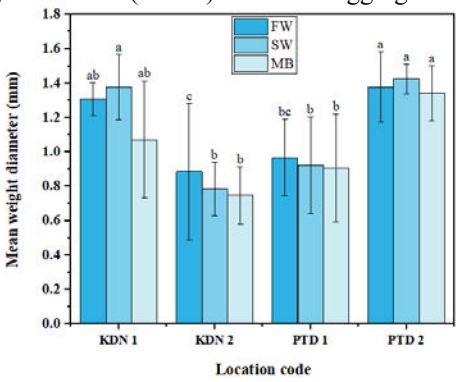

Fig. 1. Variation of soil aggregate stability of selected PSPs, as determined following Le Bisonnais method

MWD values for all three treatments were significantly (P<0.05) different among different PSPs and the values ranged between 0.89-1.38 in FW, 0.78-1.43 in SW and 0.75-1.34 in MB. The highest soil aggregate stability values for all treatments were recorded in PTD_2 whereas the lowest values were in KDN_2 (Figure 1). The size of the major MWD fraction was >2 mm for FW and SW treatments of all PSPs; for MB, it was >0.25 mm. The relationship between aggregate stability and altitude is unclear. Based on MWD values, soil aggregate stability is categorized into five classes and accordingly, soils with >2 MWD are considered highly stable aggregates whereas aggregates <0.4 MWD are very unstable aggregates [7]. The most stable soil aggregates were found in PTD_2. All PSPs, except KDN_2, consisted of medium to stable soil aggregates for all the treatments. In KDN_2, soil aggregates in FW were stable but for SW and MB, soil aggregates were unstable. Variation of soil aggregate stability is caused due to the variation in soil texture, organic matter content, type of clay mineral and microbial activities [8]. Considering the TLRF soils, alteration of aggregate stability is a rare phenomenon under undisturbed conditions [4]. Investigation of aggregate stability of TLRFs soils is a key component in forest management. Soil aggregate matrix is linked with soil pore size distribution and participates in the regulation of the moment of soil air and water flow [8]. The stability level of soil aggregates ensures continuous flow of air and water into plant roots. Therefore, aggregate stability is considered as a key indicator of soil quality and health in the TLRFs ecosystems.

IV. Conclusion

Through the study, variation of soil physical properties with elevation was determined. When compared with standard interpretation tables, most measured soil parameters were found to be within appropriate ranges for sustaining growth and ecosystem functions of TLRFs vegetation. Overall, measured soil physical properties, especially soil aggregate stability can be considered as an ideal indicator for TLRFs soil management. It is recommended to establish relationships between these soil physical characteristics and already available above-ground vegetation characteristics of these TLRFs for establishing better conservation strategies.

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Study on Land Surface Temperature and Land Use / Land Cover Distribution in Weligama DS Division, Matara, Sri Lanka

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Abstract - Land use/ Land cover (LULC) changes are mainly related to the reduction in vegetation cover and increased built-up areas in terms of urbanization. One of the significant implications of urbanization is the increase of land surface temperature (LST). The main objective of the study was to assess the spatial and temporal changes in LST with LULC dynamics in Weligama DSD, Matara for the period 2005-2020 using Thermal infrared bands (TIR) of Landsat images. The study further aimed at mapping the spatial and temporal distribution of NDVI and NDBI of the study area and developing relationships between LST and NDVI and NDBI to assess the environmental changes in Weligama DS Division, Matara. The LULC analysis revealed that vegetation (46%) is the abundant land use in the study area, followed by built-ups (32%). Water bodies contribute a smaller percentage (06%). LST map showed a gradual increase in land surface temperature from 2005 to 2020. LST analysis revealed that higher surface temperature in built-up and bare surfaces and low in healthy vegetative areas. The minimum LST ranged from 23-24°C, maximum LST ranged from 32-32.4°C and average LST ranged from 25-27°C from 2005 to 2020. The NDBI and NDVI maps showed a gradual increase in built-up areas and a decrease in vegetation, respectively. Further it indicated that the impact of urbanization was high around the coastal line of Weligama city whereas, the inlands of the study area are occupied with vegetative lands. The developed LST regression model showed a strong positive relationship with NDBI (r^2 = 0.73, 0.61, 0.76 and 0.64) and moderate inverse relationship with NDVI (r^2 = 0.45, 0.60, 0.59 and 0.59) in 2005, 2010, 2015 and 2020, respectively.

Keywords: Land surface temperature, land use/land cover, NDBI, NDVI

I. INTRODUCTION

Population growth, widespread industrialization and migration of rural population to urban areas cause urban expansion. Urban growth and sprawl are global phenomena that significantly influence the biophysical environment, leading to severe ecological and environmental problems [1]. Rapid and unplanned urbanization can change the area's land use/ land cover (LULC), particularly reduction in vegetation cover that increase the built-up areas. One of the significant implications of urbanization is increase of land surface temperature (LST), primarily by heat discharge due to increased energy consumption, increased built-up surfaces having high heat capacities and conductivities and reduction of vegetation cover [1]. Remote sensing and GIS (Geo information system) can be used to map the LST and LULC changes by using visible, IR (Infra-red) and TIR bands and numerous spatial techniques. The analysis of temporal remote sensing data helps in understanding the land cover changes and their impact on the environment. The TIR of space-borne sensors' remote sensing data helps retrieve land surface temperature.

II. MATERIALS AND METHODS

A total of 04 satellite images were selected for the period from 2005 to 2020. Clouds free Landsat 4-5 – MSS/ TM and Landsat 8 OLI/ TIRS data (path/row 141/56) were freely downloaded from USGS website (https://earthexplorer.usgs.gov/). used to assess LST, NDVI and NDBI Acquired satellite data were of Weligama DSD (Divisional Secretariats Division). Satellite images were downloaded as separate bands and relevant bands were layer stacked and radiometric and atmospheric corrections were done using ENVI 5.3 software. Pre-processed images were clipped and masked using study area map using DSD maps from Survey Department of Sri Lanka. TIR bands were used to develop LST maps and Visible and IR bands were used to develop NDVI (Normalized difference vegetation index) and NDBI (Normalized difference built-up index) maps of Weligama DSD, Matara. Apart from time series multispectral and thermal satellite images, high resolution Google earth images are used to verify the study area's land use/ land cover information. The unsupervised classification was conducted to extract the essential information from the imageries to prepare the LULC map of the study area Landsat 8 OLI/TIRS using the 'Iso-cluster unsupervised classification' tool from ArcGIS 10.7. LSTs were derived from Landsat 8 thermal infrared (TIR) bands (band 10 & 11). The variability of retrieved LST was correlated regarding NDVI and NDBI to identify the impact of different LULC types determined on LST changes over 15-year period.

III. RESULTS AND DISCUSSION

LULC analysis reveals that the major part of the LULC of the Weligama DSD is covered by vegetation, followed by built-up areas consisting of 46 % and 32 % of the total, respectively. Study [2] showed that the land conversion for urban development (78.68-85.15%) accelerates the decrease of vegetation in the study area (21.31-14.5%) during 2012-2017, respectively. Demand for lands and constructions of building complexes and households along the Southern expressway (29.7 ha) [2] drastically affected the vegetation cover and coconut cultivation.

The average LST varies between 25.1-26.9°C for the period of 2005-2020. The highest temperatures were recorded within the built-up areas, while the lowest was in vegetation and water

bodies. LST was increased gradually from 2005-2020 in the study area (Figure 1). The high range of LST was observed around the bay and coastal line and lower in the inner land of the Weligama DSD. The development in the coastal areas of Weligama DSD using materials such as concrete, stone, metal and asphalt increased the surface radiance temperature. The minimum LST of the study area showed a gradual inclining from 23 to 24°C between 2005 and 2020 and the maximum LST approximately remained the same over 15-year period. Overall, the LST maps revealed that barren lands and built-up areas showed the highest LST due to high human activity intensity whereas, the LST is lower in the area surrounded by water bodies and vegetation. This implies that land-use types should be rationally planned and a cooling effect should be induced through green vegetation and water [2].

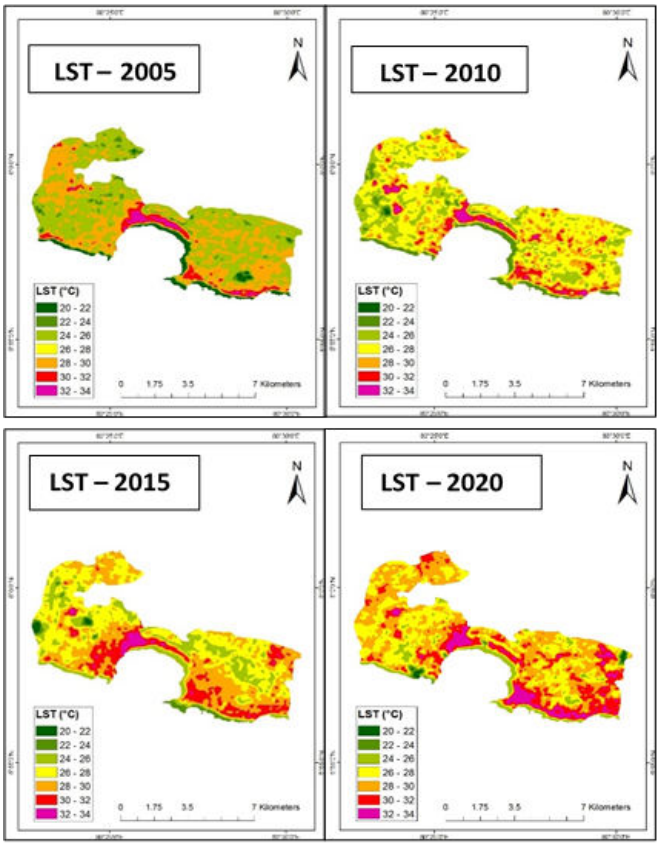

Fig. 1 Land Surface Temperature (LST) Maps, Weligama DS Division

The highest NDBI values were recorded within the urban and barren areas, while the lowest was vegetative and water bodies. The impact of urbanization was high around the bay of Weligama city. The minimum and maximum NDBI of the study area showed a gradual declining from -0.55 to -0.65 and inclining from 0.69 to 0.82, respectively, between 2005 and 2020. The trend of NDBI explains that the urban development of the study area has a steady growth over 15-year period. The maximum NDVI of the study area showed a gradual declining from 0.79 to 0.66, respectively, between 2005 and 2020. Lower NDVI values were evident in water bodies and built-up areas, while higher NDVI values were evident in vegetative areas.

The assessed NDBI and NDVI values showed significant ($p<0.05$) positive (0.85, 0.77, 0.87 and 0.80) and negative correlations (-0.67, -0.77, -0.76 and -0.78) with LST for the period of 2005, 2010, 2015 and 2020, respectively. Linear regression models were developed using relationships between NDBI and LST (without considering the water bodies). The obtained regression models revealed a strong positive correlation between NDBI and LST (r^2 = 0.73, 0.61, 0.76 and 0.64) from 2005-2020, respectively. LST maps of the study area show that the maximum surface temperatures were related to built-up areas. Therefore, it can be noted that built-up or urban land-use class induces much more surface temperature variations than other LULC classes.

Land surface temperature (LST) is sensitive to vegetation cover. The regression models revealed that NDVI and LST had moderate negative correlation (r^2 = 0.44, 0.60, 0.59 and 0.59) from 2005 to 2020, respectively. The high NDVI and low LST indicate a good cooling effect in urban cities. In urban lands, appropriately increasing the number of green areas such as parks with large trees is conducive to improving the city's thermal environment [3, 4]. The relationship between LST and NDVI could be impacted by the spatial combination of different land-use types. Overall, moderate NDVI (vegetation cover) and a high level of NDBI (built-up cover) contribute to the high spatial distribution of LST in the Weligama DS division over 15-year period.

IV. Conclusions

LST, NDBI and NDVI can be considered three primary indices to study the ecological and environmental changes. The study analyzed the applicability of freely available moderate spatial resolution satellite imagery in evaluating environmental impacts LULC pattern on the urban, suburban and rural environment and coastal ecosystem in Weligama DS Division, Matara. LST analysis revealed that higher surface temperature in built-up and bare surfaces and low in healthy vegetative areas. The assessment of NDVI and NDBI changes indicated that the impact of urbanization was high around the coastal line of Weligama city whereas, the inlands of the study area are occupied with vegetative lands such as grass and cultivable lands. The temporal differences of LST had significant correlations ($p<0.05$) with NDVI and NDBI of the study area over 15-year period. The LST showed a strong positive relationship with NDBI (r^2= 0.73, 0.61, 0.76 and 0.64) and moderate inverse relationship (r^2= 0.44, 0.60, 0.59 and 0.59) in 2005, 2010, 2015 and 2020, respectively. Based on the results drawn from the study it is identified the TIR bands of Landsat 4-5 TM and Landsat 8 OLI/TIRS images have the potential to detect the LST level and NDBI and NDVI changes in the Weligama DS division to take proper environmental management practices over urban heat issues.

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Use of 95th Percentile Temperature Data to Identifying the Heatwaves: A Novel Case Study in Anuradhapura, Sri Lanka

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Abstract – Heatwave is a prominent natural disaster observed in recent decades due to the presence of extremely hot weather. Even though the heatwave could be defined based on the hydrometeorological aspects, the studies on heatwave impact are mostly concerned with the health of human beings. Despite that, this study attempts to identify the heatwaves for April and May in the Anuradhapura district in Sri Lanka. The study used a novel approach – the 95th percentile of temperature to identify the heatwaves. Seven hot days were identified during April and May for the Anuradhapura region for the study period. Nevertheless, there is only one cold night was observed in the region during the last week of May. Based on the selected novel approach, it is identified the absence of heatwaves in the region during April and May. Even though April and May are identified as the hottest months for the region, the months receive a comparable amount of rainfall to suppress the generated heat during day time. Further, it is suggested to apply the same methodology to a season or year to identify the occurrence of seasonal and annual heatwaves in the region. Furthermore, the assessment of teleconnection between rainfall and atmospheric-oceanic oscillation with heatwaves is suggested.

Keywords: Heatwave, Anuradhapura, 95th percentile temperature

I. INTRODUCTION

The heatwave could be defined as a natural disaster due to climate change-induced extremes such as extremely hot weather with excessive temperature and humidity, and low rainfall [1]. In addition, latent cooling due to high temperature-influenced soil moisture depletion, recurrent high-amplitude Rossby wave for the hemisphere, atmospheric-oceanic oscillations like El-Nino Southern Oscillation (ENSO) and North Atlantic Oscillation, and anthropogenic activities such as urban heating and emission of greenhouse gas amplify the impacts of heatwaves.

The diverse definitions for heatwaves were derived regionally/locally mainly based on the temperature threshold levels observed in the regions/countries which could affect their citizens. Therefore, The World Meteorological Organization (WMO) generalized the globally accepted definition for heatwaves such as the presence of warming air, in which the daily maximum temperature (TMax) is higher than the mean temperature (i.e., between 1961 and 1990) by 5°C or more for 5 or more consecutive days and destroy routine human activities [2]. Nevertheless, WMO differentiated heatwave from warm spells, such as warm spells defined based on 90th or 95th percentiles of daily TMax and can be observed at any time of the year, whereas heatwaves can only be observed during the warm season. Many scientists focused on analyzing heatwave impact on the health of living beings – humans, but heatwave-associated droughts including flash droughts directly impact agriculture.

Ampitiyawatta et al. [3] showed that the 90th percentile of maximum and minimum temperatures between 1975 and 2005 in Anuradhapura were 35.4 ◦C and 25.5 ◦C, respectively. Furthermore, identified a significant increasing trend in warm nights in both the Maha and Yala seasons, where the higher increase was observed in Maha season. Despite that, this study attempts to identify the occurrence of heatwaves in the Anuradhapura district in Sri Lanka for April and May as a preliminary study using a novel approach of the application of daily mean 95th percentile temperature data.

II. DATA AND METHODS

A. Data

Two main data types – daily maximum temperature (TMax) and daily minimum temperature (TMin) data for Anuradhapura were used for the study. The available daily data consist from 1961 to 2015 (i.e., 55 years).

B. Methodology

The methodology developed by Kuglitsch et al. [4] was used to identify heatwave duration for the study with minor modifications. The daily time series of TMax and TMin for the April and May months (61 days) for each year were developed.

The long-term daily 95th percentiles were calculated using the daily TMax and TMin from March to June (i.e., one month lap from both ends), which is the calculation procedure developed by Della-Marta et al. [5]. Firstly, the mean daily TMax and TMin series for the months from March to June were calculated. In this method, the mean temperature of a certain day was calculated by averaging the temperature of a given day for entire selected years i.e., 55 years. Secondly, the 95th percentile of a certain day was calculated based on the sample of 15 days. The 15 days included seven days before and after the selected day. The 95th percentiles for each day between March to June were calculated for both the TMax and TMin daily time series. Finally, the heatwave is identified where both the mean daily TMax and TMin exceed their respective 95th percentiles by plotting the mean daily climatologies of TMax, TMin, and mean daily 95th percentiles of TMax and TMin.

Originally Della-Marta et al. [5] identified heatwave duration based on the period of three or more consecutive hot days and nights not interrupted by more than a non-hot day or night. Nevertheless, noted that in this study, the consecutive days of temperature which exceed both the mean daily 95th percentiles of TMax and TMin are identified as a heatwave duration.

Matlab R2019b software was used to analyze the data in this study.

III. Results And Discussion

A. The observed highest and lowest temperatures

The highest mean daily TMax of 35.4°C was observed on the 1st of April and the mean daily TMax gradually declined during April and May (Figure 1). The lowest mean daily TMax was 32.2°C for the Anuradhapura district. Nevertheless, the region receives monthly rainfall of 158.3 mm and 78.8 mm for April and May, respectively and due to this reason, TMax tends to decrease gradually from April to May.

On the other hand, the highest mean daily TMin or highest daily night temperature observed for the region was 25.4°C on the 58th day of the season selected or the 28th of May. The lowest mean daily TMin observed for the selected months was 24°C. Nevertheless, the mean daily TMin for the selected months gradually increased (Figure 1). The generated heat during the daytime could suppress due to the persisting rainfall during April.

B. 95th percentiles observed for the duration

The mean daily 95th percentiles for TMax vary between 32.9°C and 35.3°C. There are 7 hot days (i.e., mean daily 95th percentile for TMax exceeds the mean daily TMax) identified in this study, and Table 1 shows the identified hot days and respective temperature values (i.e., mean daily TMax and mean daily 95th percentile for TMax).

It is interesting to identify that there were no cold nights (i.e., the mean daily TMin did not exceed its relevant daily 95th percentiles for April and May for the region), except on 28th May. Nevertheless, the mean daily 95th percentile for TMin varies between 24.4°C and 25.4°C.

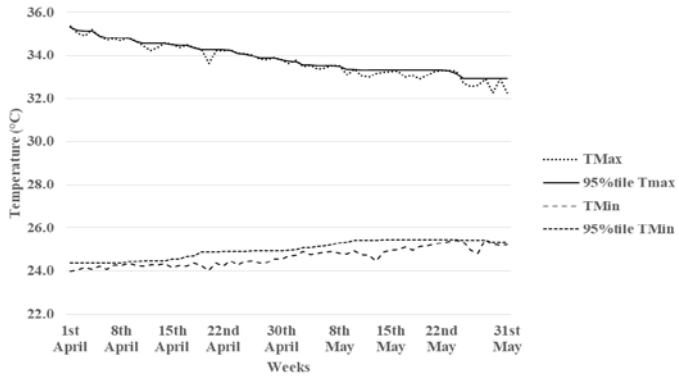

Fig. 1 The distribution of mean daily maximum and minimum temperatures, and 95th percentiles for the daily maximum and minimum temperatures April and May for the Anuradhapura district.

Table 1. Dates of hot days and their respective temperature values

Date	Mean daily TMax (°C)	Mean daily 95th Percentile TMax (°C)
1st April	35.4	35.3
4th April	35.2	32.1
10th April	34.7	34.6
23rd April	34.3	34.2
2nd May	33.8	33.7
4th May	33.6	33.5
24th May	33.3	33.2

Based on the results, it is identified that absence of heatwaves for April and May in the Anuradhapura district, where both the TMax and TMin did not exceed their corresponding 95th percentiles.

IV. Conclusion

This study adopted a novel approach of using 95th percentile temperature data to identify heatwaves in the Anuradhapura district. The study revealed the absence of heatwaves for April and May, even though there were a few hot days and one cold night for the selected season. Further, this study identified that there might be a relationship between rainfall and the changes over TMax and TMin.

Nevertheless, further investigation is suggested to continue the same methodology for a season or a year for the Anuradhapura district because analyzing for two months would not capture the effect of previous months' temperatures on the occurrence of heatwaves. It is suggested to assess the rainfall simultaneously with the temperature to identify the impact of rainfall on the dilution effect of heatwaves. Since Sri Lanka is an Island atmospheric-oceanic oscillations such as ENSO or Indian Ocean Dipole would impact the heatwaves in Sri Lanka. Therefore, it is suggested to assess the teleconnection between heatwaves and the related atmospheric-oceanic oscillations over Sri Lanka. Lastly, it is recommended to use robust data series for the calculation. The daily temperature series used in this study had a comparable amount of missing values and it would misguide the results and conclusion of the study.

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Track 12

Aquaculture & Aquatic Life

Adsorption of Methylene Blue on to Blue Water Lily Stalks

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Abstract - Present study reports a development of a novel cost-effective biomass material derived from blue water lily stalks (BWLS), *Nymphaea nouchali*, for the removal of non-biodegradable organic toxic pollutants, such as methylene blue (MB) from industrial effluents. The potential of the BWLS for the removal of MB from an aqueous solution was investigated in greater detail. Experiments were performed under various conditions including contact time, adsorbent dose, pH of the system, initial MB concentration, and temperature. Results were tested with the Langmuir, Freundlich, and Temkin adsorption isotherms to determine the most suitable adsorption model. Experimental data showed a perfect correlation with Freundlich isotherm with an R^2=0.996 representing possible multilayer adsorption. The maximum adsorption capacity of BWLS was found to be 200 mg/g at 303.15 K for an initial dye concentration of 1750 mg L^{-1}. The kinetic studies demonstrated that the adsorption obeyed a pseudo second-order model. The FT-IR spectra showed that a large number of hydroxyl groups (-OH) and carbonyl (C=O) were present on the surface. Point of zero charge for BWLS was greater than zero indicating larger negative charge distribution on the surface. The results were compared with activated charcoal (AC) at similar conditions and found out that BWLS were better. The present study demonstrated that BWLS was a promising material as a low-cost biosorbent for the removal of MB from an aqueous solution.

Keywords: Adsorption, Blue water lily stalks, Methylene blue, Activated carbon, Isotherms, Kinetics.

I. Introduction

Water pollution is one of the major problems faced nowadays due to rapid industrialization. Untreated textile effluents, which are rich in dyes and chemicals, are dumped into waterways around the world. Most of such effluents consist of non-biodegradable and carcinogenic molecules which could pose a significant threat to human and aquatic health [1]. Further, an excessive amount of such dye molecules is able to destroy the aquatic ecosystem which causes the reduction of light penetration and hinders the photosynthetic activities of the first trophic level. Thus, removal of the synthetic toxic dyes from water is essential. Many studies are conducted for the removal of dyes such as membrane filtration, photodegradation ion exchange, and biosorption. However, the techniques have limitations and hence adsorption techniques are of interest which are easy, effective, and cheap [2]. This study focuses on adsorption of MB using blue water lily stalks (BWLS) as a promising adsorbent collected from waste sites.

II. Materials And Methods

A. Preparation of adsorbents

The BWLS was collected from waste sites around the Bellanwila temple area in Sri Lanka. The collected biomaterial was carefully washed with tap water to remove any dust and other impurities followed by distilled water. The stalks were cut approximately 3 inches and then oven dried at 65 ^oC (338 K) for 24 hrs. The dried stalks were ground, sieved into 100 nm particle-sized, and washed again to remove pigments present in the biomass. This washing was done for 3 days at a rate of 100 rpm in beakers. Finally, the washed materials were again oven dried at 65 ^oC (338 K) for 24 hrs. And packed in cleaned containers. The containers were stored at room temperature for adsorption experiments.

B. Preparation of dye solution

The MB chloride [$C_{16}H_{18}N_3SCl$] was obtained from Loba Chemie India Pvt Ltd which had 98% assy. A 2.041 g of dye was dissolved in distilled water in 1 L volumetric to create a stock solution of MB with a concentration of 2000 mg L^{-1}. By applying serial dilutions, at a range of 750-1750 mg L^{-1} with 250 mg L^{-1} deviations.

C. Adsorption experiments

The adsorption studies were carried out in a batch process. The effect of initial dye concentration, temperature, contact time, and BWSL dosage was studied. The adsorption studies were carried out by adding a pre-weight 200 mg of BWSL to 25 mL of dye with a 1750 mg L^{-1} in a centrifuge tube. The mixture was agitated in a water bath shaker at 150 rpm for 2hr at a constant temperature. The supernatant solutions were analyzed using UV-Vis spectrometer at λ_{max} = 663 nm. The adsorption isotherm was plotted using dye solution (750- 2000 mg L^{-1}) at 303.15 K Kinetic experiments were also carried out at varying times until the equilibrium was reached. Characterization of biomaterial was done using FTIR.

III. Results And Discussion

A. Influence of initial dye concentration

Variation of initial concentration showed that q_e for BWLS was increasing but for AC it reached a maximum and then decreased. As such the appropriate concentration was chosen to be 1750 mg L^{-1}.

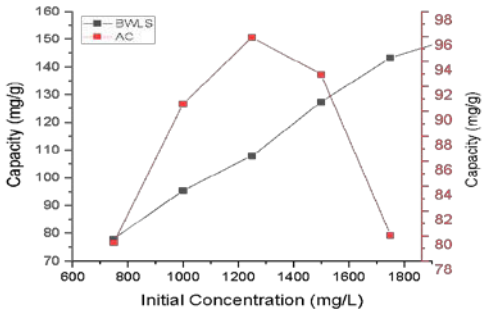

Fig. 3 Effect of initial concentration on adsorption of MB

B. *Influence of contact time*

The adsorption of MB was rapidly increasing in the first 30 min resulting in 54.68% of dye removal which reached equilibrium at a slower rate reaching a maximum of 66.2% removal with adsorption capacity (q_e) of 141.7 mg/g.

C. *Influence of temperature*

When the temperature was increased from 303.15 to 403.15 K, BWLS showed a linear increment in q_e and when the temperature was increased further a decrease in q_e was visible. The AC shows a linear variation with a positive slope. Overall results show that BWLS undergoes changes in the binding sites when the temperature was increased.

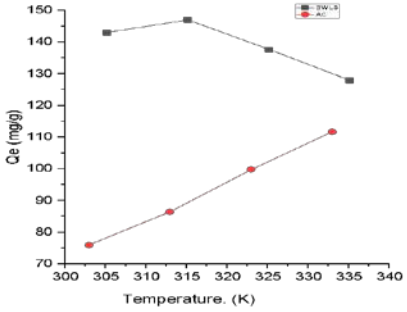

Fig 1- Variation of adsorption capacity with temperature.

D. *Equilibrium modeling*

The best-fit isotherm for BWLS was found the to be Freundlich model having a R^2=0.996 indicating probable multilayer formation. The maximum coverage adsorption capacity (Q_o) calculated shows that BWLS has 200 mg/g while AC has 86 mg/g at 303.15 K thus suggesting that BWLS is a better adsorbent material than AC.

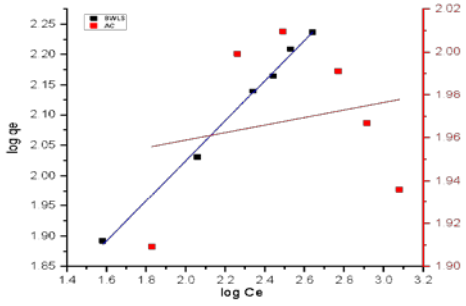

Fig. 2 Log Qe vs Log Ce, Freundlich plot at 303.15 K.

E. *Kinetic Study*

Pseudo first-order, pseudo second- order and intra particle diffusion models were evaluated in the present study. After the interpretation of the results, the pseudo second-order kinetic has the best correlation with R^2= 0.9998. This indicates the rate-determining step chemisorption. When the intra-particle diffusion plot was drawn, it showed that diffusion of adsorbate onto the micro pores takes place slowly, and thus the overall mechanism is a complex process.

D. *Influence of pH*

Increasing the pH from 4-10 showed a decrease in adsorption capacity from 157.9 - 131.5 mg/g. At higher pH, the surface of BWLS becomes negatively charged and the positively charged NH_3^+ fragments in MB get deprotonated. Then lone pair causes electrostatic repulsion and lowers the adsorption capacity.

E. *Effect of dosage*

As the BWLS powder concentration was increased from 8 to 20 g L^{-1}, the percentage adsorbed increased from 39.27% to 94 .10%. However, the q_e showed the opposite trend. The rate of removal increased due to the presence of increased surface area and the availability of more adsorption sites.

F. *Characteristics of Blue water lily stalks*

The FT-IR analysis shows the presence of a broad peak at 3348 cm^{-1} which is due to hydroxyl groups (-OH) in BWLS. The Comparison of spectra before and after adsorption illustrates unabsorbed the broad peak had turned into a sharper peak demonstrating the formation of more H- bonds with MB. Further, the presence of phenol groups can be confirmed due to the sharp peak at 1041.48 cm^{-1} which is due to –OH bending. The presence of a peak at 1643 cm^{-1} is due to carbonyl stretching[3]. The analysis shows that these functional groups can be potential active sites for the adsorption of MB.

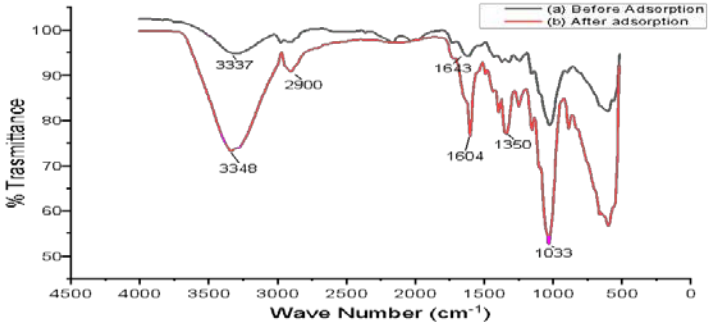

Fig 1- FTIR spectrum of BWLS (a) and BWLS absorbed MB (b)

IV. Conclusion

The present analysis reports a study for the adsorption of MB dye from wastewater using BWLS developed from waste materials as potential adsorbent which can be used as an alternative to activated carbon and other costlier adsorbents. Following the best correlation to Freundlich isotherms and having a maximum adsorption capacity of 200 mg/g at 303.15

K. The adsorption kinetic study follows pseudo-second order having chemisorption as the rate determining step.

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Habitat and Breeding Ground Preferences of the Vulnerable Fish Species Sri Lankan Cherry Barb (*Puntius Titteya*) According to the Water Quality in Aquatic Habitats in Lowland Wet Zone, Sri Lanka

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Abstract - Sri Lankan Cherry Barb (*Puntius titteya*) is a vulnerable endemic fish seen in Sri Lanka. This magnificent creature is well-established in freshwater habitats located in both low and mid-country wet zones of Sri Lanka, especially in the Kelani, Kalu, Gin and Nilwala river basins. This study aims to reveal the habitat and breeding ground preferences of the Cherry barb in the natural environment. This investigation used four water quality parameters including water pH, Total dissolved solids (TDS), Electrical conductivity (EC) and water temperature. Each of these ecosystems and fish were identified, photographed and mapped using Global Positioning System (GPS) for further studies. This study demonstrated that Sri Lankan Cherry Barb preferred acidic conditions in the water pH 6.29±0.29 (5.06-7.11) with low TDS at 16.81±2.32 ppm (8.50-22.67 ppm), EC of 32.22±4.23 µS/cm (17.00-44.00 µs/cm), and water temperature of 28.98±0.71 ^{0}C (28.00-31.97 ^{0}C). The three breeding grounds (Site 01, Site 04 and Site 06), where offspring were located, got significant lower pH (5.95±0.45), TDS (15.44±0.49 ppm), and EC conditions (28.44±6.14 µs/cm) with similar temperature range (28.93±0.47 ^{0}C). These breeding grounds were established with a medium flow rate and thick-submerged-leaf-debris layer that can reduce water pH due to the release of organic acids and polyphenols from terrestrial and organic matter debris. These findings highlighted the value of the Sri Lankan Cherry Barb as an important biological indicator of water quality in aquatic habitats. Hence, playing a critical role in biodiversity conservation.

Keywords: Puntius titteya, Ecological Habitats, Breeding grounds, Water quality

I. Introduction

Sri Lankan Cherry Barb is a tropical freshwater fish endemic to Sri Lanka and belonging to the Cyprinidae family. The cherry barb is a tiny, elongated fish with two maxillary barbs and a fairly compressed body. The Kelani River basin, Nilwala river basin and the Gin river basin are home to the two primary colour variants. The "neon" colour variety features a distinct boundary between the dorsal and lateral sides and a dorsal side that is dark brown with a mild yellowish tint. Starting at the tip of the snout, a dark brown horizontal line crosses the eye line and continues to the centre of the base of the caudal fin. Females have paler skin tones. The "Ruby" colour variant from the Nilwala and Gin River basins has a dorsal side that is dark red and a lateral side that is brighter red in colour. In this colour variant, the horizontal line is not present. Their fins have a vivid pink-red colour. They favour shallow, shady streams with slow flows and submerged aquatic vegetation with leaf litter as their preferred substratum [1]. When mating, the male swims close to the female while trying to chase other males away. The female will lay 200 to 300 eggs, which she will disperse over the substrate and on the plants. It could consume its little fry and eggs. The eggs hatch in one to two days, and after another two days, the fry is swimming freely. The cherry barb hatchlings will be around 1 cm long and clear to identify after five weeks [2]. The well-being of aquaculture animals is closely correlated with the water quality conditions in grow-out systems. Poor water quality can directly result in death, but more frequently it strains aquatic life, making it more vulnerable to infectious illnesses and infertility. Water temperature, salinity, cation imbalance, pH, gas supersaturation, electrical conductivity, toxic algae, dissolved oxygen, ammonia, nitrite, carbon dioxide, and hydrogen sulphide are the main stressors on water quality. The purpose of this study is to identify the habitat and breeding grounds that the *Puntius titteya* prefers in the wild. In six native freshwater habitats, this inquiry measured the water's pH, total dissolved solids (TDS), electrical conductivity (EC), and temperature. This species' habitat is not protected from development and disturbance since its limited distribution is primarily outside or on the fringe of protected areas.

II. Materials And Methods

A. Study area

The study areas were chosen within the Kelani river basin bordered by the Western province and the Sabaragamuwa province of Sri Lanka (6.9543° N, 80.2046° E). Six habitat locations of the *Puntius titteya* habitat locations were investigated throughout this area: Site 01 (Madola-Avissawella), Site 02 (Hewainna), Site 03 (Meethirigala), Site 04 (Galapitamadama-Avissawella), Site 05 (Waga-Indikadamukalana), and Site 06 (Wewila-Marambe). The locations were situated within the banks of lowland rainforest areas and forest patches.

B. Methods

Habitats and locations were identified using field observations. Species identification was conducted using visual observations and occasional fish catching was conducted using

standard hand-picking pond nets. All the locations were photographed by using Canon 80D Digital Single Lens Reflex (DSLR) camera with an 18-135mm lens. Moreover, all the locations were mapped using Global Positioning System (GPS) for further studies. Underwater photos were taken using a GoPro hero black-version 9 camera. Water sample collection and the on-site parameter measurements were conducted for the water pH, Total dissolved solids (TDS), Electrical conductivity (EC) and water temperature. Parameters were measured using a portable multimeter (Thermoscintific multimeter) at the site itself. The results were analyzed and graphs were formed using Microsoft Excel 2010. The statistical analyses were conducted using Graph Pad Prism 9 with a 95% confidence level.

III. Results And Discussion

Within the study schools of the fish and the breeding points and the fingerlings were studied in the breeding points. During the mating season, the body colour change turned brighter, especially males becoming brighter in red colour fins. With the water quality parameter, the TDS ranged between 8.50-22.00 ppm while the highest was recorded at site 5. The highest pH level was recorded at site 4 as 7.11±0.01, and others tend to be slightly acidic. The highest EC was recorded at site 5 as 44.00±27.11µS/cm (Table 1).

Table 1. Water quality parameters of the environmental habitats of the *Puntius titteya,* the results are represented with ± standard deviation of the mean.

Site No	Location	TDS (ppm)	Water Temperature (^{0}C)	Conductivity (µS/cm)	pH
1	Madola-Avissawella	8.50±1.90	29.40±0.65	17.00±3.80	5.06±0.11
2	Waga-Indikadamukalana	12.50±1.00	26.80±0.00	24.00±0.00	6.79±0.10
3	Hewainna	22.67±2.88	28.00±5.36	38.00±8.39	6.36±0.09
4	Wewila	20.00±3.00	28.40±0.00	40.00±6.00	7.11±0.01
5	Madola-Avissawella (Location 2)	22.00±13.56	31.97±1.47	44.00±27.11	5.95±0.41
6	Meethirigala	15.17±3.49	29.40±0.66	30.33±6.98	6.44±0.03

Considering the quality of the water for the residence habitat of the *P.titteya*, it was reflected that they prefer high purity in water considering the lack of contamination in the water bodies. Metals, minerals, and organic compounds that have been dissolved in a specific amount of water are referred to as TDS. Also, for the EC inorganic substances including alkalis, chlorides, sulphides, carbonate complexes, and dissolved salts form these conductive ions. Electrolytes are materials that break down into ions. The quantity of ions present affects the conductivity of water [3]. Lower TDS and EC conditions reflected that the water bodies have lower contaminations through environmental leachates and anthropogenic activities, and the species prefers high purity in the water to establish their breeding habitat [4].

Considering the breeding habitats, they selected significantly lower qualities of TDS, EC, and water temperature and pH conditions compared to the residence habitats (Fig. 1). Three breeding points were identified (Site 1, Site 2, and Site 3) and contemplate TDS 15.44±0.49 ppm, temperature 28.93±0.47, EC 28.44±6.14, and pH 5.95±0.45. For the breeding habitats, they tend to choose slightly acidic water conditions, and the pH conditions are significantly different (Fig. 1). Interestingly these locations are situated within the water flow and the pools where they lay eggs are more shaded by the surrounding tree canopies. The breeding location pH may effect by the leaf litter substratum that occurs in the breeding pools that build up through the fallen leaves and piled up with the water flow. During the breeding season starts, both male and female adults were frequently roaming around the pile of leaf substratum, but after the offspring occur more female adults were observed in the breeding habitats. Body lengths of around 1cm fingerlings were observed inside the layers of the substratum that may provide good hiding places and nourishment for the growth.

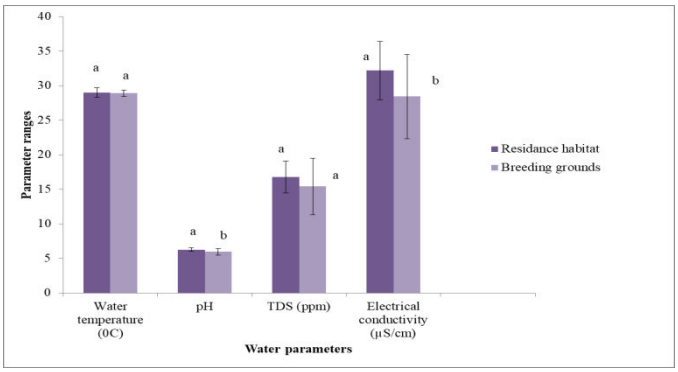

Fig.1 Water parameter comparison in the residence habitat and the breeding grounds of the *Puntius titteya*. The error bars represent the mean ± standard deviation of the mean. Means with the same letters are not significantly different among each water quality parameter (p>0.05).

IV. Conclusions

The study revealed that *P.titteya* tend to scatter more through highly purified water with a lack of contaminations and to form the breeding grounds they tend to find different water quality conditions with more cleared water. The results of the current study showed that *P. titteya* can survive in a variety of pH levels, shallow water bodies with medium flow rates, and submerged debris layers, but they need a greater purity of the water to reproduce and create effective populations. Instead of that, the presence of a healthy *P. titteya* reproducing population will provide a hint as to the higher water quality of the pertinent natural aquatic supply. The need for the conservation of this species is high because of the population depletion due to agricultural practices, energy and mining operations, natural system development with anthropogenic activities, invasive species, and climate change including storms and flooding. The findings may help to identify the habitat modification for the *P.titteya* in future place conservation plans.

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The Content of Lead and the Presence of *E. Coli* in Tilapia Sp. of Static and Dynamic Waters

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Abstract - The consumption of fish contaminated with toxic heavy metals and pathogenic bacteria poses a serious threat to human health. This study investigated the content of Lead in inland fish Tilapia obtained from three static and dynamic water bodies in the district of Colombo, Sri Lanka, and evaluated the human health risk associated with its consumption. The impact of the static and dynamic nature of the water body on the accumulation of lead was also investigated. Furthermore, the presence of pathogenic bacterial species was also evaluated using PCR-based methods. This study discovered that the levels of Lead were within the maximum permissible limits set by the international food standards regulatory authorities and that it is unlikely that the content of Lead in muscles Tilapia would pose human health risks to moderate-level fish consumers. It was also revealed that there is no significant difference in the content of lead present in fish muscles based on the type of water in the fish habitat. However, the PCR-based determination of pathogenic bacteria discovered the presence of *E. coli* in the gills of the fish indicating that the consumption of inland fish Tilapia in raw or unprocessed form could pose a serious risk to human health.

Keywords: Lead Toxicity, E-Coli, Tilapia

I. INTRODUCTION

Fish is a major component of the Sri Lankan diet, accounting for up to 50% of the total protein consumption in 2019. Tilapia is the mostly consumed inland fish in Sri accounting for over 60% of the total inland fish harvest. However, Fish has been discovered to be a major source of harmful microorganisms and poisonous substances such as heavy metals. The consumption of fish contaminated with heavy metals and pathogenic bacteria is known to endanger human health and well-being.

Lead is one of the most ubiquitous metals and has been mined by men for centuries. However, no level of lead is essential or advantageous to the human body, and also no safe threshold of exposure has been determined for lead. *E. coli* is one of the most versatile microorganisms known to mankind with both useful and harmful features based on their pathotypes. Enteric diseases, such as diarrhea or dysentery, are caused by at least six different pathotypes, while other pathotypes cause extra-intestinal diseases, such as urinary tract infections and meningitis.

Previous research has focused on heavy metals in inland fish from the North Central Province. However, no studies have been conducted to establish the levels of lead and the presence of pathogenic bacteria in Tilapia obtained district of Colombo. The district of Colombo had a total fish production of 3,420 Mt out of which 150 Mt were inland fish in the year 2019. Furthermore, no research has been undertaken to determine the effect of the static and dynamic nature of the water body in the fish habitat on lead accumulation. The present study aims at evaluating the content of lead and the risk associated to human health from the consumption of Tilapia obtained from the district of Colombo and to examine the difference in lead accumulation in fish taken from static and dynamic water sources. Furthermore, the study also identified the presence of pathogenic *E. coli* in Tilapia obtained from the district of Colombo.

II. MATERIALS AND METHODS

A. Sampling Fish

The samples (n = 8 from each location) were collected in January and February 2022 from three static water bodies (Beire, Polgasowita, and Diyawanna) and three water bodies with dynamic water (Athurugiriya, Werasa, and Meda Ela) in the District of Colombo. The samples were maintained at a temperature below 4°C during transport. Samples used for the bacterial analysis when bought into the laboratory were immediately stored at -20°C until further processing.

B. Analysis of Lead

Mass optimization calculations were performed as a part of the method development to determine the dry mass of skeletal muscles that need to be dry-ashed to achieve a method detection limit of 0.1 ppm. The dry-ashing method employed for the determination of the Lead content was then validated by evaluating the Matrix Effect, Limit of Detection (LOD), Limit of Quantification (LOQ), and Spike Recovery. Analysis of the content of lead in skeletal muscles of Tilapia was conducted according to the dry ashing process published in AOAC 999.11 with minor modifications using a Hitachi ZA3000 Atomic Absorption Spectrophotometer (Hitachi High-Technologies Corporation Japan) [2]. The effect of the static and dynamic nature of the water in the fish habitat on the content of accumulated lead was evaluated by conducting a t-test.

C. Human Health Risk Assessment

The potential human health risk associated with the consumption of Tilapia contaminated with lead was evaluated as described by Kithsiri et al. (2020). Initially, the content of lead was compared with Maximum Permissible Limits (MPL) followed by an evaluation of the health risk using various approaches such as comparing the Estimated Daily Intake (EDI) against Reference Dose (RfD) values reported by USEPA. The non-carcinogenic human health risks were evaluated by calculating the target hazard quotient (THQ). Furthermore, the maximum allowable daily fish consumption

limits for adults (CR_{lim} in kg/day) and the maximum allowable fish consumption rate per week CR_{mw} (meals/week) were also calculated.

D. Bacterial Analysis

Bacteria were collected by swabbing the gills of the Tilapia Sp. using sterilized swabs. The bacteria were then cultured on Luria Broth (LB) agar medium and incubated at 40°C for 24hrs. DNA was then extracted using the boiling method of DNA extraction. The extracted DNA was then subjected to two PCR amplifications using Universal Bacterial (UNIBAC) primers with forward primer 5' AAC TGG AGG AGG GTG GGG AT 3' and reverse primer 5' AGG AGG TGA TCC ACC CGC A 3'. The extracted DNA was also amplified using *E-coli* specific forwards primer 5'CAT TGA CGT TAC CCG CAG AA 3' and reverse primer 5'CGC TTT ACG CCC AGT AAT TCC 3'. The temperature conditions were denaturation 5 mins, 94°C; 30 cycles of 30 mins, 94°C; 30mins, 55°C; 40 mins, 72°C; and final extension 10mins, 72°C. The amplified PCR products were then analyzed using Agarose gel electrophoresis.

III. RESULTS AND DISCUSSION

A. Method Development and Validation

The LOD and LOQ in the dry-ashed matrix were determined to be 0.03 ppm and 0.09 ppm. The obtained detection limits were then used for the calculation of the Method Detection Limit (MDL). Furthermore, the matrix effect that resulted when the dry ashing procedure was followed was evaluated to be 6.25%. Matrix effects below 12% are considered negligible. Consequently, a simple external calibration was used over the method of standard addition.

The Food and Agriculture Organization (FAO) and other organizations such as the European Union (EU) have set the MPL of lead in fresh fish to 0.3 ppm. As such the present study aimed to employ a method with an MDL of 0.1 ppm. Results of mass optimization calculations indicated that a dry mass of 4.23 g is to be dry-ashed to reach the expected MDL of 0.1 ppm.

The precision and the accuracy of the method used for the determination of lead were then evaluated with the help of recovery studies. A recovery of 93.53% (± 4.32) was obtained for the high spike and a recovery of 91.09% (± 6.82) was obtained for the low spike. The high recoveries obtained in this study reflect the high accuracy of the employed procedure whilst the low standard deviations reflect the high precision of the method used for the determination of the content of lead.

B. Analysis of Samples

The concentration of lead in Tilapia captured from the district of Colombo was investigated for the first time. It was identified that the concentration of lead in the skeletal muscles was below the MPL's decided by the FAO and other regulatory organizations.

The t-test conducted to study the effect of the static and dynamic nature of the water body in the fish habitat on the accumulation of heavy metals indicated that no significant difference exists in the content of lead present in the skeletal muscles of Tilapia based on the type of water in its habitat as the obtained p-value was greater than the standard p-value of 0.05.

Table 1. Concentration of Lead in Tilapia sp. obtained from static and dynamic water sources

Static Water Bodies		Dynamic Water Bodies	
Location	Avg. Lead content (ppm)	Location	Avg. Lead content (ppm)
Diyawanna	0.14 (±0.01)	Meda Ela	0.22(±0.01)
Beire	0.12 (±0.01)	Athurugiriya	0.17 (±0.02)
Polgasowita	0.15 (±0.02)	Werasa Ganga	0.15 (±0.01)

C. Human Health Risk Assessment

Because there was no substantial difference in the accumulated lead content of the two types of water bodies, the human health risk assessment was not undertaken separately for static and dynamic water bodies, instead, a common human health risk assessment was undertaken using the highest concentration of metal ions identified in this study in edible muscle tissues [1]. The EDI was calculated to be 0.0005 mg/kg per day in an adult weighing 70 kg and was several folds lower than the reference doses reported by the US EPA. Similarly, the THQ value was calculated to be 0.127 and this was distinctively much lower than the THQ threshold value of one indicating that it is unlikely to experience non-carcinogenic adverse effects [1]. Furthermore, the CR_{lim} and CR_{mw} values of 0.47 kg/day and 15 meals/week respectively also indicate that it is unlikely that moderate-level fish consumers are at a human health risk.

D. Bacterial Analysis

The morphologies of the cultured bacteria were observed and two similar colonies were identified. These colonies were similar in almost all morphological features however a slight difference in their colors was observed [3]. As such DNA was extracted from the two colonies and subjected to PCR amplification using the UNIBAC and pathogenic *E. coli* specific primers. Upon subjecting the PCR products to gel electrophoresis the presence of bacteria was confirmed by the observation of a 370bp band, similarly, the presence of pathogenic *E. coli* was confirmed by the presence of a 99bp band. Therefore, the consumption of inland fish Tilapia in raw or unprocessed form could pose a risk to human health.

IV. CONCLUSION

The present study discovered that the lead content of Tilapia muscles from both static and dynamic water bodies was within the maximum allowable limits defined by FAO and EU guidelines, indicating its suitability for human consumption. Furthermore, the results of the human health risk assessment indicated that the lead content of Tilapia skeletal muscles from both static and dynamic water bodies was within the maximum allowable limits defined by FAO and EU guidelines, indicating its suitability for human consumption would pose non-carcinogenic human health risks to moderate level consumers. This study also concluded that there is no significant difference in the content of lead present in skeletal muscles based on the type of water in the fish habitat. However, the bacterial analysis discovered the presence of *E. coli* in the gills of the fish indicating that the consumption of Tilapia in raw or unprocessed form could pose a human health risk.

Acknowledgement

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Aquatic Life Health Quality Assessment in a Selected Region of Mahaweli River in Kandy District, Sri Lanka

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Abstract - Mahaweli River is the largest and longest river in Sri Lanka, and it is the major drinking water source for a large portion in the Central Province. The aim of this study was the determination of water quality and aquatic life health quality in a selected region of Mahaweli River. Planktons and physicochemical parameters of surface water were studies at six sites, from Tennekumbura Bridge to Victoria Reservoir for a period of three months. Almost all the measured physicochemical parameters were within the Central Environmental Authority (CEA) standards limits for aquatic life, Sri Lanka Standards (SLS) or World Health Organization's guideline for drinking water. Concentration of orthophosphate ranged between 0.232 to 0.708 mg L^{-1}, and it has exceeded the standard limit of aquatic life according to CEA guidelines (0.400 mg L^{-1}) at Site 1 and Site 2. According to the Pearson correlation coefficient (significant correlation at $p < 0.05$), it is obvious that some physicochemical parameters (temperature, Dissolved Oxygen-DO, Total Dissolved Solids-TDS, Total Suspended Solids-TSS, phosphate, sulphate, chloride fluoride and sodium) were significantly correlated to the distribution of some plankton species such as *Aulocoseira, Navicula, Synedra, Pediastrum, Fragilaria, Selenastrum, Oscillataria, Tribonema* and *Microcystis*. Furthermore, species appear in blooms (*Aulocoseira*), organic pollutants (*Navicula*) and phosphate high eutrophic water (*Microcystis*) were found indicating deteriorated water quality in Mahaweli River.

Keywords: bioindicator, environmental variables, physicochemical parameters, planktons, water quality

I. Introduction

Only 0.3% of the Earth's fresh water is accessible to humans as streams, rivers and lakes. Among many fresh water bodies in Sri Lanka, Mahaweli River is the largest and longest river, which is 335 km in length and draining area is 10 448 km^3 [1]. Most importantly, the major drinking water source for a large portion of inhabitants in the Central Province is the Mahaweli River. Therefore, the aim of this study was to determination of water quality and aquatic life health quality in a selected region of Mahaweli River. To understand the status of water body, and to determine how much deviated from the standard value, measured parameters should be compared with water quality standards.

II Materials and Methods

Six sites (Site 1: 7° 16' 50" N, 80° 40' 00" E; Site 2: 7° 16' 34" N, 80° 40' 27" E; Site 3: 7° 16' 15" N, 80° 41' 28" E; Site 4: 7° 14' 06" N, 80° 44' 36" E; Site 5: 7° 14' 18" N, 80° 44' 39" E; Site 6: 7° 13' 32" N, 80° 46' 11" E) were selected for a period of three months from Tennekumbura Bridge to Victoria Reservoir. As the riverine habitats of Sri Lanka are rapidly being altered through many anthropogenic activities [2], sampling locations were selected based on the various anthropogenic activities occurring at bank of the river. Physicochemical parameters such as temperature, pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS) and Dissolved Oxygen (DO) were measured at the site itself using digital portable meters. 5-day Biological Oxygen Demand (BOD_5), Total Suspended Solids (TSS), hardness, concentration of anions (fluoride, chloride, bromide, nitrite, nitrate and sulphate) and metal concentration (Cr, Fe, Ni, Cu, Zn, As, Cd, Pb, Hg, Ti, Na, K, Ca, Mg) were measured at the laboratory according to standard methods. For all laboratory analysis, water samples were collected into 500 mL Polyethylene Terephthalate (PET) bottles which were prewashed with a detergent, distilled water and water from the respective site to be collected. For cation determination using ICP-MS (Inductively coupled plasma-mass spectroscopy), one drop of nitric acid was added into sample bottles during the time of sample collection. Sample bottles were kept in an ice box during transportation and were stored in the refrigerator at 4°C until the analysis. Planktons were observed as biological parameters [3]. Using a plankton net (mesh size 20 µm), surface water samples were collected into acid washed dried vials, were kept in an ice box during transportation and were stored in the refrigerator at 4°C until the analysis. Diversity and abundance of planktons were studied within 4 days of sample collection using standard manuals of plankton identification under the light microscope.

III. Results and Discussion

All the onsite parameters, BOD_5, TSS and hardness were withing the Central Environmental Authority (CEA) standard limits of aquatic life, Sri Lanka Standards (SLS), or World Health Organization (WHO) guidelines for drinking water [4]. Concentration of orthophosphate ranged between 0.232 to 0.708 mg L^{-1}, and it has exceeded the standard limit of aquatic life according to CEA guidelines (0.400 mg L^{-1}) at Site 1 and Site 2, where there is high disturbance by cultivations and close households. Heavy metals like As, Cd, Hg, Pb, Ti, Zn, Cu, Ni, Cr, and some other metals (Fe, Mn, Al, Na, K, Ca, Mg) were found in all six sites during the study period. Concentration of all these cations were below the maximum permissible levels under CEA's ambient water quality guidelines, SLS or WHO standards. When considering biological parameters, distribution of species abundance and species diversity of planktons have varied depending on the sampling location and sampling time. According to the Pearson correlation coefficient (significant

correlation at $p < 0.05$), it is obvious that some physicochemical parameters (temperature, DO, TDS, TSS, phosphate, sulphate, chloride fluoride and sodium) were significantly correlated to the distribution of some plankton species such as *Aulocoseira*, *Navicula*, *Synedra*, *Pediastrum*, *Fragilaria*, *Selenastrum*, *Oscillataria*, *Tribonema* and *Microcystis*. Furthermore, species appear in blooms (*Aulocoseira*), organic pollutants (*Navicula*) and phosphate high eutrophic water (*Microcystis*) were found indicating deteriorated water quality in Mahaweli River due to agricultural activities, solid waste disposal and release of domestic effluents. Relative abundance of common plankton species observed during the study period is shown in fig. 1.

IV CONCLUSION

As a conclusion, species appear in blooms (*Aulocoseira*), organic pollutants (*Navicula*) and phosphate high eutrophic water (*Microcystis*) can be found in every site during the study period. Some reasons behind the deteriorated water quality in Mahaweli River are due to, agricultural activities, solid waste disposal and release of domestic effluents. It is necessary to improve environmental monitoring and management to control the further deterioration of water quality of the river.

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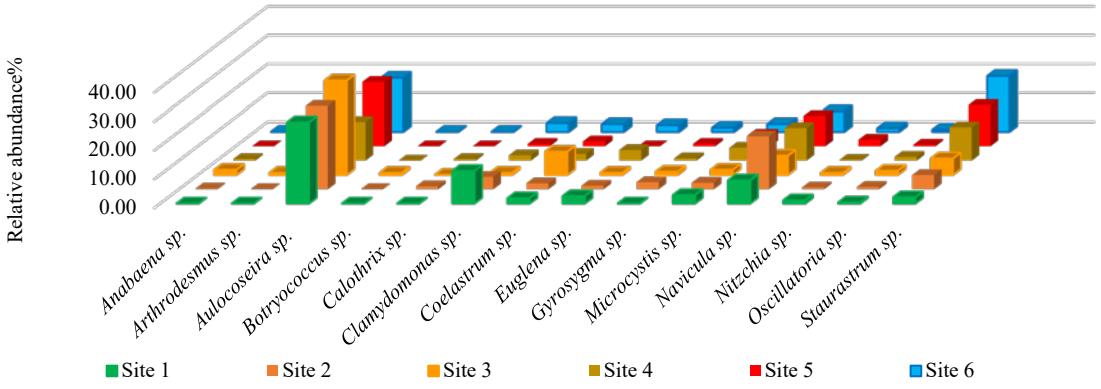

Fig. 1 Variation of relative abundance of common plankton species observed in a selected region of Mahaweli River.

Prevention and Control of Whitefly (*Bemisia tabaci*) in Two Selected Aquatic Plants (*Echinodorus bleheri* and *Echinodorus* 'Little bear')

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Abstract - Whitefly (*Bemisia tabaci*) is a serious plant pest that damage economically important plants including aquatic plants cultivated under greenhouse conditions all over the world. *Echinodorus bleheri* and *Echinodorus* 'Little bear' are economically important two aquatic plants species and a variety which exports from Sri Lanka. *Echinodorus bleheri* and *Echinodorus* 'Little bear' are normally cultivated as emergent plants under greenhouse conditions by using hydroponic systems. These species have more potential to infest with whiteflies and a significant rejection for export due to whitefly attack is a serious problem in aquatic plant industry. Present study was conducted to find out the most effective treatment method to prevent and control the whitefly in *E.bleheri* and *E.* 'Little bear' at the primary stage of the life cycle. In this study insecticide 0.5 L/acre [Fenobucarb – BPMC] (T1) was used as the control and three treatments were liquid soap treatment (T2), immersion the plant in water for 10 days (T3) and application of herbal [extraction] (onion peel and garlic peel) (T4) by using completely randomized design. The results obtained from the one way ANOVA revealed that there is a significant difference among treatment ($P<0.05$). The lowest mean number of eggs, pupa and adults were showed in T3. Further and the lowest egg hatching rate (0%) was obtained in T3 up to 10 days after treatment of both plant species. Hence, immersion of *E.bleheri* and *E.*'Little bear' in water (for 10 days) can be recommended as the most efficient treatment method to the control of whitefly (*Bemisia tabaci*) up to 10 days.

Keywords: Whitefly, Echinodorus, pest control, Aquatic plants

I. INTRODUCTION

Bemisia tabaci is a serious pest of economically important crops all over the world. Its importance as a field agricultural pest has grown in recent years, and it is now one of the most economically devastating pests of greenhouse crops. In recent years, traditional chemical control of whitefly species has become more challenging. In many greenhouses various insecticides are applied per week to control insect populations. As a result, resistant populations of this species can be found highly all across the world (Mohammadali *et al.*, 2019). They are plant feeders with sucking, piercing mouthparts. Adults have a body length of more than 2 mm and a wingspan of more than 3.5-4.0 mm (Byrne and Bellows, 1991). The egg, four nymphal instars (scales), and the adult make up the majority of the whitefly life cycle. At the rear of the leaf, adult female whiteflies lay 200-400 eggs in circular patterns. The eggs hatch into nymphs between 5 and 10 days after being laid, after which they move a short distance away from their egg cases and begin to feed on plant leaves, sucking sap from tissues (Perring *et al.*, 2018).

B. tabaci feeds a wide variety of ornamentals, garden plants and weeds (Abubakar *et al.*, 2022). *Echinodorus bleheri* (Withanage, Bambaranda and Jayamanne, 2013) and *Echinodorus* 'Little bear' are most prominent aquatic plants in the international market. When *E.bleheri* and *E.* 'Little bear' are normally cultivated as emergent plants under greenhouse conditions by using hydroponic systems and it has more potential to infest with whiteflies.

In Sri Lanka mainly use BPMC (Fenobucarb) as effective insecticide for control whitefly commercially. Other than that there are different organic (soap treatment, herbal extracts), chemical and mechanical (handling) methods which are used by farmers to control whitefly.

II. MATERIALS AND METHODS

This experiment was conducted under greenhouse condition in poly tunnels at Ratnasiri Fernando & Co (pvt) Ltd, Pugoda, Sri Lanka. Two months aged *Echinodorus bleheri* and two week aged *Echinodorus* 'Little bear' plant pots were randomly selected from culture tanks with newly laid whitefly eggs. These plant pots were arranges as three plants per pot.

BPMC insecticide (Control / T1), liquid soap solution (T2), immersion in water for 10 days (T3) and herbal extraction (T4) were the applied treatments. The experiment was laid out in Randomized Complete Block Design with 12 replications per one treatment including control. The insecticide used in this experiment was obtained from the local market and was sprayed at field recommended doses (0.5 L/acre). The experiment was carried out separately for two plant species. Each plant was covered with polythene cover to prevent spread of whitefly and to obtain accurate observation results. Herbal extraction was extracted from using onion peel (5g) and garlic peel (5g) and blended with 0.5 L of water. The experimental tank was covered using an insect proof net to prevent spreading whitefly. Fertilization was kept uniform throughout the experiment on all pots.

After 10 days the whitefly population in each plant was recorded early in the morning. Data were collected in the beginning (before applying treatment) and after 10 days (after applying treatment). In the abaxial side of the leaflets, the number of whitefly eggs, pupa and adults were counted in each evaluation, by slowly turning the leaflet upside-down in order to prevent the escape of the insects. The total heights of plants were measured using a tape before and after (after 10 days) applying treatments. Number of leaves were counted before and after (10 days) applying treatment (Abubakar *et al.*, 2022). The egg hatching rate was calculated by using this below formula:

*Egg hatching rate = (Number of eggs hatched/Total number of eggs) * 100%*

One-way ANOVA combined with Tukey test and paired sample t-test was carried out to understand differences between treatments ($p<0.05$). All statistical analysis were crried out using the softwares Microsoft Excel (2010) and Minitab 18.

III. RESULTS AND DISCUSSION

Table 1. Egg hatch rate% of *E.bleheri* and *E.* 'Little bear' plants treated with BPMC (control), liquid soap (T2), immersion in water (T3) and herbal extraction (T4), observed at after application of treatment

	T1 Control	T2 liquid soap	T3 Immersion in water	T4 Herbal extraction
Echinodorus bleheri	16.81a	25.28a	0	9.51a
Echinodorus 'Little bear'	10.59a	25.27a	0	13.21a

Values with different superscripts within the same column differ significantly ($p<0.05$).

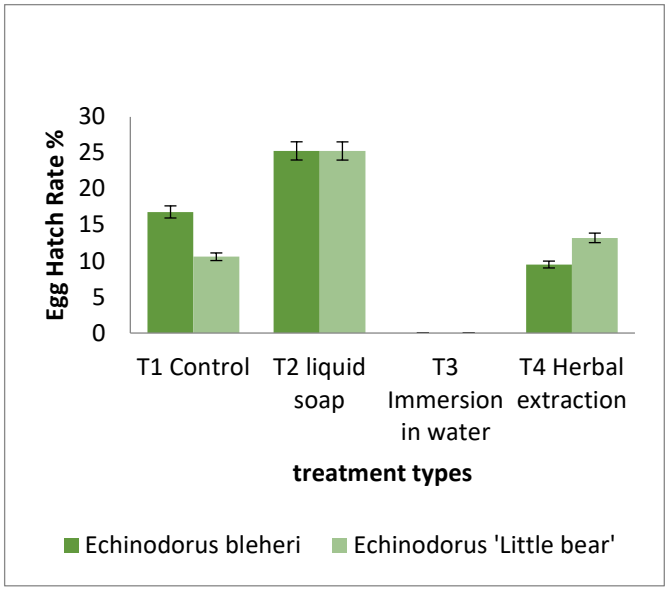

Figure 01 Egg hatch rate% of *E.bleheri* and *E.* 'Little bear' plants treated with BPMC (control), liquid soap (T2), immersion in water (T3) and herbal extraction (T4), observed at after application of treatment

As the results are shown in the above graph (Figure 01), BPMC treatment (16.81%), Liquid soap treatment (25.28%), Herbal extraction treatment (9.51%) showed higher percentages of egg hatch rate. Immersion in water (0%) showed the lowest persentages of egg hatching rate.

As the results are shown in the above graph (Figure 01), BPMC treatment (10.59%), Liquid soap treatment (25.27%), Herbal extraction treatment (13.21%) showed higher percentages of egg hatch rate and Immersion in water (0%) showed the lowest egg hatching rate.

IV. CONCLUSION

Considering the efficiency of prevention and control of whitefly population in the selected two plant species, the most effective and convenient method is immersion for 10 days in water. Further research should be conducted for other crops to understand whether this finding is applicable for them.

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A Mathematical Model of Crocodile Population

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Abstract – Crocodiles have been identified as a species which have indicated a strong survivorship over millions of years from pre-historic era. Sex of a crocodile hatchling is determined by incubation temperature of the egg during gestation. A nesting site of crocodiles is located in a river basin and it has been classified into three sub-regions according to the temperature variation which depends on the spatial distance from the water surface. Due to the low incubation temperature, all the hatchings of region (I) are females. In region (II), there is an equal likelihood to produce a male or female hatching and all male hatchings are produced in region (III). Following the criteria of Temperature-Dependent Sex Determination (TSD), a mathematical model of four first order non-autonomous differential equations, has been formulated based on a theoretical fraction of female population which incubate in region (I). In our approach, this theoretical fraction was modified in order to capture the dynamical evolution of the sex ratio more accurately than the outputs of existing models. Then, the carrying capacity term was also modified in order to analyze the dynamical evolution of the sex ratio under the influence of periodic flooding in the nesting sites. Finally, long term variation of the crocodile population was qualitatively interpreted using the numerical simulations of the model.

Keywords: Temperature-dependent sex determination; Differential equations; Sex ratio; Carrying capacity

I. INTRODUCTION

The influence of temperature-dependent sex determination (TSD) has been detected in all reptilian groups. Besides the genetic sex determination (GSD), TSD is highly observed among crocodiles [1],[2],[3]. In this scenario, male hatchlings are more likely to be produced under relatively high temperature values whereas more female off springs are born under low incubation temperature [2]. Temperature of a nesting site increases with the distance from the water surface, so the ratio of males to females hatched increases with an increasing distance from the river.

According to the temperature distribution of a river basin, three sub regions which indicate significant difference of the sex ratio of hatchlings.

- Region I (Wet marsh): All hatchings are females.
- Region II (Dry marsh): 50% of the produced hatchings are males where the others are females.
- Region III (Dry levees): All hatchings are males.

According ecological facts, existence of large number of female crocodiles assures a strong survivorship of the species. In [2], female population percentage of each region of a typical crocodile habitat is given as 79.6% for region (I), 13.6% for region II and 6.7% for region III. These figures have been used as carrying capacity values of each region where the influence of periodic floodings is not encountered.

The dynamical model of female and male population is preliminarily based on the theoretical fraction of female population which incubate in region (I). This fraction is defined as a function of carrying capacity of region (I) and the female population of it. In [3], it has stated that the fraction is not fully capable of capturing all the feature of variation. Therefore, a modified fraction has been alternatively defined satisfying all required conditions. It is observed that nesting sites of region (I) could be severely affected in periodic flood situations [1],[2],[3] and the periodic variation is also apparent in the carrying capacity of region (I). On this condition, carrying capacity term of region (I) was modified by inserting an experimentally estimated sinusoidal term [3]. Then, the variation of sex ratio was qualitatively interpreted by using the existing and modified approaches.

II. MATERIALS AND METHODS

It has been observed that only a fraction of females can incubate their eggs in the region (I). This fraction should be a function of the carrying capacity (k_1) and the female population (f_1) of region (I). In [2], it has been stated that fraction does not perfectly indicate the portion of female crocodiles incubate in region (I). Therefore, the fraction was modified as follows,

$$F = \frac{k_1^2}{k_1^2+f_1^2} \ldots (1)$$

The modified fraction satisfies the necessary conditions, $F \to 0$ as $f_1 \to \infty$ and $F \to 1$ as $f_1 \to 0$. Then the new version of set of first order non-autonomous differential equations is defined using the same derivation procedure in [2],[3].

$$\frac{df_1}{dt} = b\left(\frac{k_1^2}{k_1^2+f_1^2}\right) f_1 - pf_1 \ldots (2a)$$

$$\frac{df_2}{dt} = \frac{b}{2}\left(\frac{f_1^3}{k_1^2+f_1^2}+f_2\right)\left(\frac{k_2^2}{k_2^2+\left(\frac{f_1^3}{k_1^2+f_1^2}+f_2\right)^2}\right) - pf_2 \ldots (2b)$$

$$\frac{dm_2}{dt} = \frac{b}{2}\left(\frac{f_1^3}{k_1^2+f_1^2}+f_2\right)\left(\frac{k_2^2}{k_2^2+\left(\frac{f_1^3}{k_1^2+f_1^2}+f_2\right)^2}\right) - pm_2 \ldots (2c)$$

$$\frac{dm_3}{dt} = b\left(\frac{k_3^2}{k_3^2+\frac{\left(\frac{f_1^3}{k_1^2+f_1^2}+f_2\right)^6}{\left(k_2^2+\left(\frac{f_1^3}{k_1^2+f_1^2}+f_2\right)^2\right)^2}}\right)\left(\frac{\left(\frac{f_1^3}{k_1^2+f_1^2}+f_2\right)^3}{k_2^2+\left(\frac{f_1^3}{k_1^2+f_1^2}+f_2\right)^2}\right) - pm_3 \ldots (2d)$$

In the equations (2a) - (2d), k_i *(i=1,2,3)* denote the carrying capacity of each region I, II and III. f_1 and f_2 denote the population of female crocodiles of region I and II where m_2 and m_3 denote the male population of each region II and III. In addition, the effective birth rate and death rate are denoted by b and p respectively ($b>p$).

It can be shown that the system (2) is Lipchitz continuous with respect to the variables $f_1(t)$,$f_2(t)$, $m_2(t)$ and $m_3(t)$ and it confirms the existence of unique solutions of the system [3]. In order to represent the influence of periodic floods in the carrying capacity, k_1 is modified as follows,

$$k_1(t)=\begin{cases}\bar{k} & t\le a\\ \bar{k}+A\sin\left(\frac{t-a}{T}\right) & t>a\end{cases} \quad ...(3)$$

In this case, the influence of periodic floods has been introduced after a y ears. T he p eriod o f f loodings (T) a nd amplitude (A) are experimentally estimated and $k_1(t)$ indicates its maximum value ($\bar{k}$) during the time without floods and minimum value is indicated at the peak of flood situation [2],[3].

It can be shown that the system (1) which is modified by incorporation of the term $k_1(t)$, has periodic solutions.

III. Results and Discussions

In this work, a qualitative model was formulated to interpret the dynamics of sex ratio of crocodile population with the influence of periodic floodings. The formulated dynamical equations (2a) - (2d) and modified carrying capacity $k_1(t)$ were numerically simulated with experimental data in [2][3] using MATLAB@. In order to avoid the dependence of the solutions on initial conditions, the carrying capacity was kept constant up to 50 years and a flooding cycle of 63($\approx 20\pi$) years, was then incorporated in equation (3) along with experimental parameter values $\bar{k}=0.797$, $A=0.790$ [3]. Since the system (2) is locally asymptotically stable, its long-term dynamical evolution is independent of the initial conditions [3]. In this work, the qualitative model has been only developed to investigate the trends of population growth and it has not focused on specific ecological data. Therefore, the initial value of each model variable was chosen to be $f_1(0)=10$, $f_2(0)=10$, $m_2(0)=10$ and $m_3(0)=10$.

Confirming the influence of periodic floodings, female population of region I of figure 1(a), has indicated an oscillation with much greater amplitude than the population of region (II) and (III). Moreover, periods of total population variation of figure 1(e), modeled by both existing and modified approaches are equal to the corresponding periods indicated in figure 1(a). It should be noted that region (I) directly is affected by the floods and the population growth of other two regions is dependent on region (I).

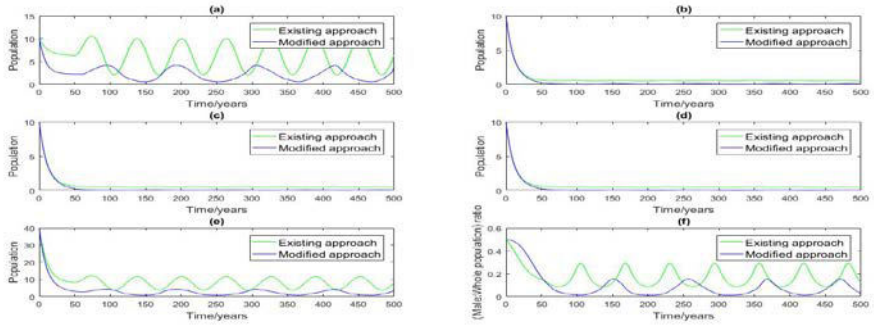

Figure 1. (a): Variation of female population of region I modelled by the existing approach and modified approach, (b): Variation of female population of region II modelled by the existing approach and modified approach, (c): Variation of male population of region II modelled by the existing approach and modified approach, (d): Variation of male population of region III modelled by the existing approach and modified approach, (e): Variation of whole population modelled by the existing approach and modified approach, (f) Dynamics of the sex ratio, Male population: whole population

According to the ecological interpretations in [1],[2], existence of high female crocodile population confirms an optimal growth of the population. Dynamical evolution of sex ratio given in figure 1(f) indicates the steady state sex ratio (number of males: number of females) of existing approach, is between 0.410 and 0.095 where it is between 0.180 and 0.010 in our modified approach. In [3], this average sex ratio measured based on experimental data is given as 0.12. Comparing two approaches in this work, our modified approach has given the average sex ratio to be 0.095 where its value of the existing approach is 0.25. Therefore, our new approach has been capable of approximating more accurate sex ratio variation than the existing approach.

IV. Conclusions

The modified theoretical fraction of females who incubate in region (I), has been used to get an accurate approximation for the steady state sex ratio of a crocodile population under the influence of periodic floodings. The qualitative outlook of the results, indicates how the crocodile population growth is naturally regulated with floodings. Numerical simulations of the derived dynamical system confirmed that it is locally asymptotically stable and the long-term evolution of the population is independent of the initial conditions. The model will be improved as a stochastic model by incorporating the randomness in variation of floodings.

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Track 13

Agronomy & Biotechnology

Feasibility of Water Hyacinth (*Eichhornia crassipes*) for Potting Media of Dendrobium Orchids

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Abstract - Dendrobiums are often grown as cut flowers. Due to high economic potential, plants are mass propagated using tissue culture. Plants developed by tissue culture are required for maintenance in a plant house and potting media plays a major role in supporting growing plants. Often coconut husk pieces are used in combination with charcoal and brick pieces. This study was conducted to determine the suitability of Water hyacinth widely available in the dry zone as an ingredient in the potting media. Several combinations of potting media prepared using Water hyacinth, coconut husk pieces, charcoal, and brick pieces were tested for the *Dendrobium burana pearl srimahapho* variety in a completely randomized design with three replicates. Plant height was highest in potting media 1 (T1

- coconut husk, charcoal, and brick pieces as 2:1:1 – control) and potting media 4 (T4 - water hyacinth, charcoal, and brick pieces as 1:1:1), showed a progressive increase and differences were not significant between the two. The rest had lower plant heights than T1 and T4. The same treatments had the highest bulb formation, while T1, T4, and T5 (potting media with Water hyacinth chips and charcoal at 1:1) had the highest leaf formation. The number of roots was higher in T1, however, T6 which had only water hyacinth also had increased root production. This study confirmed the possibility of using Water hyacinth plant pieces to replace coconut husk in the potting media for maintaining orchid plants.

I. INTRODUCTION

Orchids are a group of plants in the family of *Orchidaceae* widely grown for cut flowers. Orchids, being an epiphyte are grown from sea level up to 500-600 m. It is grown commercially due to high demand from domestic and foreign markets. Mainly propagated by tissue culture. Small plants yielded from tissue culture in the laboratory under controlled conditions are required to acclimatize when transferring plantlets to plant houses. The potting mixture is crucial for the successful growth of small plants.

The potting media must effectively contribute toward higher production with a good water holding capacity, aeration, and supply of nutrients (Kaushal & Kumari, 2020). Hence a good quality growth media plays an important role in supporting orchid plants to achieve their vegetative growth and flowering (Kaushal & Kumari, 2020). There are already recommended potting media with different ingredients and ratios for orchid cultivation (Kaushal & Kumari, 2020). Coconut husk pieces, also known as coco chips are a commonly used ingredient in the potting media, and which is known for their ability to retain moisture and support root development. On the other hand, there are many plant materials that may be suitable for potting media in orchids as aerial roots need a substrate to grow on. Water hyacinth (*Eichhornia crassipes*) is widely and readily available in water environments.

Water hyacinth is considered an aquatic weed that often grows profusely in irrigation and drainage canals, lakes, and reservoirs and reduces storage and carrying capacities thus requiring it to be used for a productive purpose.

Due to high demand, prices of coconut husk have increased in the market, and orchid growers are required to incur a high cost for potting media. The stem of water hyacinth appeared fibrous and hence assumed to be able to fulfil certain requirements that are provided by coconut husks. As a result, water hyacinth could be used for partial or full replacement of coconut husk in potting media of orchids. The compost prepared from leaves, stems, and roots has been used as potting media in soilless culture (Fan et al., 2015). Therefore, this study attempted to evaluate the growth performances of Dendrobium orchids under different potting media composed of combinations of water hyacinth, coco husk, and other commonly used materials.

II. MATERIALS AND METHODS

The orchid variety *Dendrobium burana pearl srimahapho* was selected for the study. This study was conducted at Eppawala in the Anuradhapura district. Eight potting media prepared using some combinations of coco chips, charcoal pieces, roof tile pieces, and water hyacinth chips were tested for the selected orchid plants. Water hyacinth pieces were prepared by cutting into smaller pieces, then drying in the sun before using for media preparation. Potting media prepared as per the combinations shown in Table 1 were filled in ¾th of the depth of net pots. Fourteen-day-old tissue cultured orchid plants were purchased from 'Orchid Growers' Plant nursery in Kalutara. Initially, plants were transplanted in net pots of 5.3 cm in diameter and 5 cm in height and maintained in a net house. Each treatment had eight pots and was arranged in a completely randomized design (CRD) with three replicates. After two months, plants in the mentioned net pots were transferred to

larger pots of 13 cm in diameter and 9 cm in height and maintained for five months.

Table 1. Potting media prepared using different combinations of selected ingredients and used as experimental treatments

Treatment No.	Composition of potting mixture, parts			
	Coconut husk chips	Water hyacinth chips	Charcoal pieces	Brick pieces
T1 - Control	2	0	1	1
T2	1	1	1	1
T3	0	2	1	1
T4	0	1	1	1
T5	0	1	1	0
T6	0	1	0	0
T7	1	0	0	0
T8	1	0	1	1

Data were collected every other week commencing from the first week onward and continued until week 21. The data included plant height, number of bulbs, leaves, and roots formed, and the length and width of leaves produced during the period of observations.

Plant height, length, and width of leaves were analysed using analysis of variance, and means were separated using Fisher's Protected LSD when the treatment effect was significant at $p \leq 0.05$. Count data were analysed using non-parametric analyses.

III. RESULTS AND DISCUSSION

Plant Height of orchid plants

Mean plant height varied among the treatments from the beginning. Until 11 weeks, there was no noticeable change in the plant height of all treatments. Thereafter, there were noticeable variations in the plant height. T1 (coconut husk, charcoal, and brick pieces as 2:1:1 – control) and T4 (water hyacinth, charcoal, and brick pieces as 1:1:1), showed a progressive increase in plant height and differences were significant from the rest of the treatments.

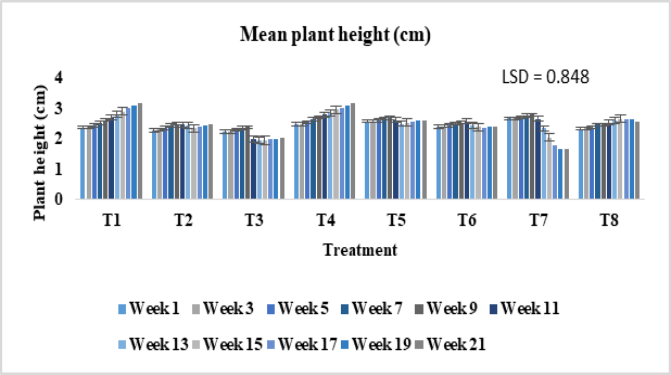

Figure 1. Bi-weekly plant height of orchid plants as influenced by the potting media.

T2 (coconut husk, water hyacinth, charcoal, and brick pieces as 1:1:1:1), T5 (Water hyacinth and charcoal only as 1:1), and T8 (coconut chips, charcoal, and brick pieces at 1:1:1) had similar trends but the plant heights were lower than T1 and T4. Treatments 2, 3, 5, 6, and 7 showed no increase in plant height, instead, there was a decrease after the seventh week. Treatment 1 is the control that had coconut husk had similar growth to plants in treatment 4 which had no coconut husk but Water hyacinth. This confirms the similar potential for the use of Water hyacinth in place of coconut husks.

Number of new bulbs

The number of new bulb formations did not take place in most of the treatments during the 5-month period. However, treatments 1 and 4 showed increasing the number of bulbs after 9 weeks after transplanting. Treatment 7 showed a decreasing number of bulbs after some time, indicating the deterioration of bulbs of orchids when only coconut chips (husk) were in the potting media.

Leaf number per plant

The highest production in terms of the leaf number was found in treatments 1, 4, and 5. Leaf number showed its increase after 13 weeks in treatments 1 and 4. The rest of the treatments showed a decrease in the leaf number. Although T5 (Water hyacinth chips and charcoal at 1:1) had a decrease in leaf number, the plants had the second highest leaf number among the treatments. This shows that Water hyacinth is not inferior in its support to orchid plants.

Root number per plant

The highest root number was in T1. Similar, but lower root production occurred in the rest of the treatments, except in T7 which had only coconut husk and showed a decline in root production after the ninth week. T6 which had only Water hyacinth pieces did show an increase in the root number. Therefore, Water hyacinth seems to be better in promoting root production of orchids.

IV. CONCLUSION

This study compared the potential of different ingredients for potting media to maintain tissue-cultured orchid plants in plant houses. Coconut husk pieces, air-dried water hyacinth stem, leaf pieces, charcoal, and brick pieces were tested with different combinations. The results confirmed the suitability of water hyacinth similar to coconut husk pieces and hence recommended to be used for full or partial replacement of coconut chips in potting media for orchids.

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Identification of Major Weed Types in Broadcasted Paddy Fields Using Multispectral UAV Images

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Abstract: Identification of major weeds categorized into grasses, sedges, and broad-leaf weeds, in broadcasted paddy fields using multispectral images from unmanned aerial vehicles (UAVs) was tested at the Rice Research and Development Institute, Bathalagoda, Sri Lanka, for site-specific weed management. The results from the image analysis showed that multispectral UAV images captured at 30 feet (approx. 9.1 m) height can be used to identify the three weed categories in paddy fields after generating weed maps using Pix4Dfields® software with the modified Excess Green Index. However, the grasses [e.g. *Echinochloa crus- galli* (L.) Beauv] and sedges (e.g. *Cyperus iria* L) were difficult to be differentiated from each other even though broad leaf weeds [e.g. *Monochoria vaginalis* (Sw.) Willd] could be identified separately using the maps. Therefore, further research is recommended.

Keywords: Weed species, Rice varieties, Multispectral UAV Images, PIX – 4D Field software

I. INTRODUCTION

Rice is the staple food of Sri Lankans and rice production needs to grow on par with the growing demand to safeguard food security. Weeds are one of the troublesome biotic threats to rice productivity. Different weed species and their relative densities equally contribute to the decrease in rice yields at the field level. Weeds in lowland paddy fields are traditionally controlled by adjusting the stagnant water levels. In the paddy production system, the longer presence of the weeds has resulted in a greater reduction in crop yield. Therefore, weed control becomes an important part of rice cultivation. Understanding the potential damage to a crop by weeds during the growing season is fundamental to the effective management of the crop [1].

The most common method of controlling weeds today is the application of herbicides, but this method reveals the potential risks to consumers as well as the environment especially when misused. The development of herbicide resistance in weeds is a major issue with the long-term use of herbicides with the same mode of action, making this tool ineffective and costly. Therefore, an integrated approach combining management practices, scientific knowledge, and new technological interventions like UAV multispectral drone technology may enable to reduce cost, save time, and improve the efficiency of weed control in a complex weed community found in cultivated paddy lands [2]. Recent research has shown the potential use of vegetative indices to identify weeds in paddy fields using UAV images [4]. Further strengthening such weed identification techniques will enhance the precision of site-specific and species-specific weed management programs in the paddy fields. This study was conducted to test whether multispectral UAV images could be used effectively to differentiate grasses, sedges, and broad leaf weeds in broadcasted paddy fields using a modern software platform.

II. METHODOLOGY

Field Establishment of Crops and Weeds

The study location was the Rice Research and Development Institute (RRDI), at Batalegoda, Sri Lanka, situated in the Low Country Intermediate Zone and the agro-ecological region IL1b. Location coordinates are N 7’ 31’ 47’’ E 80’ 26’ 23’’. Land preparation was done according to the recommended practices by the Department of Agriculture (DOA) and the plots at a size of 18 m^2 was established with rice-only, weed-only, and rice + weeds. Two new improved 3.5 months varieties (At362 and Bg352), and a traditional variety (Pacchaperumal) were selected for the study. Three most prominent weed species in broadcasted paddy fields namely, a grass - *Echinochloa crusgalli* (L.) Beauv, sedge - *Cyperus iria* L. and broadleaf - *Monochoria vaginalis* (Sw.) Willd was used as the test weed species. Each plot was planted with one rice variety, one weed species, and one combination of rice variety + weed species. The fertilizer application was done according to the DOA recommendations. Weeds emerging in each plot, other than the species tested, were removed either manually or using herbicides based on their selectivity.

A. Image Analysis and Statistical Analysis

The DJI P4 Multispectral Agricultural Drone® with six special cameras was used to collect UAV images. The multispectral camera comprised 1 RGB camera and five cameras covering blue, green, red, red-edge, and near-infrared bands - all on a 3-axis, stable gimbal with a 2 MP global shutter. Multispectral drone images were obtained from the first week after sowing to the 14th week every other day. Images were obtained from three heights: 25 feet (7.6 m), 30 feet (9.1 m), and 40 feet (12.2 m). The NDVI and Modified Excess Green Index [4] were used to generate weed maps using Pix4Dfields® version 1.10.1, a commercial software that is used to analyze UAV images using vegetative indices (NDVI, Excess Green Index, etc.).

III. RESULTS AND DISCUSSION

The results showed that images captured from 9.1 m height showed a better visualization compared to that acquired from 7.6 m. Wind effect also disturbed the image quality if obtained from the drone flown at 7.6 m height. The image quality did not differ when the drone was flown at heights of 7.6 m or 12.2 m. The thermal view provided better visualization of rice plants (verified after ground truthing) in red colour and weeds were indicated in red-yellow colour (Figure 1). *Monochoria vaginalis* (broadleaf weed) could be differentiated from its shape and red-yellow colour (Figure 2). However, grasses and sedges were difficult to be differentiated from each other even though broad leaf weeds could be identified separately using the maps. Therefore, the vegetative index-based image analysis facilitated by FiX4D software is not adequate to produce precise weed maps.

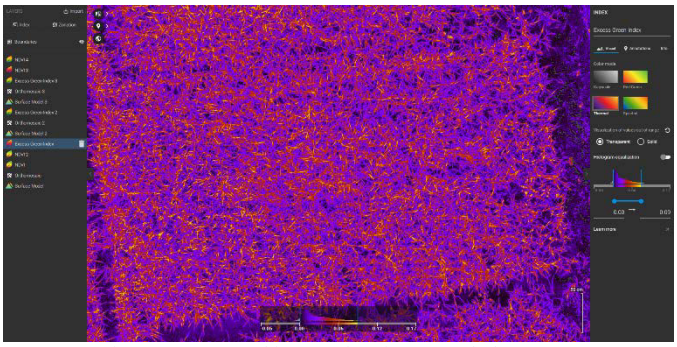

Figure 1: Processed image of a Rice + weed plot

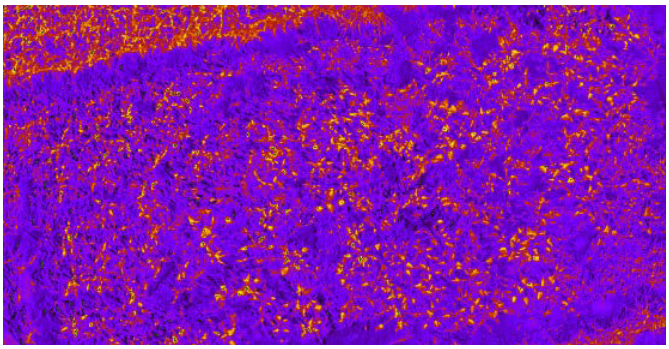

Figure 2: Processed image of Weed only plot: *Monochoria vaginalis*

IV. CONCLUSION

The use of UAVs can increase the sustainability of weed management by accurately identifying major weed types separately in the crop fields. The vegetative index-based image analysis using Fix4D commercial software was not adequate to map different weed species available in broadcasted paddy fields even though weed could be partially differentiated from rice. There is a need to have a software platform developed to suit local conditions that can be used for UAV image processing with a semantic segmentation-like deep learning approach to enhance the precision of weed identification in lowland paddy fields in Sri Lanka.

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Evaluation of Nitrogen Leaching Losses from Leafy Red Onion Cultivation Under Growers' Practice of Fertilizer in Kalpitiya

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Abstract - Loss of Nitrogen due to leaching has become not only a critical problem in agriculture, but also a major environmental and health problem in Sri Lanka. Nitrogen (N) is the most dynamic nutrient which leads to a rapid downward movement in soil in the forms of nitrate (NO_3^-) and ammonium (NH_4^+). Sandy Regosol (WRB, FAO legend: Haplic Arenosols) is the dominant soil type in Kalpitiya, where vegetable cultivation is intensively practiced. Red onion is a major short-term crop widely cultivated in Kalpitiya with excessive use of fertilizer. A Promising problem in red onion cultivation is the leaching of nutrients, especially N, since this crop is mostly grown in sandy textured soils. This study was conducted to evaluate the contribution from red onion grown in Kalpitiya to contaminate groundwater through N leaching under the management practices of growers. The leached NO_3^- throughout the season was 338.48 kg/ha whereas leached NH_4^+ throughout the season was 4.68 kg/ha. The concentration of NO_3- in leachate fluctuates over the growing season and NO_3^- in leachate was ranged from 35.1 mg/L - 160 mg/L which was higher than the WHO permissible level of NO_3^- (50 mg/L) for drinking water in most sampling events. According to the results, 422.62 g of applied N was leached per 100 kg of leafy red onion harvested from the growers' practices of fertilizer. The nitrogen leaching percentage during the season was 81.87% according to the grower managed fertilizer practice. This is mainly due to the intermittent application of nitrogenous fertilizer throughout the season. These findings highlight the need for a novel fertilizer management approach for reducing nitrogen leaching in red onion cultivation in Kalpitiya peninsula.

Keywords: Groundwater, Nitrate leaching, Sandy Regosol

I. Introduction

Intensive agricultural practices in Kalpitiya have caused excessive usage of fertilizers. The excessive permeability sandy Regosol soil and the over irrigation due to the presence of semi-arid climatic conditions in the area have a greater impact on groundwater quality in Kalpitiya. Red onion is one of the most widely grown cash crops in Kalpitiya which is highly responsive to fertilizer. Onion demands a high level of nutrients, often requires the supply of soluble fertilizers [1]. However, higher doses of applied inorganic fertilizer alone generates several deleterious effects on the environment and human health. It should be replenished in every growing season because inorganic fertilizers are rapidly lost by either volatilization or leaching in drainage water and it causes dangerous environmental pollution by NO_3^- accumulation in underground water [2]. Farmers in the Kalpitiya area add an excessive amount of chemical fertilizers expecting higher yield from the low fertile sandy soil. Since 1990s, the groundwater aquifers in Kalpitiya remain contaminated with higher levels of nitrate due to intensive agricultural practices and the nitrate pollution in Kalpitiya area is considerably higher than the other agricultural areas of the country [3]. Therefore, this study was conducted to evaluate the contribution from red onion grown in Kalpitiya to contaminate groundwater through N leaching under the fertilizer management practices of growers.

II. Materials And Methods

This study was carried out in Kandakuliya agricultural land in Kalpitiya from 2020 to 2021. Lysimeters covering a 0.28 m^2 land area by each was installed 90 cm below in the 7.2 m^2 plots before planting of Jaffna Local variety. Fertilizer was applied according to the grower practice which was five split applications of urea at 100 kg/ha, Triple super phosphate at 250 kg/ha, onion fertilizer (N:P:K-12:9:9) at 125 kg/ha, blue granules (N:P:K-12:12:17) at 62.5 kg/ha and calcium nitrate at 62.5 kg/ha in ten days intervals. This was replicated three times in 7.2 m^2 plots. Irrigation was done twice a day and leachate samples of each replicate was collected from lysimeters at weekly intervals and leached volume was measured. The NO_3^- and NH_4^+concentrations of collected leachate were analysed using ion selective electrodes (CPI 505, Elmetron, Poland). Applied irrigation water volume and its NO_3^- and NH_4^+concentrations were also measured. Both fertilizer and irrigated water were considered as input source of nitrogen and total N input was calculated. The Leafy red onion harvest was recorded 48 days after planting.

III. Results And Discussion

The concentration of NO_3^- and NH_4^+in irrigated water were 6.88 ppm and 1.80 ppm respectively. The concentration of NO_3^- in leachate was ranged from 35.1 mg/L - 160 mg/L. The nitrate concentration in the leachate was higher than the WHO permissible level of NO_3^- (50 mg/L) for drinking water in all samplings except 1st and last week (Fig. 1). The leached NO_3^-throughout the season was 338.48 kg/ha whereas leached NH_4^+ throughout the season was 4.68 kg/ha. The leached nitrogen percentage was calculated by dividing the leached nitrogen amount by total input nitrogen. The total input N amount was 97.8 kg/ha during the season. It was found that 81.87% of applied N has been lost throughout the season. Intermittent application of nitrogenous fertilizer may cause for the high N leaching throughout the growing season.

According to the calculation, 422.62 g of applied N was leached per 100 kg of leafy red onion harvested according to the growers' practices of fertilizer management.

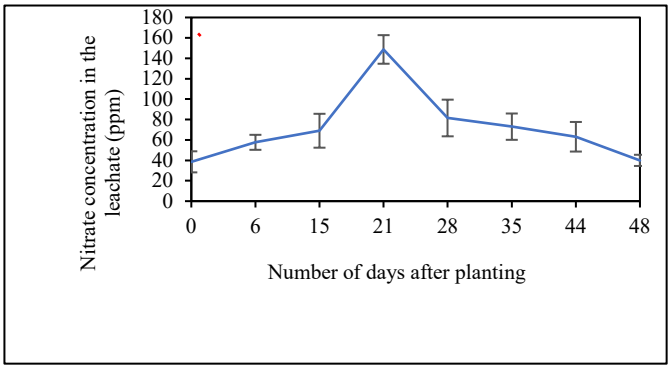

Fig.1 Variation of average nitrate concentration throughout the cropping season

IV. Conclusion

Results of this study reveal that the concentration of nitrate in leachate is substantially higher in the red onion cultivated land of Kalpitiya peninsula. The over application of nitrogen fertilizer along with frequent irrigation caused higher levels of nitrate leaching. This concludes the need for a novel fertilizer management approach for reducing nitrogen leaching in this red onion cultivation system. It also highlights the necessity of adequate treatment of groundwater that removes excess nitrate prior to use for drinking purposes.

Acknowledgement

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Effect of Organic and Inorganic Fertilizers and their Combinations on the Growth and Productivity of Groundnut

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Abstract – Ground is a legume capable of utilizing atmospheric nitrogen (N_2) to fulfill its N requirement. Supplementation of N using inorganic fertilizers may hinder the capacity of N fixation, thus the crop may have to depend on inorganic N fertilizers. On the other hand, well-structured soil may help in improving N fixation and hence growth and development and yield of groundnut. This study tested two field preparation methods (main plots), three combinations of inorganic and organic fertilizers (subplots), and two groundnut varieties (sub-sub plots) in a split-split plot design with three replications at the Grain Legume and Oil Crops Research and Development Centre, Angunukolapelessa in the Hambantota District of the Southern Province of Sri Lanka. The results revealed that land preparation methods had significant effects ($p \leq 0.05$) on total pod weight and the total seed weight, where the ridge and furrow method showed higher values compared to the flatbed method. Three fertilizer combinations had no significant effect ($p \geq 0.05$) on the plant height, canopy width, the number of days to flowering and peg formation, total pod yield, total seed weight, as well as seed filling percentage. The varietal effect was significant ($p \leq 0.05$) for the days to cover the ground, and the canopy width, total pod yield, and seed filling percentage, where the variety Lanka Jambo outyielded the variety, Tissa. This study suggested that the organic fertilizer with inorganic amendments gave similar results compared to the use of inorganic fertilizer only. Further studies are suggested before making recommendations.

Keywords: Groundnut, Yield, Inorganic fertilizer, Organic fertilizer

I. INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is a popular legume with high contents of edible oil, protein, fats, energy, minerals, and vitamins. Groundnut is mostly cultivated for seeds for human consumption in Sri Lanka. Department of Agriculture, Sri Lanka has released eight groundnut varieties, of which five varieties namely, Tissa, ANKG1, ANKG2 (Lanka Jumbo), ANKG3, and ANKG4 are the cultivated varieties in different agroecological conditions at present. Being a legume, nitrogen fixation mainly provides nitrogen (N) to satisfy the N requirement of the crop. However, the use of N fertilizer, especially urea, has been a practice to supply N to the groundnut, like other short-term leguminous crops. Due to the recent economic crisis and the banned importation of inorganic fertilizers to the country, the application of urea and other recommended fertilizers became impractical and was a critical issue for agricultural production in the country. Hence, there has been a need for finding out alternatives to manage the supply of N and other essential nutrients to promote the cultivation of groundnuts in Sri Lanka.

To facilitate N fixation, promoting atmospheric N to pass to the root environment where nodules are located is a vital requirement. Planting bed preparation [1], use of compost to improve soil structure and supply nutrients [2], and use of gypsum to promote soil aggregation and plant availability of Ca [3] are measures for promoting N availability to root nodules. Due to low availability of nutrients in compost [4], a combination of different sources of nutrients and the soil and planting bed preparation may be required to ensure a favourable soil environment and adequate nutrient requirements for maintaining the productivity of groundnut. Therefore, this study assesses the effect of field preparation method, fertilizer type, and variety on ground nut productivity.

II. MATERIALS AND METHODS

The experiment was conducted during the 2021/22 *Maha* season at the Grain Legume and Oil Crops Research and Development Centre, Angunukolapelessa (DL_{1b}) in the Hambantota District of the Southern Province of Sri Lanka. A 2 x 3 x 2 factorial experiment was arranged in a split-split plot design using two types of planting beds (P), viz. flatbeds, ridge-and-furrows assigned to main plots, and three combinations of fertilizers [viz. F1: 16, 20, and 37.5 kg/ha of N, P, and K, respectively as Urea, Triple Super Phosphate, and Muriate of Potash, followed by 14 kg N as Urea at flowering (DOA recommendation); F2: 6.4 t/ha of compost as basal dressing followed by 35 kg/ha Ca as Gypsum (28 kg S) at flowering; F3: 6.4 t/ha of compost as basal dressing followed by 35 kg/ha Ca as Gypsum (28 kg S) and 4.4 kg/ha of K as MOP at flowering)] assigned to subplots and two popular groundnut varieties, viz. *Tissa* and *Lanka Jambo* assigned to sub-sub plots were tested. All treatments were arranged with three replicates. All the treatments and selected levels were randomly allocated to experimental plots.

As observations, growth and yield characters were recorded. Both the canopy width and plant height were recorded at 50% flowering. At harvest, total pod yield, total seed weight, and percent filled seeds were recorded. In addition, the number of days to flowering and peg formation was recorded. Data were statistically analyzed using ANOVA and the means were separated using Fisher's protected LSD [5].

III. RESULTS AND DISCUSSION

Phenological stages

The effects of factors on the time to reach a specific growth stage were significantly influenced by fertility management and the variety. The time to ground cover formation was shortened in the treatment that had the DOA-recommended fertilizers (F1), while Compost + Gypsum + KCl (F3) received plots had taken non-significantly a longer time (three days). Compost followed by Gypsum and KCl at flowering took five more days to reach the ground cover compared to the DOA-recommended synthetic fertilizer treatment. Vegetative growth of the variety Lanka Jumbo in the early stages was significantly lower than the variety Tissa.

Growth Characteristics

Plant height, canopy width, and the number of branches per plant at 50% flowering were significantly greater in the Tissa variety than in Lanka Jumbo. On the other hand, plant height was significantly greater in the DOA-recommended fertility management practice than compost + gypsum + KCl combination, but the compost + gypsum combination showed a non-significantly lower plant height than the DOA recommended fertilization.

Yield of groundnut

Total pod yield was significantly influenced by the type of plots and the variety. Ridge and furrows (2040 kg/ha) outyielded flatbeds (1694 kg/ha). Of the two varieties, Lanka Jumbo gave a significantly greater pod yield (2153 kg/ha) than Tissa. Total seed weight was significantly greater in ridge and furrows (1682.6 kg/ha) compared to flatbeds (1273.8 kg/ha). The percentage of filled seeds was greater in the variety Tissa (72.83%) than in Lanka Jumbo. However, the total seed yield was non-significantly greater in Lanka Jumbo (1595.2 kg/ha) than in Tissa (1361.3 kg/ha). This indicates fertilizer treatments had no significant effects on pod yield and seed yield as well as seed filling percentage.

Table 1. Effects of plot type, fertility management, and variety on total pod yield, total seed yield, and the percentage of filled seeds of groundnut.

Treatment 1/	Total Pod Yield kg/ha 2/	Total seed Weight kg/ha	Filled seeds %
Type of plots (P)			
Ridge & Furrow	2040 a	1683 a	70.83 a
Flatbeds	1695 b	1274 b	65.00 a
LSD (p<0.05)	322	280	ns
Fertility management (F)			
F1 -Urea +MOP + TSP	1788 a	1399 a	68.08 a
F2 - Compost + CaSO4	1847 a	1369 a	65.66 a
F3 - Compost + CaSO4 + KCl	1968 a	1667 a	70.00 a
LSD (p<0.05)	ns	ns	ns
Peanut Variety (V)			
Tissa	1582 b	1361 a	72.83 a
Lanka Jumbo	2153 a	1595 a	63.00 b
LSD (p<0.05)	323	ns	9.71
CV%	23.79	26.06	19.68

Legend: 1/ LSD - Least significant difference; MOP – Muriate of potash. TSP – Triple super phosphate; $CaSO_4$ – Calcium Sulphate (Gypsum); KCL – Potassium Chloride; CV – Coefficient of variability.
2/ Values within a column followed by the same letter are not significantly different at $p \leq 0.05$.

IV. CONCLUSION

Groundnuts performed better in ridge and furrow-type plots than in flatbed-type plots during the *Maha* season. Although different growth characteristics showed different effects between the two varieties, Lanka Jumbo had inherently higher pod and seed yields than the variety of Tissa. The results confirmed that the use of compost together with inorganic amendments helps maintain the crop growth and the yield of groundnuts similar to the DOA-recommended synthetic fertilizer.

Acknowledgment

The authors acknowledge the financial and logistical support provided by the Department of Agriculture, Sri Lanka.

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Study on the Low-Cost Methods for Tissue Culture Applications in Orchid

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Abstract - Orchid is one of the most important cut flowers, grown in Sri Lanka. Quality raw material supply is a key success for orchid cultivation and scarcity leads to major concern in sustainable growth of the industry in a long run. Mass cultivation by micro propagation techniques can be successfully used to mass propagation of orchids; thus, cost benefit is less due to the high cost. Aim of this research was to replacement of expensive agar with low-cost substance for *in vitro* sub culturing of Cattalya seedlings. Two-month-old Cattleya seedlings were subcultures on Murashige and Skoog media (MS) as basal media. As gelling agents' sago, semolina, corn flour, semolina + agar, corn flour + agar was used. Used agar as the control treatment. Cultures were maintained inside the culture room. Number of leaves, Number of roots, Leaf length, leaf width and percentage of contaminations were recorded at four-week intervals. Sago and semolina + agar showed higher performance and low contamination percentage as alternative gelling agent in the MS media. The results of this study propose that sago, semolina, and corn flour can be used as an alternative gelling agent in MS media. This low-cost method might be uplift the orchid culture in Sri Lanka.

Keywords: Alternative gelling agent, Alternative water source, Orchid subculture

I. INTRODUCTION

Orchid is very popular and widely used as a decorative garden plant, cut flower and as a potted plant. It is most important and popular cut flower in the world. It has different colors and color combinations which attract the beauty of the flower as unique. Since orchid flower has a long life as an ornamental flower leads to high market share in cut flower industry.

Commercial grown orchid varieties are produced by cross pollination, and they are multiplied by micro propagation for commercial market. The development of in vitro method has vastly improved the germination of orchid seeds and accelerates the production of orchid plants. Introduction of the tissue culture technology is useful to produce high quality planting material all over the world [1]. Recently the orchid industry is expanding with tissue culture technology.

Agar is the most widely used gelling agent for the preparation of solid and semi-solid media [2]. This contributes to matrix potential, humidity, and affects the availability of water and dissolved substances within the culture vessel. Research results have shown that sago, semolina, corn, wheat, laundry starch, rice and potato flour can be used as agar substitutes [3, 4]. This study is focused on, to evaluate the effect of alternative media components and development of Cattleya seedlings in Sri Lankan context.

II. MATERIALS AND METHODS

MS media was prepared as basal media. Control experiments were performed on 7 g/l agar using different concentrations of different gelling agents to solidify the medium. Distilled water was used as the water source. pH was adjusted into the range of 5.6-5.80. Solution was heated by using gas cooker. When the nutrient solution was boiling, gelling agent was dissolved by thoroughly stirring. The media was poured into sterilized empty jam bottles covered it by cellophane film. 45ml of media was poured into each bottle, and media height was about 1.5cm. Finally, the media was autoclaved under 121°C and 1.5kg/cm^2 for 20 minutes.

Table 1. Different gelling agents and their weight for treatments in MS media

Treatment	Agar (g)	Sago (g)	Semolina (g)	Corn flour (g)
T1	7			
T2		120		
T3			90	
T4				90
T5	3.5		45	
T6	3.5			45

Mature old leaves of two-month-old *in vitro* cultured seedlings were cut and removed. using sterilized tools under laminar flow cabinet seedlings were established on different gelling agent media bottles by using forceps. Four seedlings were planted in one jam bottle. The culture bottles were sealed well with cellophane films and maintained in an air-conditioned growth room at 26 ± 2 °C, 25 % RH and under fluorescent illumination with 16-hour photoperiod. After about 4 weeks (at this point plants were well established in the medium) the established plants were transferred to a same media after recording the plant growth parameters. They were also maintained under the same conditions as described.

Each treatment was consisting of 10 replicates and there were four seedlings per one experimental unit. All the seedlings were uprooted carefully from the culture media and kept on the petri plate. Then numbers of root, number of leaves were counted. Leaf length and leaf width were measured using 1mm graph paper attached on the bottom of petri plate.

Data were recorded at intervals of 4 weeks to 3 months. Experiments were organized as a fully randomized design with 10 replicates. Data were analyzed using the SAS software package and significant differences between treatments were identified using his ANOVA procedure at the 5% probability level. Mean separation was performed using Duncan's multi-interval test.

III. RESULTS AND DISCUSSION

When using sago as a gelling agent no significant difference was not observed in growth parameters compared with control (agar). The contamination occurred in sago medium was 13%. Semolina treated medium was not significantly affected on the growth parameters, except leaf length when comparing with control. Leaf length showed the lowest significant difference compared with agar medium. Also, the contamination percentage is quite higher than in other medium. It was 20% contamination occurred in semolina medium.

Corn flour treated medium was not significantly affected on growth parameters except number of leaf & leaf length, when compared with agar medium. Number of leaf and leaf length showed lowest significant difference compared with agar medium. The contamination percentage was 12% in corn flour medium. Semolina and agar medium was not significantly affected on all growth parameters, when compared with control. The contamination percentage was 13 %. Corn flour and agar mixture of gelling agent also not significantly affected on growth parameters except for number of leaves compared with control. Number of leaves showed lowest significant difference compared with control, while making the contamination percentage is 11% in this medium.

IV. Results and Discussion

According to the results it can be concluded that agar can be replaced with Sago and Agar + Semolina as gelling agent in MS media.

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Posters

Design of a Higher Order Modulator/ Demodulator for VLC by Combining ASK and FSK

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Abstract - Visible light communication is a famous data communications variant which uses visible light between 380nm and 750nm. Here, the modulation used is a form in which the light signal varies in order to represent various symbols of a message signal. In order to achieve higher order modulation; in frequency shift keying, the number of frequencies are required to be increased and in amplitude shift keying, the number of amplitude levels are needed to be increased. In this paper, a new higher order modulator is proposed by combining the above modulation schemes which can be used in visible light communication. The proposed model is expected to reduce bit error rates at any given signal to noise ratios targeting better quality of service. The performance of the proposed model is validated through the simulations.

Keywords: Amplitude shift keying, Bit error rate, Frequency shift keying, Modulation, Signal to noise ratio, Visible light communication

I. INTRODUCTION

Modulation is the process of encoding information from a message signal in a way that is suitable for transmission. Modulations in visible light communication (VLC), are the forms in which the light signal varies in order to represent various symbols of the message signal. Quadratic amplitude modulation (QAM) is identified as a higher order modulation scheme with good performance [1]. It can be considered as a combination of amplitude shift keying (ASK) and phase shift keying (PSK) modulations. But such modulation schemes are ideally not to be used in VLC as they need accurate detection of the phasor. Hence, ASK and frequency shift keying (FSK) [2] would be the modulation options that can be used for such communications.

Bit error rate (BER) is a critical parameter for evaluating systems that transmit message information from one place to another. Signal to noise ratio (SNR) is a well-known measure of how the signal and noise power compare. It has a direct impact on a system's error probability and performance. The combination of ASK and FSK modulations together to prove that it has a reasonably low BER relative to SNR [3-5].

II. METHODOLOGY

We have used two methods to measure the performance of this new modulation scheme. BER of the new modulation scheme has been found by theoretical calculations and MATLAB simulations are done to determine the BER relative to SNR of ASK/FSK modulation.

The below model shows the physical implementation of combined ASK/ FSK modulator and demodulator.

A. System Model

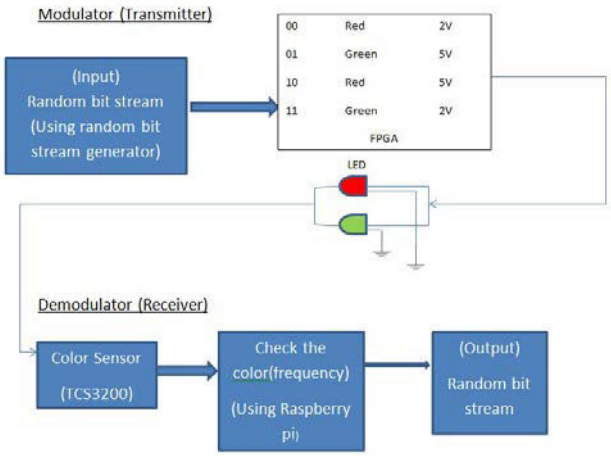

Fig. 1 System implementation of combining ASK/FSK

Two frequencies and two amplitudes are used in this system. The two frequencies are red and green respectively. And the amplitudes are assigned as 5V and 2V. In the transmitter's side, a random bit stream is input to a programmable device (FPGA/ Raspberry pi) and then two bits at a time will be considered according to the table below,

Table 1: Symbol assigning for LEDs

Symbol	Colour of LED	Amplitude
10	G	A1
11	G	A2
00	R	A1
01	R	A2

According to Table 1, the symbol assignment of LEDs and respective amplitudes can be identified, as an example, if the received symbol is 01, then the red LED will on with a voltage of 2V.

In the demodulator's side, the received colour intensities will be identified using a TCS3200 colour sensor and a programmable device, and it will be decoded back to a bit stream. This output bit stream is expected to have a less number of errors.

B. BER Analysis

Here, both the signals of ASK and FSK have been combined to achieve four different coding levels. The resultant message signal of the combined ASK/FSK would be then

00 – $A_1 \cos(2\pi f_1 t)$

01 – $A_1 \cos(2\pi f_2 t)$

10 – $A_2 \cos(2\pi f_1 t)$

11 – $A_2 \cos(2\pi f_2 t)$

Accordingly, the basis functions (ϕ) were evaluated using the Gram-Schmidt orthogonalization process, for M=4, N<= 4 where M refers to the number of signals and N for number of basis functions.

Assume that f_1 and f_2 are sets of orthogonal frequencies.

$$\Phi_1 = \frac{\sqrt{2}}{Tb} cos\ (2\pi f_1 t)$$

$$\Phi_2 = \frac{\sqrt{2}}{Tb} cos\ (2\pi f_2 t)$$

C. BER simulation.

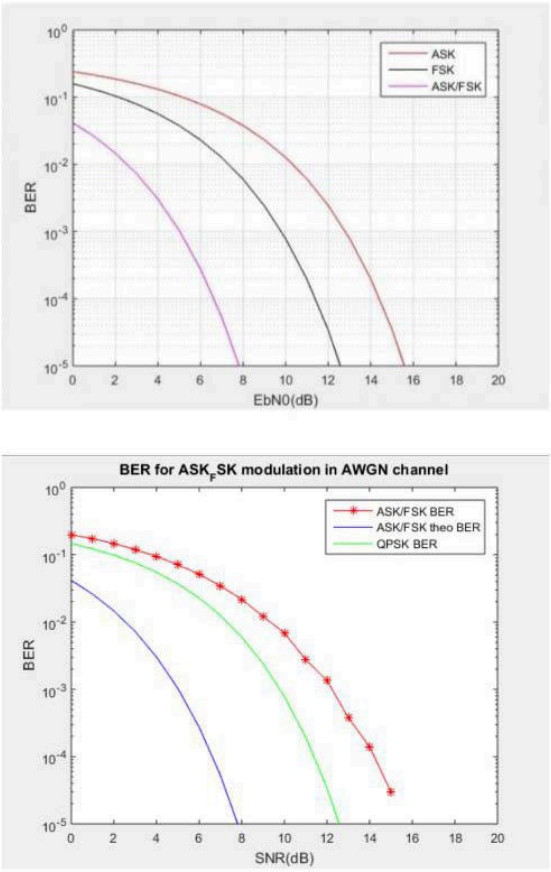

Fig. 2 BER comparison of ASK, FSK, QPSK and ASK/FSK

III. RESULTS AND DISCUSSIONS

The BER relative to SNR in AWGN channel are plotted in figure 2. According to above figure 2, 1st graph, we can observe that SNR (E_bN_0) vs BER curve of ASK modulation is on top of the graph and below that, the curve of SNR vs BER graph of FSK modulation can be observed. From these observations, it is clear that the BER is lower and efficiency of FSK modulation is greater than efficiency of ASK modulation which has a high BER because error probability of ASK is high according to Figure 1.

In this research, our aim was to combine ASK modulation and FSK modulation and to prove that the combination is more efficient. Hence, we can observe the curve of SNR vs BER of ASK/FSK modulation is underneath ASK and FSK curves. We can identify that ASK/FSK modulation has higher efficiency than FSK modulation because error probability is less in its modulation according to the graph. As a summary, when considering the BER of the three modulation schemes, it can be seen that, *ASK < FSK < ASK/FSK.*

According to the 2nd graph we have compared the theoretical and simulation results of QPSK and combined ASK/FSK modulation. QPSK's theoretical BER shows lesser performance than ASK/ FSK theoretical BER performance, but since it cannot be adapted into VLC, it can be observed that combined ASK/FSK might be a better solution. Accordingly, we have proved that combined ASK/FSK modulation has a low BER and has a better performance for VLC.

IV. CONCLUSION

BER performance of the proposed modulation scheme for VLC is evaluated and verified with the simulation. According to the simulations, combined ASK/FSK digital modulation scheme shows better performance compared to individual modulations. In future, the physical implementation of the modulator and demodulator of combined ASK/ FSK modulation will be done and the practical BER will be compared with the simulated BER.

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Sri Lankan Sign Language Detection Using Machine Learning

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***Abstract*—Sign language detection is a way of communication for deaf people to share their thoughts with others. From the recent survey, it is noted that there are over three hundred thousand deaf people in Sri Lanka. Approximately 9% of the population in Sri Lanka has a loss of hearing. Conveying their ideas and emotions to normal people is the real challenge for deaf people. Therefore, we propose a real-time Sign Language Recognition system using machine learning and further implement hardware for effective communication of deaf people. In this proposed method, we included gestures, numbers, alphabets, and other words in sign language. In the modern world, convolutional neural networks (CNN) are widely used in the modern world for various purposes. We have also used CNN to recognize sign language gestures in our project. There'll be a robotic arm in the hardware implementation part, and it can show letters and numbers by hand, so it creates a system for two-way communication.**

Keywords **CNN-Convolutional Neural Network, Open Pose, YOLO V5**

I. Introduction

Sign language is a visual language using hands, gestures, and facial expressions, especially used by deaf and muted people. There are some references to ancient Greek people who also used hand gestures in the 5th century BC. People have used sign language for a long time. There are many sign languages in the world, like American, Indian, Japanese, Russian, etc. [1] sign language detection systems have been developed to provide a communication medium for normal and deaf people in recent years.

In this system, we are proposing a Sri Lankan Sign Language interpreter. Here we are planning to implement the system using multiple gestures and single-frame sign languages. The external camera of the interpreter captures the poses and sends them to a raspberry pi. The frames of that captured video will be processed. With this, we can implement a fast and accurate interpreter. During that time, words will display on the monitor for the captured signs and gestures. Our system has a robotic arm for making short replies for deaf people. It can show the alphabet and numbers. Our model will work in real-time. So, using this, we can implement a fast and accurate interpreter.

II. System Model

A. Sign Language Interpreter

This block diagram shows how our proposed sign language interpreter works. When a deaf person inputs his/her sign language to our system through the camera, it'll be given in text form. So the normal person can easily understand what the deaf speaker is trying to convey.

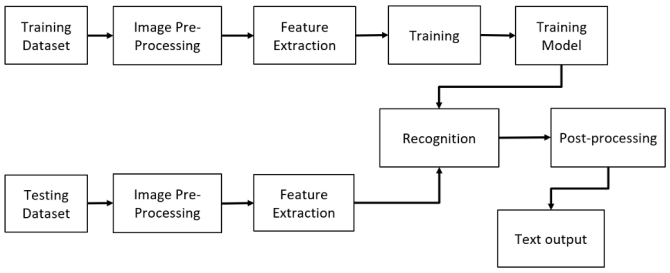

Fig. 1. Block diagram of Sign language interpreter

B. Robot Arm

This block diagram shows how the normal user conveys his or her ideas to a deaf person. For example, through the interpreter, a normal user understood what the deaf person was trying to convey, so he needed to reply back using sign language. So if the normal person types what he needs to convey, the robot arm will perform the required action for the text.

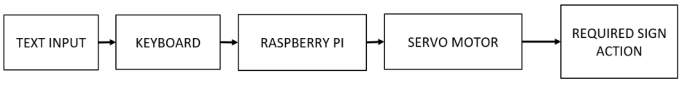

Fig. 2. Block diagram of Robot Arm

III. Related Work on Literature

- In [1] use image or video processing techniques,2-D Vision-based techniques and-D Vision-based techniques, and Convolutional Neural Network (CNN).which is used to create a model named signet, which can recognize signs, based on supervised learning of data. this system

has a high accuracy of 98.64 % under a variable scale. They use a skin-colour segmentation algorithm to detect the face of the signer and then eliminate it by replacing it with black pixels, the largest connected component algorithm for hand region segmentation; and the Viola-Jones face detection algorithm. This system can recognize 26 alphabets, 500 signs, dynamic signs, 20 gestures, and numbers. static alphabets with a training accuracy of 99.93% and a testing and validation accuracy of 98.64%. However, this system was not a fully automated sign language recognition system.

- [2] proposed a complete skeleton of an isolated video-based Indian Sign Language Recognition System. This system includes image processing techniques and computational intelligence techniques in order to deal with sentence recognition, and computational intelligence techniques in order to deal with sentence recognition. Features generated using these techniques make the feature vector unique for a particular gesture. Using vision-based systems for image processing, the fusion algorithm is used to extract edges and use Otsu's algorithm to result in an edged image. It has 96% accuracy rate. [2] developed a system for recognizing a subset of the Indian sign language, including gestures as well. but it's not a real-time regeneration system.
- [3] proposed digital image processing techniques and artificial neural networks for recognizing different signs. [3] uses image processing techniques and artificial neural networks to recognize different signs. This technique is used for extracting features and recognizing signs. Classification is done using a subtractive clustering algorithm and a fuzzy inference system. This system automatically identifies fingerspelling in Indian sign language. but it can not find two-handed signs and gestures

IV. Machine Learning approach

Software applications can become more accurate at predicting outcomes through machine learning, which is a type of artificial intelligence (AI). So authors are using machine learning in the system to get efficient output. The goal of machine learning algorithms is to construct a model from sample data, also known as training data, so that it can make predictions or decisions without being explicitly programmed.

A. Dataset collection

For this project, the authors created their own data set for the Sri Lankan sign language. It includes Tamil alphabets, Sinhala alphabets, English alphabets, 0 to 9 numbers, and frequently used gestures by deaf people. For the YOLO V5 training created your own videos and extract those into frames. For the open pose training created gesture videos. in the gesture videos, 4 people acted sign gestures.Figure 3 describes the sample datasets. After collecting raw images as datasets, the authors started preprocessing and augmentation. They used Flip in augmentation because both signers are right-handed. So there is a requirement for the left-signers.

NUMBERS DETECTION	SINHALA	TAMIL	ENGLISH
3602 Source images	5601 Source images	4548 Source images	8433 Source images
Almost 400 images per class	Almost 466 images per class	Almost 379 images per class	Almost 320 images per class
Auto-Orient and Resize 416x416	Auto-Orient and Resize 416x416	Auto-Orient and Resize 416x416	Auto-Orient and Resize 416x416
Flip(H&V), Brightness	Flip(H&V), Brightness	Flip(H&V), Brightness	Flip(H&V), Brightness
Total 8219 images	Total 9248 images	Total 9646 images	Total 14128 images
Training 7154 images	Training 7555 images	Training 7845 images	Training 11654 images
Testing 344 images	Testing 547 images	Testing 634 images	Testing 834 images
Validation 721 images	Validation 1146 images	Validation 1167 images	Validation 1640 images

Fig. 3. Datasets analysis of Project

but the authors managed with augmentation techniques. After finishing augmentation and preprocessing, the dataset doubled in size. Later, the datasets are divided for training, validation, and testing with a ratio of 7:2:1.

B. Training

Yolo is used for object detection. YOLO is a type of CNN algorithm. Following figure shows how CNN algorithms work on this project. The first convolution layer simplified this complex image. The filtering process happens in this layer. The next layer is the pooling layer. This layer makes the process much faster and it creates a pooled feature map. After that, the upcoming layers extract small features like hand positions, finger positions, angles between toes, etc. So the output will be highly accurate. The final layer is the Yolo layer. This layer generates predictions from anchor fields for feature detection. High frame rate and low training time are the best advantages of Yolo.

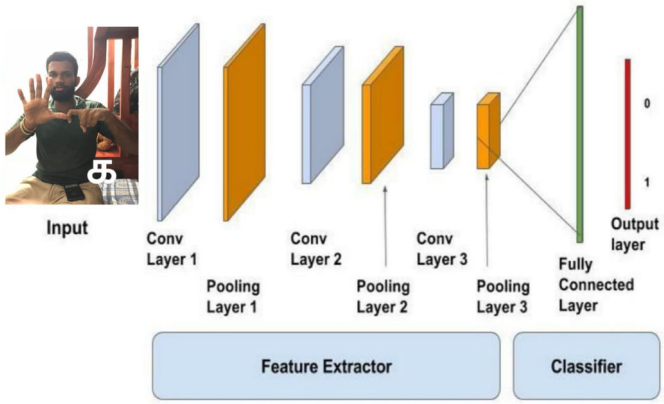

Fig. 4. CNN Architecture

Training a model simply means Learning (determining) appropriate values for all weights and biases from labelled examples Raw data is labelled by Robo Flow software. Because supervised machine learning is used in this part. A minimum of 100 inputs is needed for the CNN algorithm. In this project, 600 to 800 photos are put as input for one sign because it gets a more efficient output. All label data will be trained using YOLOv5 and gestures will be trained by open pose. Yolov5

is a kind of CNN algorithm. It can detect objects in real time with great accuracy. An open pose detects human body poses such as facial and hand movements. So, in this research paper, YOLO V5 and Open Pose are used for training.

V. Results analysis

The sign language will be detected and extracted, as will hand positions and shapes. The detected shapes or hand positions will be sketched and merged with the input image, which is displayed on the screen. This system detects all signs and displays the respectful letters for each sign when a user performs a finger s pell. T he fi rst 3 co lumns in ab ove figure 4 clearly show the training losses and validation losses. The first 3 columns are box loss, object loss, and class loss. All the losses are decreasing with the increasing number of epochs. So the trained model will be more effective for our product.

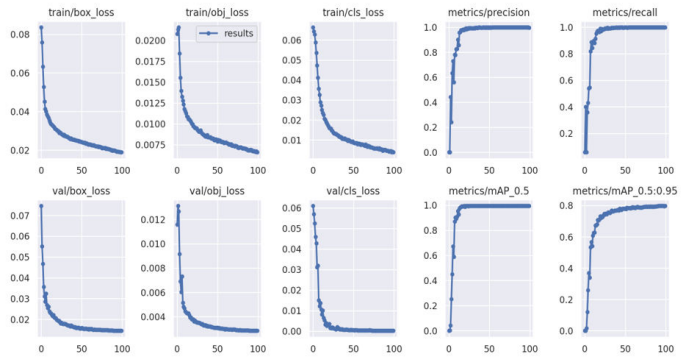

Fig. 5. Training, Validation Losses graph of Sinhala alphabets

Class	Images	Instances	P	R	mAP@.5	mAP@.5:.95: 100% 34/34 [00:08<00:00, 4.01it/s]
all	1088	1090	0.999	0.998	0.994	0.798
Ah	1088	65	0.998	1	0.995	0.848
ae	1088	74	0.999	1	0.995	0.75
aee	1088	83	0.999	1	0.995	0.815
ahh	1088	119	0.999	1	0.995	0.775
e	1088	61	0.998	1	0.995	0.776
ee	1088	118	0.999	0.992	0.995	0.815
i	1088	84	1	0.988	0.986	0.799
ii	1088	83	0.998	1	0.995	0.752
o	1088	86	0.998	1	0.995	0.83
oo	1088	150	0.999	1	0.995	0.863
u	1088	92	0.999	1	0.995	0.8
uu	1088	75	1	1	0.995	0.749

Fig. 6. Trained Model Details of Sinhala Alphabets

Figure 5, shows all the classes in the Sinhala alphabet like Ah, ahh, ae, aee, i, ii, u, e, ee, O and Oo. For a better model, precision and recall must stay high. In figure 4.2, there are precision and recall for all the classes. Precision and recalls always stay near to one. So, our model is an effective one. after After finishing our trained model for the Sinhala alphabets, we started testing the prediction using Google Colab. Figure 4.3 clearly shows the output of the Sinhala alphabet detection. The trained model predicted the gestures with more than 80% confidence. So, the trained output was tested effectively.

VI. Future works

We are planning to increase sign language recognition by increasing the number of signs and words. They are also planning to introduce sign language recognition to various regions, for example, Indian sign language and American sign language. We tried to implement it by using a single robot arm now. So, we are planning to implement using the full robot model in the near future. When the Neuralink chip comes to market, we can implement the system using it. So, there is no need for an external interpreter.

VII. Conclusion

There is no specific Sri Lankan sign language interpreter in the market. In this research paper, we are proposing a Sri Lankan sign language interpreter. Here we proposed the system using YOLO V5 for alphabets and Open Pose for continuous signs. We had been trained in the system using the YOLO V5 till now. The trained output came with good accuracy.

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Abstract on HID Theory (Hidden Ignitable Domain) for Management

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Abstract - In an organization where people lead with KPIs or targets can be lead into various anxious events. Many individuals go through psychotrauma, psycho downfalls or psycho de motivation and it can lead to frustrations and that can sequentially lead to depression and then to suicide. My 30 years of experience in many multinational organizations, both local and overseas and working with SMEs and entrepreneurs, I have witnessed people with lack of self-motivation to overcome such hard situations. Students also has this issue of losing confidence of themselves, to a subject and even with their lives due to lack of coping skills. Positivity is not an element in your genes. It has to be acquired. High performance is a mentally acquired status. Speed of work or your capacity has to be earned and move to your brain. Bruce W.Tuckman,Thomas L.Sexton mentioned and sighted, Comparisons between self-believers, the self-unsure, and self-doubters showed that self-believers perform the most, outperform even their own self-expectations, and are unaffected by most external conditions while self-doubters perform the least (almost nothing), underperform even their own self-expectations, but perform more in structured, well-defined situations with the opportunity for goal-setting and planning beforehand and feedback afterward [1].

Bruce W.Tuckman,Thomas L.Sexton, once again sighting a study that is elaborating self-efficacy theory of Bandura's says, Unlike other studies, the relationship between those self-beliefs, and behaviour was measured over a series of behavioural trials. College females took a series of mathematical word problem tests in which they chose the level of problem difficulty and the amount of effort to expand. A path analysis procedure was used to test the relationships based on Bandura's self-efficacy theory. Self-efficacy was, at the beginning of the task, the major contributor to task level choice but it was past behaviour that emerged as the primary predictor of future choice. After three trials persistence was related to self-efficacy and previous performance [2]. According to Freud's psychoanalytic theory, the id is the primitive and instinctual part of the mind that contains sexual and aggressive drives and hidden memories, the super-ego operates as a moral conscience, and the ego is the realistic part that mediates between the desires of the id and the super-ego [3].

Key words – psychotrauma, positivity, high performance.

I. INTRODUCTION

Beyond Freudian theory or any motivational theory there are people who keep the motivation going. The purpose of my study is to introduce a theory to the Management world by using Social Science where I discover the hidden ignitable domain or the 4th energy of a person (Centre of ignition and continuity) and to discover the way in which a person can send positive feedback to amygdala to stay positive for a very long time. Therefore, the issue that I will research about is to understand how and why people maintaining inner motivation. Apart from amygdala reacting to energies such as id, ego and super ego, how the conversion should happen from fear to cheer [4]. My central claim is that when this 4th energy releases and retain, a person can keep the motivation and he/she can be positively programmed. Especially sales personal, hard jobs workers, entrepreneurs and SMEs need this motivation. A person can sustain his or her psychic energy if it can be reminded continuously. By doing so, certain aspects need to understand, among the structures of the limbic system, the amygdala plays an important role in controlling motivational behaviours, such as reward-related motivation as well as appetitive and aversive behaviours. Therefore, using a technique called ***"psychic energy conversion" or PEC*** (where self-discovery, loud audible motivation, picture association, self-consciousness and trigger motivation on self-belief.

PEC speaks to the amygdala and it has to retain the psychic energy. This awakens the hidden energy where it stores in the brain . Therefore, this allows amygdala to replace fear emotions from positive emotions. Amygdala has hidden energy to release to convert fear to cheer. The amygdala is responsible for processing strong emotions, such as fear, pleasure, or anger. It might also send signals to the cerebral cortex, which controls conscious thought. Signals sent from the thalamus to the autonomic nervous system and skeletal muscles control physical reactions. In summery the order of PEC is, start with meditation,1st time Self drawing to see perception, Positive picture seeing to the candidates, Self-awareness, Picture association, Loud audible motivation, 2nd time Self drawing, Picture association, Loud audible motivation, Self-trigger activities (One to one motivation tagging, Wood breaking, Glass breaking), Picture association, Loud audible motivation,3rd time Self drawing.

Also, there is a theory called Locus Theory [5]. Within psychology, Locus of Control is considered to be an important aspect of personality. Locus of Control refers to an individual's perception about the underlying main causes of events in his/her life. Or, more simply: Do you believe that your destiny is controlled by yourself or by external forces (such as fate, god, or powerful others)? This understanding of Locus of Control is consistent, for example, with Philip Zimbardo (a famous psychologist): A locus of control orientation is a belief about whether the outcomes of our actions are contingent on what we do (internal control orientation) or on events outside our personal control (external control orientation).

2.METHODOLOGY

Using PEC method or a qualitative method, where self-discovery to trigger motivation on self-belief was used in the study to investigate a person's inner self-motivation and sustainability of motivation for a period of time. This technique was initiated with a person who was lazy, lethargic and left out. Then through retention tactics motivation levels can be further boosted.

A.Stimuli

Positive words association was used to simulate the candidate and used a fit-to-task method to stimulate internal factors such as belief and inner confidence.

B.Cognition re-building

Through rapid positive words association, the amygdala then programme to receive positive information to re-build negative and lazy thoughts.

C.Data collection

A record sheet was given to the candidate outlining the key elements of activities to track his progress explaining his current lethargic self-situation.

D.Data Analysis

This record sheet of qualitative information will be reviewed in front of the candidate to explain the progress.

He will be able to see a clear positive development where he has used his 4th personality to motivate himself.

III. RESULTS AND DISCUSSION

Self-efficacy (attitude/ abilities/ cognitive skills) changed 100% of the individual to create a positive impact on self-image. Organic self - motivation was observed through picture association indicated a very strong change in self-perception where earlier it was in a weak situation.

II. CONCLUSION

Evidence provides that support to increase belief of factors of self-efficacy results in inner self belief. Also, it was proven that an energy results in adjustment to personality and self-belief. HID therefore categorically an energy that is hidden and can be awaken and sustain. However, results also shows that this process of changing inner perception to a positive framework reflects on high productivity.

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Effects of Compost, Biochar, and Inorganic Fertilizer Combinations on the Growth and Yield of Bushita Bean (Vigna unguiculata)

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Abstract - Soil organic matter (SOM) is a critical component of soil management to support the growth and development of crops. Compost and biochar are popular soil amendments used to enhance the SOM content. The current study was conducted to determine the contribution of biochar in raising the growth and pod yield of bushita beans and the benefits of supplementing with inorganic fertilizers. The experiment was conducted in a farmer's field at Vitharandeniya in the district of Hambantota, Sri Lanka from February to May 2022. Six soil amendment levels and two fertilizer management levels were tested in a 6 x 2 factorial experimental arranged in a split-plot design with three replicates. Growth and yield data were gathered during the study. The results showed that plant growth in terms of height, and yield and yield components, i.e., the number of pods per plant, the length of pods, weight of pods per plant, and pod yield were greater in plots that received 2% SOM from biochar, compared to the same content of SOM by compost, none and 1% SOM by biochar. Adding biochar to maintain 3 and 4 percent SOM did not significantly raise bushita bean yield. Application of fertilizer raised bushita bean pod yield, but the difference was not significant. Therefore, maintaining 2% SOM using biochar was found beneficial. Since this finding is based on a single season experiment, further work is suggested before making firm recommendations.

Keywords: Bushita bean, soil amendments, compost, biochar, inorganic fertilizer.

I. Introduction

The bushita bean is a popular vegetable cultivated in many Asian and African countries. Synthetic fertilizer has been widely used for growing bushita beans in Sri Lanka. The government of Sri Lanka made efforts to promote the use of organic fertilizers (OF). Several types of organic fertilizers were re-introduced among the growers [1]. This includes compost, several types of liquid formulae prepared out of different organic waste, vermicompost, biochar, etc. Since bushita bean belongs to a group of legumes, it possesses the N fixation using atmospheric N_2 to obtain the N requirement. The N fixation process requires the flow of atmospheric N_2 to root nodules. The application of organic matter is known to improve the soil structure thus facilitating the N fixation process [2]. The farmers are encouraged to use compost and biochar using plant parts, mulch, and animal waste.

Organic amendments such as compost, vermicompost, etc. are known to promote soil structure and the retention of nutrients in soil. One of the popular ways of applying organic matter is by biochar which is also known to enhance the retention of carbon and cations in soil [1]. For severely depleted soils with scarce organic matter, and insufficient water and fertilizer supplies, biochar is known to support soil development and crop production [4]. In the absence of adequate evidence testing the role and benefits of biochar would help identify suitable fertility management options for bushita bean cultivations. Therefore, the current study was conducted to compare the effects of biochar with commonly used organic fertilizers on the growth and yield of bushita beans.

II. Materials and Methods

This study was conducted from February to May 2022 in upland in Vitharandeniya of the Hambantota District, Sri Lanka. Bushita bean was the experimental crop. Five soil amendment levels, viz. no amendment, 2% soil organic matter (SOM) with compost, and 1, 2, 3, and 4 percent SOM using Biochar (prepared using rice chaff) were tested with and without inorganic fertilizers in a 6 x 2 factorial arrangement using a split-plot design with three replicates. Soil amendments were randomly assigned to main plots and fertilizer levels to subplots. The experimental site was ploughed, harrowed, and levelled, and seed beds (6m long and 1.5m wide) were prepared. Soil amendments were added to corresponding plots and mix with the topsoil two days before seeding. Subplots assigned to receive inorganic fertilizer, 16 kg N, 25 kg P, and 17.5 kg K per hectare were applied as the basal dressing and 25 kg N and 17.5 kg K as the top dressing one month after seeding as per the Department of Agriculture (DOA) recommendation for bushita crop [4].

The crop was managed as per DOA recommendation [4]. Plant growth in terms of plant height, time to reach phenological stages, and yield data were collected. Analysis of variance was performed for data using SAS software and means were separated using Fisher's protected Least Significance Difference (LSD) test.

III. Results and Discussion

Growth of bushita bean

Plant height was significantly influenced by both soil organic matter and fertilizers (Table 1). The highest plant height was in plots that received 2% SOM with biochar and was significantly different from the plots that received no soil amendments and compost. This indicates that all plots that had biochar (2% SOM) had higher growth than the rest. Significantly lower plant heights were in plots that received no soil amendments and were not significantly different in the quantity of biochar applied. In this performance, compost was inferior to the control as it had the lowest plant height.

The yield of bushita beans

Yield and yield components of bushita beans were significantly influenced by the type and rate of soil amendments and the fertilizer treatments (Table 2). Among the soil amendments, all yield components and the total pod yield (2170 kg/ha) were significantly lowest in compost-added plots. The

highest pod yield was in plots that received 2% Biochar, but plots receiving no soil amendments, and 3 and 4% biochar also had non-significant bushita bean yields. This indicates that biochar offered a higher yield than compost.

Table 1. Effects of organic amendment and fertilizer application on mean plant height at 4 and 8 weeks after seeding (WAS) and dry weight of plants at 4 WAS of bushita bean.

Treatment	Plant height, cm		Plant dry weight 4 WAS, kg/ha
	4 WAS 1/	8 WAS	
Organic amendment			
No amendment added	32.6 b	51.2 ab	1648.1 ab
2% SOM with compost	18.0 c	26.6 c	990.7 c
1% SOM with Biochar	32.9 b	54.2 a	1416.7 b
2% SOM with Biochar	37.3 a	54.2 a	1944.4 a
3% SOM with Biochar	34.7 ab	53.5 ab	1759.3 ab
4% SOM with Biochar	35.8 ab	50.5 b	1750.0 ab
LSD (p<0.05)	4.12	3.14	365.7
Fertilizer application			
No fertilizers applied	29.2b	45.9 b	1478.4 b
Fertilizer applied 2/	34.5a	50.8 a	1691.4 a
LSD (p≤ 0.05)	2.39	1.82	211.2
CV%	10.32	5.16	18.34

Legend: 1/ Values followed by the same letter in the column are not significantly different at p≤0.05.
2/ Subplots receiving inorganic fertilizers as per the Department of Agriculture recommendation (16 kg N, 25 kg P, and 17.5 kg K per hectare as the basal dressing, and 25 kg N and 17.5 kg K as the top dressing one month after seeding) [4].

The use of DOA fertilizer recommendation raised both pod number per plant and pod yield, but the differences were not significant.

Table 2. Effects of organic amendment and fertilizer application on mean pod no per plant, mean pod weight, mean pod length, and pod yield of bushita bean.

Treatment	Number of pods per plant 1/	Weight of pods/plant g	Mean pod length cm	Pod Yield kg/ha
Organic amendment				
No amendment added	11.4 a	6.0	24.8 ab	7915.5 ab
2% SOM with compost	2.7 d	5.0	21.7 d	2169.7 c
1% SOM with Biochar	8.4 c	6.8	25.6 a	6514.6 b
2% SOM with Biochar	11.0 ab	4.7	22.7 cd	8166.6 a
3% SOM with Biochar	9.7 bc	5.1	23.5 bcd	7810.2 ab
4% SOM with Biochar	10.1 ab	5.6	24.2 abc	6907.4 ab
LSD (p<0.05)	1.5	Ns	1.86	1635.1
Fertilizer application				
No fertilizers applied	8.5	5.5 a	23.8	6380.6
Fertilizer applied 2/	9.2	5.6 a	23.7	6780.6
LSD (p≤ 0.05)	Ns	Ns	Ns	Ns
CV%	13.31	15.97	6.2	19.76

Legend: 1/ Values followed by the same letter in the column are not significantly different at p≤0.05.
2/ Subplots receiving inorganic fertilizers as per the Department of Agriculture recommendation (16 kg N, 25 kg P, and 17.5 kg K per hectare as the basal dressing, and 25 kg N and 17.5 kg K as the top dressing one month after seeding) [4].

IV. Conclusion

The results of this study confirmed that the biochar-treated plots were superior to compost-treated plots. Among the biochar soil organic matter levels adjusted with the use of biochar, 2% of the soil organic matter (SOM) provided with biochar gave the highest bushita bean yield. Adding higher biochar levels did not provide additional benefits. Although the use of inorganic fertilizers raised bushita pod yield, the differences were not significant. Therefore, adding biochar to maintain 2% soil organic matter content is recommended based on this study. It is suggested to repeat the study before making firm recommendations.

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Effect of Salinity Stress on Brix %, Growth, and Yield in Chili Pepper

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Abstract: Chili peppers (*Capsicum* spp.) are the most widely used spices for any cuisines and are getting popular not only as spices but also as a kind of vegetable. Taste components are very important factors when chili pepper using as a vegetable. Therefore, present experiment was conducted to find out the effect of salinity stress on the Brix, pod parameters, yield, and plant growth in chili pepper. The experiment was conducted in a greenhouse condition with three salinity levels using NaCl. The results and outcomes show that salinity stress conditions positively affect the Brix percentage of the harvest. However, salinity stress conditions negatively affected the plant growth and yield parameters.

Keywords: Brix, Chili pepper, Salinity stress, Taste components

I. INTRODUCTION

Chili pepper (*Capsicum annuum)* is the fruit of plants from the genus *Capsicum*, a member of the nightshade family, Solanaceae, are widely grown for their fruits, which may be eaten fresh or cooked (e.g., in salads, baked dishes, salsa, pizzas, etc.), used as a dried powder, or processed into oleoresins. It has been domesticated for more than 6000 years [3]. Peppers are commonly broken down into three groups: bell peppers, sweet peppers, and hot peppers. Most popular pepper varieties fall into one of these categories or as a cross between them [1]. Variations of the yield and the taste components in the chili pepper can be attributed to cultivar differences; additionally, as hereditary and environmental factors [6]. High concentrations of salts in soil and drought stress conditions are often responsible for large decreases in the yield of a variety of crops worldwide. It was estimated that about 20% (45 million ha) of irrigated land, producing 1/3 of the world's food, is salt-affected [5]. However, to the best of our knowledge, few investigations regarding the influence of environmental factors, especially salinity stress, on the Brix %, yield parameters, and growth parameters have been found. Accordingly, this study was composed to determine the effect of salinity stress on Brix %, yield, and growth in chili pepper.

II. MATERIALS AND METHOD

The Experiment was conducted as a pot experiment in a greenhouse at the Research field of Shinshu University, Minamiminowa, Nagano, in Japan in 2020, using the *C. annuum* cultivars; 'Sapporo Oonaga Nanban' and 'Sisito'. Our previous studies recorded that 'Sapporo Oonaga Nanban' had the highest Brix percentage among 39 tested chili strains cultivable in Japan [2] and we selected 'Sisito' as a non-pungent cultivar. In addition, we selected 'Sisito' due to its very low pungency and it was a common cultivar used in Japan for eating and also experiments.

Seedlings of similar height were transplanted in plastic pots filled with 1 kg of the same commercial potting medium. Six individuals of each cultivar were used for each treatment. After calculating the bulk density, the plastic pots filled with the medium occupied 130 mL of water. So, water supply with considering the daily temperature. As the treatments applied three salinity levels applied using sodium chloride (NaCl); the levels were excessive salinity [E; 10 dS/m (6.4 g/L)], additional salinity [A; 5 dS/m (3.2 g/L)], and the normal salinity as control [C; 0.9 dS/m (0.57 g/L)]. In both years, treatment application started after the seedlings were transplanted and harvest was collected at 40 dates after planting (DAF). Harvested fruits were used for analyzing the Brix value. The number of fruits, fruit weight, total yield, number of leaves, number of branches, and plant height was recorded on a per plant basis. A Randomized Complete Block Design was used to analyze the experimental data.

Solution preparation and analysis of Brix

Brix is primarily a measure of the sugar concentration in a solution. Extracts were prepared from fruit tissue ground using a grinder (YMB-400, Yamazen) and filtered through a 125-mm filter paper (ADVANTEC). Extracts were used directly to measure the Brix value with a digital portable refractometer (Pen-J, Atago Co., Ltd., Tokyo, Japan).

III. RESULTS AND DISCUSSION

The fruit Brix percentage of all cultivars in the salinity stress-treated plants tended to increase in both cultivars with increasing salinity in the soil. These results agreed with previous studies of water-stressed (drought) chili pepper [4]. Wu and Kubota (2008) also reported that the Brix of tomato fruits increased when the EC of the nutrient solution was increased.

However, the number of fruits, number of leaves, plant height, number of branches, total yield, and fruit weight were significantly lower in all cultivars with increasing salinity in the soil than the low salinity level.

When plants were grown under the salinity stress conditions, the size and weight of the fruits decreased compared to those grown under the control. According to [7], salinity stress significantly impacted the plant height and fresh and dry biomas of the chili pepper plants.

Fig. 1. The Brix at different levels of salinity stress condition in 'Sisito'. Different lowercase letters, a, b, and c, above the bars indicate significant differences among treatments, (Tukey's pairwise test, $P < 0.05$). Error bars indicate the standard error.

IV. Conclusion

The quality of the fruit getting increased with decreasing the stress conditioned. Therefore, it is important to find out the equilibrium point at which a profitable harvest with the highest quality can obtained through further experiments.

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Table 1. Effect of salinity stress for plant growth parameters, pod parameters, and yield of chili pepper.

Variety	Salinity Stress	No. of Fruits	No. of Leaves	Plant Height (cm)	No. of Branches	Total Yield (g/plant)	Fruit Weight (g)
Sapporo	E	24.3 a	88.8 a	34.3 a	7.3 a	150.0 a	6.20 a
	A	51.5 b	127.0 a	43.5 a	8.0 a	370.8 b	7.20 b
	C	69.8 c	183.8 b	62.3 b	11.0 b	637.7 c	9.15 c
Sisito	E	42.5 a	69.5 a	55.3 a	5.5 a	212.5 a	5.18 a
	A	52.8 b	131.3 b	66.5 b	9.0 b	369.3 b	7.25 b
	C	73.0 c	209.3 c	81.0 c	10.5 b	657.0 c	9.03 c

Different letters a, b and c for the treatments (control, C; additional salinity stress, A; and excessive salinity stress, E) indicate significant differences using Tukey Pairwise test at the 5% level.

Effect of Phosphorus Fertilizer and Temperature on Plant Growth and Fruit Parameters in *Capsicum* spp.

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Abstract - Chili pepper (*Capsicum* spp.) is an important spice in the world food industry. Plant growth and fruit parameters vary with changing environmental factors and many experiments have been conducted to find out environmental effect for plant and fruit parameters in chili pepper except phosphorous (P) fertilizer and high temperature. Japanese agricultural soil rich in P fertilizer because of long term fertilizer application. High temperature is one of the major abiotic stress affecting plants, having adverse effects on growth and quality of the fruits of most plants. Therefore present experiment was conducted to find out the effect of excess phosphorus fertilizer and high temperature stress on plant growth and fruit parameters of chili. Three P fertilizer treatment (60, 300 and 600 g. m^{-2}) and two temperature treatment (high temperature stress and control) were used for this experiment respectively in 2019 and 2020. According to the results, high temperature stress and excess P fertilizer condition negatively affected the plant growth and reduced the fruit size, length, weight and number of fruits than the control conditions. Therefore when growing chili pepper it is better to control temperature condition and supply only adequate P fertilizer quantity to get good growth and yield.

Keywords: Temperature stress, Phosphorus fertilizer, Chili pepper

I. Introduction

Capsicum annuum L. is the most widely grown spice in the world and one of five domesticated chili pepper species. Capsaicinoids, which accumulate in the vesicles and vacuoles of epidermal cells of the placenta, are substances that are responsible for the pungent taste in chili [1]. Chili is mainly used in the food industry and capsaicinoids in the pharmaceutical and medical industries. Chili plant growth and yield are changed by environmental factors such as drought stress, Salinity stress, parthenocarpy, temperature condition, light condition and fertilizer condition. Plants require P to synthesize adenosine triphosphate (ATP), sugars, and nucleic acids. Japanese agricultural soil is typically enriched in P due to long-term excessive P fertilizer application [2]. According to the Climate Change models predictions, the air temperature will increase between 1 to 4°C by the end of the 21st century, because of the greenhouse effect [3]. But, there are a limited number of experiments on the effect of temperature stress with chili pepper because it is difficult to provide temperature stress without causing an effect on drought stress and light condition. Therefore, the objective of this study was to find out the effect of excess P fertilizer and high temperature stress conditions on chili pepper plant growth and fruit parameters.

II. Materials and method

Experiments were conducted in Alpine Field Research and Education Centre, Faculty of Agriculture, Shinshu University, Minamiminowa, Nagano, Japan (a. s. l. 733 m) in 2019 and 2020.

Experiment 1 (high-temperature effect)

The temperature experiment was conducted from 30th of June to 15th of September in 2019 using the 'Takanotsume' and 'Sapporo' (*C. annuum*) variety treated with two different temperature conditions (High temperature stress and control). High temperature stress was provided to the chili plants in a greenhouse with an average temperature between 42.9 ^{0}C - 13.4 ^{0}C. As the control, a set of chili plants were grown outside the greenhouse where the average temperature lied between 35.9 ^{0}C -11.6 ^{0}C. Plastic water logging plates were used to provide the excess water condition to avoid drought stress. 50% black shade net was used as control the light condition effect.

Experiment 2 (excess P fertilizer effect)

P fertilizer experiment was conducted from the 15th of May to the 30th of September, 2020. The maximum average temperature was 35 ^{0}C and the minimum average temperature was 20.5 ^{0}C. Same chili varieties used in the above experiment, were used with three different levels of P fertilizer treatments 60, 300 and 600 g·m^{-2} by adding 'Multi Phosphate' (available P: 35%). Water was applied considering the daily temperature and weather conditions. If the temperature was above 30 0C, 130 mL of water was added to the soil 3 times a day. On rainy days or if the day temperature was below 30 0C, 130 mL of water was applied twice a day.

In both experiments, plants were transplanted into plastic pots (18 cm in diameter, 3.5 L) filled with commercial potting media

(Nae-Ichiban; Sumitomo Forestry Landscaping Co., Ltd, Tokyo, Japan), when seedlings have approximately grown up to 100-150 mm in height. The potted plants were placed in the greenhouse with 50% shading. Five individual replicates were carried out for each treatment in both experiments. The first set of flower buds were removed after applying the treatments. Other crop management practices and standard recommendations followed in Japan were applied for growing peppers for both experiments. The pericarp of fruits turned into fully red colour fruit is considered as late mature fruits and those fruits were harvested on a pre-decided day. Fruit and plant parameters (fruit length, fruit weight, number of fruits, number of branches, number of leaves and plant height) were measured after harvesting.

III. Results and Discussion

In experiment 1, measured fruit length, weight, number of fruits, branches, leaves and plant height of both chili varieties were significantly high in numbers in the control temperature condition than the temperature stress condition (Table 1). High temperature adversely affects the physiological parameters of tomato plants, and consequently reduces plant biomass production [4].

In experiment 2, 60 P fertilizer treatment showed significantly high values for all plant parameters except the number of branches and number of leaves in 'Takanotsume' and 'Sapporo'(Table 1). Excess P indirectly affects plant growth by reducing Fe, Mn and Zn uptake [5]. That might be affected to reduce fruit and plant parameters in chili plants.

IV. Conclusion

Temperature stress and excess P fertilizer negatively affect plant growth and reduce fruit size and weight. Therefore before planting chili pepper, it is important to control temperature stress conditions and measure the soil-available P level and avoid adding excess P fertilizer to obtain proper plant growth and big sized chili fruits.

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Table 1. Change in plant and fruit parameters of 'Takanotsume' and 'Sapporo' in given different temperature treatment in 2019 and different P fertilizer treatments in 2020.

	Varity		Fruit length (cm)	Fruit weight (g)	No. of fruit	No. of Branches	No. of leaves	Plant height (cm)
Temperature treatment (2019)	Takanotsume	Control	6.68 a	3.31 a	88.4 a	8.2 a	226.4 a	80.2 a
		High T- Stress	5.7 b	2.8 b	70 b	6.8 b	187.8 b	70.6 b
	Sapporo	Control	12.26 a	6.34 a	78.2 a	11.2 a	169.6 a	71 a
		High T- Stress	9.16 b	5.22 b	62 b	8.2 b	140.6 b	55.8 b
P fertilizer treatment (2020)	Takanotsume	60 g. m^{-2}	6.46 a	3.18 a	85.8 a	7.0 a	220.8 a	78.8 a
		300 g. m^{-2}	5.48 b	2.39 b	68.2 b	7.8 a	225.2 a	69.6 b
		600 g. m^{-2}	5.46 b	2.34 b	64.2 b	8.0 a	217 a	66.8 b
	Sapporo	60 g. m^{-2}	11.88 a	5.98 a	74 a	9.6 b	174 a	72.4 a
		300 g. m^{-2}	9.4 b	5.26 ab	56.2 b	11.8 a	176.6 a	55 b
		600 g. m^{-2}	8.84 b	4.96 b	58 b	11.4 a	177 a	57.8 b

Different letters a and b indicate significant differences of each treatment using Tukey pairwise test at the 5% level.

Agronomic Performance and Varietal Evaluation of Cowpea [*Vigna unguiculata* (L.) Walp] under Organic and Inorganic Fertilizers in Sri Lanka

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Abstract – Cowpea is a widely cultivated food legume of Sri Lanka. With the banning of the importation of inorganic fertilizers cultivation of cowpea suffered and its prices drastically went up. This necessitated the finding of alternative sources of supplying essential plant nutrients. Six cowpea varieties, viz. *ANKCP 01, ANKCP 02, Dawala, Waruni, ANKCM 13-6,* and *CP 246* were evaluated at Grain Legume and Oil Crop Research and Development Centre, Angunukolapelessa both in field and simulation modeling. Both cowpea varieties and fertilizer management significantly influenced the growth and yield of cowpea. Among the levels of fertility management, the use of DOA recommended practice, and the application of compost at 10 t/ha with the recommended fertilizers significantly improved the growth and Yield parameters, while of the varieties, ANKCP 01 significantly outyielded the rest of the varieties. Crop simulation using APSIM for Dawala variety, a popular variety simulated the same results in this study, which indicated the potential of using the APSIM model for simulating crop growth and yield of cowpea.

Keywords: *Cowpea, Compost, Organic Fertilizer, APSIM*

I. Introduction

Cowpea (*Vigna unguiculata* L. Walp) is a member of the Leguminosae family [1]. The extent of production of cowpea in 2020 was 11,518 ha [4] with total seed production of 13,216 MT by 2020 [5]. Cowpea is grown in a wide range of soil conditions with well-drained loam and in a range of pH of 6-7 [2]. Cowpea thrives in regions with rainfall ranging from 500 to 1500 mm throughout the growing season [3] and at temperatures between 20-35°C [2].

At present, agricultural production in Sri Lanka suffers due to many limitations, and a lack of inorganic fertilizers because of the banning of importation. To maintain the plant protein supply to the population, there is a need for maintaining plant nutrient availability with alternative sources. The use of organic fertilizers is a way to supplement essential nutrients although they contain relatively low nutrient contents. Cowpea being a legume, possesses the ability to fix atmospheric nitrogen (N) [6]. The cultivation of cowpea would help reduce or avoid the application of inorganic fertilizers to supply N, which is a major essential nutrient of every crop. Hence, there is a need of testing potential alternatives to determine their ability to supplement N and other essential nutrient requirements to maintain the growth and yield of cowpea.

Agricultural system simulation models could be a useful tool to assess the performance of crops under different management systems. In direct agronomic research, resource requirements such as time, labor, and cost are compared with on-farm trials. This is time-consuming. The use of crop simulation helps decision-making effectively and allows the exploration of options that would not be possible using field experimentation-only approaches. In the present study, Agricultural Production Systems Simulator (APSIM) model was used to simulate the fertilizer performance of selected cowpea varieties.

II. Materials and Methods

This study was composed of two parts: 1) study the effects of fertility management on the performance of selected cowpea varieties, and 2) evaluate the performance of crop simulation using the APSIM model for predicting the growth and yield of cowpea.

The first part was a field study conducted at the Grain Legume and Oil Crop Research and Development Centre (GLOCRDC) at Angunukolapelessa in the southern province of Sri Lanka. The experimental site lies at coordinates N 6^0 9' 56.05'' and E 80^0 54' 11.22''. The experimental treatments were arranged in a Split Plot Design in a randomized complete block design with three replicates. Twenty-four treatments composed of 4 x 6 factorial combinations were tested. Four levels of soil amendments included no fertility management (control), compost at 6 mt/ha, compost at 10 mt/ha, and the Department of Agriculture (DOA) recommendation (application of compost at 10 mt/ha and N, P, and K at 16, 19.7, and 37.5 kg/ha, respectively using urea, triple super phosphate, and muriate of potash, respectively at basal dressing, and 13.8 kg/ha of N in the form urea at top dressing), while six varieties of cowpea recommended by the DOA, viz. *ANKCP 01, ANKCP 02, Dawala,* and *Waruni, ANKCM 13-6,* and *CP 246.* The fertility management practices were assigned to main plots and the varieties to subplots. Both growth and yield data were gathered during the study.

The normal data were analyzed using the Analysis of Variance (ANOVA) in SAS. When the factors were significant at $p \leq 0.05$ the means were separated using Fisher's Protected Least Significant Difference (LSD) procedure.

In the crop simulation study, the cowpea variety Dawala was used and the APSIM – cowpea module in the APSIM version 7.10 was used for growth and yield simulation. Data required for model parameterization and validation were obtained from the Grain Legume and Oil Crop Research and Development Centre (GLOCRDC) at Angunukolapelessa. Daily weather data, i.e., daily maximum and minimum temperatures, rainfall, sunshine hours, and soil data, i.e., physical and chemical properties, were obtained from the GLOCRDC and used.

III. Results and Discussion

A. Field Experiment

Performance of cowpea

The growth of cowpea was significantly influenced by both fertility management and varieties. Among the growth parameters, DOA recommended fertility management practice gave significantly the highest plant height, leaf area index

(LAI), highest chlorophyll content, and the highest branches per plant compared to the rest of the practices, except for 10 t/ha of compost use. The lowest values were observed in the control that received neither compost nor inorganic fertilizers. The variety influence was variable among the growth parameters.

Phenological stages

The time to reach growth also varied significantly among the cowpea varieties, though the differences were in the range of 1-3 days.

Seed yield of cowpea

The seed yield of cowpea ranged from 766 to 1350 kg/ha, and the highest yield was in the DOA recommended practice (1350 kg/ha) (Table 1). However, the application of 10 mt/ha alone had a non-significant seed yield (1177 kg/ha) to the DOA recommended practice. The lowest seed yield was in the control plots (749 kg/ha).

Among the varieties of cowpea used, ANKCP 01 (1468 kg/ha) had the highest seed yield while ANKCM 13-6 (1329 kg/ha) had non-significantly lower seed yield.

Table 1. Effects of fertility management and varieties on the number of pods per plant, 100-seed weight, seed yield, and gross income of cowpea.

Treatment 1/	No. of pods Per plant	100-seed weight g	Seedyield kg/ha	Gross income Rs./ha 3/
Fertility management				
No fertility management	16.18 c	16.56	749.18 c	374,592 c
Compost at 6 t/ha	22.13 b	16.89	1075.82 b	537,908 b
Compost at 10 t/ha	23.36 ab	17.06	1176.74 ab	588,370 ab
DOA Recommendation 2/	25.20 a	16.72	1350.07 a	675,037 a
LSD ($p \leq 0.05$)	2.34	ns	188.81	94,406
Cowpea variety				
ANKCP 01	20.13 b	17.83 a	1468.20 a	734,110 a
ANKCP 02	20.28 b	22.83 a	951.60 c	475,778 c
Dawala	22.14 b	17.33 b	810.90 c	405,445 c
Waruni	25.76 a	12.58 d	1329.70 b	664,862 ab
ANKCM 13-6	22.29 b	15.25 c	1200.70 b	600,333 b
CP 246	19.78 b	15.00 c	766.70 c	383,333 c
LSD ($p \leq 0.05$)	2.62	1.19	231.25	115,623
CV%	14.62	8.55	25.76	25.76

Legend:1/ LSD - Least significant difference; CV – Coefficient of variability
2/ DOA Recommendation includes application of compost at 10 t/ha and the use of recommended fertilizers., N, P, and K at 10, 7.0, and 50kg/ha, respectively.
3/ Gross income was calculated assuming a current farmgate price of Rs.500/-per kg of seeds.

Gross income

Among the gross income, the highest was in the DOA recommended fertility management practice (Table 1). However, there was no significant difference between the same treatment and 10 t/ha of compost treatment. Yet the difference was Rs. 86,667 per hectare. The rest had lower gross income values.

The varietal difference for seed yield clearly existed. The highest gross income was found in the variety ANKCP 01 (Rs. 734,110/ha). Although the variety Waruni had non-significantly lower gross income, it was Rs. 69,248/ha.

B. Modelling Experiment

Prediction of cowpea seed yield with APSIM-cowpea model for Dawala variety as shown in Figure 1 had a coefficient of variability (CV%) was 10.2 % and 0.3 % and a standard deviation of 46.46 and 1.22 for seed yield and days to flowering, respectively. The CV value of less than 20% indicates as good fit of models (REF). This indicated the potential of simulating the seed yield of cowpea varieties.

The simulated and observed yield of Dawala under fertility management practices confirmed its potential use in future research. The predicted and observed gap was due to unexpected submergence of a plot because of heavy rains that reduced the mean seed yield of the same variety.

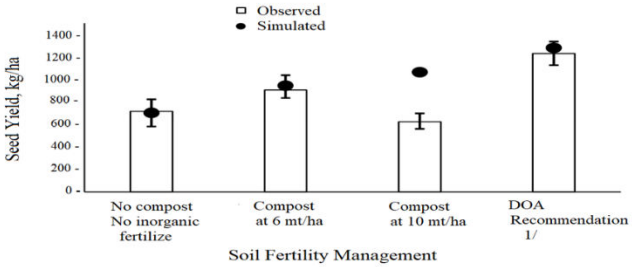

Figure 1. Simulated and observed seed yield of Dawala variety of Cowpea by the APSIM-Cowpea Model.

Legend: 1/ DOA Recommendation includes application of compost at 10 t/ha and the use of recommended fertilizers., N, P, and K at 10, 7.0, and 50kg/ha, respectively.

IV. Conclusion

The results of the field experiment, it can be concluded based on growth and yield parameters and growth parameters that the use of compost as a soil amendment provides beneficial effects. In addition, organic amendments improve soil physical characteristics thus increasing the efficiency of applied inorganic fertilizers. This has been clearly shown based on the differences among no fertility management, use of 10 t/ha compost and the latter with the addition of inorganic fertilizers as per the DOA recommendation. Varietal effects is seen clearly and ANKCP 01 giving highest yields.

The results of the crop simulation using APSIM showed its future potential to predict seed yield of cowpea.

The current study helps recommend the use of compost at 10 mt/ha combined with the DOA recommendation of inorganic fertilizers over 10 mt/ha compost alone as the recent prices provide higher advantages to the growers.

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Leaching of Trace Elements, Heavy Metals and Antimony from Polyethylene Terephthalate Bottled Drinking Water in Sri Lanka

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Abstract - Polyethylene terephthalate (PET) bottles used in the bottled drinking water (BDW) industry possess a high potential for leaching trace elements (LTM) into the water. There is a dearth of research on LTM composition from PET resins in Sri Lanka. Thus, scientific surveillance had qualitatively and quantitatively carried out to analyze bottle-grade PET samples. Frequently imported three resin brands designated as A, B, and C were frozen and finely grounded, then studied by X-ray fluorescence spectroscopy (XRF) and microwave digestion followed by inductively coupled plasma mass spectroscopy (ICP-MS). Outcomes were found to be Sb > Ti > Ge > Mn > Zn > Co while Cu and Ca were only recorded in resin C and A respectively. A high percentage of Sb was detected due to its leading catalytic ability, and the range can be present as 174.84 to 144.78 μg g^{-1}. Yet, Ca appeared five times higher than Sb in Resin A. Considering the results and regulations, PET-bottle and BDW parameters demonstrate contradictions. In the "Food Act No. 26 of 1980", Sb is regulated at a 0.005 mg l^{-1} for the mineral drinking water category but not for BDW though both are packed in PET bottles. Similarly, Cu, Mn, and Zn were considered water quality parameters in "SLS 894" but there is no reasonable consideration of LTM from the PET resins in "SLS 1336". In addition, migration, toxic and maximum permeability limits of the above species are strongly recommended for future research concerns. This will reflect an upgraded qualitative and quantitative study of BDW in Sri Lanka.

Keywords: Polyethylene terephthalate, bottled drinking water, catalytic metals (Sb)

I. Introduction

Polyethylene terephthalate (PET) is an extensively used packaging material for the manufacturing of bottled drinking water (BDW). However, the reliability of PET-made bottles vitally depends on health and safety concerns. To that end, LTM contained in the PET including Zn, Mn, Co, Cu, Ge, Ti, and Sb may potentially be leached into the water at BDW usage. During the synthesis of PET, these elements were anxiously chosen to catalyze the polymerization process [1]. Therefore, manufacturer-wise element composition may vary. Still, Sb appeared to be an abundant choice. As a consequence, a strong regulatory background is essential to control consumer safety. In contrast, the Sri Lankan regulatory framework, "Food Act No. 26 of 1980" [2], "SLS 894" (BDW water standard) [3], and "SLS 1336" (PET packaging standard) [4] are the key guidelines for the BDW industry. However, there is no adequate coverage and recognition of some of these trace elements in the above standards.

A. Problem statement

National PET requirement accounts for hundreds of thousands of US dollars' worth of annual imports yet there is a dearth of investigations regarding the trace element composition of PET resins and the credibility of our current regulatory framework against them. Thus, conducting surveillance study on common trace elements and Sb in frequently imported PET resin brands help to ensure the reliability of local BDW safety as well as decision-making purposes on future amendments to current regulations.

B. Objectives

Qualitative and quantitative analysis of possible trace metal species in frequently imported PET resin brands followed by determination of default Sb amounts, comparison studies of current Sri Lankan act, and standards versus analysis outcome to ensure credibility are the objectives of this study.

II. Methodology

Frequently import, three resin brands were designated as A, B, and C. Then treated with liquid nitrogen (LN) for 20 minutes and finely ground using "DJ-04 series 10A" laboratory grinder. Grounded resins were analyzed by "Fischerscope" XAn G.2.19.1 model XRF analyzer. Microwave digestion was carried out by "ETHOS EASY" milestone advanced system using 0.3g of sample with 10 mL "LOBE CHEMIE" Analytical Reagent grade 69 – 70% HNO_3. Digested solution and washings of remaining inside the vessel by ultra-pure water were filtered and directly collected into a 100.0 ml volumetric flask. The content was diluted up to the mark with the same water. 10 ml of prepared filtered solution was transferred into a 50.0 ml volumetric flask and diluted with ultra-pure water up to the mark to get 2% acidity. The analyzable sample was further filtered using a 0.45 μm cartridge and vigorously swirled using the VORTEX instrument. The prepared sample was analyzed for Sb using

the "Thermo Scientific iCAP Q" ICP-MS. Blank analysis was prepared by1 ml HNO_3 acid with 49 ml ultra-pure water mixed in a 50.0 ml volumetric flask. To obtain the result following formulations were used. If the instrumental response was X μg l-1;

$$\text{Sb concentration} = \frac{X\ \mu g\ /\ l}{0.3\ g} \times 0.05L \times 10 \quad (2.1)$$

$$\text{Blank Sb concentration} = X\ \mu g\ l^{-1} \times \frac{50}{49} \quad (2.2)$$

III. Results and Discussion

Resin samples were treated with LN to reduce the thermoplastic effect and introduced brittle nature during the grinding process. Regards to, table 3.1; all three resin samples were positive for selected trace elements and the sequence can be represented as Sb > Ti > Ge > Mn > Zn. while Cu and Ca were detected only in resin A and C respectively. This reflects manufacturer-wise catalytic variation and thus demands specific regulations to control LTM. The amount of Sb presence in all three resins appeared to be generally higher than other elements. Thereby, it reveals the effectiveness of Sb as a catalyst in PET synthesis. Still, in Resin A; the Ca amount is approximately five times higher than the Sb amount. Default Sb level was found to be 147.62 $\mu g\ g^{-1}$, 174.84 $\mu g\ g^{-1}$, and 144.78 $\mu g\ g^{-1}$ respectively for resin A, B, and C. where values are within the mid-levels of the literature range of 100 to 300 µg g^{-1} [5]. However, considering both PET-bottle and bottled water, the quality guidelines given in regulations demonstrate contradictions and a less informative nature. Withal, Sb content in the two subcategories of bottled water explained in the "Food Act No.16 of 1980" is regulated at a 0.005 mg l^{-1} for the mineral drinking water category but not for BDW though both are packed in PET bottles. Similarly, only Cu, Mn, and Zn were regulated in the "SLS 894" as water quality parameters, but attention was not given to any LTM in the "SLS 1336" which is intended to control the quality of PET-bottle.

IV. Conclusion

Referring to the "Food Act " and "SLS 894", except for Cu, Mn, and Zn all other trace elements were either less informative or completely absent. Forbye, it reveals the unawareness of the leaching potential of these metals since both the "Food Act " and the "SLS 894" represents the water quality of BDW. Moreover, "SLS 1336" intended to regulate PET bottle quality, observed to be in absence of any detail on trace metals. Thus, the parameters indicated in the three documents were not reflecting the true requirement. Furthermore, Sb regulated in the NMBDW section of the "Food Act " is absent in the BDW section of the same document. Hence, the "Food Act" is unable to identify PET bottles as a potential source of metal contamination. Based on a future study regarding migration levels of the above catalytic metals and their toxic levels, maximum permeability levels have to be set. Finally, a proper amendment is required to cover major trace elements in BDW standards to sustain continuous quality management of the industry.

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Table 3.1: Comparison of trace elements with regards to acts and standards of Sri Lanka

Parameter	Food act No.26 (mg l^{-1} max)		SLS 894:2003 (mg l^{-1} max)	SLS 1336:2017 (mg l^{-1} max)	Abundance (%) by XRF			ICP-MS results (µg g^{-1})		
	BNMDW	BDW			Resin A	Resin B	Resin C	Resin A	Resin B	Resin C
Sb	0.005	N/A	N/A	N/A	0.76	0.92	0.85	147.62	174.84	144.78
Mn	0.5	0.5	0.5	N/A	0.31	0.42	0.39	-	-	-
Zn	N/A	3.0	3.0	N/A	0.09	0.17	0.08	-	-	-
Ti	N/A	N/A	N/A	N/A	0.44	0.77	0.59	-	-	-
Ge	N/A	N/A	N/A	N/A	0.42	0.46	0.50	-	-	-
Co	N/A	N/A	N/A	N/A	0.38	0.41	0.34	-	-	-
Cu	1.0	1.0	1.0	N/A	N/D	N/D	0.78	-	-	-
Ca	N/A	N/A	N/A	N/A	3.74	N/D	N/D	-	-	-

N/D = Not detect, N/A = Not available, BNMDW = Bottled Natural Mineral Drinking Water, BDW = Bottle Drinking Water, SLS = Sri Lankan Standards.

Blue and Grey Water Footprint Assessment: A Case Study from a Small-Scale Batik Industry in Sri Lanka

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Abstract - The majority of batik production is carried out by small and medium-scale business holders based on home industries in Sri Lanka. Thus, they tend to discharge their wastewater into the environment without proper treatment. Due to the use of synthetic dyes, the discharge of batik wastewater causes negative consequences on the health of humans as well as the environment. In addition, the batik industry often involves the use of an excessive amount of water in its production. This study aimed to determine the blue water footprint (BWF) and grey water footprint (GWF) of the small-scale batik industry in Sri Lanka and gain understating of the perspective of the batik craftsmen on their water usage. A questionnaire was conducted through an in-depth interview with the selected industry to find out the step with the most water usage, and strategies used to minimize water usage as well as wastewater generation. BWF was determined by direct measurement, while GWF was estimated by calculating the water required to dilute COD concerning Naphthol dye. The water footprint analysis estimated the BWF as 10 L per 6 m^2 cloth which has a much higher portion of the total water footprint and GWF as 2.6 L per 6 m^2cloth. Thus, the results of this study indicate the need to increase the awareness of batik producers to reduce their water usage and treatment of wastewater up to the environmental standards.

Keywords: Batik, water footprint, Naphthol dye, pollution, awareness of batik craftsman, water usage

I. INTRODUCTION

Batik is evolved as a textile product that is produced by traditional handicrafts [1]. In Sri Lanka, the majority of batik production is carried out by home-based small and medium-scale factories. Most of these factories do not have proper wastewater treatment facilities and tend to discharge their wastewater directly into the soil or river causing environmental pollution. Inefficient water usage alone with degraded water quality leads to water scarcity in the regions with batik industries [2].

Batik production often involves the use of synthetic dyes which are used for coloring the patterns drawn on the fabrics rather than the use of natural dyes. Naphthol and VAT are the most commonly used synthetic dyes as these synthetic dyes can be easily applied to fabrics [3]. These dyes are reported with carcinogenic characteristics for human health and are not biodegradable due to the complexity of bonds [2]. Wastewater discharged from batik industries contains heavy metals like Fe, Cu, and Zn accumulated in soil and plants [2]. In addition, batik wastewater causes decoralization and odor in the water of the adjacent dig well through infiltration [4].

1.1 Batik production system

Batik production systems usually consist of two stages as preparation stage and the production stage as shown in Figure During the preparation process, materials and tools are prepared. After the preparation stage, the production process is started. The production process includes drawing patterns, wetting, waxing, application of dyes, removal of dyes, drying, and ironing. Patterns are drawn in the fabrics using a pencil and wax is applied to prevent unwanted areas from being dyed. Clothes are immersed in dye liquids to color the patterns and washed to remove excess dyes. The clothes are boiled to remove the wax on the fabrics. The procedure is repeated if it is required to apply more than one color to the cloth.

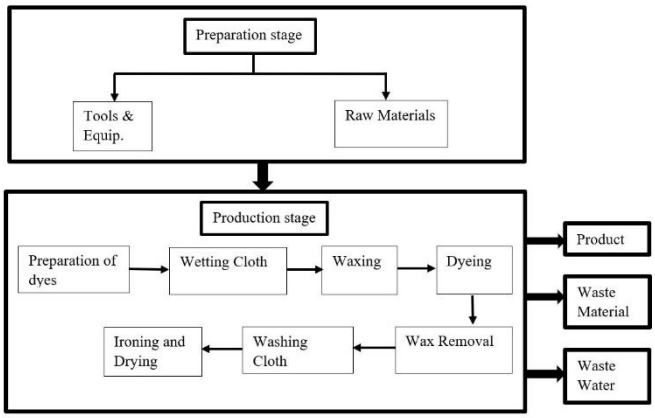

Figure 1: Production process of the batik industry

1.2 Environmental awareness of batik craftsman

The behavior of the batik producer is considered one of the key factors affecting water use in the batik industry [5] because behavior is related to the understating and knowledge of batik craftsmen [3]. For instance, a batik craftsman with less knowledge of the environmental impacts of his industry will not take any actions to increase the water efficiency of his production, shifting from synthetic dyes to natural dyes and discharging wastewater with proper treatment. Thus, the use of a qualitative approach allows us to understand the level of environmental awareness of the batik craftsmen and provides suggestions to increase their water effectiveness.

1.3 The water footprint assessment approach

The water footprint (WF) measures the amount of freshwater appropriated for productive activities, both in terms of the water used (green and blue WF) or polluted (grey WF) [6]. BWF is defined as the water used in the process, whether it is absorbed into the finished product or evaporates during production [4]. The green water footprint is the amount of rainwater that is stored in the soil's root zone before being evaporated, transpired, or absorbed by plants) [6]. The GWF indicates the water required to assimilate the pollutants [7].

Estimation of the water footprint of the industries and taking actions to minimize and keep the water footprint at a low level is crucial as fresh water is vital for the existence of humans and it has a limited supply) [3]. In this study, BWF and GWF were determined.

II. Materials and Methods

2.1Qualitative approach

This study was conducted in an industry located in Pugoda which has been producing batik for a longer time. A list of questions was prepared in order to know the perspective of batik craftsmen concerning water usage and wastewater generation during batik production. The questions were also asked to indicate the step with the most water usage, and the strategies used for water saving and reducing wastewater generation and management.

A one-to-one interview was conducted based on the prepared questions. All the data from the interview were recorded and reported in narrative form.

The quantitative data were collected for the BWF and GWF as follows.

2.2 Blue water footprint (BWF)

The major steps in batik production that use water include wetting, application of dyes, removal of the wax, and washing. Wetting is done in a barrel with a 16 L capacity, filled with water, so that water is required to wet one piece of cloth was estimated as 1 L. The application of naphthol dye involved the use of two separate tubs for the preparation of the dye. Consequently, each process in the dying required 2 L per 6 m^2 cloth. The wax removal process consumed 1.5 L per piece of cloth. Washing required 5.5 L per 6m^2 cloth.

2.3 Grey water footprint (GWF) Assessment of Batik

Since some batik industries tend to discharge their wastewater into the soil, the GWF calculation based on the point source pollution cannot be used [8] so, in this study, GWF was calculated based on the amount of water requires to dilute the COD until it reaches the acceptable standard set by Sri Lankan government.

GWF was calculated based on the following equations [8].

$$df = \frac{[COD]sample}{[COD]limit} \quad (1)$$

The COD concentration concerning the use of naphthol in batik production and water quality standard for textile wastewater being discharged for irrigation purposes which were imposed by the Sri Lankan government were used for the calculation of the dilution factor(df):

Finally, the dilution of water (dw) in L is calculated based on the following equation [2]:

$$dw = (df - 1) \times \text{wastewater volume} \quad (2)$$

III. Results and Discussion

3.1Qualitative analysis

According to the selected batik craftsman, naphthol dye is mainly used for the dyeing process in their industry. It involves the use of a large amount of water for the dye preparation process compared to other types of dyes which increases the water use of batik production on large scale. Moreover, washing is considered the most water-consuming step as it requires washing the clothes several times during production. The batik craftsman didn't take many actions to minimize the water usage during the production other than doing mass production at one time because they used well water as their water resource. Thus, they think they can use much as water for their production as they have an unlimited supply of well water. Furthermore, the batik craftsman did not measure regularly the water use in their products except for the dye preparation process which requires a fixed amount of water. They recover back the synthetic dye during the washing process to reduce the toxicity of the wastewater as well as production cost. The batik craftsman has developed a wastewater treatment plant with a preliminary treatment facility. After the treated wastewater is discharged onto the land for irrigation purposes. The batik craftsman did not satisfy with the purification by the current wastewater treatment plant and wanted to replace it with an upgraded one and reuse the treated water in the production process.

3.2 Bluewater footprint and gray water footprint analysis

The BWF was estimated as 10 L per 6 m^2 cloth. Washing is indicated as the most water-consuming process in the selected industry as shown in table 1.

Table 1: Water use for the batik production

Process	Water consumption (L)	Water usage (L/PC)
Wetting	16	1
Preparation of dye	32	2
Wax removal	24	1.5
Washing	88	5.5

The COD value relevant to the use of naphthol dye was considered 504 mg/L [9] for the GWF estimation in this study. GWF was estimated as 2.6 Lper6m^2cloth. Therefore, the results indicated that selected the small-scale batik industry accounts for a much higher BWF compared to its GWF.

The water usage in the batik industry mainly depends on the scale of the production, and the origin of dyes(synthetic/natural) [5]. The findings of the qualitative approach of this study indicate that water usage mainly depends on the attitudes of the batik craftsman rather than the scale. So, even the small industry may end up with a much higher water footprint due to the excessive usage of freshwater. As per a study conducted in Bogor, Natural dyeing produces 550.60 kg/100 pieces of batik, which is equivalent to 19.11 m^3 of wastewater per ton of batik produced, compared to 614.38 kg/100 pcs of batik or 25.28 m^3 of wastewater per ton of batik generated by the synthetic dyeing process [5]. Thus, the use of synthetic dye such as Naphthol increases water usage in the selected industry as it consumes a large amount of water for the preparation.

The GWF showed less contribution to the total water footprint in this study because the recovery of Naphthol dye from the wastewater also reduces the amount of water required for the dilution of wastewater.

IV. Conclusion

The BWF has a higher portion of the total water footprint than the GWF. Despite the magnitude, even small-scale batik producers consume a large amount of water in their production. Thus, the awareness among batik producers needs to be increased to reduce their water usage during production and treat the wastewater up to imposed environmental regulations before discharge into the environment.

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Demanding for Higher Standards to Safeguard Laboratory Animal Rights in Sri Lanka, A Legal Analysis

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Abstract - The country of Sri Lanka is one where the society we lived in upholds human rights as a matter of national policy. However, the legal framework does not emphasize animal rights. This study, which will pay special focus to the welfare rights of laboratory animals, will examine the significance and pressing requirement of enacting strong regulations to protect those rights, with particular attention paid to Sri Lanka's usage of laboratory animals. Since the 1960s, Sri Lanka has used laboratory animals for research and medical education, mostly utilizing about 2000–3000 mice, rats, Guinea pigs, rabbits, and zebra fish annually, however, the laws have not changed over time. On a global scale, nations have taken major steps to protect the rights of laboratory animals, whereas Sri Lanka is still trailing behind. This study aims to examine common gaps in ethical guidelines regarding the use of laboratory animals' rights. Legislative provisions and regulations are employed as primary data in this study, and scholarly articles, newspaper articles, and academic critiques are used as secondary data. The researcher depends on the qualitative technique. Higher legal standards have been enacted in relation to the rights of laboratory animals in nations like the UK, the USA, and India. As a result of this detailed inspection, the researcher suggests that Sri Lanka develop separate legislation to safeguard the rights of laboratory animals.

I. Introduction

Assuring the welfare of non-human animals is the sole objective of animal welfare, including all factors such as appropriate housing, management, disease prevention and treatment, responsible care, and humane handling. As the most intellectual species on Earth, humans have a responsibility to safeguard the welfare of all other living forms in order to uphold liberty, justice, and equality for all. Animal research is an integral part of scientific and medical advancements all around the world. Nevertheless, there are additional ways in which the use of animals in scientific and medical research poses a harm to non-human creatures. Regardless of its goal or benefit, animal testing is viewed as cruel and needless by both animal rights extremists and anti-vivisectionist organizations. The aim of animal welfare is nothing else except to Animals have been employed in Sri Lankan laboratories since 1960 and for medical education since 1950. Despite the fact that animals have been employed for a variety of scientific experiments in laboratories, they have not had appropriate legal protection to ensure at least the bare minimum of their rights or welfare concerns. to Prevention of Cruelty Animals Ordinance, No 13 of 1907 is now inadequate, thus the Animal Welfare Bill of Sri Lanka has not been passed as a law. Internationally, countries have taken significant steps to safeguard the rights of animals, with an emphasis on laboratory animals, but Sri Lanka is still lagging even in the absence of an updated measure of legislation to speak up for the voiceless. In addressing the aforementioned, this research will be based on the animal cruelty and ignorance of animal welfare issues prevalent in Sri Lanka due to the lack of proper legislation to take actions, giving special attention to the context of laboratory animals. The researcher will stay on focusing the following objectives through this research; to identify different types of cruelties that happen to animals used in laboratory use, to analyse prevalent law and regulations relating to scientific animals, to synthesise international law relating to safeguard of scientific animal welfare and to recommend justice to laboratory animals through a new legislation.

II. Materials and Methods

The researcher used qualitative approaches to conduct this study, gathering combining primary and secondary data. While analyzing and critically evaluating those sources the researcher will fulfill research objectives. The primary sources used are the Prevention of Cruelty to Animals Ordinance No.13 of 1907 in Sri Lanka, the statutes of the UK, USA, and India. It describes regulations pertaining to the care of animals, particularly experimental animals. Scholarly articles, and journal articles have been used as secondary sources of this research.

III. Results and Discussions

Prevention of Cruelty to Animals Ordinance No.13 of 1907 is considered as the prevalent law in Sri Lanka relating to Animals Rights. This Ordinance has been amended many times as, 1912, 1917, 1919, 1921, 1927, 1930, and 1945 and lastly as No 22 of 1955. But there is no provision for the welfare rights of laboratory animals. The Animal Welfare Bill which is to be gazetted discusses the welfare of animals used for scientific purposes. Section 42(1) states that "No person shall use live animals for teaching or research or experimentation unless such a person has obtained a permit for the said purpose from the authority".

According to section 42(2) in issuing a permit, the authority shall have regard, amongst other considerations that it considers relevant, to the availability of alternative methods and devices that do not involve experimentation on live animals, including computer simulations and other audio-visual methods, synthetically produced models, ethically sourced cadavers, and clinical experiences.

Regarding the statements of the Animal Welfare Bill, it appraises the legal aspects of using laboratory animals for scientific purposes but not about the welfare rights of laboratory animals used for scientific research. In addition, The Sri Lankan Association of Laboratory Animal Science has proposed a set of criteria expecting to ensure the humane use of animals in Sri Lanka for the advancement of science. In this guidance,

Section 3 of the guideline proposes that the primary consideration of the welfare of laboratory animals including the maintenance of physiological and psychological conditions as a

responsibility of the research team. But this is only a guideline that can be followed by a research team or not and not an essential consideration as it is not a law within the country. Globally, many countries have taken significant measures to ensure the welfare rights of Laboratory Animals. The USA has The Animal Welfare Act and Health Research Extension, to guarantee the proper treatment of animals while being used in such research. Australia has The Code of Practices for the Care and Use of Animals for Scientific Purposes to promote the ethical, humane, and responsible care and use of animals for scientific purposes. Sri Lanka still has low prominence towards the welfare rights of laboratory animals.

IV. CONCLUSION

Therefore, it is much evident that, in foreign jurisdictions, laws have been implemented to provide better standards to protect non-human animals used in laboratories.

Since Sri Lanka employs between 2000 and 3000 animals yearly for scientific research. Therefore, the lack of a higher standard of laws to protect animals in laboratory use is at a crucial time. Thus, it is recommended by this research that it is almost past time to implement new legislation in order to safeguard the welfare rights of animals used in laboratories.

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Factors Influencing Student Dropouts at Postgraduate Online Programs

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Abstract

One indicator of an online program's efficacy is the dropout rate. By-passing geographic, social, economic, and temporal barriers, distant learning studies addresses the educational demands of residents and improves educational advantages inside a country's geographical jurisdiction or even outside its borders. The main purpose of the study is to understand the factors influencing student dropouts in the postgraduate online programs. The research has been conducted with a quantitative approach. Data collection was conducted via a personally administrated questionnaire, interviews and a variety of academic sources have been utilized. The factors influencing the student dropouts in the postgraduate online programs were identified as student skills, level of satisfaction, external factors and internal factors. The major findings of the study was that all factors are essential in order to minimize the student dropouts.

Keywords: **Online education, postgraduate programs student skills, level of satisfaction, external factors and internal factors.**

I. INTRODUCTION

The rise in popularity of online learning is altering the face of education [6]. As mentioned by Willging & Johnson (2004, p. 105) [5], questions have been raised concerning the efficacy of this new approach to delivering education. One indicator of an online program's efficacy is the dropout rate. By-passing geographic, social, economic, and temporal barriers, the approach known as distant learning studies addresses the educational demands of residents.

Online courses enroll more students than traditional campus courses, but they also have higher attrition rates, according to a study of enrolment and attrition rates for the online MBA program at West Texas A&M University. According to Willging & Johnson (2004, p. 106) [5], in order to perform that study, 15 graduate business courses over the last three years taught both on-campus and online by the same professor were examined. Attrition (reduction in the number of registered students), despite the enormous interest in suitable design and development, is one of the key problems of online education.

The main purpose of the study is to identify the factors influencing student dropouts in the postgraduate online programs. It is essential to conduct the research in order to reduce student dropouts. Only limited number of researches have been conducted regarding student dropouts and postgraduate online programs offered in Sri Lanka.

II. MATERIAL AND METHODS

The primary data collection tool used was a personally administrated questionnaire and interviews for a sample size of 35 students. Data was gathered with both open ended and close ended questions. Some of the key questions asked were ‘What influenced you to join the postgraduate online program?’, ‘Are you familiar with using a computer?’ and ‘Were you able to attend for the virtual lectures with your busy time schedule?’. Secondary sources of data including books, journals and academic publications have been utilized. The outcomes of the study were compared with the data available in the literature.

III. RELATED WORKS

Various models were analyzed to understand the factors influencing student dropouts in the postgraduate online programs. According to the findings, the factors influencing the student dropouts in the postgraduate online programs were identified as student skills, level of satisfaction, external factors and internal factors. The theories and models used are relevant for the study since it is applicable to the online education setting and particularly distinguishes between unconventional and traditional students.

Tinto’s Student Integration Model

According to Tinto (1993) [1], throughout a student's enrollment in a program, interactions between the student and his or her educational environment contribute to attrition. 50% of respondents agreed the same. However, Tinto's model has only limited application for educators who wish to research the persistence of nontraditional students who differ from conventional students in terms of their nature and features (Rovai, 2003 [4]; Bean & Metzner, 1985 [2]). Tinto acknowledged that when employed with nontraditional students, his paradigm needed to be modified (Tinto, 1982) [1].

Bean and Metzner’s Student Attrition Model

A conceptual model for nontraditional students' dropout was created by Bean and Metzner [2] in 1985 and included factors such as academic performance, intention to leave largely impacted by academic and psychological results, background and defining elements, and environmental variables. 50% of respondents agreed with the academic performance. Unconventional students are more impacted by the outside world than traditional students.

Kembers’ Longitudinal Process Model

As a result, Kember (1989) [3] suggested a longitudinal process model of drop-out distant education and offered ideas for evaluating the model (e.g., developing reliable instruments, conducting both qualitative and quantitative research, etc). In Kember's longitudinal model (Kember, 1989) [3], it is acknowledged that factors that intervene between initial student characteristics/background and persistence should be taken into account when analyzing students' social and academic integration. 70% of respondents agreed that internal factors influenced them.

Rovai's Persistence Framework

Rovai (2003) [4] suggested a composite persistence model that was mostly based on the two models. The model included two pre-admission variables—student characteristics and skills before to admission—as well as two post-admission variables—external factors and internal factors (e.g., finances, employment hours, outside encouragement, etc). (e.g., academic integration, social integration, self esteem, interpersonal relationship, study habits, advising, absenteeism, etc.). 50% of respondents agreed that external factors affected them.

4. RESULTS AND DISCUSSION

Through the data gathered from the primary and secondary sources, it was identified that as student skills, level of satisfaction, external factors and internal factors influence student dropouts in the Postgraduate online programs.

Table 01: Factors Influencing Student Dropouts in the Postgraduate Online Programs

Factor	% of respondents
Student skills	50
Level of satisfaction	50
External factors	50
Internal factors	70

As presented in the table, internal factors have majorly influenced student dropouts in the postgraduate online programs. Time constraints acted as a major issue when collecting data. Students skills, level of satisfaction and external factors have acted as influencers as well.

Student skills

Rovai (2003) [4] added student competencies such computer literacy, information literacy, time management, reading and writing, and computer-based interaction. The dropped out students of the Postgraduate division (SLTC Research university) mentioned that time management was a key issue since most of the students were managing studies along with jobs. Rovai (2003) [4] mentioned the importance of student abilities prior to an online course or program, but few researches have specifically looked at these elements.

Level of Satisfaction

The dropped out students of the postgraduate online program stated that level of satisfaction is essential. Interviews with participants in a distance master's degree provided by Boise State University were undertaken. Interviews were conducted with students who left the distant learning program and those who stayed in it between 1989 and 1996. The degree of satisfaction with the program's first/ second course was the key determinant as stated by Willging & Johnson (2004, p. 105) [5].

External factors

The external elements that are most frequently examined or noted include time constraints, family issues, finances, work status, and management assistance. These issues were stated by the interviewed candidates as almost all of the candidates were doing jobs and faced the above issues. Time conflict is the one that is mentioned the most frequently (Willging & Johnson, 2004) [5] among these. The majority of online students are part-time workers with many responsibilities because they are working.

Internal factors

Tinto (1993) [1] included academic integration, social integration, goal commitment, institutional commitment, and learning community. Several internal aspects, including study habits, counseling, absenteeism, course availability, program fit, contentment, were also covered by Bean and Metzner (1985) [2]. Additionally, Rovai (2003) [4] incorporated student demands such program clarity, self-esteem and school identity. These factors were also accepted by the interviewed candidates.

IV. CONCLUSION

The use of online learning is growing in the education sector due to post COVID and work demands. Student skills, level of satisfaction, external and internal reasons were identified as the factors influencing the student dropouts in the postgraduate online programs. Each factor must be taken into consideration in order to reduce student dropouts in the postgraduate online programs. If all factors are positively met, the students would retain in the postgraduate online programs.

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A Comparative Study of Chamber Music Groups, Orchestras & Bands

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Abstract - The late 14th to early 16th century Italian Renaissance, a time of intellectual and artistic growth. The Italians were particularly fascinated by music, poetry, literature, and the arts. Despite the fact that composers produced more intricate music, it only stated the notes that were to be played and could essentially be played on a wide range of instruments. Then, in 1607, Claudio Monteverdi, an Italian composer and the father of opera, made the decision that he understood exactly how he wanted his music to sound. In order to get the instruments, he desired, he composed music expressly for them: two violins, four flutes, two cornets, one harp, etc. This enormous group, which had distinct functions for each instrument, was the precursor of the orchestra we know today. When studying different aspects of music, one finds a variety of instrumental combinations. Suggestions have been made about Orchestra, Chamber Orchestra and the band. But it is possible to identify the special features of these combinations in the study or use of comparison of each of these categories. That is, similar features and unequal features can be added to this balance. In this study, I will focus on the three elements of orchestral composition mentioned above. Thus, the balance here is studied through the special features of these three elements.

Keywords: Orchestra, Chamber Orchestra, Band, Instruments, Combination.

I. INTRODUCTION

In the 16th century, instrumental music was gradually becoming emancipated from being no more than an imitation of vocal music; but nonetheless, this long remained the model for instrumental composition. The history of instrumental music in the 17th and 18th centuries is largely the story of the establishment of a truly independent instrumental idiom [3].

Instrumental music evolved into a variety of styles, genres, and forms between the years 1450 and 1550 [2]. There was independent instrumental music before in the shape of dances, fanfares, and the like, however, musicians performed from memory or with improvised embellishments, the music has either not survived or has only remained in a rough form. Although there seems to be more focus on instrumental music after 1450, this may be an illusion caused by the fact that more instrumental music was recorded. Additionally, instrumental music found in Renaissance texts and prints is quite rare nowadays.

II. METHODOLOGY

For this study, I'm going to follow the combination of musical instruments that includes three main parts,

- Chamber Music Groups
- Orchestras
- Bands

1. Literary research - Books were written about instruments' history.
2. Internet Sources - Browse information by studying websites, watching web pages, and YouTube online videos.
3. Participatory observations - Participating as a cellist in various types of orchestras in Sri Lanka.

III. RESULTS AND DISCUSSION

A. CHAMBER MUSIC GROUPS

The essential difference between chamber music and music for an orchestra or band is that in chamber music there is only one player for each part: the instruments are not duplicated, so if a player is missing there is a gap in the music. Because chamber music is played by soloists it has a particularly intimate quality. Although often performed nowadays in concert halls, it is really music designed to be played in a room rather than in a large public auditorium. The word 'Chamber' is actually derived from the Latin word for 'Room' [10].

A 20th-century term implying an orchestra of modest size consisting, for example, of a small body of strings together with a selection of wind instruments, either singly or in pairs (though trombones and tuba are normally excluded). Such an orchestra is ideal for performing 18th- Century works such as the symphonies of Haydn and Mozart, and also 20th- Century works specifically written for a small orchestra rather than a full symphony orchestra [1].

Of course, there aren't many participants. The term "chamber music" is not typically used to describe music that is performed by just one or two musicians, such as a piano sonata or a violin and piano sonata. At the low end, there are almost never more than three players, and the norm is that there are at least three participants. A trio, quartet, quintet, sextet, septet, or octet is made up of three musicians. A quartet, quintet, sextet, or septet is made up of five players. The terms "trio," "quartet," and so on, have two distinct meanings, denoting both the number of musicians and the type of music that is being referred to. A sonata for four string instruments or a group of four string players are both acceptable definitions of the term "string quartet," for instance.

Open scores are used by composers while writing chamber music; nevertheless, each musician often just have their own part in front of them (as they do in an orchestra). When the piano is playing in a group with other instruments, its part is

printed in the score underneath theirs. The pianist performs from this score. Bar lines are drawn uninterruptedly through every stave that belongs to an instrument of the same sort (wind, strings, or keyboard), but not across staves that belong to different kinds of instruments.

B. Orchestras

Even if the boundary separating a chamber music ensemble from an orchestra might be subtle, it nevertheless exists. Today, the term "orchestra" refers to a collection of musicians that always includes strings (but typically also other instruments), with each string part being played by many musicians rather than a single soloist. First and second violins, violas, cellos, and double basses make up a string orchestra, which is composed entirely of strings. Each component has several players; therefore, it is possible to break it into smaller parts. When this occurs, the music is designated as divisi (or simply div.), and when they reunite, it is designated as unis ('in unison').

A tiny orchestra including additional instruments in addition to strings is simply referred to as a "chamber orchestra" to avoid needless confusion; the music it performs is not chamber music. Early orchestras were all tiny orchestras by today's standards. They were erratic ensembles of instruments at the start of the 17th century, but with time they become more uniform. By the time of J.S. Bach, strings and a continuo instrument had established themselves as the foundation to which other instruments could be added; by the end of the 18th century, the continuo had been dropped, and the orchestra had settled into what is essentially its modern form—even though it was still to become much larger. Strings, woodwind, brass wind, and percussion are the four parts of the "full orchestra" or "symphony orchestra" in this contemporary configuration.

There are several ambiguities in the divisions. Horns, for instance, form a distinct group of instruments because, while it is obvious that they do not belong in the woodwind section of the orchestra, neither are they typically thought to belong in the brass section, which only consists of the so-called "heavy brass" instruments, such as trumpets, trombones, and tubas. Similar to the percussion section, the timpani are not typically included. Additionally, several instruments that were added to the orchestra in the 19th or 20th century cannot be easily classified into any of the traditional categories. A good example is the harp, which, while undeniably a string instrument, clearly differs from violins and other string instruments and does not belong in the orchestra's string section.

Although additional strings have had to be employed as other, more powerful instruments have been introduced to the orchestra, composers seldom specify the exact number of strings needed. A modern orchestra would typically have around 12 violas, 10 cellos, 14 first violins, 14 second violins, and 8 double basses. Some instruments only have one performer each, such as "2 flutes," which designates two flutists playing the first and second flute parts, respectively.

C. Bands

'Band' is a rather vague word that in the past has been used to refer to almost any sizeable collection of instrumentalists, even to what we would now call an orchestra. In modern usage, the word generally implies a large group of wind and percussion players, such as a **brass band** or a **military band**. Neither of these includes strings (for the very good reason that they normally play out of doors, where strings would be ineffective), but they are not the same. The essential difference is that brass bands do not include woodwind instruments but military bands do. Both include many instruments not normally found in the symphony orchestra (though usually related to those that are); both also vary somewhat from one country to another in the particular mixture of instruments [10].

A name which may be given to any fairly large combination of instrumentalists, but often referring in particular to a group which consists mainly of wind players – such as a brass band, a military band, or a symphonic band. The word 'band' may also be applied to particular groups of instruments, such as accordion band, steel band, percussion band, and so on. The word has also been widely used in jazz and popular music (e.g. jazz band, dance band, big band) [1].

The symphonic wind band (also known as a concert band) is comparable to a military band in that both woodwind and brass instruments are used, but unlike a military band, it has no links with parade grounds. Since about the middle of the 20th century, several notable composers have been inspired to write for it in a broad range of styles, including Prokofiev, Schoenberg, and Copland.

Jazz bands, dance bands, and the ensembles that eventually took their place as popular entertainment are significantly more diverse and frequently feature instruments besides wind and percussion, such the double bass, guitar, and piano (or, more recently, electronic keyboard instruments). The West Indian "steel bands" are primarily percussion ensembles, but their instruments, which were expertly crafted from the most basic materials, most notably oil drums, can generate surprisingly complex tones.

IV. CONCLUSION

In a clever way, the general aim of orchestra and band performers is the same. To please the audience, they work to maintain the symphony, credibility, and immaculate melody and rhythm. Musicians must arrange a variety of musical instruments for performance. The band and orchestra still differ from one another. A musician in the ensemble is without a stringed instrument to play. To keep a seamless tone impact with the best clarity in resonance and credibility, two groups utilize distinct instruments.

Marching on the stage or the floor are the band members. The same conventional design is maintained. With a variety of musical instruments, an orchestra troupe is discovered seated on the ground. A competent leader is clearly observed playing instruments in a band to keep everyone engaged. It's not required for the conductor to play any instruments when leading the orchestra. Standing on the concrete floor, he leads the ensemble.

In discussing the findings of this study, a general consensus can be reached on these three aspects. That is, playing the instruments, which is the common denominator of these three elements. It also shows the size of the instruments used for each

component and the volume of sound it emits. The volume emitted by a large orchestra is greater than the volume emitted by a chamber orchestra. Also, the sound of bands is determined by the instruments used for those bands and what type of band it is. In this research, however, we focused on each of these three aspects individually. It made it possible to explore the similarities and differences between these three elements.

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Key Challenges Faced by Households for Food Access by Covid-19

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Abstract - Food is essential for life. Maintaining food through the supply chain is important for sustainability. As the coronavirus diseases Covid 19 had affected the life globally, there is a challenge to access food across the world. The study aimed to find out the key challenges faced by households to access food and change of consumer behavior during the Covid 19 pandemic situation in Jaffna district. Data collection was carried out in Jaffna district using interviews, group discussions and questionnaire methods. Fish mongers, vegetable sellers and shop keepers were interviewed regarding the purchasing behavior of consumers. A questionnaire was distributed among the local residents to find the challenges faced by the pandemic situation. The lock down affected the livelihood of wagers who rely on their daily income for nearly three weeks in March- April 2020. As the movement of people was restricted in the first phase, people found it difficult to reach the essential food items. The livelihood of the day-to-day workers was affected by the national curfew implemented throughout the country. Closure of markets due to the spreading of disease, fear of purchasing seafood in the second phase, instability of prices of groceries, unavailability of raw foods and restricted entry into the food corners are the identified key challenges in accessing food. Charity services by the volunteers in the district helped to reduce the hunger of the needy people. However, after the pandemic people showed interest in the short supply chain. Purchasing vegetables from farmers directly from the field is an additional advantage for the farmers.

Key words: Covid 19, Household, Food access, Pandemic

I. INTRODUCTION

The Covid 19 pandemic had disturbed the economy and food system globally and locally [8]. After identifying cases in Sri Lanka, the government implemented national lock down aimed at controlling the pandemic. Quarantine, travel restrictions and isolation of small villages were in practice [3].

Various levels of lock down were initiated in the countries which are affected by the Covid 19 pandemic depending on the infection mortality rates. Countries that implemented their own health regulations and social distancing, as well as people are expected to follow them strictly [10]. In Sri Lanka, the lock down was initiated in the third week of March 2020. The movement of the people was restricted until the third week of April in Jaffna. Thereafter for few weeks curfew was implemented in weekends. Residents of the district were under pressure during the period to find food to consume. Consumer behavior started to change and home cooking was preferred by the majority.

The study aimed to investigate the key challenges faced by households to access food and change in consumer behavior during the Covid 19 pandemic situation in Jaffna district.

II. METHODOLOGY

The study was conducted in Jaffna district and the data collection was focused based on the pandemic situation from the period of March 2020 December 2020. A questionnaire was distributed among randomly selected 50 residents of households to investigate the challenges faced for food access during the lock down period in Jaffna district from March to April 2020 and thereafter. Local farmers, vegetable sellers, fish mongers and shop keepers were interviewed in order to find out the purchasing behavior of consumers.

III. RESULTS AND DISCUSSION

The lock down made negative impact on the income and physical assess of food [2]. Food is key factor for consumer sustainability. Covid-19 blocked the normal food supply chain functions. The normal life style of the people was changed and people find it difficult to access food [1].

Closure of markets due to the spreading of disease, fear of purchasing seafood in the second phase, instability of prices of groceries, unavailability of raw foods, restricted entry into the food corners are the identified key challenges to access food from the study.

Home cooking was preferred in the pandemic situation as people were reluctant to purchase cooked food from outside. During the lockdown period work from home and online learning were initiated. As there were fewer options to buy food from outside, frequency and amount of food preparation were increased greater than before with the limited grocery available at houses.

Shop keepers reported that the purchasing behavior of consumers changed. They paid attention in purchasing dry foods such as rice, lentils, soya and laundry soaps before lock down in order to use them during the lockdown period. Panic buying of nonperishable food items was observed worldwide [4]. The goods ran out quickly as consumers buy them in excess amount.

Instability of the price of food raw materials is another problem faced during the lockdown period and thereafter,

the price of paddy, black gram and turmeric went high. As some cereals, lentils and spices are imported from other countries, it was hard to import them during the pandemic situation [11].

Due to the spread of diseases, the markets were closed and the sellers had to shift to mobile vegetable markets where they had to spend extra money to hire vehicles. People show interest towards buying vegetables direct from the local farmers at the field. Local welfare societies arranged facilities to consume fruits and vegetables directly from farmers where both farmers and consumers benefited. Agriculture contributed to the national economy, food security and employment in the country [9]. Social media played a big role in advertising the details of availability of food items [12]. Loses of food items especially fruits and vegetables were observed due to closure of markets and restrictions on transport. Access to milk and eggs was not affected like other food items as they could be obtained from local households.

In the second phase of Covid 19 in Sri Lanka, disease was started to spread from fish market and the demand of fish getting lower thereafter. Grocery shop owners reported that demand for eggs went high. Chicken, eggs, canned fish and dried fish were replaced the seafood.

According to the survey, the families rely on day-to-day work found it difficult to run the family during the lock down period and were at a risk of losing their livelihood [5]. However, during the lock down period funds were raised from local volunteer people and those who migrated to foreign countries in order to distribute dry food items to the needy people throughout the districts. Welfare societies, youth clubs, women organizations, charity organizations and temple trusts played a major role in food distribution. Fund collected from the staff of various organizations was used to donate essential food packages to the deprived families of daily wagers who lost their income during curfew. The alumni of Faculty of Medicine, University of Jaffna took part in relief activity of Covid-19. Supplementary food packets were given to vulnerable group of people. The nutritional supplements were purchased from the organizations that are run by women-headed families and differently-abled persons. Undernourished children from families of deprived daily wagers were provided with the nutritional supplements.

Home gardening was encouraged by the government during the period with the theme of from garden to table where seeds were distributed to people in order to encourage self-consumption [6].

IV. CONCLUSION

The Covid-19 crisis has raised awareness among people regarding the importance of food access. As the state-imposed curfew was implemented throughout the country with the spread of deadly virus, the situation greatly affected the daily wage earners. Residents of Jaffna faced difficulties to access food items during the lock down period. Charity services by the volunteers took major role to reduce the hunger of needy people in the district.

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An Overview of Microplastic Contamination and Research Gaps in Sri Lanka

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Abstract - Microplastics (MPs) have gained the attention of scientists, researchers, policymakers, and the general public as one of the controversial environmental issues of the decade. Recent researches suggest that MPs have already infiltrated both the terrestrial and aquatic ecosystems in many countries including living organisms. This study reviews the current research focuses, findings, and gaps in the content of Sri Lanka. Most of the available research is focused on coastal environments where a higher level of MPs contamination was reported. Furthermore, they have claimed fishing industry, tourism and urbanization are key contributors to MPs pollution in coastal waterways. A handful of researchers have found MPs in food products that were collected from retail shops raising concerns about the food security of the nation. Therefore, it is vital to understand the MPs situation in terms of infiltration of water and food supply, air, ecology, MPs associated contaminants, and the potential health risk to humans, to identify the key MPs producers/polluters/sources and the severity to mitigate the MPs pollution by introducing or changing the existing plastic waste management laws and policies.

Keywords: microplastic pollution, policies, review

I. Introduction

Microplastics (MPs) are ubiquitous and slowly-degrading contaminants in waters, soils, and air measured at 5 mm or less in size. The situation and the fate of MPs are hot topics in the scientific community. The present global plastic production is about 320 million metric tons while single-used plastic accounts for half of the total production. It is estimated that about 58% of plastic waste enters the natural environment and eventually becomes MPs. It is estimated that about 938 metric tons of plastic waste are being produced daily in Sri Lanka while about 300.3 metric tons of plastic waste are being collected, the rest is not even collected properly [1]. Personal care products, cosmetics, and fabrics are some of the main sources of primary MPs that are being released unintentionally into the environment. Furthermore, incidents such as the X-Press Pearl container vessel disaster have released unprecedented amounts of MPs into the ocean around Sri Lanka. This study reviews the MPs situation in Sri Lanka and provides comprehensive undemanding current research trends and gaps that need to be addressed by future researchers.

II. Materials and Methods

A literature review was conducted using the two keywords "Microplastics" and "Sri Lanka" while limiting the period to 2015 onwards in google scholar. Ongoing research and preliminary studies were found using Sri Lankan University databases, and Research gate while government, and recognized NGO websites were used to gather reports.

III. Results and Discussion

Sri Lanka, being a developing country consumes relatively small amounts of plastics estimated at 6 Kg/year (per capita) compared to Europe and the USA stand at per capita consumption of 50 and 68 Kg/year, respectively [2]. In nature, due to different reasons these plastics brakes down into much smaller MPs. The degree of MPs pollution and its fate needs to be understood. This study has found a handful of peer reviews articles investigating MPs pollution in Sri Lanka most of which are very recent publications. Furthermore, several preliminary publications were also available in the form of conference and symposium publications. Researchers have identified different sources of MPs and key factors in plastic pollution leading to the occurrence of MPs such as urbanization, unsustainable tourism, and recreational activities, fishing activities, development projects, and waste mismanagement. The majority of the research carried out in Sri Lanka was focused on marine and coastal environments as mentioned in Table 1 where most of them were carried out on the western and southern coasts of Sri Lanka since much of the urban population and coastal economic activities such as tourism, fisheries, and several industries are located. But it is important to focus on other coastal areas and waterways such as rivers, "Oya", estuaries, etc. as some researchers have suggested that rivers and other waterways bring MPs from inland to the ocean [3]. The river Mahaweli is the longest in Sri Lanka associated with several major cities such as Kandy, which meet the sea on the northeast coast of Sri Lanka making it an ideal MPs transporter. But there is very little information available on MPs status in such environments in Sri Lanka. Few researchers have reported that the Sri Lankan food supply has been compromised by MPs, but the understanding is currently limited. Furthermore, the infiltration of MPs into living bodies is need to be investigated further.

Most of the developed countries still working on MPs and there are no specific rules or regulations for MPs in the food

Table 1. Summary of recent studies on MPs in Sri Lanka (PP- Polypropylene, PE- Polyethylene, PES- Polyester, ABS -Acrylonitrile Butadiene Styrene, PVC- Polyvinyl chloride, LDPE- Low-density PE, HDPE - High-density PE

Research Area	Location	Key Findings
Coastal environment	The southern coast, Sri Lanka. Surface water	0.23 to 0.33 MPs/m^3 (Average) HDPE, PP, PS [4]
Coastal environment	The southern coast, Sri Lanka Beach and beach sediment	60% of the sand samples and 70% of the water samples. PP (highest), PE, PE+PP, and PS [5].
Food	Puttalam, Hambantota, and Elephant Pass salterns. Commercial salt	MPs were presented in all types of salts LDPE, HDPE, PVC, etc. [6].
Coastal and lagoon Environment	Marine Protected Areas of Southern, Sri Lanka. Bundala and Hikkaduwa	Coastal sediments 111 MPs/m^2 and waters 0.515 MPs/m^3.PE, PP, and PS (in some locations) [3].
Coastal environment Food	Fish (Sardinella gibbose) West coast, Sri Lanka (Negombo)	The highest MPs 7.2 MPs/m^3 (Pitipana). MPs were found in fish guts. PVC, ABS, PES, PE, and PP [7].
Food	Dried fish (*Spratelloides delicatulus*)	0.27 ± 0.04 per g of fish [8].

according to European, United States, Australia, and New Zealand regulators, but there are some specific regulations to control MPs pollution such as primary MPs from cosmetics and personal care products. Sri Lanka also has taken initiatives to address MPs pollution directly and indirectly through NAPPWM 2021-2030. Even though there were initiatives such as the "Pilisaru" National Solid Waste Management Project, this is the 1st such initiative aimed to reduce plastic pollution through the 3Rs principle. Reduction of single-use plastics by 80% and reduction of marine plastic pollution by land base activities are some of the goals of this initiative that address the marine plastic issue. The 5th goal aims to reduce marine plastics pollution and has pointed out knowledge gaps such as the issue of the product containing primary MPs, bioaccumulation, and human-health impacts of MPs that are needed to be investigated [1]. An overview of MPs contamination and research gaps in Sri Lanka is given in Fig.1.

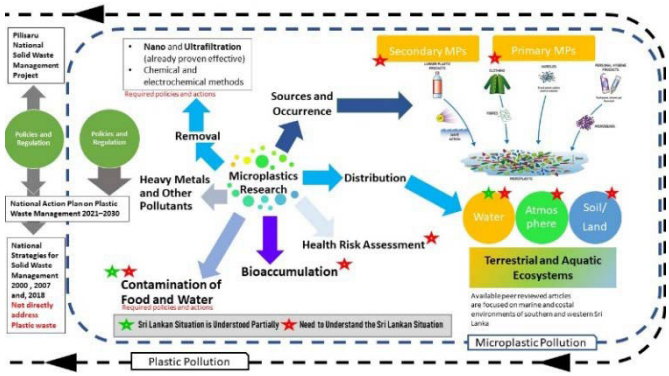

Fig. 1. An overview of MPs contamination and research gaps in Sri Lanka

IV. Conclusion

Several recent studies have found a higher level of MPs in different places in Sri Lanka, most of which are mainly concentrated in southern to western coastal environments. There is a lack of studies that investigate the situation of MPs in different aspects such as the occurrence and distribution of MPs in major rivers, estuaries, etc, afflation of heavy metals and other pollutants, the occurrence of airborne MPs, and, human health risk assessments.

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