



02nd SYMPOSIUM ON OCEAN AND FRESHWATER SYSTEMS
Expanding Resilient Blue Horizons

PROCEEDINGS 2024

ISSN 3051-4657

Faculty of Fisheries and Marine Sciences & Technology
University of Ruhuna, Sri Lanka
In Collaboration With
China-Sri Lanka Joint Center for Research & Education



Proceedings

02nd Symposium on Ocean and Freshwater Systems

08th November 2024



**Faculty of Fisheries and Marine Sciences & Technology
University of Ruhuna
Sri Lanka**



**Proceedings of the 02nd
Symposium on Ocean and Freshwater Systems**

“Expanding Resilient Blue Horizons”

ISSN 3051-4657

Barcode: 9 773051 465005

All Rights Reserved

© 2024 Faculty of Fisheries and Marine Sciences & Technology, University of
Ruhuna, Sri Lanka

Editorial Board:

Editor-in-Chief

Dr. U.A.D. Jayasinghe

Co-Editor

Dr. K.R. Gamage

Members

Prof. T.P.D. Gamage

Prof. R.A. Maithreepala

Prof. K.H.M.A. Deepananda

Prof. P.B.T.P. Kumara

Dr. D.M.U.A.K. Premarathne

Editorial communications by Dr. A.M.K.A. Bandara

Cover page designed by Ms. Ruwini Karangoda.



02nd Symposium on Ocean and Freshwater Systems Organizing Committee

Chairperson

Prof. H.B. Asanthi
*Department of Limnology and Water Technology,
University of Ruhuna, Sri Lanka*

Co-chair

Prof. Weiqiang Wang
*South China Sea Institute of Oceanology, Chinese
Academy of Sciences, Guangzhou, China*

Secretary

Dr. S.S. Herath
*Department of Fisheries and Aquaculture, University of
Ruhuna, Sri Lanka*

Members

Prof. P.B.T.P. Kumara
*Department of Oceanography and Marine Geology,
University of Ruhuna, Sri Lanka*

Dr. Gang Pan
*South China Sea Institute of Oceanology, Chinese
Academy of Sciences, Guangzhou, China*

Dr. K.R. Gamage
*Department of Fisheries and Aquaculture, University of
Ruhuna, Sri Lanka*

Dr. U.A.D. Jayasinghe
*Department of Limnology and Water Technology,
University of Ruhuna, Sri Lanka*

Dr. K.S.S. Atapaththu
*Department of Limnology and Water Technology,
University of Ruhuna, Sri Lanka*

Dr. R.M.G.N. Thilakarathna
*Department of Oceanography and Marine Geology,
University of Ruhuna, Sri Lanka*

Mrs. R.D.N. Wijesinghe
*Department of Fisheries and Aquaculture, University of
Ruhuna, Sri Lanka*



Foreword

The Faculty of Fisheries and Marine Sciences & Technology (FMST) is proud to present its biennial research Symposium on Ocean and Freshwater Systems (SOFS) for the second time under the theme “Expanding Resilient Blue Horizons”. SOFS was initiated in the year 2022 as a platform for showcasing final year research done by the undergraduates of the degree programmes conducted by the FMST. Now it has spread wings to cover postgraduate and international research as well. Although there are plenty of research symposia organized by the universities throughout the country, most of them are multidisciplinary in nature trying to cover many subjects within a limited time frame. On the contrary, SOFS focuses only on research issues in freshwater and marine environments and plays a unique role within this discipline in Sri Lanka. With the global trend in searching ways to expand blue economies, as an island nation, we carefully selected the theme focusing on resilience of the environment along the course of sustainable development. The Editorial Board carefully selected 30 articles for this proceeding after a double-blind review process for which we received the support of experts outside FMST. International contributions which were not subject to peer review have been incorporated as plenary speeches. The Editorial Board is not responsible for the content in the articles published here and it remains with the respective authors. On behalf of the Editorial Board, I take this opportunity to thank the authors who submitted their valuable research findings and innovative ideas to SOFS 2024, and to all reviewers for their tireless efforts in shaping up those articles. The Editorial Board wishes good luck for all the stakeholders of SOFS 2024 and expects this Proceedings would provoke thoughts on expanding resilient blue horizons.

Dr. U.A.D. Jayasinghe

Editor-in-Chief/ SOFS-2024



Contents

Message from the Vice Chancellor, University of Ruhuna	i
Message from the Dean, Faculty of Fisheries and Marine Sciences & Technology	ii
Message from the Director, China-Sri Lanka Joint Center for Education and Research	iii
Message from the Chairperson of Organizing Committee	iv
 Keynote Speech	 v
Sri Lanka's prospects for a blue economy <i>Dr. Shamen P. Vidanage</i>	
 Guest Speech	 x
Long-term coastal current observations in southern Sri Lanka <i>Weiqiang Wang, Terney Pradeep Kumara, Zhenqiu Zhang, Yao Luo and Gang Pan</i>	
 Plenary Speech I	 xi
Reversal of multidecadal sea level trends in the Southwest Indian Ocean thermocline ridge <i>Lei Huang, Wei Zhuang, Wenfang Lu, Yang Zhang, Deanna Edwing and Xiao-Hai Yan</i>	
 Plenary Speech II	 xii
Thermal sensitivity of mangrove leaf endospheric microbiome: niche plasticity of generalist and specialist bacteria <i>Nethmini R.T, Qing He, Qinghua Hou, Qingxiang Chen, Xiaolei Li, Tianyu Zhang and Nan Li</i>	
 Plenary Speech III	 xiii
Vulnerability of global coral reef habitat suitability to ocean warming, acidification and eutrophication <i>Yi Guan, Sönke Hohn, Christian Wild, Agostino Merico</i>	
 Plenary Speech IV	 xiv
Water resources management in Sri Lanka in a global context: challenges and key solutions <i>Tilak Priyadarshana</i>	
 Technical Session I	 1
Ocean and Lagoon Health	
Proximate composition and heavy metal content of <i>Crassostrea madrasensis</i> in Puttalam Lagoon, Sri Lanka <i>Salgadu M.C.K.S., Wijesinghe R.D.N., Iroshanie R.G.A. and Radampola K.</i>	2
Occurrence of microplastics in green mussels (<i>Perna viridis</i>) in Negombo and Kalpitiya lagoons, Sri Lanka <i>Perera L.D.K.N., Bandara E.G.Y.K.C. and Radampola K.</i>	3
Determination of heavy metals and microplastics in water and sediment of Rekawa lagoon with special reference to the modification of Kapuhenwala causeway <i>Patabendi P.K.V.N, Atapaththu K.S.S and Asanthi H.B.</i>	4



Proximate composition and heavy metal content in *Marcia opima* (Venus shell clam) in Kalpitiya Lagoon, Sri Lanka 5

Wijethilaka M.N.S., Wijesinghe R.D.N., Iroshanie R.G.A. and Radampola K.

Trace metal accumulation in *Holothuria atra* in south and northwestern coasts of Sri Lanka 6
Hapugoda W.M.N.D., Dissanayake P.A.K.N., Asanthi H.B. and Guruge K.P.G.K.P.

Macroinvertebrates as ecological indicators in Rekawa lagoon, Sri Lanka 7
Sudusinghe K. D., Wijewardene L. N and Asanthi H.B.

Determination of heavy metals in *Oreochromis niloticus* from Sooriyawewa reservoir, Sri Lanka 8
Liyanage S.W., Wijesinghe R.D.N. and Sanjaya H.L.K.

Technical session II 9

Aquaculture Development

Extraction and quantification of edible alginates from selected brown algae species in Ahangama and Beruwala rocky intertidal reefs, Sri Lanka 10

Kodikara S.S.M., Thilakarathna R.M.G.N. and Yapa Y.M.A.L.W.

Antibacterial activity of two selected seaweeds (*Sargassum ilicifolium* and *Caulerpa racemosa*) against foodborne pathogenic bacteria 11

Liyanage L.C.D, Bandara E.G.K.Y.C and Rathnapala J.M.S.N.

Socio-economic status of the freshwater ornamental fish farming in Matara district of Sri Lanka 12

Jayasingha J.M.K.G.B., Sanuja R.G. and Rathnapala J.M.S.N.

Determination of the optimum level of a commercial probiotic on growth performance, feed utilization efficiency, and immunity of GIFT Tilapia, *Oreochromis niloticus* 13

Herath H.M.H.L., Bandara A.M.K.A. and Rathnapala J.M.S.N.

Assessment of variations of egg size and fecundity of female Nile Tilapia *Oreochromis niloticus* (Linnaeus, 1757) reared under controlled and wild conditions 14

Sachini Nimesha S.A., Bandara E.G.K.Y.C. and Herath S.S.

Effectiveness of *Bruguiera gymnorhiza* and *Avicennia marina* leaf extracts on the control of common fungi in fish feed 15

Kumari P.L.A.C., Manel Kumari W.G.S., Yapa Y.M.A.L.W. and Herath S.S.

Effect of binder materials on physicochemical characteristics and sensory properties of *Catla* sausage 16

Mendis A.T.A., Wijesinghe R.D.N. and Radampola K.

Comparison of the impact of storage strategies on the postharvest quality of giant freshwater prawns through a sensory evaluation 17

Kuragodage A.U., Deepananda K.H.M.A., Jayasinghe U.A.D. and Jones C.

**Technical session III 18****Sustainable Fisheries**

Assessing the current status of parrotfish (Family: Scaridae) fishery in southern Sri Lanka: a candidate to be protected 19

Mallawaarachchi M. K. B. M. M., Radampola K. and Kumara P. B. T. P.

Reproductive periodicity of the sea urchin *Tripneustes gratilla* (Linnaeus, 1758) in Ahangama rocky reef, Sri Lanka 20

Kulasekara W.G.S.N., Thilakarathna R.M.G.N. and De Croos M.D.S.T.

Socio-economic aspects of bivalve collectors and consumers in Kalpitiya Lagoon of Sri Lanka 21

Balasinghe B.H.M., Wijesinghe R.D.N., Iroshanie R.G.A. and Radampola K.

Fecundity and egg size variation in Nile Tilapia *Oreochromis niloticus* (Linnaeus, 1757) collected from Uyan Wewa and Nilwala Athuru Ela in Sri Lanka 22

Archchaka R., Herath S.S. and Sanuja R.G.

Evaluating the efficacy of *Tephrosia vogelii* (Fish Poison bean) leaf powder as an anesthesia on *Oreochromis niloticus* (Nile tilapia) 23

Pushpakanthan A., Herath S.S. and Sanuja R.G.

Present status of frigate tuna (*Auxis thazard*) fishery in Dodanduwa, Sri Lanka 24

Ekanayaka E.M.T.C., Sanuja R.G. and Deepananda K.H.M.A.

Present status of beach seine fishery in southern coast of Sri Lanka 25

Imasha K.I.C., Deepananda K.H.M.A. and Bandara E.G.K.Y.C.

Technical session IV 26**Ecology & Environmental Management**

Determination of the maximum permissible level of tannin in wastewater released to surface waters 27

Luxshayan P., Maithreepala R.A., and Sanjaya H.L.K.

Evaluation of acute toxicity of textile dye (reactive red 123) on *Chlorella vulgaris* and *Spirulina platensis* 28

Thinujan M., Maithreepala R.A., Asanthi H.B., and Atapaththu K.S.S.

A comparative analysis on diel vertical migration of zooplankton in littoral and limnetic zones of a reservoir in Sri Lanka 29

Jayawardhane S.S., Jayasinghe U.A.D. and Wijewardene L.N.

Using *Anabaena*-*Azolla* ecological interactions towards developing organic fertilizers 30

Kottage K.S.G., Asanthi H.B. and Wijewardene L.N.

Effect of substrate in aquaponic system developed with *Poecilia reticulata* and *Piper betle* on growth performance of fish and plant. 31

Perera K.G.M.C., Sanuja R.G. and Herath S.S.



Effect of the particle size of aqua-soil media on the growth performance of <i>Bacopa monnieri</i> (Lunuwila) plant	32
<i>Senavirathna S.H.R, Nuwansi K.K.T and Radampola K.</i>	
Stress responses of <i>Azolla</i> sp. and its symbiotic <i>Anabaena azollae</i> against oxyfluorfen	33
<i>Rajith T, Atapaththu K.S.S. and Asanthi H.B.</i>	
Multi criteria decision analysis (MCDA) of land-use using sentinel-2 imaginary as a proxy to predict nutrient inputs into a reservoir cascade system	34
<i>Rodrigo M.C.S., Sanjaya H.L.K. and Jayasinghe U.A.D.</i>	
Panel of Reviewers	35
Author Index	36



Message from the Vice Chancellor, University of Ruhuna

It is with great pleasure that I extend my warmest greetings to the participants of the Second Symposium on Ocean and Freshwater Systems (SOFS), organized by the Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna, under the theme 'Expanding Resilient Blue Horizons.' I appreciate the faculty for its continued commitment to advancing research through this impactful biennial symposium.

The Faculty of Fisheries and Marine Sciences & Technology is dedicated to its mission of equipping future generations with the knowledge and skills needed to sustainably manage natural resources. By integrating theoretical learning, self-directed research, and practical experience in fields such as fisheries, aquaculture, oceanography, marine geology, limnology, and water technology, the faculty empowers students to make meaningful contributions to their fields.

The United Nations Sustainable Development Goals (SDGs) offer valuable guidance for research in these areas. Notably, SDG 1: No Poverty aligns closely with fisheries and aquaculture research objectives, while SDG 6: Clean Water and Sanitation connects directly with advancements in water technology. These goals emphasize the importance of research and development as interconnected tools for addressing emerging global challenges and advancing sustainable solutions.

Although Sri Lanka is rich in traditional knowledge and sustainable practices, these resources are often underutilized in modern development efforts. Today's young researchers face the challenge of integrating new technologies with traditional approaches to manage marine and freshwater ecosystems sustainably. Their contributions will not only help achieve the SDGs but also pave the way toward resilient blue horizons. The theme of the second SOFS is therefore both timely and relevant, providing essential guidance to the next generation of researchers.

This symposium offers an excellent platform for knowledge exchange and collaboration, focusing on both biotic and abiotic resources in marine and freshwater systems. I acknowledge the efforts of the authors, organizers, contributors, and sponsors in bringing this event to fruition. I extend my best wishes for a successful symposium and look forward to the valuable insights and innovative ideas that will emerge.

Prof. Sujeewa Amarasena
Vice-Chancellor
University of Ruhuna



Message from the Dean, Faculty of Fisheries and Marine Sciences & Technology

I am honored to announce the second Symposium on Ocean and Freshwater Systems (SOFS) of the Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna, scheduled for 08 November 2024. This symposium is of significant importance to our faculty and the broader fisheries and marine sciences community, and I am proud to share this moment with you all. The China-Sri Lanka Joint Center for Research and Education (CSL-CER) co-chairs the SOFS-2024, and the Sampath Bank PLC serves as a strategic collaborator for the symposium.

The Faculty of Fisheries and Marine Sciences & Technology, founded in 2005, has spearheaded fisheries, freshwater, and marine sciences education and research in the tertiary education system of the country. SOFS of the faculty is a routine event in the academic calendar of the faculty to disseminate high-quality research findings of students and researchers. The faculty board recognized the theme of the second symposium; “Expanding Resilient Blue Horizons”. SOFS-2024 is of great importance to the faculty because the research findings of the faculty graduates are also communicated to the scientific community. Proceedings of the SOFS-2024 consist of 30 research communications, the outcome of the independent research of the graduands of the faculty. The quality of the abstracts in the proceeding has been maintained by the peer-reviewing process through expert reviewers and the editorial board panel appointed by the Faculty Board.

I sincerely thank CSL-CER for Co-Chairing and Sampath Bank PLC for their strategic collaboration. I sincerely thank Prof. H.B. Asanthi, Chairperson of the scientific committee, Dr. U.A.D. Jayasinghe, Editor-in-Chief of the SOFS 2024, and all other scientific/ organizing committee members and the editorial board for their tremendous effort for the symposium's success. I gratefully welcome Dr. Shamen P. Vidanage, keynote speaker of the SOFS-2024, and I highly appreciate the panel of expert reviewers. As the Dean of the faculty, I also wish to convey my sincere gratitude to the faculty's academic, academic support, and non-academic staff for extending their entire support and cooperation for the success of SOFS-2024. I also congratulate the faculty graduates for being important stakeholders of SOFS-2024. I want to remark on Senior Professor Sujeewa Amarasena, the Vice-Chancellor of the University of Ruhuna, for his moral support and inspiration to complete the event successfully.

I hope the Second Symposium on the Ocean and Freshwater Systems of the Fisheries and Marine Sciences & Technology faculty will be a great success.

Prof. K.H.M. Ashoka Deepananda

Dean/ Faculty of Fisheries and Marine Sciences & Technology
University of Ruhuna



Message from the Director, China-Sri Lanka Joint Center for Education and Research

On behalf of the China-Sri Lanka Joint Center for Education and Research (CSL-CER), led by the South China Sea Institute of Oceanology (SCSIO) and the University of Ruhuna (UoR), I extend my warmest congratulations on the occasion of the second symposium on Ocean and Freshwater Systems, organized by the Faculty of Fisheries and Marine Sciences & Technology, UoR and CSL-CER, under the theme "Expanding Resilient Blue Horizons".

The CSL-CER was approved by the Chinese Academy of Sciences (CAS) and Sri Lanka's Ministry of Higher Education. It plays a vital role in fulfilling the intergovernmental agreement for technological cooperation signed during the Chinese President's visit to Sri Lanka a decade ago. In 2009, SCSIO and UoR laid a solid foundation for this cooperation. Through joint efforts, a regional marine environmental real-time observation network has been established since 2013. The Shiyao Research Vessels have conducted fourteen successful scientific expeditions in the eastern Indian Ocean. The data collected from these observations have been invaluable to Sri Lankan scientists and the international scientific community, including initiatives such as the International Indian Ocean Expedition (IIOE-2). Building on these data and ocean modelling, CSL-CER have established a regional marine forecasting system that now provides vital weather forecasts for local stakeholders. Notably, this system proved instrumental in providing real-time data that helped extinguish a fire on a carrier near Colombo Port in May 2021. Moreover, in our commitment to nurturing the next generation of Sri Lankan earth science scholars, we offer ANSO (Alliance of National and International Science Organizations) and UCAS (University of Chinese Academy of Sciences) scholarships to Sri Lankan students, enabling them to pursue doctoral and master's degrees at CAS institutes. The first cohort of students graduated from SCSIO and returned to Sri Lanka in June 2019. To date, over 100 Sri Lankan students have been recruited to SCSIO and other CAS institutes. These students represent the backbone of future collaboration between our two countries.

Over the past ten years, the significance of CSL-CER has been reaffirmed in two joint statements issued by the governments of China and Sri Lanka in October 2023 and March 2024. The CSL-CER will continue to serve as an important platform for China-Sri Lanka cooperation in marine sciences and will remain open to the international community of marine sciences and oceanography.

At this moment, I wish the symposium great success. I take this opportunity to congratulate all the authors, symposium organizers, and contributors for making this symposium a reality.

Prof. Changsheng Zhang

*Director, China-Sri Lanka Joint Center for Education and Research,
Deputy Director-general, South China Sea Institute of Oceanology, Chinese Academy of Sciences*



Message from the Chairperson of Organizing Committee

Faculty of Fisheries and Marine Sciences & Technology decided to initiate a symposium as an avenue for undergraduates to show their talents in research as a final product of their practical and theoretical knowledge and experience gained through BScHons in Fisheries and Marine Sciences and BScHons in Marine and Freshwater Sciences Degree programmes conducted by the faculty. Following this decision, the Symposium on Oceans and Freshwater Systems (1st SOFS) under the theme of “Utilization of Aquatic Systems for Future Challenges” was conducted on 08 December 2022. The research output for this symposium was mainly based on the undergraduate research project conducted as an eight-credit course unit at level IV of the degree programme. In this biannual SOFS series, the 2nd symposium is held on 08 November 2024 under the theme of “Expanding Resilient Blue Horizons”. It is my great pleasure to write this message to the proceedings of the 2nd SOFS which contain 35 research abstracts under four technical sessions on; ocean health vs climate calamities, aquaculture development & blue economy, freshwater systems & environmental issues, and sustainable fisheries. Each research abstract was separately reviewed by two reviewers under the blind reviewing process and their volunteer task is highly appreciated. The Keynote speech on ‘Sri Lanka Prospects for Blue Economy’ by Dr Shamen P. Vidanage, Country Representative, International Union for Conservation of Nature (IUCN) will align future research towards the development of proper management and utilization of knowledge and aquatic resources towards the blue economy of Sri Lanka.

I wish to express my deepest gratitude to Senior Professor Sujeewa Amarasena, the Vice Chancellor of the University of Ruhuna, for his guidance and support during the whole process of this work. My special thank goes to the China-Sri Lanka Joint Center for Research and Education (CSL-CER) for funding this event and I am grateful to the Chinese delegates for serving as the cochair and sharing their research experience at the technical sessions. Further, I acknowledge our strategic collaborator Sampath Bank Sri Lanka for their immense support. I cordially acknowledge the Dean of the Faculty, all the committee members of 2nd SOFS, all the academic, academic supportive, and nonacademic staff members and students of the faculty who supported this event in different ways. I also would like to thank the editor-in-chief, the editorial board and the IT committee for their delightful work in launching the proceeding book at the inauguration ceremony and all who supported in numerous ways to achieve the goal of this event.

Prof. H.B. Asanthi

Chairperson of Organizing Committee/ SOFS-2024
Faculty of Fisheries and Marine Sciences & Technology
University of Ruhuna



Keynote Speech

Sri Lanka's prospects for a blue economy

Dr. Shamen P. Vidanage

Country Representative, International Union for Conservation of Nature (IUCN), Sri Lanka

E mail: shamen.vidanage@iucn.org

Blue Economy and its Global Context

Blue Economy, also known as the ocean economy, encompasses a sustainable economy for the ocean based marine environment, related biodiversity, ecosystems, species and genetic resources, including marine living organisms and natural resources in the seabed, while ensuring their sustainable use.

A global level Cost Benefit Analysis (CBA) commissioned by the High-Level Panel for A Sustainable Ocean Economy (The Ocean Panel) to strengthen the evidence base of the forthcoming “Towards a Sustainable Ocean Economy” report in 2020. Based on the results, the Ocean Panel proposes that a sustainable ocean economy can simultaneously deliver on three dimensions at the global level. They are 1. protect: reduce greenhouse gas (GHG) emissions while safeguarding biodiversity; 2. produce: contribute to sustainably powering and feeding a planet of 9.7 billion people in 2050; and 3. prosper: create better jobs and support more equitable economic growth, household income and well-being with generating more benefits than the costs incurred in doing so with attractive returns on investment. The study indicates, on the whole, sustainable ocean-based investments yield benefits at least five times greater than the costs. Over 30 years, investing US\$ 2.0–\$ 3.7 trillion globally across the four areas would generate a net benefit of \$ 8.2–\$ 22.8 trillion. (High-Level Panel on Ocean Economy, undated).

Ocean-based industries such as fishing, offshore energy, shipping and coastal tourism had been conservatively estimated to be 3.5–7.0 percent of world gross domestic product, a value that was predicted to double by 2030. As of 2010, ocean-based industries contributed some 31 million direct full-time jobs, and the number is estimated to be higher when considering jobs provided via informal or artisanal employment (High-Level Panel on Ocean Economy, undated).

Blue Economy opportunities for Sri Lanka

Given the Sri Lanka's strategic position in the Indian Ocean with its large extent of EEZ - approximately eight times of its land area, the Blue Economy presents Sri Lanka with great opportunities to address pressing socioeconomic challenges that it encounters. It is evident that the sustainable management of these marine resources are capable in creating jobs, promoting social inclusion, and driving economic growth in coastal communities while safeguarding marine biodiversity and ecosystem health.

One of Sri Lanka's key Blue Economy sectors is the fisheries, where untapped value of nearly 40-50% of fishery waste discarded annually. Improving technology to minimize fishery waste and transforming waste into products of value could enhance profitability and reduce ecological footprint of fishing in associated coastal and marine areas. Additionally, appropriate expansion of mariculture, seaweed culture, and sustainable aquaculture practices would support biodiversity, create employment, and capable in contributing to managing pollutions. Vast potential for harnessing renewable energy from ocean resources (mostly wind and wave energy), could

contributes to Blue Economy and enhances the progress towards achieving Sri Lanka's net zero target by 2050 and building overall climate resilience of people and nature. Further expansion of Marine and coastal tourism is another important economic area. Segments of nature based and cultural/heritage tourism in protected and conserved marine areas, coastal ecosystems such as lagoons, and coral reefs provides sustainable alternatives to predominant mass tourism models can promote local economic growth with contributions to coastal and marine conservation areas and habitats.

Sri Lanka's Blue Economy ambitions are supported by its active participation in international frameworks such as the Commonwealth Blue Charter and the UN Decade of Ocean Science for Sustainable Development and engagements with multilateral environmental agreements. In its current role as chair (2024- 2025) of the Indian Ocean Rim Association (IORA), Sri Lanka is in a position to explore opportunities and to lead regional initiatives, promoting shared governance and resource management across the Indian Ocean region.

As indicated by UNDP and LKI (2023), Sri Lanka's Blue Economy strategy has to integrate economic development with environmental responsibility, building a resilient framework to support long-term growth. By fostering a sustainable approach across fisheries, tourism, energy, and conservation, Sri Lanka can unlock its ocean economy's full potential, providing economic stability, reducing environmental impacts, and setting an example for other Indian Ocean and small island developing nations. Through cohesive policy action, international partnerships, and community engagement, Sri Lanka is well-positioned to lead by example, harnessing its Blue Economy to promote an inclusive, sustainable future for generations to come.

To achieve this vision, it will be critical to take action to transform ocean-based economic sectors and ecosystems towards sustainability. A recent position paper by the UNDP and the Lakshman Kadirgamar Institute (LKI) outlines strategic frameworks such as the Marine Spatial Plan (MSP), advocating for integrated ocean governance that aligns conservation goals with economic aspirations. This plan encourages an inclusive, multisector approach by engaging government, private industry, and civil society, creating a cohesive structure for economic development grounded in sustainability (UNDP and LKI, 2023).

Some Areas for Consideration in Pathway to Blue Economy in Sri Lanka

Sustainable Ocean Planning: As highlighted by the Ocean Panel, for sustainably manage 100% of the ocean area under national jurisdiction and to realize the transformations, countries need to develop and implement a Sustainable Ocean Plan. Doing so can provide governments, citizens, businesses, coastal communities, and other stakeholders with a range of economic, social and environmental benefits over time. The best tool for ocean planning today is Marine Spatial Planning (MSP) it has been highlighted as a priority by many (Kumara, 2017) nearly a decade now. In this light, the government of Sri Lanka is in the process of its MSP roadmap launching in immediate future and paving the base for full scale MSP to achieve this task. If the incumbent government grasp this opportunity initiated by Ministry of Finance along with other national level stakeholders, there will be an unprecedented opportunity to launch a full scale MSP reaping blue economy benefits with the support of other parallel initiatives taken by international organizations and foreign funded projects.

Highest Level Patronage to be given to Blue Economy: lack of progress in ocean planning by way of implementing MSP is mainly due to siloed approach that we have in the country in managing a vast resource like ocean with overlapping and sometimes ambiguity in mandates. Therefore, it is proposed that a separate and dedicated Secretariat be established under the Presidential Secretariat with direct guidance with the president for fostering Blue Economy to steer and consolidated the



efforts towards Blue Economy in getting all relevant agencies and stakeholders engaged. This will also help accessing direct external support to Sri Lanka in the lines of Blue Economy and even foreign direct investment (FDI) to advancement from where we are today towards properly managed ocean area with ensuring its maximum sustainability under our national jurisdiction in foreseeable future with country ownership.

Make use of the existing global networks: There are many networks working on sustainable ocean economy / Blue Economy that Sri Lanka could leapfrog in sustainable ocean economy benefitting from the wealth of knowledge available including guidance, case studies and technical assistance. Furthermore, becoming members of these networks and active engagement as a government will be beneficial to expedite the journey towards Blue Economy with the use of experience of other nations. Two of most prominent such initiatives are: The High-Level Panel for A Sustainable Ocean Economy (The Ocean Panel) and Global Ocean Accounting Partnership (GOAP).

Factoring Value of Nature into Decision-making: Dasgupta Review (Dasgupta, 2021) elaborates that much of Nature and the processes governing it are silent and invisible and make it impossible for markets to record adequately the use we make of Nature's goods and services. That inadequacy extends naturally to the goods and services that we produce from nature, including from the ocean. There is thus an inevitable wedge between the market prices of goods and services and their social scarcity values. This has far reached implications for our conception of our place in Nature. Low market prices for Nature's goods and services have encouraged us to regard ourselves as being external to Nature. Sri Lanka has just commissioned a project under the Global Environmental facility (GEF) cycle 7 project on Natural Capital Assessment and Accounting NCAA on coastal resources and in a blended financing project titled Sri Lanka Coral Reef Initiative with funding from the Global Fund for Coral Reefs (GFCR). Wider awareness raising in the area of investing in nature needs to be launched to capitalize on opportunities available for Sri Lanka to come out of the economic crisis with factoring nature into decision making especially into ocean decision-making.

Research and Development: Research is of paramount importance in harnessing the full potential offered by the vast blue resources surrounded by Sri Lanka. Having national research priorities, collaboration between universities and research organizations in Sri Lanka and cooperation and collaboration with regional and global research is vital for the Blue Economy approach. Controversies to be minimized in accommodating providing access to vessels and aircrafts for research by way of establishing a transparent standard operating procedure (SOPs) to guide future decisions on approval of foreign research vessels / aircrafts facilitating joint research in our waters in a nonaligned manner with any party. As highlighted by UNDP and LKI (2023) the development of the Blue Economy with a science-based approach is essential and integral as that will provide a basis for informed decision-making and adaptive management. This underlines the importance of technical assistance, technology transfer and capacity building to the pursuit of sustainable development. Applied and long-term research for blue economy in catering to the industry needs to be identified and given prominence.

Biotechnology: There is a growing global market for marine biotechnology products and processes. It is estimated to be around US \$ 6.3 billion in 2023 and expected to be around US\$ 13.6 billion by 2034. As of 2023, North America has the main market share capturing 44% of it. This is also an area needs to be considered for exploration with better planning with collaborative partnerships in Sri Lankan waters. Provisions under the Access and Benefit Sharing under the Nagoya Protocol of the UN Conventional Biological Diversity explored and legal framework to be established to benefit from bioprospecting in our EEZ. Marine biotech may make critical contributions in development of new antibiotics and algal based biofuels through right partnerships and strong legal backing. In

this aspect, regional and global framework of Blue Economy become essential and useful which is already embedded in BE concepts.

Maritime safety and security: Sri Lanka being a strategic node of the Sea Lanes of Communication (SLOC), venture into providing maritime safety and security services for safe navigation of commercial vessels in the Indian ocean region. Foster regional corporation through Indian Ocean Rim Association (IORA) capitalizing on Sri Lanka's current Chairmanship, stronger cooperation among defense establishments, data and vital information sharing, joint naval exercises and coordination with global partners make this effort more efficient and successful. .

Innovative financing: The government must also find innovative ways to unlock financing in the public sector. Previous blue economic case studies have employed climate finance instruments, such as debt-for-nature swaps and blue bonds, that have used private finance to raise public funds. The government must develop a blue economic framework that outlines clear priorities that feed into a sustainable economic development strategy. Such a framework would provide guidance to Sri Lankan policymakers within the government but also communicate priorities to private investors, who can target sectors that stand to benefit from the blue economic model. Climate finance and other conservation investments will only take place with investor confidence, which is enabled through such strategic frameworks. Therefore, it is vital that the government take the appropriate steps to kickstart this development process to unlock the potential of the Blue Economy without further delaying.

Nature Solutions Finance (NSF) Hub: This is the most recent initiative that was launched at the IUCN's 8th Regional Conservation Congress in September 2024. It is a project by ADB to specifically focus on catalyzing finance into Nature-based Solutions (NbS) to support nature-based climate actions and biodiversity conservation. Its establishment will be an opportunity to develop innovative solutions to address the intertwined crises of nature and climate. The NSF Hub's goal is to increase investments in NbS projects across Asia and the Pacific by proactively developing scalable and bankable demonstration projects by creating a platform with practical NbS solutions centered around innovative finance approaches. It aims to do this through a partnership approach with global development entities in the nature space along with concessional fund sources who can work together with ADB under a focused roadmap of activities. This new initiative will help us accessing funding for Blue Economy related matters where NbS is a part.

Potential for Blue Bonds in Sri Lanka: It can be considered the time is opportune for Sri Lanka to go for innovative conservation financing. Interestingly enabling environment is already created in Sri Lanka in many ways. For instance, the Central Bank of Sri Lanka (CBSL) came up with Sustainable Financing Road Map for Sri Lanka in 2021 followed by Sri Lanka Green Financing Taxonomy in 2022. The BIOFIN project in Sri Lanka assisted (Biodiversity Financing Initiative of UNDP) in formulating Biodiversity Financing Plan in 2018 for the Ministry of Environment which as presented to CBSL and Ministry of Finance then.

Sri Lanka's journey towards Blue Economy is suggested to be expedited by taking it under Presidential Secretariat giving the highest level of priority with a clear policy, strategy and an action plan. In this regard, the Position Paper on Sri Lanka's Blue Economy by UNDP and LKI, 2023 provides a better way forward. Desire for Blue Economy for Sri Lanka should go beyond its current document process to a gradual implementation process, and it should become the vision for the ocean based sustainable development by achieving economic growth, environmental conservation and social equity.



References

- Commonwealth Secretariat (2022) An Ocean of Opportunity: Commonwealth Blue Charter Progress Report, 2022.
- Cooray, N. S., Premarathna, U., Atapaththu, K. S. S., & Priyadarshana, T. (2022) Development and Challenges of Indian Ocean Blue Economy and Opportunities for Sri Lanka. In M. N. Islam & S. M. Bartell (Eds.), *Global Blue Economy: Analysis, Developments, and Challenges*. Taylor & Francis Group.
- Dasgupta, P. (2021) *The Economics of Biodiversity: The Dasgupta Review*. (London: HM Treasury) available at www.gov.uk/official-documents.
- High level panel for a Sustainable Ocean Economy (undated) 100% Sustainable Ocean Management: An Introduction to Sustainable Ocean Plans. Available at: <https://oceanpanel.org/publication/100-sustainable-ocean-management-an-introduction-to-sustainable-ocean-plans/> (Accessed: 20th October 2024).
- Kumara, T. P. (2017) *Blue Economy: Prospects and Challenges for Sri Lanka*. Bandaranaike Centre for International Studies Signature Seminar (pp. 14-27). Colombo: Bandaranaike Centre for International Studies.
- Ratnayake, W. (2022) Sri Lanka's Future: Towards a Blue Economy. Presidential Address of the SLAAS Section F. Sri Lanka Association for the Advancement of Science Proceedings of the 78th Annual Sessions 2022 - Part II.
- UNDP and Lakshman Kadirgamar Institute of International Relations and Strategic Studies (2023) Position paper on Sri Lanka's Blue Economy. Available at: <https://www.undp.org/srilanka/publications/sri-lankas-blue-economy-position-paper-undp-sri-lanka-lakshman-kadirgamar-institute-international-relations-andstrategic#:~:text=The%20paper%20provides%20guiding%20principles,society%2C%20and%20the%20private%20sector.> (Accessed: 20th October 2024).



Guest Speech

Long-term coastal current observations in southern Sri Lanka

Weiqliang Wang^{1*}, Terney Pradeep Kumara², Zhenqiu Zhang¹, Yao Luo¹, and Gang Pan¹

¹South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou, China

² Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna, Sri Lanka

*Email: weiqliang.wang@scsio.ac.cn

Abstract

This study outlines a comprehensive plan to monitor coastal currents variations in Southern Sri Lanka. Recognizing the region's critical role in the Northern Indian Ocean's salinity balance and its susceptibility to climate change, the project aims to monitor coastal currents variations on seasonal to interannual timescale. Several fixed observation sections, each approximately 20 kilometers in length covering the width of coastal currents, are to be deployed in the west, south, and east coasts of Sri Lanka. The unmanned surface vessel (USV) is used to detect the coast currents' variations from surface to bottom repeatedly on above fixed observations, better performing once per season. Simultaneously, CTD profiles, and automatic weather stations will be deployed to get more information of current dynamics and atmospheric conditions. The observation plan will contribute to a better understanding of coastal processes, supporting marine ecosystem management and enhance disaster prevention in the face of climate change.

Keywords

Long-term observation, coastal waters, currents, unmanned surface vessel, Sri Lanka

Acknowledgement

The project was supported financially by the China-Sri Lanka Joint Center for Education and Research, which was established by SCSIO and UoR.



Plenary Speech I

Reversal of multidecadal sea level trends in the Southwest Indian Ocean thermocline ridge

Lei Huang^{1,2,3,5}, Wei Zhuang^{1*}, Wenfang Lu⁴, Yang Zhang³, Deanna Edwing³ and Xiao-Hai Yan^{3,2}

¹ State Key Laboratory of Marine Environmental Science, College of Ocean and Earth Sciences, Xiamen University, Xiamen, China.

² Joint Center for Ocean Remote Sensing, University of Delaware-Xiamen University, Newark, DE, USA.

³ College of Earth, Ocean and Environment, University of Delaware, Newark, DE, USA.

⁴ School of Marine Sciences, Sun Yat-sen University, Zhuhai, China.

⁵ Cooperative Institute for Marine and Atmospheric Studies, University of Miami, Miami, FL, USA.

*Email: wzhuang@xmu.edu.cn

Abstract

It has been reported that the sea level falls in the tropical Southwest Indian Ocean (SWIO) from the 1960s to the early 2000s. However, a rising trend of 4.05 ± 0.56 cm/decade has occurred during the recent two decades with our analysis showing that manometric sea level contributes 41% to this sea level rise. 30% of this rise is due to steric sea level (SSL) change in the upper 2000 m with SSL rise in the upper 300 m of secondary importance. Conversely, thermal expansion below the thermocline (300–2000 m), likely caused by water mass spread from the Southern Ocean, induces major contribution to SSL changes. Overall, this study highlights the importance of ocean mass and deeper water thermal structure in regulating tropical SWIO sea level rise in a changing climate, as well as the need for observations and direct assessment of the abyssal ocean beneath 2000m.

Keywords

Southwest Indian Ocean, sea level rise, ocean mass change, thermal expansion, heave and spice

Acknowledgement

National Key R&D Program of China (2019YFA0606702), the Natural Science Foundation of Fujian Province of China (2023J01021), and the China Scholarship Council.



Plenary Speech II

Thermal sensitivity of mangrove leaf endospheric microbiome: niche plasticity of generalist and specialist bacteria

Nethmini R.T, Qing He, Qinghua Hou, Qingxiang Chen, Xiaolei Li, Tianyu Zhang and Nan Li*

Key Laboratory of Climate, Resources and Environment in Continental Shelf Sea and Deep Sea of Department of Education of Guangdong Province, Department of Oceanography, Key Laboratory for Coastal Ocean Variation and Disaster Prediction, College of Ocean and Meteorology, Guangdong Ocean University, Zhanjiang 524088, China

**Email: nli0417@163.com*

Abstract

Leaf endospheres harbor diverse bacterial communities, comprising generalists and specialists, that profoundly affect ecosystem functions. However, the ecological dynamics of generalist and specialist leaf-endophytic bacteria and their responses to climate change remain poorly understood. We investigated the diversity and environmental responses of generalist and specialist bacteria within the leaf endosphere of mangroves across China. Our findings revealed a predominance of specialists, whereas generalists exhibited broader niche breadth. Temperature was the key factor driving community dissimilarity in both groups, yet it negatively influenced the alpha diversity. Interestingly, temperature had a limited impact on functional profiles, while soil nutritional factors were critical in shaping the functional profiles. Stochastic processes governed community assembly in both bacterial groups, altering the β -nearest taxon indices as temperatures increased. Our findings indicate that the halophytic leaf endosphere favors microbial niche specialization, due to its unique microenvironment and discrete niches, showing thermal sensitivity in terms of the microbial community profile. This study provides novel insights into niche differentiation and environmental adaptation mechanisms of leaf endophytic microbes in woody halophytes in response to environmental perturbations.

Keywords

Generalist–specialist, leaf endosphere, mangrove, climate change, environmental perturbation

Acknowledgement

Guangdong Ocean University Innovative Team (Early warning of marine disasters) (Grant number 2023KCXTD015), the Scientific Research Start Funds of Guangdong Ocean University.

Plenary Speech III

Vulnerability of global coral reef habitat suitability to ocean warming, acidification and eutrophication

Yi Guan^{1,2*}, Sönke Hohn³, Christian Wild⁴, Agostino Merico^{3,4}

¹Key Laboratory of Climate, Resources and Environment in Continental Shelf Sea and Deep Sea of Department of Education of Guangdong Province, Department of Oceanography

²Key Laboratory for Coastal Ocean Variation and Disaster Prediction, College of Ocean and Meteorology, Guangdong Ocean University, Zhanjiang 524088, China

³Systems Ecology Group, Leibniz Centre for Tropical Marine Research, Bremen, Germany

⁴Department Marine Ecology, Faculty of Biology and Chemistry (FB 2), University of Bremen, Bremen, Germany

*Email: yiguan@gdou.edu.cn

Abstract

Coral reefs are increasingly threatened by global and local stressors, with their responses varying based on environmental conditions. This study used coral reef occurrence data, representing long-term adaptation, combined with global environmental datasets to evaluate the impact of global stressors (sea surface temperature rise and ocean acidification, represented by aragonite saturation state, Ω_{arag}) and local stressors (nutrient enrichment from nitrate and phosphate) on coral reef habitat suitability. By determining the relative distance of coral communities to their regional environmental optima, we estimated changes in habitat suitability across the tropics in response to incremental stressor increases: a 0.1 °C rise in temperature, a 0.02 $\mu\text{mol/L}$ increase in nitrate, a 0.01 $\mu\text{mol/L}$ increase in phosphate, and a 0.04 decrease in Ω_{arag} . Our findings indicate that only 6% of coral reefs globally are resilient to both local and global stressors and could serve as temporary refugia. Local stressors threaten 22% of reefs, while global stressors affect 11%. The majority, 61%, are vulnerable to both types. Effective wastewater treatment could mitigate local eutrophication and expand temporary refugia to 28%, providing a crucial buffer while global efforts to address broader environmental changes continue.

Keywords

Coral reefs, eutrophication, global warming, habitat suitability, ocean acidification



Plenary Speech IV

Water resources management in Sri Lanka in a global context: challenges and key solutions

Tilak Priyadarshana

Department of Limnology and Water Technology, Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna, Matara, Sri Lanka

**Email: tilak@fish.ruh.ac.lk*

Abstract

The world is currently grappling with an unprecedented water crisis, driven by a complex interplay of environmental, social, and economic factors. Over 2 billion people live in regions experiencing high water stress, a figure projected to rise significantly in the coming years due to various interrelated challenges. Climate change stands out as a critical driver, with rising temperatures altering precipitation patterns. This leads to more frequent and severe droughts in some areas, while others face increased flooding. The Intergovernmental Panel on Climate Change (IPCC) warns that by 2050, water availability is expected to decline in many regions, exacerbating existing shortages and placing additional stress on vulnerable populations. As the global population grows—projected to reach nearly 10 billion by 2050—the demand for water is anticipated to increase dramatically. Rapid urbanization will see cities absorbing over 60% of the world's population by mid-century, exerting immense pressure on local water resources and often resulting in over-extraction and pollution. The UN estimates that by 2030, nearly 700 million people may be displaced due to intense water scarcity, heightening competition for this vital resource. Unsustainable agricultural practices, industrial activities, and inadequate wastewater management significantly contribute to the crisis. Agriculture accounts for approximately 70% of global freshwater use; excessive irrigation and reliance on chemical fertilizers lead to substantial water wastage and pollution. In this context, Sri Lanka's situation—while unique due to its geography and cultural context—mirrors many of these global trends. The country faces the dual challenge of managing limited water resources while meeting the needs of its growing population and economy. Key challenges for Sri Lanka include pollution, with around 70% of rivers contaminated primarily by industrial runoff and agricultural chemicals; climate change, which results in increased variability in rainfall; and groundwater depletion, exacerbated by rising demand. Addressing these multifaceted challenges necessitates a comprehensive approach that integrates innovative strategies, community involvement, and effective policy reforms. Integrated Water Resources Management (IWRM) offers a holistic framework for the coordinated development and management of water, land, and related resources. Sustainable water management requires international cooperation and a robust policy environment to promote effective practices. In conclusion, a multifaceted approach integrating IWRM, innovative technologies, community engagement, and strong policy frameworks is essential for achieving global water security and environmental sustainability.

Keywords

Climate change, drought management, global water crises, water resources management, water scarcity



ISSN 3051-4657

Proceedings of the 02nd Symposium on Ocean and Freshwater Systems (SOFS) – 2024
Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna, Sri Lanka.

Technical Session I

Ocean and Lagoon Health

Proximate composition and heavy metal content of *Crassostrea madrasensis* in Puttalam Lagoon, Sri Lanka

Salgadu M.C.K.S.^{1*}, Wijesinghe R.D.N.¹, Iroshanie R.G.A.² and Radampola K.¹

¹ Department of Fisheries and Aquaculture, Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna

² Department of Oceanography and Marine Geology, Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna

*Email: salgadukithmini@gmail.com

Abstract

Oysters are a highly abundant shellfish group in Puttalam Lagoon, Sri Lanka. They are successful filter feeders that feed off nutrients in water. This study was conducted to analyze proximate composition and heavy metal content of *Crassostrea madrasensis* at two sites; Kandakuliya (KK) and Gangewadiya (GW) in Puttalam Lagoon, Sri Lanka. A total of 30 oysters were collected from both sites and morphometric parameters, and proximate composition of oyster flesh were analyzed. The presence of heavy metals (Pb, Cd and Cu) in flesh of oysters, lagoon water and sediments were also assessed. Results revealed that the length and weight (7.95 ± 0.42 cm, 457.97 ± 19.52 g) of oysters in KK were significantly higher than those (6.45 ± 0.52 cm, 199.35 ± 20.22 g) in GW. The moisture% of oyster flesh was significantly higher in GW (90.26%) compared to that of KK (80.36%). The crude protein (46.17%-46.22%), lipid (1.60%-1.67%), and ash contents (11.58%-11.64%) of oyster flesh were not significantly different among two sites. The pH, temperature, EC, salinity and TDS (8.10 ± 0.02 , $33.77 \pm 0.82^\circ\text{C}$, 72.16 ± 10.68 mScm⁻¹, 36.56 ± 0.17 PSU, 24.67 ± 5.46 ppm) of water in KK were significantly higher than those of water (7.88 ± 0.20 , $31.72 \pm 0.64^\circ\text{C}$, 49.35 ± 5.17 mScm⁻¹, 25.48 ± 0.91 PSU, 20.45 ± 0.16 ppm) in GW. The concentrations of Pb (0.0153 - 0.0157 mg g⁻¹) and Cd (0.0013 - 0.0015 mg g⁻¹) in oyster flesh were above the WHO/ FAO standard permissible limit in both sites. The Pb (0.1964 - 0.2436 mg L⁻¹), Cu (0.1520 - 0.2300 mg L⁻¹) and Cd (0.1477 - 0.1819 mg L⁻¹) concentrations in water samples from both sites were above the standards of CEA. The Cd concentration (0.0037 - 0.0055 mg g⁻¹) in sediments from two sites exceeded the WHO/ FAO lower permissible limit but Pb (0.0104 - 0.0114 mg g⁻¹) and Cu (0.0049 - 0.0064 mg g⁻¹) were below the permissible limit. Despite being a nutritious food source, oysters have Pb and Cd levels exceeding WHO/ FAO standards that may cause potential health risks.

Keywords

Oysters, heavy metals, proximate composition, Puttalam Lagoon

Occurrence of microplastics in green mussels (*Perna viridis*) in Negombo and Kalpitiya lagoons, Sri Lanka

Perera L.D.K.N.*, Bandara E.G.Y.K.C. and Radampola K.

Department of Fisheries and Aquaculture, Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna

*Email: kusalneranjan21@gmail.com

Abstract

Microplastics (MPs), plastic particles less than 5 mm are considered as an emergent pollutant, which affects the aquatic ecosystems throughout the world. As an aquaculture commodity green mussel (*Perna viridis*) has high nutritional value and market demand. Current study investigated the MP contamination in green mussels, water, and sediments in Negombo lagoon (NL) and Kalpitiya lagoon (KL). Ten green mussels, three water samples (1L) and three sediment samples (1kg) from each site were collected. Nitric acid digestion protocol was used to isolate MPs by digesting organic matters. MPs were recorded in mussels, water and sediment samples with 100% detection frequency. Polymer composition was determined by Fourier-Transform Infrared Spectroscopy method (FTIR). The mean abundance of MPs/individual was significantly higher in NL (885.54 ± 221.56) compared to that of KL (394.41 ± 92.17). Similarly, MPs abundance in water and sediments of NL (62.66 ± 11.50 MPs/L, 226.33 ± 17.78 MPs/kg) was significantly higher than that of KL (31.66 ± 1.52 MPs/L, 68.33 ± 9.81 MPs/kg). Detected MPs were categorized into fragments, fibers and beads according to their shape. Fragments and fibers were the dominant morphotype in mussels, water and sediment of both lagoons. Predominant color was found as black followed by red and blue in all samples in NL and KL. Identified MPs were categorized into large ($\geq 750 \mu\text{m}$), medium ($250 \mu\text{m}$ - $750 \mu\text{m}$) and small ($< 250 \mu\text{m}$) size classes and the availability of small size MPs were significantly higher than medium and large size particles. According to FTIR analysis, polyethylene was the only polymer type identified with an adequate accuracy. This study provides thoughtful insights on how food safety and human health are affected by MPs. Policies should be implemented to reduce the MPs contamination in aquaculture environments.

Keywords

Microplastics, *Perna viridis*, Negombo lagoon, Kalpitiya lagoon, FTIR

Determination of heavy metals and microplastics in water and sediment of Rekawa lagoon with special reference to the modification of Kapuhenwala causeway

Patabendi P.K.V.N., Atapaththu K.S.S and Asanthi H.B.*

Department of Limnology and Water Technology, Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna.

**Email: asanthi@fish.ruh.ac.lk*

Abstract

Microplastics (MPs) and heavy metals are ubiquitous environmental pollutants that severely damage marine, freshwater, and terrestrial ecosystems. Coastal lagoons sink accumulated pollutants from both terrestrial and marine inputs. Rekawa lagoon is one of the important coastal water bodies found in the southern coastal belt which supports many economic activities including fishing, tourism, and education in Sri Lanka. The present study was carried out to examine the heavy metals and MPs in sediments and water of Rekawa lagoon, selecting seven randomly distributed sampling sites across the lagoon. Sampling was conducted in the first and last weeks of September 2023 and then flooding disrupted the continuous sampling. Copper (Cu), cadmium (Cd) and lead (Pb) in water and sediment were analyzed using atomic absorption spectroscopy. The abundance of MPs in preserved samples was estimated microscopically after the standard digesting method followed by filtering through GF/C filter papers (5 μm pore size). The concentration of Cu was relatively higher (12.43 – 26.66 μgg^{-1} dw) than that of Pb (6.86 – 14.60 μgg^{-1} dw) and Cd (1.03 – 1.387 μgg^{-1} dw) in sediment. Cu, Pb and Cd concentrations of the lagoon water were comparatively low (Cu: 0.019 – 0.054, Pb: 0.006 – 0.016, Cd: 0.006 – 0.010 mg/l) and those concentrations did not exceed the recommended level provided by World Health Organization (WHO). Compared to two decades ago, Cd, and Pb content of both sediment and lagoon water were significantly higher, and the Cu content was low. Three of the sampling sites close to the seawater inlet showed a significantly higher abundance of MPs both in water and sediment and it was significantly higher in the last week of September ($p < 0.05$). In water and sediments, fragments were the most abundant type of MPs and their dominant color was blue. The FTIR analysis confirmed that most of the abundant MPs were polystyrene and polyethylene respectively in water and sediment. The abundance of MPs was relatively higher at the sites close to the seawater inlet whilst heavy metals concentrations were higher towards the land side. Our findings would probably benefit as baseline data when deciding criteria to manage heavy metal and MPs pollution in coastal water bodies of Sri Lanka.

Keywords

Microplastics, heavy metals, Rekawa lagoon, sediment, water

Proximate composition and heavy metal content in *Marcia opima* (Venus shell clam) in Kalpitiya Lagoon, Sri Lanka

Wijethilaka M.N.S.^{1*}, Wijesinghe R.D.N.¹, Iroshanie R.G.A.² and Radampola K.¹

¹ Department of Fisheries and Aquaculture, Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna

² Department of Oceanography and Marine Geology, Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna

*Email: nirashawijethilaka143@gmail.com

Abstract

Marcia opima (clam) is one of the highly abundant bivalve species found in Kalpitiya lagoon. Despite its abundance, this clam remains an underutilized food resource in Sri Lanka due to low consumer demand. This study was focused on analyzing the proximate composition and the heavy metal content of the *M. opima* in Kalpitiya Lagoon. Heavy metal content of the water and sediment samples were analyzed using the atomic absorption spectrophotometer. Clams (50 Calms/site) water and sediments were collected from two sites ie: Kandakuliya (KA) and Gangewadiya (GA). The moisture (80%), ash (1.3%), crude lipid (2.5%), crude protein (41%) in clams were not significantly different in KA and GA. The heavy metal concentrations in water were in the order of $Pb > Cu > Cd$ at both sites. The Pb ($0.24-0.19 \text{ mgL}^{-1}$), Cu ($0.23-0.15 \text{ mgL}^{-1}$) concentrations in water were significantly higher in KA than that in GA but Cd ($0.18-0.14 \text{ mgL}^{-1}$) concentration was significantly higher in GA compared to KA. The Pb, Cu, Cd concentrations in water at both sites exceeded the permissible level given by FAO. The Pb ($11.0-10.0 \text{ mgkg}^{-1}$) and Cd ($5.0-3.0 \text{ mgkg}^{-1}$) concentrations in sediment were not significantly different in both sites. The Cu concentration ($6.0-4.0 \text{ mgkg}^{-1}$) in sediment was significantly higher in KA than that in GA. The Cd concentration in sediment exceeded the permissible level given by FAO. Cu ($0.9-0.6 \text{ mgkg}^{-1}$) and Cd ($0.8-0.5 \text{ mgkg}^{-1}$) concentrations in clams were significantly higher in KA compared to GA. The Pb ($1.0-2.0 \text{ mgkg}^{-1}$) and Cd ($0.8-0.5 \text{ mgkg}^{-1}$) concentration in clams in both sites exceeded the permissible level given by FAO. The pH (8.09 ± 0.02), Conductivity ($72.16 \pm 10.68 \text{ } \mu\text{Scm}^{-1}$), Salinity ($36.56 \pm 0.17 \text{ psu}$), total dissolved solid ($24.67 \pm 5.46 \text{ ppt}$) were significantly higher in KA than in GA. The results indicated that clams were a highly nutritious food resource, though the concentrations of Cd and Pb exceeded the permissible level. Therefore, this raises concern about the potential health risk associated with their consumption and indicates the need of regular monitoring for food safety.

Keywords

Proximate composition, heavy metals, moisture, ash, crude lipid, crude protein

Trace metal accumulation in *Holothuria atra* in south and northwestern coasts of Sri Lanka

Hapugoda W.M.N.D.¹, Dissanayake P.A.K.N.^{1*}, Asanthi H.B.² and Guruge K.P.G.K.P.³

¹Department of Oceanography and Marine Geology, University of Ruhuna, Matara

²Department of Limnology and Water Technology, University of Ruhuna, Matara

³Department of Animal Science, Uva Wellassa University, Badulla

*Email: kushlanid@fmst.ruh.ac.lk

Abstract

Trace metals are a significant group of aquatic pollutants due to their ability to bioaccumulate and through the food web resulting from their non-biodegradable property. Sea cucumbers are popular in the export industry as beche-de-mer. They are considered bioindicators to investigate the pollution level in marine and coastal ecosystems due to their feeding behavior. This study was conducted to assess trace metal accumulation in body wall tissues of *Holothuria atra* in Sri Lanka. A total of 20 *H. atra*, 03 sediment, and 03 seawater samples were randomly collected from the intertidal zones of three sampling sites (Kalpitiya, Madiha, and Dondra) during March to October 2023. The samples were prepared according to the AOAC protocol and subjected to microwave digestion to determine the concentrations of copper (Cu), zinc (Zn), iron (Fe), chromium (Cr), cadmium (Cd), and lead (Pb) using inductively coupled plasma optical emission spectrophotometry (ICP-OES). The trace metal concentrations in *H. atra* ranged; Cu (3.54 - 5.54), Zn (193.66 - 298.07), Fe (205.3 - 249.02), Cr (8.93 - 12.11), Cd (2.10 - 8.27), and Pb (3.17 - 10.03) mg/kg on dry weight basis. Trace metal concentration in sediment across three sites was identical in the order of Zn > Fe > Cr > Cu > Pb > Cd. Zinc showed the highest concentration (5.941 - 7.032 µg/L), and Cd showed the lowest concentration (0.003 - 0.007 µg/L) in seawater across three sites. Bioconcentration factors for Pb and Cd were lower than 1. Cu, Fe, and Cr concentrations in *H. atra* were below the permissible levels, while Zn exceeded the permissible limits. Pb and Cd concentrations in *H. atra* were above the maximum permissible levels established by WHO and FAO guidelines. The total target Hazard Quotient (<1) revealed no potential health risk for target populations by the consumption of *H. atra*. In conclusion, *H. atra*, from the coasts of Kalpitiya, Madiha, and Dondra, can be still considered safe for human consumption.

Keywords

Trace metals, sea cucumbers, bioaccumulation, bioindicators, ICP-OES



Macroinvertebrates as ecological indicators in Rekawa lagoon, Sri Lanka

Sudusinghe K. D., Wijewardene L. N and Asanthi H.B.*

Department of Limnology and Water Technology, Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna

*Email: asanthi@fish.ruh.ac.lk

Abstract

Macroinvertebrates are essential biological elements for maintaining the function and integrity of ecosystems and also for assessing and monitoring the ecological state of a particular ecosystem. In this study, the ecological status in Rekawa lagoon was determined using macroinvertebrates. Sampling was performed in September 2023. Physico-chemical parameters of water, including temperature, salinity, pH, Dissolved oxygen concentration (DO), total dissolved solids, water depth, and Secchi depth were measured. Macroinvertebrates were identified up to the species level. Family Biotic Index (FBI), Biological Monitoring Working Party (BMWP) index, and Average Scores Per Taxon (ASPT) were calculated. Spatial differences were determined by using ANOVA and Redundancy analysis (RDA) was carried out to examine the variation of macroinvertebrates and their relationship to environmental variables. The taxonomic families Aoridae, Gammaridae, Aegidae, Belostomatidae, Chironomidae, Thiariidae, Nassariidae, Lymnaeidae, and Nereididae of the macroinvertebrates were identified in the Rekawa lagoon. There was no significant difference in FBI in seven sampling sites ($p > 0.05$). According to FBI, water quality was “Fairly poor” and the degree of organic pollution was “Substantial pollution likely” in all seven sites. Site 1 which was near the outlet of a fish farm had a significantly higher difference in BMWP scores compared to other sites ($p < 0.05$). Both BMWP scores and the ASPT index indicated that all seven sites are “polluted and impacted”. According to RDA, samples from site 6 had an overgrowth of *Najas* sp. and showed a positive correlation with DO (adj. $R^2 = 46.14\%$; model significance $p < 0.05$). Further, *Chironomus* sp. larva (red blood worm) showed a significant positive association with salinity indicating their high tolerance for salinity. The *Gammarus* sp. was significantly and positively associated with DO concentration (adj $R^2 = 46.14\%$, $p < 0.05$). Our study highlighted that pollution control and management practices are needed to preserve and conserve the biodiversity of the Rekawa lagoon.

Keywords

Biotic indices, macroinvertebrates, redundancy analysis, Rekawa lagoon

Determination of heavy metals in *Oreochromis niloticus* from Sooriyawewa reservoir, Sri Lanka

Liyanage S.W.^{1*}, Wijesinghe R.D.N.¹ and Sanjaya H.L.K.²

¹Department of Fisheries and Aquaculture, Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna, Matara

²Department of Limnology & Water Technology, Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna, Matara

*Email: sanduliyana1998@gmail.com

Abstract

Fish are ideal bioindicators for monitoring aquatic ecosystems due to their sensitivity to environmental changes and ability to accumulate substances like heavy metals. This study analyzed the heavy metal levels in *Oreochromis niloticus* (Nile Tilapia), water, and sediments in the Sooriyawewa reservoir, Sri Lanka. Consumable-sized fish ($n = 10$) (22.0 ± 1.1 cm) were randomly collected from the fresh catch of fishermen. Water and sediment samples were collected in triplicate from three locations nearby: cultivation lands (L1), reservoir dam (L2), and the major inlet (L3). Atomic absorption spectrophotometry (AAS) was used to measure copper (Cu^{2+}), lead (Pb^{2+}), and cadmium (Cd^{2+}) in the fish tissues (liver, gill, skin, flesh), and in water and sediment. Results revealed that the highest concentration ($0.45 \pm 0.2519 \text{ mg kg}^{-1}$) was in the liver while the lowest concentration was in the flesh which were not detectable. Heavy metal accumulation in fish tissues followed the order $\text{Cu} > \text{Pb} > \text{Cd}$, with Cd being undetected. However, Cu concentration in the liver did not exceed the maximum permissible limit (0.5 mg kg^{-1}) set by the WHO. Heavy metal levels were consistently lower in water than in sediments, with only Cu detectable in water. In sediment samples, heavy metals were distributed in the order of $\text{Cu} > \text{Pb} > \text{Cd}$ and they were significantly lower ($p < 0.05$) at L2 while highest was found at L3. According to the results, Cu, Pb, and Cd concentrations in the fish, water, and sediment did not exceed the recommended maximum permissible limit by WHO. However, further research and regular monitoring are essential to evaluate the potential health hazards.

Keywords

Nile Tilapia, Sooriyawewa reservoir, heavy metals, atomic absorption spectrophotometry



ISSN 3051-4657

Proceedings of the 02nd Symposium on Ocean and Freshwater Systems (SOFS) – 2024
Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna, Sri Lanka.

Technical session II

Aquaculture Development

Extraction and quantification of edible alginates from selected brown algae species in Ahangama and Beruwala rocky intertidal reefs, Sri Lanka

¹Kodikara S.S.M.*, ¹Thilakarathna R.M.G.N. and ²Yapa Y.M.A.L.W.

¹Faculty of Fisheries and Marine Science & Technology, University of Ruhuna, Matara

²Faculty of Science, University of Ruhuna, Matara

*Email: senurisiyathmakod@gmail.com:

Abstract

Seaweeds are comprised with large concentrations of polysaccharides and bioactive compounds. Sodium Alginate (SA) extracted from brown algae is a biodegradable, non-toxic polymer and it is the most adaptable polysaccharide found in nature. Sri Lanka harbours a rich diversity of macroalgae enriched with bioactive compounds and polysaccharides such as SA. This study was carried out to extract and quantify the SA content of brown algae *Sargassum crassifolium*, *Sargassum ilicifolium*, *Sargassum turbinatifolium*, *Padina* sp., *Dictyota* sp., and *Turbinaria ornata* in Ahangama and Beruwala rocky reefs in 2023. Fresh samples 1 kg of each species were collected from two sites. The SA was extracted and validated by using FT-IR spectroscopy. Among the species collected, *S. crassifolium* had the highest mean yield of SA (Ahangama; $1.9502 \pm 0.0979\%$ DW, Beruwala; $1.7897 \pm 0.0100\%$ DW) and *Padina* sp. had recorded the lowest mean of SA (Ahangama; $0.3393 \pm 0.0055\%$ DW, Beruwala; $0.0046 \pm 0.0002\%$ DW). ANOVA tests were conducted to determine statistical significance. There was a significant difference in the SA yield among the different brown seaweed species in the Ahangama study site ($F_{(3,33)} = 13.004$, $p < 0.05$). *S. crassifolium*, *S. ilicifolium*, *S. turbinatifolium* and *Padina* sp. of Ahangama reef have also recorded a higher yield of SA than the Beruwala reef ($F_{(3,33)} = 13.004$, $p < 0.05$). Moreover, methanolic extracts gained from selected seaweeds exert a wide range of functional groups such as O-H stretching for Alcohol and Phenol, C-C stretching for Aromatics, C-N stretching for Aliphatic amines etc. Results of this study revealed that SA yield varies among brown algae species as well as the same species in different locations and all alginate levels of the species were lower than the previous studies. Although the SA extraction method was not appropriate for the production of alginate at an industrial scale, it was effective in obtaining pure alginate.

Keywords

Brown seaweed, sodium alginate, Sri Lanka, Ahangama reef, Beruwala reef

Antibacterial activity of two selected seaweeds (*Sargassum ilicifolium* and *Caulerpa racemosa*) against foodborne pathogenic bacteria

Liyanage L.C.D, Bandara E.G.K.Y.C and Rathnapala J.M.S.N.*

Department of Fisheries & Aquaculture, Faculty of Fisheries and Marine Science & Technology,
University of Ruhuna

*Email: sajanij@fmst.ruh.ac.lk

Abstract

Emergence of antibiotic resistance in bacterial pathogen is one of the biggest global threats to public health in the 21st century. Thus, seeking natural ingredients having the antibacterial activity to treat bacterial infections created a higher interest. The purpose of this study was to determine the antibacterial activity of *Sargassum ilicifolium* and *Caulerpa racemosa* collected from Ahangama, the Southern coast of Sri Lanka, against food borne pathogens of Gram-positive and Gram-negative bacteria. 95% Ethanol extraction of both seaweeds was tested against food borne pathogenic bacteria by using the disc diffusion method. A concentration of 25 mg/mL, 50 mg/mL, and 100 mg/mL were prepared by dissolving the extracted powder in 2% Ethanol. Tetracycline (1mg/mL) was used as the positive control while 2% Ethanol was used as the negative control. The tested food borne pathogenic bacterial species were *Bacillus cereus* (ATCC 14579), *Proteus vulgaris* (ATCC 13315), and *Staphylococcus aureus* (ATCC 25923). The obtained minimum inhibition zones in each treatment were statistically analyzed using one-way ANOVA. All tested bacterial species have resulted significant ($p < 0.05$) antibacterial effects compared to the negative control under different concentrations of two seaweeds. Both extracts displayed concentration-dependent activity, while *S. ilicifolium* exhibit stronger inhibition compared to *C. racemosa*. The findings have revealed that significant antibacterial efficacy with *S. ilicifolium* exhibiting higher inhibition zones against *Bacillus cereus* (8.75 ± 0.28 mm) and *Staphylococcus aureus*, (8.36 ± 0.22 mm) particularly at concentrations of 100 mg/mL. Similarly, *C. racemosa* showed potent antibacterial activity, especially at 100 mg/mL concentration for *Bacillus cereus* (8.04 ± 0.08 mm). Also, *Proteus vulgaris* has resulted in the inhibition zones of 7.98 ± 0.14 mm and 7.56 ± 0.26 mm, respectively for 100 mg/mL of *S. ilicifolium* extraction and *C. racemosa* extractions. Fourier Transform Infrared Spectrometer (FTIR) analysis have indicated that the presence of phenolic compound is the major functional group in both seaweeds, which might contribute to the antibacterial activities of both seaweed species against the respective food borne bacterial pathogens. Thus, 100 mg/L of ethanolic extracts of *S. ilicifolium* and *C. racemosa* can be used as effective antibacterial agents, especially against Gram-positive foodborne pathogenic bacteria. Also, both seaweed extracts were found to be more effective against Gram-positive bacteria than Gram-negative bacteria.

Keywords

Caulerpa racemosa, *Sargassum ilicifolium*, foodborne pathogenic bacteria, minimum inhibition zone, FTIR

Socio-economic status of the freshwater ornamental fish farming in Matara district of Sri Lanka

Jayasingha J.M.K.G.B., Sanuja R.G. and Rathnapala J.M.S.N.*

*Department of Fisheries & Aquaculture, Faculty of Fisheries and Marine Science & Technology,
University of Ruhuna*

**Email: sajanij@fmst.ruh.ac.lk*

Abstract

Sri Lankan ornamental fish sector has expanded with the increasing number of aquarium owners, growers, breeders, and exporters which has had a favorable impact on the development of the local and export market. The present study was conducted to assess the status of ornamental fish farming in Matara district and identify underlying causes crucial to the industry's sustainability. The survey was conducted for 31 farms selected from 07 Divisional Secretariats where had the highest number of farms using a two-stage stratified random sampling method from the registered 141 ornamental fish farms in 16 Divisional Secretariats. Data were collected from August to November 2023 regarding the production process, economic aspects, marketing aspects, problems, and prospects of ornamental fish farms using a structured and pre-tested questionnaire, in-depth interviews, and focus group discussions. The results revealed that ornamental fish farming is dominated by middle-aged male farmers who have different educational levels and occupations. Training and experience analysis, which reveals that 67.74% of farmers have undergone training, highlights the importance of formal training. Operational practices mainly focus on breeding and rearing activities, and most depend on their sources of fingerlings. Competitive presence in the local market and their willingness to join the export market highlighted market opportunities. However, high feed costs, infrastructure constraints, and unpredictable yields were identified as challenges faced by farmers in ornamental fish production. Likert scale responses indicated different perceptions among farmers regarding the profitability and market viability of the industry. SWOT analysis focuses on internal and external factors that might affect the industry. This study provides a comprehensive overview of the freshwater ornamental fish industry in Matara district which can be used to gain valuable insights for stakeholders, policy makers, and farmers of the industry.

Keywords

Freshwater ornamental fish industry, Matara district, socio-economic status, SWOT analysis, operational practices

Determination of the optimum level of a commercial probiotic on growth performance, feed utilization efficiency, and immunity of GIFT Tilapia, *Oreochromis niloticus*

Herath H.M.H.L., Bandara A.M.K.A. and Rathnapala J.M.S.N.*

*Department of Fisheries & Aquaculture, Faculty of Fisheries and Marine Science & Technology,
University of Ruhuna*

*Email: sajanij@fmst.ruh.ac.lk

Abstract

Traditional strategies to combat bacterial and viral pathogens, such as high doses of antibiotics have raised concerns about the development of antibiotic-resistant strains in aquaculture industry. Consequently, supplementing feeds with probiotics is widely preferred as a sustainable method to enhance the growth performance and higher survival rates of aquatic organisms. The present study was conducted to evaluate the effect of commercial probiotic, “NOVA BACILAC FISH” on growth performance, feed utilization efficiency, stress resistance and hematological parameters of GIFT tilapia (*Oreochromis niloticus*). Eight weeks of feeding trials were conducted to examine the effect of different probiotic levels. Fish with an average length of 4.0 ± 0.08 cm and weight of 1.0 ± 0.09 g were stocked at a density of 15 fish per tank. Commercial probiotic levels were introduced in diets as ED1 (Diet with 0.1% probiotic), ED2 (Diet with 0.25% probiotic), ED3 (Diet with 0.5% probiotic) and their effects were compared with the control diet which was not included with probiotic. Each treatment was followed in three replicates. During the experiment, fish were fed up to satiation. At the end of the experiment, the percentage Specific Growth Rate (%SGR), percentage Average Daily Gain (%ADG) and Food Conversion Ratio (FCR) were calculated. Simultaneously, salinity stress test and hematological analysis were performed to study the effect of the used probiotic doses on fish health. Between 4th and 8th week of feeding trial, the growth performance of fish fed with 0.5% probiotics diet was significantly higher than those of other treatments. Results showed that ED3 treatment had the highest body weight of 19.86 ± 0.28 g and body length of 10.75 ± 0.8 cm at the end of the study. Similarly, %SGR (5.60 ± 0.09) and %ADG (39.44 ± 2.27) were significantly higher in ED3 than those of other treatments. Moreover, the lowest FCR value (0.85 ± 0.02) was observed in fish fed by 0.5% probiotic diet (ED3). After exposing the experimental fish to the salinity stress test at 27 ppt, significantly lowest cumulative mortality index (CMI) was observed in fish fed by 0.5% probiotic diet (ED3). The blood profile analysis showed the significantly highest Red Blood cell (RBC) count ($1.91 \pm 0.02 \times 10^6 \text{ mm}^{-3}$) in ED3 treatment. According to the present study, 0.5 % of dietary supplementation of commercial probiotic “NOVA BACILAC FISH” can be used to improve the growth performance, immune status, and stress resistance of GIFT tilapia.

Keywords

Oreochromis niloticus, commercial probiotic, growth performance, feed utilization, stress test

Assessment of variations of egg size and fecundity of female Nile Tilapia *Oreochromis niloticus* (Linnaeus, 1757) reared under controlled and wild conditions

Sachini Nimesha S.A., Bandara E.G.K.Y.C.* and Herath S.S.

Department of Fisheries and Aquaculture, Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna, Matara

*Email: yogya@fish.ruh.ac.lk

Abstract

Fecundity estimation is the main approach used in fisheries management to predict the reproductive potential of a fish population. Studies related to this aspect of Nile Tilapia, *Oreochromis niloticus* are lacking in Sri Lanka. The present study was carried out to compare the reproductive potential of female Nile Tilapia with respect to fecundity and egg size in controlled and wild conditions. Nile Tilapia from Tilapia Breeding Centre at Udawalawa, NAQDA were selected as the fish reared in controlled conditions whilst the wild fish were collected from fish stalls near the Nilwala River at Bandaththara. Fifteen egg bearing female fish were collected from each site. Mean total length and weights of fish were 26.23 ± 0.77 cm and 275.99 ± 25.89 g in Udawalawa and 25.04 ± 0.56 cm and 252.1 ± 11.10 g in Nilwala river respectively. Ten morphometric parameters of each fish were measured. After dissecting, the total no. number of eggs was counted, and the diameters of eggs were measured. The data were analyzed using one sample t-test. Fish collected from Udawalawa had a significantly higher ($p < 0.05$) mean total weight of eggs/fish than that of Bandaththara. Fish from Udawalawa had higher mean total fecundity (1746.67 ± 238.65) when compared with the fish from the wild (1366.67 ± 104.65). Furthermore, fish from Udawalawa had higher relative fecundity (6.31 ± 0.36 g⁻¹) than the fish from Bandaththara (5.43 ± 0.51 g⁻¹). Egg diameters of fish ranged from 1.38-1.82 mm and 1.43-2.15 mm in Udawalawa and Bandaththara respectively. Study revealed that female Nile Tilapia in controlled conditions had higher total and relative fecundities when compared to the fish in the wild. But the eggs collected from Nile Tilapia from Udawalawa had significantly lower diameters than that of wild. The findings of the present study will provide an insight for sustainable management of Nile Tilapia fishery in Sri Lanka.

Keywords

Fecundity, Nile Tilapia, captivity, wild fish

Effectiveness of *Bruguiera gymnorhiza* and *Avicennia marina* leaf extracts on the control of common fungi in fish feed

Kumari P.L.A.C.¹, Manel Kumari W.G.S.², Yapa Y.M.A.L.W.³ and Herath S.S.^{1,*}

¹ Department of Fisheries and Aquaculture, Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna, Matara

² Department of Botany, Faculty of Science, University of Ruhuna, Matara

³ Department of Chemistry, Faculty of Science, University of Ruhuna, Matara

*Email: sakunthala@fish.ruh.ac.lk

Abstract

Deterioration of fish feed by microorganisms is a major issue in fed-aquaculture. Antifungal properties of mangrove plants have potential to control feed deterioration in aquafeed. Thus, this study was aimed to identify fungi species in deteriorated commercial fish feed and evaluate the antifungal activity of *Bruguiera gymnorhiza* and *Avicennia marina* leaf extracts against identified fungi species. In this study, fungi were isolated from deteriorated fish feed on potato dextrose agar (PDA). Based on morphological characters and microscopic features, two fungi isolates were identified as *Aspergillus* sp. and *Rhizoctonia solani*. Leaf extractions of *B. gymnorhiza* and *A. marina* were prepared by dissolving 100 g of oven-dried leaf powder in either sterilized distilled water or 95% ethanol (1:5 w/v). Aqueous and ethanolic extracts of both plants were tested against *Aspergillus* sp. and *Rhizoctonia solani* using the Kirby-Bauer disk diffusion method. Briefly, six extracts including four individual crude extracts such as aqueous extracts of *B. gymnorhiza* and *A. marina*, ethanolic extracts of *B. gymnorhiza* and *A. marina* and two combined crude extracts such as combined aqueous extracts of *B. gymnorhiza* and *A. marina* combined ethanolic extracts of *B. gymnorhiza* and *A. marina* in 1:1 (v/v) were tested against *Aspergillus* sp. and *Rhizoctonia solani* in PDA in triplicates. Sterilized distilled water and 95% ethanol were used as controls. Plates were incubated at room temperature (approx. 30 °C). Growth inhibition zone was measured after 72 hours considering the distance between the growing edge of the colony and the paper disc containing crude mangrove extract. Data were analyzed with one way ANOVA followed by Tukey's test in SPSS. There were significant differences ($p < 0.05$) in inhibition zones between treatments and controls. All six extracts showed promising antifungal activity against both fungi isolates. For both *Aspergillus* sp. and *Rhizoctonia solani*, the highest mean inhibition zone was recorded in combined crude extracts of aqueous and ethanol whereas the lowest mean inhibition zone was recorded for crude extracts of *A. marina* (both ethanolic and aqueous). The overall results indicated the potential application of *B. gymnorhiza* and *A. marina* leaf extracts as a source of natural antifungal compounds to control common fungal contamination in feed ingredients and finished fish feed.

Keywords

Fish feed, antifungal activity, mangroves

Effect of binder materials on physicochemical characteristics and sensory properties of *Catla* sausage

Mendis A.T.A.*, Wijesinghe R.D.N. and Radampola K.

Department of Fisheries and Aquaculture, Faculty of Fisheries and Marine Sciences and Technology, University of Ruhuna, Matara

*Email: tharukaamanthi28@gmail.com

Abstract

Catla catla is a freshwater fish, which is often considered as a low-valued food fish in Sri Lanka. Value added products such as fish sausages can be developed to enhance the marketability of lower valued food fish. During sausage preparation, binders are added to improve the physicochemical characteristics of the sausages. This study investigated the influence of binder materials (wheat flour or chickpea flour) on the physicochemical characteristics and sensory properties of *Catla* sausage. The prepared sausages i.e.: chickpea flour sausages (CFS) and wheat flour sausages (WFS) were kept in a freezer for 4 weeks and proximate composition and physical properties were analyzed at every two weeks. Sensory evaluation was performed on days 1 and 28 after sausage preparation to assess taste, appearance, color and odor by five-point hedonic scale. Proximate analysis revealed that WFS exhibited significantly higher % moisture (66.15 ± 0.96) compared to that of CFS (63.40 ± 2.46). WFS showed significantly higher % protein (43.28 ± 3.14) compared to that of CFS (40.16 ± 5.30). The pH of CFS (6.52 ± 0.22) and WFS (6.50 ± 0.30) were not significantly different. The folding ability of both WFS and CFS showed higher value which was level 5. The study showed that, cooking yield % was not significantly different between WFS (93.64 ± 1.32) and CFS (93.19 ± 1.15). On day 1 CFS received lower scores for appearance (1.40 ± 0.59), color (1.45 ± 0.68), odor (1.35 ± 0.48) and taste (1.63 ± 0.49) which indicated the preferable sensory attributes of CFS. At day 28, CFS received lower scores for appearance (1.00 ± 0.00), color (1.40 ± 0.50) and odor (1.73 ± 0.88) and WFS received higher scores for appearance (2.53 ± 0.74), color (2.80 ± 0.77) and odor (2.93 ± 0.79) which indicated a preference towards CFS compared to WFS. Cost analysis showed the price/sausage for the WFS was Rs.8.56 while that for CFS was Rs.10.22. Despite the production cost of sausages, CFS had a superior sensory attribute that suggested a better consumer preference. The present study indicates that Chickpea flour can be successfully used to prepare the *Catla* sausage.

Keywords

Catla catla, fish sausage, chickpea flour sausage, wheat flour sausage

Comparison of the impact of storage strategies on the postharvest quality of giant freshwater prawns through a sensory evaluation

Kuragodage A.U.^{1*}, Deepananda K.H.M.A.¹, Jayasinghe U.A.D.² and Jones C.³

¹*Department of Fisheries and Aquaculture, Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna, Sri Lanka*

²*Department of Limnology and Water Technology, Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna, Sri Lanka*

³*Centre for Sustainable Tropical Fisheries and Aquaculture, College of Science and Engineering, James Cook University, Australia*

*Email: udarikuragoda@gmail.com

Abstract

Product quality and shelf life of giant freshwater prawns (GFP) can be influenced by different factors including handling and storing techniques. It determines consumer acceptability and satisfaction, and sensory evaluation provides immediate access to high-quality information from the viewpoint of the customer. Consumer acceptability of GFP stored under different storing techniques and durations were ascertained through sensory evaluation. Fresh GFP purchased at fish landing centers of the Ridiyagama reservoir of Sri Lanka were transported to the laboratory within an hour in flake ice and were arbitrarily divided into three groups. Specimens of the first group was chilled with flake ice, second group was air-blast frozen at -35 °C for four hours and stored at -20 °C, and the third group directly frozen at -20 °C. Sensory evaluation of cooked (at 175°C for 15 min with 1% salt) GFP involved assessing odor, flavor, and texture using a modified QIM scale by a trained panel of ten individuals. The panel rated the overall acceptability of the cooked GFP samples on days 3, 6, 9, 12, 15, 18, and 21 of the storage periods. Significant differences ($p < 0.05$) were observed in sensory ratings based on storing condition and duration. The evaluated organoleptic characteristics indicated that the GFP was in very good condition during the first 24 hours on ice; however, its quality gradually diminished over the storage period. Cooked GFP samples were rated as 'good' quality for the first six days, with the quality remaining at an 'acceptable' level for the next three days of ice storage. Blast-frozen GFP maintained "good" condition throughout the entire storing period, whereas -20°C frozen GFP transitioned from good to acceptable quality by day 6 and maintained that level throughout the storing period. Present results indicate that storing GFP in ice is effective for short-term preservation, while blast freezing is the most effective storing technique to maintain the quality over an extended period. Present findings highlight the necessity of identifying the factors reducing postharvest quality during the storage of GFP to ensure high-quality exports.

Keywords

Consumer acceptability, air-blast frozen, organoleptic characteristics, sensory ratings, postharvest quality

Acknowledgement

Australian Centre for International Agricultural Research (ACIAR) grant FIS/2018/157 provided financial support.



ISSN 3051-4657

Proceedings of the 02nd Symposium on Ocean and Freshwater Systems (SOFS)– 2024
Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna, Sri Lanka.

Technical session III

Sustainable Fisheries

Assessing the current status of parrotfish (Family: Scaridae) fishery in southern Sri Lanka: a candidate to be protected

Mallawaarachchi M. K. B. M. M.¹, Radampola K.^{1*} and Kumara P. B. T. P.²

¹*Department of Fisheries & Aquaculture, Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna, Matara.*

²*Department of Oceanography and Marine Geology, Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna, Matara.*

**Email: kumudu@fish.ruh.ac.lk*

Abstract

Parrotfish are one of the important groups that maintain ecological stability in the coral reef ecosystem which is mainly impacted by reef fisheries. However, information on parrotfish abundance and availability in the market in Sri Lanka is scarce. In this study, parrotfish community structures were studied during October to December 2023 time period in Southern Sri Lanka. Utilizing the underwater visual census method along the belt transect (2 × 25 m, 5 transects/site), diversity indices were calculated to assess the reef fish diversity structure in Polhena, Kottegoda and Dodanduwa areas. The (%) abundance of parrotfish was calculated to estimate the population status of parrotfish in their natural habitat. The fish market surveys were conducted for the fishermen (46) and consumers (30) to gain better understanding on their attitude, opinion and suggestions on parrotfish fishery. Fifteen visual belt transects yielded 16 fish families including Scaridae fish family. The (%) abundance of the Scaridae family was recorded as 15.76%, 10.39%, 25.43% in Polhena, Kottegoda, Dodanduwa respectively. Seven parrotfish species were identified. The analysis revealed that the perspectives and practices of key stakeholders influence the conservation status of parrotfish species. More fishermen caught parrotfish as bycatch and few fishermen (Polhena-20%, Kottegoda-0, Dodanduwa-6.67%) target parrotfish specifically. The parrotfish are abundant in fish markets during non-monsoonal periods. The identified fishing methods for the parrotfish were spearfishing, fishing net used to catch lobsters (Polo del), and hook & line (Panna). Most of fishermen (75.56%) and consumers (60%) agreed that the parrotfish are ecologically important, and this species should be protected. Fishermen remarked that over the years' parrotfish harvest declined in all the locations. In summary, this study highlights the importance of sustainable management and conservation of parrotfish species in Sri Lanka.

Keywords

Coral reef, market survey, fishermen, consumers, Parrotfish

Reproductive periodicity of the sea urchin *Tripneustes gratilla* (Linnaeus, 1758) in Ahangama rocky reef, Sri Lanka

Kulasekara W.G.S.N.^{1*}, Thilakarathna R.M.G.N¹. and De Croos M.D.S.T.²

¹ Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna, Matara

² Faculty of Livestock Fisheries & Nutrition, Wayamba University of Sri Lanka, Gonawila

*Email: saumyakulasekara7@gmail.com

Abstract

Sea urchins are ecologically, and economically important species distributed in many shallow marine benthic habitats. Among edible sea urchins, *Tripneustes gratilla* is abundant and crucial for controlling macroalgae on Sri Lankan coastal reefs. This study focused on the reproduction periodicity of *T. gratilla* in the Ahangama Reef, Sri Lanka. Monthly samples (approx. 24) of sea urchins were collected from February to October 2023. Samples were dissected to extract gonads. The Gonado somatic index (GSI (%)) was calculated and histological examinations of gonads were carried out. *T. gratilla* at Ahangama Reef exhibits continuous asynchronous reproduction with peak spawning periods in April, August, and September. Male and female reproductive cycles were synchronized. The highest mean GSI (%) values in April (male: $5.769 \pm 0.581\%$, female: $5.022 \pm 0.535\%$) suggests the maturation of the majority of urchins in this population, and the subsequent decline in mean GSI (%) in May (male: $2.729 \pm 0.581\%$, female: $1.847 \pm 0.535\%$) reflects the spawning. Gametogenesis consists of five gametogenic stages; growing, premature, mature, spent, and recovering. All stages of gametogenesis were present every month throughout the study period, indicating the continuous reproduction of *T. gratilla* population at Ahangama rocky reef. Peak GSI (%) of males in April coincided with the highest mature stage frequency (36.36%). Similarly, The sudden drop in GSI (%) in May coincided with the high spent and recovering stage frequencies of both males (spent – 27.27%, recovering - 36.36%) and females (spent - 38.46%, recovering - 61.54%) which indicate the accumulation of nutritive phagocytes immediately after spawning. Both GSI % values and histological evidence revealed that *T. gratilla* has a continuous asynchronous reproductive cycle, with the majority of the *T. gratilla* population at Ahangama rocky reef spawning in April which is the first inter-monsoon period in Sri Lanka.

Keywords

Sea urchin, gametogenesis, percentage gonadosomatic index

Socio-economic aspects of bivalve collectors and consumers in Kalpitiya Lagoon of Sri Lanka

Balasinghe B.H.M.^{1*}, Wijesinghe R.D.N.¹, Iroshanie R.G.A.² and Radampola K.¹

¹*Department of Fisheries and Aquaculture, Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna*

²*Department of Oceanography and Marine Geology, Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna*

**Email: madubashahasantha@gmail.com*

Abstract

Bivalves are highly nutritious food commodities which are abundant in Kalpitiya lagoon, Sri Lanka. The present study aimed to collect information on the socio-economic aspects, attitudes, and perceptions of both bivalve collectors and consumers in the Kalpitiya lagoon area from August to October 2023 period. Information on demographic characters, attitudes & perceptions, was collected through semi structured questionnaires from thirty bivalve collectors and forty-nine bivalve consumers. Results revealed that the majority of the bivalve collectors belonged to the age class 50-60 years (30%) and children under the age of 10 (6.67%) were also involved in bivalve collection activities with their parents. Both males (53.33%) and females (46.67%) involved in bivalve collection. A higher bivalve collection was observed during the months of April to October. The majority (43.33%) of bivalve collectors spent nearly 2 hours collecting bivalves. Hand picking, foot method, diving and utilization of instruments were common to collect the bivalves. Majority of the collectors (33.33%) had an average daily income between 1000-2000 LKR. Majority of the consumers bought bivalves at the harvesting site from collectors (43.59%), and 30.61% of the bivalve consumers preferred to spend around 1000-2000 LKR to buy bivalves. In Kalpitiya Lagoon, the observed edible varieties of bivalves were cockles, mussels, oysters, and clams. The reasons cited for non-consumption included, unpleasant flavor (22.22%), unpleasant appearance and fear of food poisoning (18.52%), high price (14.81%), causing allergies (11.11%), previous food poisoning and other reasons (7.41%). Reasons for the bivalve consumption were low price (29.81%), taste (25%), nutritional value (19.23%), easy availability (18.27%), and no definitive reason (7.69%). Bivalve consumer attitudes and preferences towards different bivalve species differed considerably according to their demographic and socio-economic status.

Keywords

Hand picking, foot method, diving, bivalve consumption

Fecundity and egg size variation in Nile Tilapia *Oreochromis niloticus* (Linnaeus, 1757) collected from Uyan Wewa and Nilwala Athuru Ela in Sri Lanka

Archchaka R.*, Herath S.S. and Sanuja R.G.

Department of Fisheries and Aquaculture, Faculty of Fisheries and Marine sciences & Technology, University of Ruhuna

*Email: Ashaachchu8@gmail.com

Abstract

The inland fisheries sector in Sri Lanka was developed through the introduction of exotic tilapia, particularly Nile tilapia. This study was aimed to determine the relative and absolute fecundity and compare the egg size variation of Nile tilapia in Uyan Wewa (reservoir) and Nilwala Athuru Ela (canal) in Matara district. Approximately thirty (30) Nile tilapia samples were collected from each site. The total body length and body weight of fish were measured, and the length-weight relationship of fish was calculated for two sites. Ten randomly selected female fish were used to determine the fecundity and egg size variation. Fecundity was determined using gravimetric method and the short and long axes of eggs were measured to determine the egg diameter and egg volume. The independent sample t-test was used to compare the results between two sites. Results indicate that the mean total length of Nile Tilapia in Uyan Wewa was 20.04 ± 0.32 cm while was that was 18.62 ± 0.23 cm in Nilwala Athuru Ela. The mean body weight of Nile tilapia in Nilwala Athuru Ela (133.0 ± 2.6 g) was significantly higher than that of Uyan Wewa reservoir (125.6 ± 3.6 g). The student t-test showed that there were negative allometric growths in both sites. The mean absolute fecundity (991 ± 35) was significantly higher in Nilwala Athuru Ela than that of Uyan wewa (789 ± 62). A similar pattern was observed in relative fecundity, and it was $7.3 \pm 0.1 \text{ g}^{-1}$ in the canal and $6.2 \pm 0.2 \text{ g}^{-1}$ in the reservoir. The mean egg diameter and egg volume of Nile tilapia in Nilwala Athuru Ela shows the highest values ($1.05 \pm 0.79 \text{ mm}$ and $0.63 \pm 0.11 \text{ mm}^3$ respectively) while egg diameter and egg volume of fish collected from Uyan Wewa were $0.95 \pm 0.19 \text{ mm}$ and $1.46 \pm 0.26 \text{ mm}^3$ respectively. Independent sample t-test proved that total fecundity, relative fecundity, egg diameter, egg volume of fish collected from two sites were significantly different ($p < 0.05$). According to the results, the absolute and relative fecundity and egg diameter of Nile tilapia in Nilwala Athuru Ela was significantly higher than that of Uyan Wewa.

Keywords

Nile tilapia, gravimetric method, absolute fecundity, canal, reservoir

Evaluating the efficacy of *Tephrosia vogelii* (Fish Poison bean) leaf powder as an anesthesia on *Oreochromis niloticus* (Nile tilapia)

Pushpakanthan A.*, Herath S.S. and Sanuja R.G.

Department of Fisheries and Aquaculture, Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna, Matara

*Email: pushpakanthan97@gmail.com

Abstract

Anesthetic agents play a crucial role in aquaculture by mitigating stress and minimizing injuries among cultured fish, thereby maintaining their overall health. The efficacy of *Tephrosia vogelii* leaf powder as a potential anesthetic agent for Nile tilapia (*Oreochromis niloticus*) was investigated in this study. Fish poison bean is naturally more available and has shown sedative and anesthetic effects in terrestrial studies. The study involved preparing leaf powder solutions of four concentrations (5-20 mg/L) for two size categories such as small (0.7–1.6 g) and large size (3.5-6.5 g) of Nile tilapia. Through meticulous observation and video recording of the four stages of anesthesia based on behavior of fish As1 (fast swimming behavior), As2 (gaping behavior and some different positions of swimming), As3 (losing equilibrium), As4 (failure to respond to intense environmental stimuli), and two recovery stages RC1 (long-lasting balance restoration) and RC2 (Total recovery) were documented for each concentration. The findings revealed notable variations in anesthetic periods among different concentrations, with lower concentrations prolonging the induction of anesthesia. In concentration 5 mg/L, it took more longer time to reach (Response to visual stimuli and swimming avoidance), while 20 mg/L facilitated quicker induction for both small and large fish. Moreover, recovery time increased significantly with higher concentrations, suggesting a dose-dependent effect. Physicochemical parameters such as total dissolved solids (TDS), pH, salinity, and dissolved oxygen (DO) exhibited concentration-dependent variations, further highlighting the importance of dosage in achieving desired anesthetic effects. Behavioral responses to the anesthetic included distinctive changes such as slow and erratic swimming, increased opercular beat rate (18- before As1, 22- after RC2) and partial loss of equilibrium, providing valuable insights into the physiological impact of *Tephrosia vogelii* leaf powder on Nile tilapia. Small fish groups were more sensitive to the leaf powder solution compared to larger fish in all concentrations. Effective concentrations for anesthesia were determined, with 10 mg/L identified as optimal for both size group of fish. Overall, the results demonstrated the efficacy of *T. vogelii* leaf powder as an anesthetic agent for Nile tilapia, offering a promising alternative of stress-free manipulation in aquaculture practices by providing valuable insights into dosage-dependent effects and physiological responses. Further research could explore the broader applicability of *T. vogelii* leaf powder across different fish species and aquaculture settings, enhancing its utility in promoting animal welfare and productivity within the aquaculture industry.

Keywords

Fish poison bean, *Tephrosia vogelii*, Nile tilapia, anesthetic time, recovery time

Present status of frigate tuna (*Auxis thazard*) fishery in Dodanduwa, Sri Lanka

Ekanayaka E.M.T.C.*, Sanuja R.G. and Deepananda K.H.M.A.

*Department of Fisheries & Aquaculture, Faculty of Fisheries and Marine Sciences & Technology,
University of Ruhuna, Matara*

**Email: tchathurinda@gmail.com*

Abstract

Small-scale fishery plays a key role in annual fish production in Sri Lanka. Ring net fishery in Dodanduwa area mainly targets the large school of frigate tuna (*Auxis thazard*). The present study includes (a) studying the present status of the frigate tuna considering the length-weight relationship and condition factor, (b) identifying the management strategies of fishing in the Dodanduwa area through a socioeconomic survey, and (c) studying the environmental variability in fishing grounds. Year-round fishing activity and high fishing effort are the main characteristics of this fishery. A positive allometric growth in frigate tuna revealed that the fish lived in good condition and showed healthy development. Monthly mean values of Sea Surface Temperature (SST) - 27.83 °C and Sea Surface Chlorophyll Concentration (SSCC) - 1.41 mg/m³ indicated that they were at optimum levels for *A. thazard*, inhabiting the south-west coast of Sri Lanka. The main reason for the maximum yield of fish from June to July within the southwest monsoon period is the prevalence of the optimum environmental conditions for *A. thazard* inhabiting the southwest coast of Sri Lanka. SST were 26.8 °C, 27.6 °C, and 29.1 °C from June to August 2023, respectively. SSCC was higher in June (1.864 mg/m³) and July (1.864 mg/m³) than August 2023 (0.5 mg/m³). The study revealed that frigate tuna fishing was the primary income source of the fisher community. Most of the fishers earn 1000-5000 LKR daily. Poor income management impedes the growth of the economic status of the fishers. Middle-aged fishers dominate fishing, with less attraction from the younger generation. The study affirms that a community-based management approach would assist in achieving a sustainable fishery in the study area.

Keywords

Ring-net fishery, length-weight relationship, relative condition factor, socio-economic survey



Present status of beach seine fishery in southern coast of Sri Lanka

Imasha K.I.C., Deepananda K.H.M.A.* and Bandara E.G.K.Y.C.

Department of Fisheries and Aquaculture, Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna, Matara.

**Email: ashoka@fish.ruh.ac.lk*

Abstract

Beach seine fishery is one of Sri Lanka's oldest fishing methods. The study aims to assess the status of beach seine harbors and fisheries activities, direct and indirect involvement of people, target species, management strategies, and factors influencing the status of the beach seine fishery in Matara, Tangalle and Galle fisheries administrative districts. Data was collected from October to November in 2023 by using standard ethnographic methods. Galle district has the majority of beach seine harbors (62.5%) on the southern coast while Matara district has the least (6.25%). Tangalle district has the highest number of active beach seines (62.41%), followed by Galle (30.08%) and Matara (7.52%). Anchovies were identified as the main target species and 75% of beach seine harbors primarily use cod ends with mesh size of 5 mm. Beach seine sites typically have 10-15 skilled crew and 20-40 temporary laborers. Ninety percent of harbors are impacted by the southwest monsoon restricting fishing activities from October to April. Beach seine operations follow a rotational sequence, either on a daily basis or through a time-based method. The catch on the southern coast includes various coastal pelagic and demersal fish species, such as those from the families Engraulidae, Clupeidae, Carangidae, Trichiuridae, Sphyrinaeidae, Lactariidae and Scombridae. Profits are divided equally, with one half is given to the owner and the other half to permanent workers, while a portion of the yield is given to temporary workers. Most of the interviewed fishermen believe that purse seine fishing activities negatively affect beach seine harvests leading to the decreased interest among the younger generations. Further studies and management strategies are vital to prevent the collapse of this traditional fishing method. Proper analysis of coastal constructions should consider local community opinions as well. Addressing illegal fishing methods, and providing reliable fishing equipment and government subsidies are recommended for maintaining the sustainability of this fishing method.

Keywords

Beach seine fishery, southern coast, management strategies



ISSN 3051-4657

Proceedings of the 02nd Symposium on Ocean and Freshwater Systems (SOFS)– 2024
Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna, Sri Lanka.

Technical session IV

Ecology & Environmental Management

Determination of the maximum permissible level of tannin in wastewater released to surface waters.

Luxshayan P.*, Maithreepala R.A., and Sanjaya H.L.K.

Department of Limnology & Water Technology, Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna, Matara.

luxshayan03061997@gmail.com

Abstract

Tannins are found in many field herbs and legumes. They are astringent and bitter plant polyphenols that bind, precipitate or shrink proteins and certain other organic compounds. Tannin is released to the environment by the industries that are based on plant materials as their raw materials. The dissolution of Tannic Acid (TA) in water affects the physiochemical parameters of wastewater. This change can cause toxic effects on living organisms and change the ecosystem balance. As phytoplankton are the base of a food chain, *Chlorella vulgaris* was used for the estimation of the minimum tolerance level of TA in this study. *Chlorella vulgaris* is resistant to harsh conditions and invaders. Different concentration of TA of concentrations from 0 ppm to 100 ppm at an interval of 10 ppm and from 100 ppm to 1000 ppm at an interval of 100 ppm was prepared and the change of physiochemical parameters such as pH, Chemical Oxygen Demand (COD), Salinity, Conductivity, TDS, Temperature of water was measured. The limit was determined at the concentration of TA which breaches any of the water quality standard published by Central Environmental Authority (CEA) of Sri Lanka. The parameters such as pH and Chemical Oxygen Demand showed rapid variations even at smaller concentrations. At a TA concentration of 70 ppm, the pH goes below the permissible level of 6.0 and at a concentration of 200 ppm of TA the COD goes above the permissible level of 250 ppm. An acute toxicity assessment was carried out after providing suitable laboratory conditions for the growth of *Chlorella vulgaris*. During acute toxicity assessment, primary producers survived up to a concentration of 60 ppm. The cell count increases slightly in the first day for control setup, 50 ppm, 60 ppm, and 70 ppm. The rate of increase was more in 60 ppm than in 50 ppm compared to 0 ppm. Though, 70 ppm shows slight increase in day 1 afterwards the cell count was constant throughout 4 days. The cell count change in 80 ppm and 90 ppm concentration showed sudden increase in day 1 and afterwards the cell count was constant throughout 4 days. Therefore our study suggests that the maximum permissible level for Tannin in wastewater released to the environment should be less than 60 ppm.

Keywords

Tannic acid, Chlorella vulgaris, chemical oxygen demand, primary producers, acute toxicity

Evaluation of acute toxicity of textile dye (reactive red 123) on *Chlorella vulgaris* and *Spirulina platensis*

Thinujan M., Maithreepala R.A., Asanthi H.B., and Atapaththu K.S.S.*

Department of Limnology and Water Technology, Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna

*Email: keerthi@fish.ruh.ac.lk

Abstract:

Microalgae are an ecologically important group of organisms in the aquatic environment due to their major role as primary producers. They are highly vulnerable to an array of stresses including different types of manmade chemical products, including textile dyes. Although many of textile dyes are known to be emerging environmental toxicants in aquatic environments, information on their toxicity on aquatic microalgae is limited. Therefore, the present study was designed to assess the stress responses of aquatic microalgae using *Chlorella vulgaris* (Green algae) and *Spirulina platensis* (Blue-green algae) against reactive red 123 (RR123) which is frequently used in textile industries. *C. vulgaris* and *S. platensis* were exposed to solutions with six concentrations (0 (control), 80, 120, 160, 200, and 240 mgL⁻¹) of RR123 dye. Each concentration with three replicates was exposed to the above two species for 96 hours following standard guidelines (Organization for Economic Co-operation and Development guidelines 201). At the end of the experiment, algae growth rate, growth inhibition, pigment contents (chlorophyll-a, chlorophyll-b, and carotenoids), H₂O₂ contents, and morphological changes of algae exposed to different concentrations were compared. A risk assessment was performed to determine the risk by using the EC₅₀ value. The highest growth rates of both algae were observed in the control groups, and growth rates decreased in a concentration-dependent manner where the lowest growth was exhibited in algae exposed to the highest dye concentration (240 mgL⁻¹). The EC₅₀ values for the toxicant were 122.21 and 71.91 mgL⁻¹ for *C. vulgaris* and *S. platensis* respectively. The pigment contents of both algae decreased with increasing the exposure level. After 96 hours of exposure, the EC₅₀ values for the toxicant's effect on chlorophyll-a, chlorophyll-b, and carotenoid of *C. vulgaris* were 99.5, 101.45, and 105.5 mgL⁻¹, respectively, while the same values of *S. platensis*, were 38.45, 38.5, and 39 mgL⁻¹ respectively. Present findings indicate that *S. platensis* is more vulnerable than *C. vulgaris* for RR123 dye, and their responses against the tested dye were species-specific. The findings of this study are important to clarify the interaction between textile dye waste and aquatic microalgae, and such information would benefit in formulating criteria for aquatic ecosystem management.

Keywords

Reactive red 123, specific growth rate, EC₅₀, *Chlorella vulgaris*, *Spirulina platensis*

A comparative analysis on diel vertical migration of zooplankton in littoral and limnetic zones of a reservoir in Sri Lanka

Jayawardhane S.S., Jayasinghe U.A.D.* and Wijewardene L.N.

Department of Limnology & Water Technology, Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna.

**Email: asanka@fish.ruh.ac.lk*

Diel Vertical Migration (DVM) is a behavior displayed by many zooplankton in freshwater and marine habitats to avoid the visual predation risk. Usually, they perform a behavior pattern of ascending to the upper pelagic region during the nighttime and descending to deeper water layers during the daytime. The present study aimed to investigate the DVM of zooplankton in a tropical reservoir and compare the differences if any in limnetic and littoral zones. The research was conducted in Hambegamuwa reservoir in Monaragala District, Sri Lanka. Zooplankton samples and abiotic data were collected at four-hour intervals throughout 24 hours in each sampling day. Three sampling days from dry season to rainy season (August 2023 to November 2023) were considered. All data were collected at fixed depths i.e. surface and 3 ft in the littoral zone and surface, 3 ft and 6 ft in the limnetic zone. Three main zooplankton phyla were identified as Rotifera, Arthropoda and Sarcomastigophora, and were quantified as individuals L⁻¹. They included seven genera of Rotifera and two genera of Arthropods. Canopy cover, aquatic vegetation and other hydrological parameters were different between the littoral and limnetic zones. In the limnetic zone, the DO had a significant negative correlation with depth ($r = -0.828$) and turbidity had a significant positive correlation with depth ($r = 0.626$). In the limnetic zone, the bottom layer exhibited the highest percentage abundance values of zooplankton in the morning, while the topmost layer has higher values during the darker hours. The results exhibited that only the limnetic zone possessed a DVM pattern of zooplankton. Same taxonomic group exhibited different DVM patterns at limnetic and littoral zones. In littoral zone, only the phylum Sarcomastigophora exhibited DVM. Abundant food availability and shelter from vegetation reducing predation risk might be the reasons for the absence of the DVM pattern in the littoral zone.

Keywords

Diel vertical migration, zooplankton, littoral zone, limnetic zone, reservoir

Using *Anabaena-Azolla* ecological interactions towards developing organic fertilizers

Kottage K.S.G., Asanthi H.B. and Wijewardene L.N.*

Department of Limnology & Water Technology, Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna

*Email: nisansalaw@fish.ruh.ac.lk

Abstract

Worldwide interest in organic farming is growing, due to human health risks and the environmental effects of commercial inorganic fertilizers. However, the low availability of nitrogen (N) in organic fertilizers poses a main deterrent, leading to using nitrogen-fixing plants like *Azolla* as a nitrogen source. *Azolla* sp. is a floating aquatic fern that contains 4-5% of N from its dry weight. Symbiotic *Anabaena azollae* increases N content through N-fixation. This study aimed to determine the responses of both *Anabaena azollae* and *Azolla* sp. grow in liquid Cow Dung (CD) and Banana Peel (BP) water. The 0.25g of *Azolla* sp. was cultured in water (control) and two treatments such as liquid CD, and BP in a concentration series with triplicates. The biotic parameters of *Azolla* sp. (wet weight (FW), Surface Area (SA), Relative Growth Rate (RGR) and Total Nitrogen content (TN)) and *Anabaena azollae* (Heterocyst Frequency (HF) and the Total number of *Anabaena* Filaments (TF)) were measured at three-day intervals. Also, water quality parameters were monitored every three days during the 21-day experiment. The significantly high FW (0.314 g), SA (16.097 cm²), RGR (0.012 g/g/day) and the highest TN (3.092 mg N/mg) of *Azolla* sp. were recorded at treatment with CD: BP volume ratio of 1:0 (T₀) in the BP series (p<0.05). The maximum HF of *Anabaena azollae* was recorded as 19.35 % in T₀ of the BP series while the highest TF was reported as 21 in both T₀ of the BP series and treatment with a CD: BP volume ratio of 1:1 (T₁) of the CD series. The correlation analysis between the biotic parameters of *Azolla* sp. and *Anabaena azollae* indicated that RGR predicts microscopic measurements of *Anabaena azollae*. The overall results showed that the CD medium solely yielded the best growth and TN of *Azolla* sp. These findings aid in developing organic fertilizers with *Azolla-Anabaena* symbiosis, benefiting freshwater ecosystems and human health.

Keywords

Azolla sp., *Anabaena azollae*, total nitrogen content, organic fertilizers

Effect of substrate in aquaponic system developed with *Poecilia reticulata* and *Piper betle* on growth performance of fish and plant.

Perera K.G.M.C.*, Sanuja R.G. and Herath S.S.

Department of Fisheries and Aquaculture, Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna, Matara

*Email: k.g.manula@gmail.com

Abstract

Aquaponics produce both fish and plant in one production system and efficiently utilize the resources. This study was designed to evaluate suitable substrate for betel plant (*Piper betle*) in an aquaponic system with guppy (*Poecilia reticulata*). Coconut peat and sponge were tested in this study as two substrates along with two types of control. Control 1 (CT1) had only fish, and Control 2 (CT2) contained fish, and a floating rafter filled with lids of pet bottles. Two treatments included fish, and plants grown in either sponge (TS) or coconut peat (TC) substrates. Treatment TS and TC contained three plants grown in pots with the relevant substrate, submerged in the floating rafter like CT2. Triplicated treatments were randomly arranged in 60L fiberglass tanks at initial stocking density of 15 fish per tank (0.1859 ± 0.0012 g weight). The initial plant height was 16.1 ± 1.2 cm. Fish were fed near satiety twice a day for eight weeks. Growth performance of fish and water quality parameters were compared in one-way ANOVA followed by Tukey's test at 5% significance level. At the end of the experiment, significantly highest final mean weight of fish was observed in TC (0.5059 ± 0.0025 g) followed by TS (0.4689 ± 0.0028) and it was lowest in CT1 (0.4303 ± 0.0008). Similarly, TC treatment showed the significantly highest percentage Specific Growth Rate (%SGR) of fish (1.79 ± 0.02) followed by TS (1.65 ± 0.02). The significantly lowest %SGR was observed in CT1 (1.51 ± 0.00) and CT2 (1.53 ± 0.01). Although, mean feed intake of fish was significantly higher in TC compared to other treatments, Feed Conversion Ratio was not affected by treatments. Among the tested water quality parameters, temperature was not affected by treatments. Water pH values in this study ranged from 6.1 ± 0.02 (CT1) to 6.5 ± 0.01 (TC) and pH of TC treatment was significantly higher than that of other treatments. The significantly highest NH_3 concentration was reported in CT1 (0.92 ± 0.02 mg/L) followed by CT2 (0.61 ± 0.02 mg/L) and it was lowest in CT1 (0.20 ± 0.02 mg/L). The NO_3^- concentration of both TC and TS was lowest compared to CT1 and CT2. The independent sample t-test showed that plant growth performance in terms of total chlorophyll, stem perimeter and final plant height of betel plant were affected by substrate, and it was highest in TC. These results revealed that an aquaponic system with guppy fish and betel plants enhances growth performance, and survival rate of fish. Further, among tested two substrates, coconut peat is the best substrate for betel plant when used in aquaponic system.

Keywords

Growth performance, stress resistance, chlorophyll content, water quality, aquaponics

Acknowledgement

Faculty research grant (RU/FMST/RP/2017/05) provided necessary resources.

Effect of the particle size of aqua-soil media on the growth performance of *Bacopa monnieri* (Lunuwila) plant

Senavirathna S.H.R.^{1*}, Nuwansi K.K.T² and Radampola K.¹

¹ Department of Fisheries and Aquaculture, Faculty of Fisheries and Marine Sciences, University of Ruhuna

² National Aquatic Resources Research and Development Agency, Crow Island, Colombo 15

*Email: ramodikasenavirathna@gmail.com

Abstract

The substrate will create a suitable environment for the growth of aquatic plants. It provides a place to roots, source of nutrients and in some cases medium to reproduce. Inappropriate particle size of the substrate will affect the growth of aquatic plants, thus this study focused on investigating a suitable particle or grain size of aquarium soil for the growth performances of the popular ornamental aquatic plant *Bacopa monnieri*. Aqua soil prepared using compost and topsoil (1:1 as a powder) was used as the control treatment. Three different grain sizes of aquarium soil (T1-3 mm, T2-5 mm, and T3-7 mm) were prepared by making balls from the mixture. The stem cuttings of *Bacopa* plants (10 cm) were potted in pots (5 cm diameter, 7 cm height) with relevant aqua-soil mixtures in submerged condition (10 cm above plant) for seven weeks period. Plant wet weight, dry weight, plant height, root length, leaf length, leaf width, leaf area, and number of leaves/ plants were taken to measure the growth performance of the plant. As water quality parameters, water temperature, pH, conductivity, TDS, TSS and DO were measured. Results indicated that the maximum height shown by plants in T2 (14.08±1.07 cm) and both those of T2 and T3 were significantly higher when compared to control and T1. The final dry weight and % dry weight gain of plants in T2 was significantly higher when compared to that of T1, T3 and control. The % wet weight gain of plants in T2 was significantly higher compared to that of the control. The results showed that T2 showed significantly higher plant dry weight (1.09±0.19) g, % wet weight gain (44.85±4.28), % dry weight gain (46.33±3.37), number of leaves (24.00±4.75) and chlorophyll content (16.01±0.82 µg/g) compared to other treatments. There is no significant difference in conductivity, TDS, TSS and DO values among all the treatments. The study revealed that aquarium soil with the grain size of 5 mm (T2) was the most effective aquarium soil type among tested treatments for the efficient growth of *Bacopa* plant.

Keywords

Bacopa monnieri, particle size of substrate, plant growth, aqua soil

Stress responses of *Azolla* sp. and its symbiotic *Anabaena azollae* against oxyfluorfen

Rajith T, Atapaththu K.S.S. and Asanthi H.B.*

Department of Limnology and Water Technology, Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna, Matara

*Email: asanthi@fish.ruh.ac.lk

Abstract

Non-target aquatic plants in agricultural lands are highly vulnerable to various stresses including agrochemicals. The present study assessed the stress responses of aquatic macrophyte *Azolla* sp. and its symbiotic *Anabaena azollae* against a common herbicide; oxyfluorfen. The capability of atmospheric nitrogen fixation by *Anabaena azollae* is an added advantage for *Azolla* and its living environment. *Azolla* sp. (2 g fresh weight) was exposed to six different concentrations of oxyfluorfen [0 (control), 60, 80, 100, 120, and 140 $\mu\text{g L}^{-1}$]. These concentrations were selected based on several preliminary trials. Each treatment with three replicates was randomly allocated into 18 experimental units in a complete randomized design and the experiment lasted for 96 hours under laboratory conditions. The plant growth, pigment content (chlorophyll and anthocyanin), H_2O_2 concentration, peroxidase activity (POD), and Indole acetic acid (IAA) content of *Azolla* sp were measured at the end of the experiment while the microscopic observations were recorded daily. The growth rate of *Azolla* sp. was significantly different among treatments ($P < 0.05$). The chlorophyll-a and anthocyanin content were significantly reduced by the oxyfluorfen ($P < 0.05$), where the highest concentrations of chlorophyll-a (460 $\mu\text{g/g}$ Fresh Wt) and anthocyanin (0.6 $\mu\text{g/g}$ Fresh Wt) were found in the control and 100 $\mu\text{g L}^{-1}$ treatments respectively. Increased H_2O_2 concentration and the POD activity together with low IAA content indicated oxidative stress in plants exposed to oxyfluorfen. Except in the control, roots of *Azolla* exposed to oxyfluorfen detached after 24 hours of exposure, while plants became pink in colour in 80, 100, 120, and 140 $\mu\text{g L}^{-1}$ treatments. Shrinking of the filaments of *Anabaena azollae* was observed in each concentration of oxyfluorfen at 96 hours of exposure and the absence of filaments was observed in plants exposed to 140 $\mu\text{g L}^{-1}$ concentration. The stress caused by oxyfluorfen on *Azolla* sp. disrupted its symbiotic relationship with *Anabaena azollae* at the concentration of 140 $\mu\text{g L}^{-1}$ after 96 hours of exposure. Further studies are recommended to observe the possible recovery process of *Azolla* sp. and *Anabaena azollae*.

Keywords

Azolla sp., anthocyanin, oxyfluorfen, peroxidase, indole acetic acid

Multi criteria decision analysis (MCDA) of land-use using sentinel-2 imaginary as a proxy to predict nutrient inputs into a reservoir cascade system

Rodrigo M.C.S., Sanjaya H.L.K.* and Jayasinghe U.A.D.

Department of Limnology and Water Technology, Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna

**Email: kelum@fish.ruh.ac.lk*

Abstract

With the emerging anthropogenic activities, the excess nutrient levels within reservoirs may become a threat to the balance of aquatic ecosystem leading to drastic changes. This study was done to investigate whether there would be any correlation between Land use/Landcover (LULC) patterns and the reservoir nutrient distribution within a cascade system because, the tank cascade system acts as a water purification center within the catchment. Thirappane Cascade System (TCS) which is located in Anuradapura district was selected as the study area. The LULC map was generated using a sentinel-2A image with a resolution of 10m and maximum likelihood classification method. Five categories of LULC patterns (water body, forest cover, chena cultivation, barren lands, build up areas) were used for the classification and the kappa statistical method was used to determine the accuracy level (kappa statistic= 0.83). Surface water samples from the reservoirs and soil samples from the relevant catchment areas were collected by considering the LULC pattern. Water and soil quality parameters that can be affected generating nutrient hotspots were measured. Nutrient hotspot maps for relevant catchment areas and nutrient distribution maps for six reservoirs were created using Multi Criteria Decision Analysis (MCDA) method and Inverse Distance Method (IDW) in QGIS software. LULC areas near Meegasegama, Alisthana and Bulankulama reservoirs had high nutrient hotspots than the other LULC areas in this cascade system. Reservoir nutrient level also was very high when compared to other reservoirs. Total phosphorus level varied from 0.08 ± 0.02 mg/L to 0.43 ± 0.11 mg/L ($p < 0.05$) and total nitrogen level varies from 3.40 ± 0.97 mg/L to 11.38 ± 0.73 mg/L ($p < 0.05$) within the cascade system. The developed model concluded that a high amount of nutrient was accumulated in Meegasegama, Alisthana and Bulankulama reservoirs and finally purified water was delivered to the Thirappane reservoir. Hence, Meegasegama, Alisthana and Bulankulama areas act as nutrient barriers and accumulate high amounts of nutrient within the reservoirs as well as within the relevant catchment areas. Furthermore, water quality in the cascade system had been significantly influenced by the LULC pattern of the catchment areas. Similar studies can be used to plan the LULC pattern of a reservoir cascade system for improving the sustainable management of those aquatic environments.

Keywords

Reservoir cascade system, land use/ land cover, nutrient hotspots, multi criteria decision analysis

Acknowledgement

Australian Centre for International Agricultural Research (ACIAR) grant FIS/2018/157 provided financial support.

Panel of Reviewers

Reviewer**Affiliation**

Prof. Upali Amarasinghe	University of Kelaniya
Prof. Saman Athawuda	University of Peradeniya
Prof. Thushara Chaminda	Fac, of Engineering, University of Ruhuna
Prof. Upali Chandrasekara	University of Kelaniya
Prof. Chamari Dissanayaka	University of Sri Jayawardenapura
Prof. Suneetha Gunawickrama	Fac, of Science, University of Ruhuna
Prof. Yashoda Hirimuthugoda	Fac, of Agriculture, University of Ruhuna
Prof. Nishantha Kalutharage	Fac, of Science, University of Ruhuna
Prof. Deepthi Lakmini	Fac, of Agriculture, University of Ruhuna
Prof. K. Masakorala	Fac, of Science, University of Ruhuna
Prof. MT Napagoda	Fac, of Medicine, University of Ruhuna
Prof. Harshani Peris	Fac, of Allied Health Sciences, University of Ruhuna
Prof. Dammini Premachandra	Fac, of Science, University of Ruhuna
Prof. Chinthaka Sanath	Fac, of Science, University of Ruhuna
Prof. AL Sandika	Fac, of Agriculture, University of Ruhuna
Prof. Nilantha De Silva	Fac, of Agriculture, University of Ruhuna
Prof. Mangala De Silva	Fac, of Science, University of Ruhuna
Prof. MPKSK De Silva	Fac, of Science, University of Ruhuna
Prof. Saman Wijesekara	Wayamba University of Sri Lanka
Dr. TG Dayananda	Fac, of Science, University of Ruhuna
Dr. AGSS Dharshani	Wayamba University of Sri Lanka
Dr. WAHP Guruge	Fac, of Science, University of Ruhuna
Dr. FS Idroos	University of Sri Jayawardenapura
Dr. HB Jayasiri	Ocean University of Sri Lanka
Dr. Kolitha Kamal	United Nations Office for Project Services
Dr. MPP Kumara	Ocean University of Sri Lanka
Dr. KKT Nuwansi	Ocean University of Sri Lanka
Dr. Chintla Perera	University of Kelaniya
Dr. AAM Subodinee	Fac, of Agriculture, University of Ruhuna
Dr. GGN Thusari	Uva Wellassa University
Dr. NP Vidanapathirana	University of Colombo
Dr. Kelum Wijenayaka	Wayamba University of Sri Lanka
Dr. Sarath Wijerathna	Ocean University of Sri Lanka
Dr. YMALW Yapa	Fac, of Science, University of Ruhuna
Mr. NPP Liyanage	Uva Wellassa University

Author Index

A

Agostino Merico, xiii
Archchaka R., 22
Asanthi H.B., 4, 6, 7, 28, 30, 33
Atapaththu K.S.S., 4, 28, 33

B

Balasinghe B.H.M., 21
Bandara A.M.K.A., 13
Bandara E.G.K.Y.C., 11, 14, 25
Bandara E.G.Y.K.C., 3

C

Christian Wild, xiii

D

De Croos M.D.S.T., 20
Deanna Edwing, xi
Deepananda K.H.M.A., 17, 24, 25
Dissanayake P.A.K.N., 6

E

Ekanayaka E.M.T.C., 24

G

Gang Pan, x
Guruge K.P.G.K.P., 6

H

Hapugoda W.M.N.D., 6
Herath H.M.H.L., 13

Herath S.S., 14, 15, 22, 23, 31

I

Imasha K.I.C., 25
Iroshanie R.G.A., 2, 5, 21

J

Jayasingha J.M.K.G.B., 12
Jayasinghe U.A.D., 17, 29, 34
Jayawardhane S.S., 29
Jones C., 17

K

Kodikara S.S.M., 10
Kottage K.S.G., 30
Kulasekara W.G.S.N., 20
Kumara P. B. T. P., 19
Kumari P.L.A.C., 15
Kuragodage A.U., 17

L

Lei Huang, xi
Liyanage L.C.D., 11
Liyanage S.W., 8
Luxshayan P., 27

M

Maithreepala R.A., 27, 28
Mallawaarachchi M. K. B. M. M., 19
Manel Kumari W.G.S., 15
Mendis A.T.A., 16



N

Nan Li, xii
Nethmini R.T, xii
Nuwansi K.K.T, 32

P

Patabendi P.K.V.N, 4
Perera K.G.M.C., 31
Perera L.D.K.N., 3
Pushpakanthan A., 23

Q

Qing He, xii
Qinghua Hou, xii
Qingxiang Chen, xii

R

Radampola K., 2, 3, 5, 16, 19, 21, 32
Rajith T, 33
Rathnapala J.M.S.N., 11, 12, 13
Rodrigo M.C.S., 34

S

Sachini Nimesha S.A., 14
Salgadu M.C.K.S, 2
Sanjaya H.L.K., 8, 27, 34
Sanuja R.G., 12, 22, 23, 24, 31
Senavirathna S.H.R, 32
Sönke Hohn, xiii
Sudusinghe K. D., 7

T

Terney Pradeep Kumara, x
Thilakarathna R.M.G.N, 10, 20
Thinujan M., 28
Tianyu Zhang, xii
Tilak Priyadarshana, xiv

W

Wei Zhuang, xi
Weiqiang Wang, x
Wenfang Lu, xi
Wijesinghe R.D.N, 2
Wijesinghe R.D.N., 8, 16, 21
Wijethilaka M.N.S., 5
Wijewardene L. N, 7
Wijewardene L.N., 29, 30

X

Xiao-Hai Yan, xi
Xiaolei Li, xii

Y

Yang Zhang, xi
Yao Luo, x
Yapa Y.M.A.L.W., 10, 15
Yi Guan, xiii

Z

Zhenqiu Zhang, x



Strategic
Collaborator



Sampath Bank
WE PRESENT YOUR FUTURE

ISSN 3051-4657



9 773051 465005