



World Health
Organization



IWA WATER SAFETY CONFERENCE & EXHIBITION 2026 SRI LANKA

7th International Water Safety Conference

PROCEEDINGS

23RD - 25TH MARCH

The National Water Supply & Drainage Board, Sri Lanka, in collaboration with the International Water Association, with co-sponsorship from the World Health Organization

IWA Water Safety Conference & Exhibition 2026



The 7th International Water Safety Conference is a collaboration between the National Water Supply & Drainage Board (NWSDB), Sri Lanka and the International Water Association (IWA), with co-sponsorship from the World Health Organization (WHO)

At CEWAS Building, Egodahena Road, Rathmalana, Sri Lanka

From 23rd to 25th March 2025

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Date: 23rd March 2026

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Session 04	Innovations and Technological Advancements in Water Reclamation and Sustainable Reuse Practices	13.00 14.20	Hall E
Session 05	Water Safety in Rural and Community Based Water Supply Systems	15.00 16.20	Auditorium
Session 06	Advancements in Sustainable Water Quality Monitoring, Smart Analytics and Reporting	15.00 16.20	Hall H
Session 07	Regulatory Approaches, Water Safety Plan Auditing and Safety in Distributions and Building	15.00 16.20	Hall G
Session 08	Innovations and Technological Advancements in Water Reclamation and Sustainable Reuse Practices	15.00 16.20	Hall E

Date: 24th March 2026

Session	Theme	Time	Location
Session 09	Water Safety in Rural and Community Based Water Supply Systems	10.30 11.50	Auditorium
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Session 12	Innovations and Technological Advancements in Water Reclamation and Sustainable Reuse Practices	10.30 11.50	Hall E
Session 13	Climate Resilient Water Supply System	13.00 14.20	Auditorium
Session 14	Outcome Based Innovations in Water Supply and Sanitation Systems	13.00 14.20	Hall H
Session 15	Impact on Emerging Contaminants in Drinking and Reclaimed Water on Public Health	13.00 14.20	Hall G
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Poster Presentations

Date: 23rd & 24h March 2026

Location - Second Floor Lobby Area



Message from the Hon. Prime Minister

Prime Minister of the Democratic Socialist Republic of Sri Lanka
I am pleased that Sri Lanka is hosting the International Conference and Exhibition on Water Safety, organized by the International Water Association (IWA), bringing together global expertise at a time when water security has become one of the defining development challenges of our era.

Access to safe drinking water and adequate sanitation remains a fundamental public responsibility and a key commitment under the United Nations Sustainable Development Goal 6-Clean Water and Sanitation. While Sri Lanka has made significant progress over 90 percent of the population now has access to at least basic drinking water services, the challenge today lies in ensuring the quality, resilience, and sustainability of water systems in the face of climate variability, rapid urbanization, and growing demand.

According to the global assessments, nearly 2.2 billion people worldwide still lack safely managed drinking water services, highlighting the urgency of strengthening infrastructure, and innovation. For island nations such as Sri Lanka, protecting water resources is closely linked to climate adaptation, ecosystem conservation, and long-term public health outcomes.

In this context, the role of the National Water Supply and Drainage Board (NWSDB) as the country's leading institution in the water sector is especially significant. By hosting this conference, the NWSDB has created an important platform for policymakers, scientists, and practitioners to exchange research, technological innovations, and practical strategies that can strengthen water safety and modernize water management systems.

I am confident that the knowledge shared through this conference including new research findings, technological solutions, and global best practices will contribute meaningfully to advancing evidence-based water management and building resilient water systems in Sri Lanka and across the region.

I extend my wishes to all delegates, researchers, professionals participating in this conference, whose work continues to safeguard water resources and ensure water security for present and future generations.

Dr. Harini Amarasuriya

Prime Minister of the Democratic Socialist Republic of Sri Lanka



Message from the Hon. Minister Ministry of Housing, Construction and Water Supply

Water and sanitation are fundamental pillars of public health, social well-being, and sustainable development. Ensuring access to safe drinking water and adequate sanitation strengthens community resilience, supports economic growth, and accelerates progress towards the Sustainable Development Goals, which underpin inclusive and peaceful societies. The Government of Sri Lanka accords the highest priority to providing safe, reliable, and equitable water and sanitation services for all citizens. The Ministry of Housing, Construction and Water Supply plays a central role in guiding national policy, strengthening institutions, and addressing emerging challenges in the water sector, particularly in the face of climate change, urbanization, and increasing demand for water resources.

The National Water Supply and Drainage Board (NWSDB), as the country's principal water service provider, supplies potable water through more than 3.2 million service connections across 342 water supply schemes, serving approximately 50.9 percent of the population. In addition to service delivery, the NWSDB contributes significantly to national development by protecting water source catchments, monitoring water quality, supporting industrial and commercial growth, and providing technical expertise in water and sanitation.

Sri Lanka has made notable progress in ensuring drinking water safety through the implementation of Water Safety Plans in all water supply schemes since 2016, with the support of the World Health Organization. This risk-based and preventive approach, together with the resilience demonstrated by the NWSDB during recent challenges such as extreme weather events, the COVID-19 pandemic, and economic constraints, reflects the strength, dedication, and professionalism of the sector.

Research, innovation, and knowledge sharing are essential to addressing current and future water security challenges. In this context, the International Water Safety Conference 2026 provides a valuable platform to exchange knowledge, showcase innovation, and strengthen collaboration at national and international levels. It marks an important milestone for Sri Lanka in advancing sustainable, resilient, and inclusive water and wastewater management.

I extend my sincere appreciation to the National Water Supply and Drainage Board, Ministry officials, and all partners involved in organizing this important event. I wish the conference every success and trust that it will contribute meaningfully towards building a healthy, resilient, and water-secure Sri Lanka.

Dr. H.M. Susil Ranasinghe
Hon. Minister
Ministry of Housing, Construction and Water Supply



**Message from the Hon. Deputy Minister
Ministry of Housing, Construction and Water Supply**

The International Water Safety Conference and Exhibition 2026 (IWSC&E 2026), held from 23rd to 25th at cewas, Ratmalana, Sri Lanka, symbolizes a collective global commitment to safeguarding water and sanitation services in an increasingly uncertain world.

Bringing together water utilities, professionals, and institutions from over 20 countries, the conference provides a vital platform for sharing knowledge, innovations, and best practices aligned with the Sustainable Development Goals, with a shared emphasis on quality, quantity, and equity in water services.

Sri Lanka's progress in the water sector reflects the importance of strong governance, institutional resilience, and people-centered service delivery. With consistent support from the Government of Sri Lanka, the National Water Supply and Drainage Board has achieved significant advances in expanding access to safe drinking water while strengthening risk management through Water Safety Plans (WSPs), Sanitation Safety Plans (SSP), and sustainable water quality monitoring. The themes addressed at this conference, including climate-resilient water safety planning, auditing of WSPs, emergency and incident management, regulatory challenges, and innovation are highly relevant to Sri Lanka's own experiences. The country has faced major challenges such as the 2004 tsunami, the COVID-19 pandemic and recent climate-induced events, including Cyclone Ditwah in December 2025. Despite these challenges, the continued delivery of essential water services, supported by preparedness, dedication, and strong inter-agency collaboration, helped minimize community hardship and sustain public confidence.

This international gathering presents an opportunity to transform shared experience into practical action. The lessons exchanged will support Sri Lanka in further strengthening climate resilience, enhancing regulatory and auditing frameworks, and adopting innovative and sustainable solutions to emerging water-sector challenges. As climate change and rapid urbanization place increasing pressure on water resources, the outcomes of IWSC&E 2026 will contribute to Sri Lanka's ongoing commitment to ensuring safe, reliable, and inclusive water and sanitation services. The collective knowledge generated through this conference will not only inform national practice but also contribute meaningfully to global efforts toward a more water-secure and resilient future.

I take this opportunity to wish IWSC&E 2026 Sri Lanka every success in achieving its intended objectives.

Mr. T. B. Sarath
Hon. Deputy Minister
Ministry of Housing, Construction and Water Supply



Message from the Secretary Ministry of Housing, Construction and Water Supply

It is with great pleasure that I extend my warm greetings to all participants of the 7th International Water Safety Conference and Exhibition, organized in collaboration with the National Water Supply & Drainage Board (NWSDB), Sri Lanka and the International Water Association (IWA), with co-sponsorship from the World Health Organization (WHO). I commend the organizers for bringing together this important global platform at the Centre of Excellence for Water and Sanitation (cewas), Ratmalana, from 23rd to 25th March 2026.

Access to safe and reliable water is fundamental to public health, economic development, and environmental sustainability. Even though Sri Lanka is not responsible for climate change, as an island it has to face many issues due to global warming. In the face of climate change, rapid urbanization, emerging contaminants, and increasing demand for water resources, the importance of water safety has never been greater. This conference is timely and highly relevant, as it provides an opportunity for policy makers, researchers, regulators, water professionals, and industry experts to exchange knowledge and practical experiences on strengthening water safety across the entire supply chain.

The selected focus themes reflect the key challenges and priorities facing the water sector today. Climate-resilient water supply systems, sustainable water quality monitoring, smart analytics, and next-generation regulatory approaches are essential to ensure long-term water security. Equally important are effective emergency and incident management, innovations in water reclamation and reuse, and outcome-based solutions that deliver measurable public health benefits. The emphasis on water safety plan implementation, auditing, distribution systems, buildings, and rural and community-based water supply systems highlights the need for inclusive and comprehensive approaches that leave no community behind.

Sri Lanka remains strongly committed to improving water and sanitation services while safeguarding public health and protecting the environment. The Ministry of Housing, Construction and Water Supply continues to support initiatives that promote innovation, capacity building, evidence-based regulation, and international collaboration. I am confident that the discussions, technical sessions, and exhibitions at this conference will generate valuable insights, practical recommendations, and partnerships that will contribute to safer water systems locally and globally.

I wish the conference every success and trust that it will be a productive and inspiring forum for all participants. I also extend my appreciation to the organizers, partners, and sponsors for their dedicated efforts in making this important event possible.

Eng. L. Kumudu Lal Bogahawatta
Secretary
Ministry of Housing, Construction and Water Supply



**Message from the Chairman
National Water Supply & Drainage Board (NWSDB), Sri Lanka**

It is my great pleasure to extend warm greetings to all delegates, researchers, professionals, academics, industry representatives, and students participating in this important conference organized by the National Water Supply & Drainage Board (NWSDB), Sri Lanka.

The water sector today faces increasing challenges arising from climate change, extreme weather events, rapid urbanization, and growing demands for reliable and safe water services. In this context, water safety has become a fundamental priority, requiring risk-based planning, robust institutional frameworks, and continuous innovation across the entire water supply chain.

I am pleased that this conference is closely aligned with the International Water Association (IWA) Water Safety Conference and Exhibition 2026, a globally recognized platform dedicated to advancing Water Safety Plans, resilience, and public health protection. The IWA Water Safety Conference and Exhibition 2026 brings together utilities, regulators, researchers, and industry experts to share global best practices and emerging solutions for safeguarding drinking water. The association of this conference with the IWA framework highlights its international relevance and technical importance.

As the national utility responsible for water supply and wastewater services in Sri Lanka, the NWSDB places the highest emphasis on water safety, service quality, and sustainability. Research and development, capacity building, and international collaboration form key pillars of our institutional vision. This conference provides a valuable platform for exchanging knowledge, presenting research outcomes, and translating scientific findings into practical solutions that strengthen water services.

The active participation of professionals from diverse backgrounds reflects the importance of collaboration in addressing complex water challenges. I am confident that the technical discussions and knowledge shared during this conference will contribute meaningfully to national priorities and global commitments, including Sustainable Development Goal 6. I sincerely appreciate the efforts of the organizing committee, reviewers, authors, and keynote speakers whose dedication has ensured the success of this event. I wish all participants a productive and rewarding conference.

With best wishes.

Chairman

**National Water Supply & Drainage Board
Sri Lanka**



**Message from the General Manager
National Water Supply & Drainage Board, Sri Lanka**

It is with great pleasure that I extend my warm greetings to all participants of the NWSDB Annual Research & Development Symposium and the International Water Association (IWA) Water Safety Conference & Exhibition – 2026.

The National Water Supply and Drainage Board proudly celebrate 51 successful years in water and wastewater service management. To date, as the total pipe borne water coverage records 62.3% in the country out of which the NWSDB has achieved an impressive pipe borne connected coverage of 51.2%, reflecting its steady progress toward sustainable water and sanitation service delivery. This milestone stands as a testament to the unwavering dedication of the entire workforce, who has worked tirelessly day and night, even during times of emergency to ensure the continuity and reliability of services. Their commitment has been the cornerstone of its persistent success. Today, we take great pride in being recognized as a financially and technically sustainable organization, steadfastly serving one of the most essential needs of the people; safe drinking water for over five decades.

In an era marked by climate changes, rapid urbanization, and increasing pressure on water resources, the role of research, innovation, and evidence-based decision-making has never been more critical. The 10th Annual Research & Development Symposium (R&D) and the IWA Water Safety Conference & Exhibition-2026 proudly hosted by the National Water Supply & Drainage Board will provide a timely and important platform for researchers, professionals, policymakers, and practitioners here and abroad to come together to share knowledge, exchange experiences, and explore innovative solutions for sustainable and safe water management.

The proactive engagement of the NWSDB in research & development, digital transformation and utility management reflects the need for progress in the water sector. Through continuous research, technological advancement, and collaborative learning, we can improve service delivery, enhance water quality and safety, strengthen resilience to climate impacts, and ensure equitable access to safe drinking water for present and future generations. Similarly, water safety, a practical risk assessment tool introduced by the WHO, remains a fundamental public health priority, demanding integrated risk management approaches from source to consumer. I would like to express my profound gratitude to the symposium & conference organizers, spearheaded by the NWSDB for their commitment to fostering a culture of innovation and learning, and for creating an inclusive forum that bridges academia, industry, and policy makers. I am confident that the deliberations, technical sessions, and strategic forums during this event will generate practical insights and actionable recommendations that will contribute meaningfully to national and global water sector development in fulfilling the Sustainable Development Goals as well. I extend my sincere appreciation to all the researchers, speakers, partners, and participants for their valuable contributions in the plenary sessions and hope you will have a productive and enriching experience at the IWA Water Safety Conference & Exhibition 2026 held in Sri Lanka. I wholeheartedly wish the R&D Symposium and Conference every success and trust that it will inspire continued collaboration, innovation, and excellence in the water sector.

Eng. T. Barathithasan
General Manager
National Water Supply & Drainage Board



Keynote Speech
Prof. Kalanithy Vairavamoorthy
Executive Director at International Water Association

Adaptive Approaches to Water Safety in a Changing Context

Water safety remains a central and evolving challenge for societies worldwide, as utilities and regulators confront growing uncertainty driven by climate variability, extreme events, ageing infrastructure, emerging contaminants, and rising service expectations. Ensuring safe, reliable, and trusted water services now requires approaches that move beyond linear models of supply and compliance.

This keynote examines how water safety principles can be translated into practical, adaptive actions within utilities and service providers. Drawing on systems thinking and adaptive governance, it highlights the importance of diversified water portfolios, fit-for-purpose service models, integrated cross-sector planning, hybrid grey-green solutions, and proactive asset management in strengthening resilience across the water cycle.

Digital innovation - including advanced data analytics and emerging AI tools - is considered as a powerful enabler of more responsive, insight-driven institutions. At the same time, the often-under-recognized value of practitioner expertise and tacit knowledge in strengthening institutional capability is emphasised.

Rather than advocating specific technologies, the focus is on strategic thinking, governance, and capability development - offering adaptable pathways for enhancing water safety and long-term service resilience under conditions of deep uncertainty.



Prof. Hiroaki Furumai

**Professor, Research Center for Water Environment Technology,
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Water Supply System and Water Safety Planning in Japan

Surface water accounts for approximately three-quarters of water supply source in Japan, and about half of that comes from dams. Rapid sand filtration is the primary method of water purification, and chlorination is mandatory. Advanced water purification methods using ozone and activated carbon are also being introduced to combat mold odors and trihalomethanes. Meanwhile, some rural areas still utilize groundwater in addition to surface water. Water supply system in Japan, established during the period of rapid economic growth in the 1960s and 1970s, is facing a triple threat: aging facilities, declining revenue due to population decline, and a shortage of engineers. However, water quality management remains crucial to ensuring a safe and reliable water supply. Based on 51 drinking water quality standards, Japan boasts world-class safety, with the majority of its water being drinkable. This is thanks to the implementation of a Water Safety Plan, which incorporates the HACCP concept, a system for proactively analyzing and managing risks throughout the entire process, from the water source to the tap. Based on the national guidelines, each water utility has formulated a plan and is implementing management systems and monitoring with the aim of preventing water quality accidents and improving the efficiency of maintenance and management. In addition, water quality standards have been set for PFAS, a new substance of concern, and new obligations will be imposed on water quality testing and compliance with the standards from April 2026.



Prof. Min Yang

**Professor, Research Center for Eco-Environmental Sciences,
Chinese Academy of Sciences**

**Establishment of the JRDC: A Milestone in Addressing CKDu, an
Urgent Health Issue in Sri Lanka**

On March 26, 2015, a formal Memorandum of Understanding (MoU) was signed between Sri Lanka's Ministry of Urban Development, Water Supply and Drainage (MUWSD) and the Chinese Academy of Sciences (CAS), in the presence of both Presidents. Its core objective was to establish the China-Sri Lanka Joint Research and Demonstration Center for Water Technology (JRDC), a platform to address two intertwined challenges: the prevalence of Chronic Kidney Disease of Uncertain Etiology (CKDu) and the lack of safe drinking water in rural Sri Lanka through research and technology development.

Funded by China's government, the JRDC was completed in 2020. This speech details the Sino-Sri Lankan joint team's two key achievements: identifying CKDu causes, and developing affordable water purification technologies. The team confirmed harmful substances in rural well water damage kidneys, causing CKDu. They developed cost-effective purification technologies, now used in rural projects to benefit over 5,000 residents and reduce CKDu risk. By integrating the resources from the government, industries and CBOs, the team is now trying to develop a self-sustainable model to expand the safe water supply facilities in Sri Lanka's rural areas.

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Research Papers Review Panel

Theme: Climate Resilient Water Supply Systems

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Dr. Biplob Pramanik, RMIT University, Australia.
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Dr. Prabha Weerakoon, University of Peradeniya, Sri Lanka.
Dr. Panduka Neluwala, University of Peradeniya, Sri Lanka.
Dr. Lashitha Rathnayake, University of Peradeniya, Sri Lanka.
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Mr. Tak Yip Choy, WSD Hong Kong SAR, China.
Mr. Duncan Middleton, SEQ Water, Australia.
Mr. Philip Dwamena-Boateng, University of Cope Coast, Ghana.
Ms. Brie Jowett, Tweedhead Shire Council, Australia.

**Themes: Advancements in Sustainable Water Quality Monitoring,
Smart Analytics and Reporting**

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Dr. Wasantha Illangasinghe, Former General Manager, NWSDB, Sri Lanka.
Dr. Madhusa Sudasinghe, University of Colombo, Sri Lanka.
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**Themes: Advancements in Sustainable Water Quality Monitoring,
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Mr. Sandis Dejus, Riga Technical University, Latvia.
Mr. Ilkka Miettinen, Finnish Institute for Health and Welfare, Finland.

Themes: Next-generation Regulatory Approaches, Effectiveness of Emergency and Incident Management in Water Supply and Sanitation Systems.

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- Group Members:
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Ms. Bettina Rickert, UBA. German.
Mr. Ikechukwu Okuzu, IWA - Nigeria.
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Themes: Effectiveness of Emergency and Incident Management in Water Supply and Sanitation Systems, Outcome Based Innovations in Water Supply and Sanitation Systems.

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Theme: Innovations and Technological Advancements in Water Reclamation and Sustainable Reuse Practices

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Dr. Sarangee Athukorala, University of Peradeniya, Sri Lanka.
Dr. Lasitha Rathnayake, University of Peradeniya, Sri Lanka.

Themes: Success and Challenges in Water Safety Plan Auditing, Impact on emerging contaminants in drinking and reclaimed water on public health.

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**Themes: Success and Challenges in Water Safety Plan Auditing,
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**Themes: Water Safety Plan Implementation,
Water Safety in Distribution Systems and Buildings.**

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Theme: Water Safety in Rural and Community Based Water Supply Systems.

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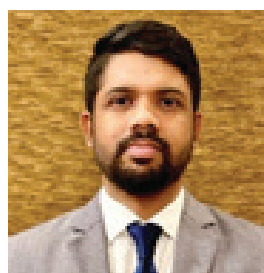
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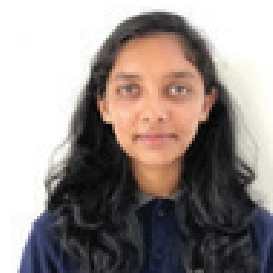
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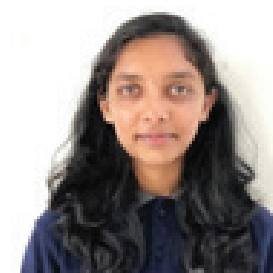
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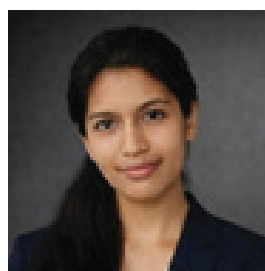
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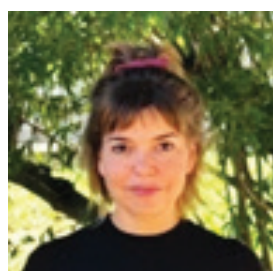
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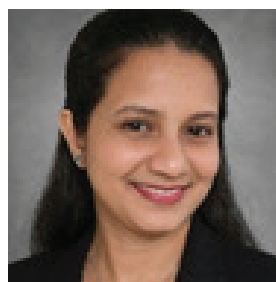
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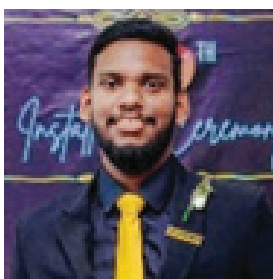
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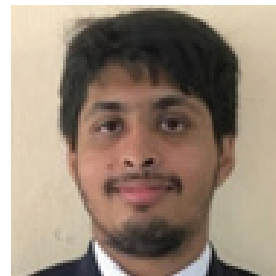
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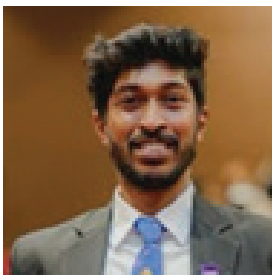
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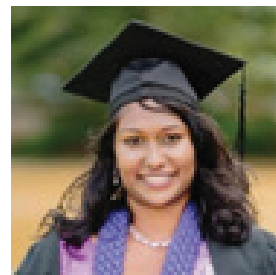
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Presentation 18
Ms. Shakuni Senevirathna
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Presentation 37
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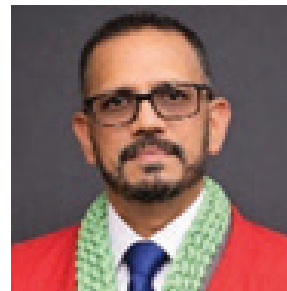
Presentation 33
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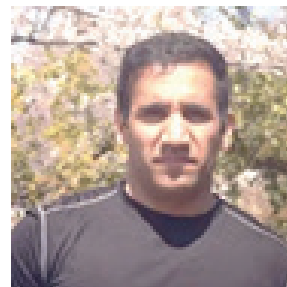
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Japan

Oral Presentations

Session 01

Climate Resilient Water Supply Systems

Session Chair	Prof. J.M.A. Manatunga
Session Co-chair	Dr. S.K. Weragoda
Rapporteur	Mr. Sobana Thennakoon



IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

Institutional Barriers to Drought Adaptation in Drinking Water Supply Systems Sri Lanka

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Keywords: Climate change adaptation; Drought resilience; Urban water management; Institutional challenges

Abstract: Frequent and intensified droughts driven by global warming pose major challenges for urban and semi-urban water practitioners, underscoring the urgency of resilient water supply schemes. The study examines institutional barriers to drought adaptation in Sri Lanka's urban water sector using a survey of 108 practitioners across 89 National Water Supply and Drainage Board (NWSDB) systems. Barriers were assessed under flexibility, networks, integration, and knowledge. Results show significant barriers in networks and integration, with knowledge-related gaps further constraining resilience and adaptive capacity.

Introduction:

Urban water supply systems are among the sectors most significantly affected by frequent droughts. Sri Lanka is highly vulnerable to climate change, with an increasing frequency of droughts in recent years (Abeysingha & Rajapaksha, 2020). Traditional water management approaches are inadequate under climate change conditions while institutional inertia often constrains transitions toward resilience (Rijke et al., 2013). Accordingly, this study aims to identify institutional barriers to drought adaptation in Sri Lanka's drinking water supply schemes.

Previous studies (Rijke et al., 2013; Clarvis & Engle, 2015) highlight governance and institutional barriers in climate resilience, while Clarvis & Engle (2015) link them to drought preparedness. However, quantitative assessments remain limited, leading this study to identify and assess institutional barriers quantitatively.

Methodology:

A survey questionnaire comprising 17 items was developed based on the four indicators proposed by Clarvis and Engle (2015)—flexibility, networks, knowledge, and integration—using a five-point Likert scale to assess institutional barriers. The questionnaire was informed by the literature, and content validity was established through expert review. Reliability analysis yielded a Cronbach's alpha value of 0.91, indicating high internal consistency. Mean values were used to interpret responses, with scores below 3.00 indicating barriers and scores above 3.00 representing enablers, based on the median of Likert-scale value 3.

This study covered 89 affected systems of NWSDB from the 2023 drought, with 108 responses from engineers, technical officers, and sociologists. A non-probability sampling method was used, allowing participant selection based on researcher judgment rather than random sampling.

Findings/Results:

The results of the analysis are shown in Table 1. The flexibility indicator is positive while all related questions scored above 3, indicating that flexibility acts as an enabler in current drought management. In contrast, Networks and Integration indicators show barriers in current practice. For knowledge, two questions scored above 3 and three below, with an overall mean of 3.03, reflecting a neutral state. Its standard deviation was 1.24, the highest among categories, suggesting relatively lower reliability in responses for knowledge.

Table 1: Results from the analysis of the questionnaire survey

Indicator	Covered questions	Mean	SD
Flexibility	Q1(3.86),Q2(3.48),Q5(3.12),Q12(3.68)	3.53	0.75
Networks	Q7(3.03),Q8(3.06),Q9(2.62),Q14(2.43),Q17(2.88)	2.80	1.00
Knowledge	Q3(2.89),Q4(2.27),Q6(3.69),Q11(3.82),Q16(2.5)	3.03	1.24
Integration	Q10(3.06),Q13(1.98),Q15(3.06)	2.70	1.02

Conclusions/Key Messages:

This study finds that flexibility currently supports effective drought management, while institutional barriers in integration and networks significantly limit overall system performance. Weak coordination between agencies, limited engagement with urban planners, and gaps in communication across governance levels constrain adaptive responses. To address these challenges, policy and practice should prioritize institutional reforms that strengthen inter-agency coordination, formalize collaboration mechanisms, and improve information-sharing between decision-makers and practitioners. Capacity-building measures, including training on drought monitoring, early warning systems, and demand management tools, are also essential. Future research should explore governance models that enhance institutional integration and assess the effectiveness of collaborative frameworks in improving drought resilience.

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IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

Evaluating the Multifunctional Benefits of Urban Stormwater Nature-Based Technologies

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Keywords: LID technologies; nature-based solutions; soil organic carbon; urban heat island

Abstract: Rapid urbanization has intensified environmental issues such as the Urban Heat Island (UHI) effect, green space loss, and water degradation. This study evaluates the effectiveness of low-impact development (LID) technologies in mitigating UHI and enhancing soil carbon storage. Soil samples from SCW, RG, and TBF were analyzed for SOC, and surface temperatures were measured using thermal imaging. Paved areas retained more heat, while TBF showed the lowest temperature (21.2°C). SCW recorded the highest SOC stock (71.2 tC/ha), demonstrating the dual role of LID systems in cooling and carbon sequestration.

Introduction:

Rapid urbanization has degraded water resources, increased pollution, and intensified urban heat (Haque et al., 2024). The Urban Heat Island (UHI) effect arises from the replacement of natural landscapes with heat-retaining surfaces (Fletcher et al., 2015). This study evaluates low-impact development (LID) technologies as nature-based solutions for reducing UHI intensity and enhancing soil carbon sequestration in urban environments.

Methodology:

The study was conducted at Kongju National University, Chungnam Province, South Korea, with nine soil-sampling events between March 2023 and November 2024 across Surface construction wetland (SCW), rain garden (RG), tree box filter (TBF). Soil organic carbon (SOC) content was measured using the Walkley-Black (wet oxidation method). To evaluate UHI mitigation, a Testo-875-1i thermal infrared camera captured images from August 2019 to August 2025, analyzed using Testo IIRSoft software, with only summer results considered.

Findings/Results:

Table 1 presents the mean soil organic carbon (SOC) percentages and carbon stocks per unit area across different LID technologies and the landscape. SOC content varied notably among the systems, with SCW (4.3%) and TBF (4.1%) showing the highest values, whereas RG recorded the lowest (2.4 %). In terms of carbon storage, SCW also

exhibited the highest SOC stock (71.2 tC/ha), while RG had the lowest (30 tC/ha). The elevated SOC levels in SCW can be attributed to enhanced plant root turnover, accumulation of organic matter and hydrocarbons transported via stormwater runoff, and the presence of bioceramic and woodchip materials in the soil media (Haque et al., 2024).

Table 1. SOC content across different LID technologies

LID technologies	SOC (%)	SOC (tC/ha)
Surface flow wetland (SCW)	4.3	71.2
Rain garden (RG)	2.4	30.0
Tree box filter (TBF)	4.1	33.5

Among the LID systems, RG recorded the highest surface temperature (25.1°C), whereas TBF exhibited the lowest (21.2°C) (Figure 1). In contrast, paved surfaces displayed considerably higher mean temperatures, ranging from 29.9°C to 32.5°C, reflecting their strong heat-retaining characteristics. These results demonstrate the effectiveness of LID technologies in mitigating the Urban Heat Island (UHI) effect by lowering surface temperatures.

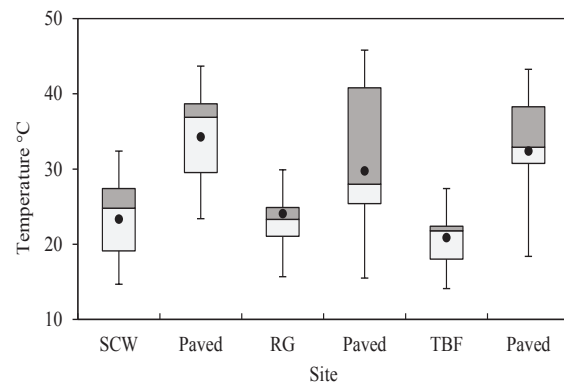


Figure 1. Comparison of Surface Temperature Variations in LID Systems and Paved Area

Conclusions/Key Messages:

This study demonstrates that LID technologies effectively mitigate the UHI effect by maintaining lower surface temperatures than paved areas while enhancing soil carbon storage. The results highlight the roles of SCW and TBF in carbon sequestration, underscoring the importance of nature-based solutions for sustainable urban development.

Acknowledgement:

Korea Environmental Industry & Technology Institute (KEITI) through Wetland Ecosystem Value Evaluation and Carbon Absorption Value Promotion Technology Development Project, Funded by Korea Ministry of Environment (MOE) (2022003630005) supported this work.

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IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

Assessing Hydrological and Flood Risk Responses to Climate Change in the Nilwala Basin, Sri Lanka

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Keywords: Climate Change; HEC-HMS; HEC-RAS; Flood Risk Mapping; Nilwala River Basin

Abstract: This study integrates CMIP6 climate projections with hydrological (HEC-HMS) and 2D hydraulic (HEC-RAS) modelling to assess future flood risk in the Nilwala River Basin, Sri Lanka. Bias-corrected rainfall inputs to a calibrated HEC-HMS model (NSE = 0.972) generated flows used in hydraulic simulations and GIS-based risk maps. Under SSP5-8.5, far-future discharge at Pitabaddara may rise 34.1%, driven by a 27.8% precipitation increase. HEC-RAS reproduced the 2017 flood moderately (CSI = 40.4%), highlighting Matara and nearby floodplains as most vulnerable.

Introduction:

Climate change has intensified extreme weather (Chathuranika *et al.*, 2022), with floods causing the most disaster-related deaths (Samarasinghe *et al.*, 2022). The Nilwala River Basin in Sri Lanka, especially Matara, is increasingly vulnerable due to monsoon-driven flooding and urban expansion (Diwyanjalee and Premarathne, 2024). While past studies focused on streamflow (Chathuranika *et al.*, 2022) or short-term forecasting (Ratnayake, Sachindra and Nandalal, 2010), few have assessed future flood risk. This study uses a coupled hydrological-hydrodynamic framework with downscaled CMIP6 projections (SSP1-2.6, SSP5-8.5) to evaluate future flood scenarios for risk management.

Methodology:

Daily rainfall (1986–2018) from five stations and Pitabaddara discharge (2000–2023) were used for model calibration and validation. CNRM-CM6-1-HR rainfall projections, selected for their skill in representing monsoon rainfall in Sri Lanka's wet zone (Jayaminda, 2024), were bias-corrected and analysed for near (2030–2052), mid (2053–2077), and far (2078–2100) futures. The Upper Nilwala Basin HEC-HMS and Lower Nilwala Basin 2D HEC-RAS models were calibrated (May 2017) and validated (May 2018). Flood risk maps were developed using AHP by integrating hazard (depth,

velocity), exposure (population, buildings, land use), and vulnerability (demographics, building features).

Findings/Results:

The calibrated HEC-HMS model projects a 34.1% increase in far-future streamflow at Pitabaddara under the SSP5-8.5 scenario, associated with a 27.8% increase in precipitation relative to the 1986–2014 baseline (*Table 1*). Model performance during calibration for the 2017 event was excellent (NSE = 0.965, PBIAS = 5.75%, RMSE = 0.2), and further improved after optimization (NSE = 0.972, PBIAS = –3.55%, RMSE = 0.2). Validation against an independent 2018 event showed moderate skill (NSE = 0.544, PBIAS = –15.11%, RMSE = 0.7).

Table 1: Change in precipitation and discharge (%) under SSP1-2.6 and SSP5-8.5 scenarios compared to the baseline period.

GCM	Change in precipitation			Change in River Discharge		
	Near future	Mid future	Far future	Near future	Mid future	Far future
SSP1-2.6	5.95	5.21	4.74	6.64	8.61	6.21
SSP5-8.5	4.35	12.17	27.78	6.22	17.28	34.11

The HEC-RAS model moderately reproduced the 2017 flood extent (CSI = 40.4%), while flood risk mapping shows increased inundation and exposure in Matara and the southern lowlands under high-emission scenarios.

Conclusions/Key Messages:

This study evaluates the impacts of climate change on streamflow and flood risk in the Nilwala River Basin using HEC-HMS, HEC-RAS, and GIS. Flood magnitude and extent increase under SSP5-8.5, emphasizing adaptive floodplain management in Matara. Excluding pumping stations and levees may explain moderate 2017 flood agreement. The framework offers a transferable approach for basin-scale flood risk assessment in data-scarce tropical regions.

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IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

Assessing the Extreme Weather Exposure of Urban Green Infrastructure for Water Safety and Stormwater Resilience

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Keywords: Climate change adaptation; urban resilience; green infrastructure

Abstract: Green stormwater infrastructure (GI), such as permeable pavements and bioretention systems, supports stormwater infiltration and pollutant reduction but remains underexamined under extreme weather. An exposure index (EI) was developed for major South Korean cities using climate modelling, bias correction, and indicator weighting. Projections showed intensified rainfall, with days ≥ 20 mm highest under SSP5-8.5, and increased temperature extremes throughout the century. The highest EI values were observed in Seoul (0.616) for permeable pavements and Daegu (0.377) for bioretention systems, emphasizing the need for resilient GI designs to maintain stormwater performance and urban water safety under future climate change.

Introduction:

Extreme weather events such as flooding, heat waves, and winter storms have become more frequent due to a $+1.1$ °C rise in global temperatures since pre-industrial times (Kim et al., 2023). Green infrastructure (GI) technologies, including permeable pavements and bioretention systems, improve stormwater infiltration and water safety but remain insufficiently assessed under extreme weather. To address this, an exposure index (EI) was developed for major South Korean cities using bias-corrected climate data and AHP-derived indicator weights to evaluate climate-related risks to urban stormwater resilience.

Methodology:

An exposure index was developed for two green infrastructure GI types, permeable pavements and bioretention systems, based on their presence in highly urbanized Korean cities. Exposure indicators were selected through a literature review and

weighted using the analytic hierarchy process (AHP). The index combined normalized values and relative weights of indicators. Quantile mapping (QM) was used for the bias-correction of climate model data, while historical weather data were obtained from the Korea Meteorological Administration and future projections from CMIP6 under the SSP1-2.6 and SSP5-8.5 scenarios were corrected and standardized using z-scores.

Findings/Results:

Exposure indicators for permeable pavements included extreme precipitation metrics (Rx1day, R20mm), temperatures (TXx, TNn), heat waves, and cold waves. Bias-corrected projections showed increases in heavy precipitation and extreme temperatures under SSP5-8.5, with R20mm in Incheon rising from 26 to 37 days by late-century. A high EI for permeable pavements was obtained for Seoul under SSP5-8.5 at 0.616, reflecting urban heat impacts, while Daegu showed high EI values for bioretention systems at 0.377 under SSP1-2.6 as shown in Figure 1, primarily due to the high frequency of heat waves and precipitation extremes. The results underscore the need for localized resilience strategies to maintain GI effectiveness under extreme weather conditions.

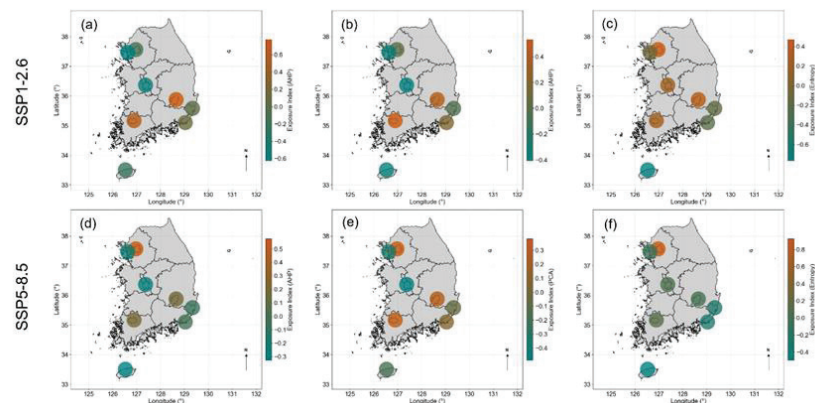


Figure 1. Spatial distribution of the extreme weather exposure index for permeable pavements across eight major cities in South Korea under SSP1-2.6 (a–c) and SSP5-8.5 (d–f) scenarios. Panels (a) and (d) show results using AHP, (b) and (e) using PCA, and (c) and (f) using entropy weighting.

Conclusions/Key Messages:

An exposure index (EI) for green infrastructure (GI) in major Korean cities was developed using climate modelling and indicator weighting. The developed indices highlight the need for resilient GI designs to enhance urban water safety and maintain stormwater performance under future climate extremes.

Acknowledgment:

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Modelling Spatial Variability of Water Yield and Its Sensitivity to Climate Factors: A Case Study of the Samanalawewa Watershed

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Keywords: Annual Water yield; Climate change; GIS; Samanalawewa Watershed

Abstract: Estimating and mapping water yield play a crucial role in the efficient planning and management of water resources. Annual water yield (AWY) was calculated and spatially represented across five time periods (2000, 2005, 2010, 2015, and 2020) using the Integrated Valuation of Ecosystem Services and Trade-offs (InVEST 3.9.2) framework. The findings revealed that mean annual water yield values for the respective years were 2.62×10^5 , 2.60×10^5 , 3.50×10^5 , 3.58×10^5 , and 2.75×10^5 $\text{m}^3 \text{ha}^{-1} \text{year}^{-1}$. These results would help in formulating watershed management policies and the implementation of proper water conservation measures in the watershed.

Introduction:

As a key component of hydrological ecosystem services, water yield serves as a fundamental indicator in ecosystem management and watershed health assessment. Water yield is defined as the total volume of water discharged from a land surface through runoff (Yang et al., 2020). This study used the InVEST 3.9.2 AWY model was utilized to calculate the relative contribution of each land parcel to average AWY. Climate variability exerts macro-scale influences on water supply by modifying watershed-level water yield through alterations in precipitation patterns and potential evapotranspiration rates. Consequently, this study aimed to assess the sensitivity of annual water yield to key climatic variables, specifically precipitation and temperature. Estimated AWY is directly connected to multiple UN Sustainable Development Goals, particularly SDG 6 (Clean Water and Sanitation), which focuses on ensuring safe water access and sustainable water resource management. Beyond this, water yield estimates are essential for achieving goals related to food security, health, clean energy, and climate action, since water availability underpins nearly all aspects of sustainable development.

Methodology:

The Samanalawewa (SW) watershed, located in Rathnapura District, Sri Lanka, covers approximately 359 km². The SW consists of 08 sub-watersheds with main tributaries that are drain into the SW Reservoir (8.97 km²). This study used the InVEST AWY model to estimate water yield in the Samanalawewa watershed across five time periods (2000-2020) at five-year intervals. The model, based on the Budyko curve and water balance principles, uses mean annual precipitation to quantify spatially distributed water yield. The input data required to run the model included land use and land cover, mean annual precipitation and potential evapotranspiration, root restricting layer depth, and plant available water content. After running the model, the resulting maps were generated using ArcGIS 10.8 software. Pearson correlation analysis was conducted to examine the relationships between water yield and two climatic variables, precipitation and temperature in the SW watershed using Minitab TM¹⁹ software.

Findings/Results:

Mean annual water yield values for 2000, 2005, 2010, 2015, and 2020 were 2.62×10^5 , 2.60×10^5 , 3.50×10^5 , 3.58×10^5 , and 2.75×10^5 m³ ha⁻¹ year⁻¹, respectively, with the highest in 2015 and lowest in 2005. Precipitation followed a similar pattern, with maximum rainfall in 2015 and minimum in 2005. Lower temperatures during peak flow periods reduced evapotranspiration, enhancing water availability. Mean annual water yield showed an overall increasing trend, except for a decline in 2020 due to reduced precipitation. The lower watershed generated higher yields than the upper part. Pearson correlation indicated a strong positive relationship between water yield and precipitation ($r = 0.990$, $p < 0.001$), consistent with Wu et al. (2022). In contrast, water yield showed a strong, statistically significant negative linear relationship with temperature ($r = -0.952$, $p < 0.001$).

Conclusions/Key Messages:

Precipitation is the dominant driver of water yield in the SW watershed, explaining 98% of the variance. While water yield is increasing, its strong dependence on rainfall makes it vulnerable to climate change. Temperature negatively affects water yield. The system shows strong dependence on climate factors, highlighting potential vulnerability under climate change. Therefore, effective monitoring of precipitation and temperature is crucial for sustainable watershed management.

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Session 02

Advancements in Sustainable Water Quality Monitoring, Smart Analytics and Reporting

Session Chair	Prof. Yuansong Wei
Session Co-chair	Mrs. N.R.S. Wickremasinghe
Rapporteur	Mr. M.I. Nazeer



IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

Evaluation of Surface Water Quality along Mahaweli River within Kandy City Limits and its Suburbs

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Keywords: Water Quality Index; Surface Water Quality; Land Use; GIS

Abstract: Surface water in tropical developing regions demands continuous quality monitoring. This study assessed the Mahaweli River within Kandy City using the Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI) integrated with Geographic Information Systems (GIS) based land-use mapping. Upstream forested areas (WQI > 80) exhibited excellent quality, while urbanized zones showed monsoonal degradation with higher turbidity, iron, and microbial levels. Forest cover above 60 % buffered pollutants, emphasizing vegetation's protective role and the need for sustainable watershed management.

Introduction:

Rapid urbanization, industrialization, and population growth have intensified pressure on freshwater resources, especially in developing regions where climatic and geological factors hinder sustainable management (Abeyasinghe & Samarakoon, 2017). The Water Quality Index (WQI) simplifies complex datasets, while GIS enhance spatial visualization and pollution source analysis (Chapman, 1992). Sri Lanka's Mahaweli River, increasingly affected by urbanization and agriculture (Mahagamage & Manage, 2014), was evaluated using CCME-WQI and GIS-based land-use mapping.

Methodology:

The study examined the upper Mahaweli River catchment using five intake sites; namely; Meewathura, Kandy Municipal Council (KMC), Greater Kandy Water Treatment Plant (GKWTP), Polgolla, and Balagolla; representing varied hydrological and land-use settings. Eleven parameters: Colour, Turbidity, pH, Electrical Conductivity (EC), Total Alkalinity, Total Hardness, Nitrate, Total Iron, Total Dissolved Solids (TDS), Coliform and E. coli Bacteria were analyzed for 2021–2022. pH and Turbidity were monitored daily, while the remaining parameters were measured monthly. The CCME-WQI was computed from scope, frequency, and amplitude using SLS 614:2013 and environmental standards. Catchments were delineated using SRTM data in Esri ArcMap 10.8, while Landsat 8 imagery was classified into four land-use types. Pearson's correlation analysis ($p < 0.05$) was performed using IBM SPSS Statistics 23 to assess the relationship between land use and surface water quality.

Findings/Results:

The spatial variation of the Water Quality Index (WQI) along the Mahaweli River (2021–2022) is illustrated in Figure 1.1, and the corresponding land-use distribution is depicted in Figure 1.2. Forest cover exceeded 60 % in upstream catchments such as Meewathura and Balagolla, while built-up and agricultural areas dominated downstream regions near GKWTP, KMC, and Polgolla. Forested zones functioned as natural buffers, minimizing sediment and pollutant inflow, whereas urbanized areas exhibited increased runoff and contamination during monsoons. CCME-WQI results indicated good to excellent quality ($WQI > 80$) in forested areas and fair to marginal quality downstream. Turbidity consistently exceeded limits, with elevated iron and microbial levels at GKWTP and KMC. Correlation analysis showed positive relationships between built-up area and pollutants, while forest and agricultural lands correlated negatively, highlighting their pollution-mitigating capacity.

Conclusions/Key Messages:

Integrating CCME-WQI with GIS-based land-use mapping proved effective for evaluating Mahaweli River water quality. Forested catchments such as Meewathura and Balagolla sustained superior quality, while urbanized zones like GKWTP and KMC showed degradation linked to runoff and limited riparian cover. Key parameters; colour, turbidity, nitrate, iron, and microbial contamination; were closely tied to land-use intensity. Strengthening riparian buffers, stormwater control, zoning enforcement, and real-time monitoring is vital for sustainable watershed and water safety management in tropical regions

Figures and Tables

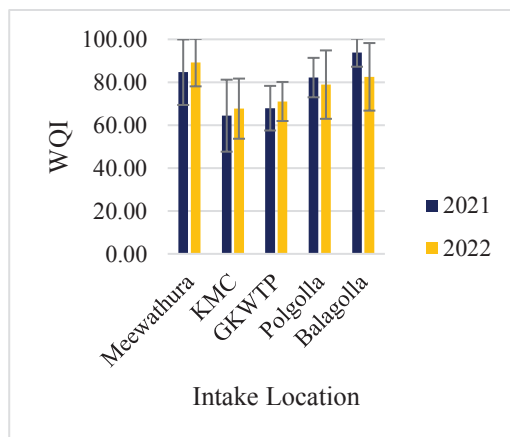


Figure 1.1: Comparison of Variation of WQI along Mahaweli River in 2021-2022

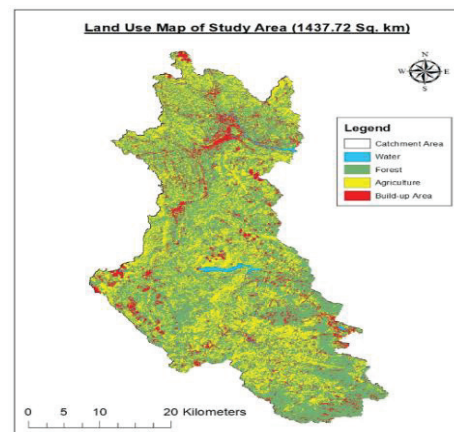


Figure 1.2: Land Use Map

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Eco-Friendly Graphite Furnace Atomic Absorption Spectrophotometry Protocol for Trace Cadmium Monitoring in Hypersaline Waters: Advancing Water Safety and Sustainable Desalination Management in Northern Sri Lanka

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Keywords: Cadmium determination; GFAAS; Hypersaline waters; Water Safety Plan

Abstract: Desalination brine discharges in Northern Sri Lanka produce hypersaline waters (TDS >56,000 mg/L), complicating trace metal monitoring. This study presents a green, optimized Graphite Furnace Atomic Absorption Spectrometry (GFAAS) method for accurate cadmium (Cd) determination in high-salinity matrices using an Analytik Jena ZEEnit 700P with 3-field Zeeman background correction. Distinct furnace programs were developed: P2 for seawater (150°C drying, 800°C pyrolysis, 1400°C atomization) and P3 for brine (atomization up to 1500°C). External calibration achieved recoveries of 84.8–106.5%, while matrix-matched calibration gave 119.3–135.0%. Two- to five-fold dilution mitigated matrix suppression, and external calibration with matrix-appropriate programs enabled reliable quantification. The method achieved LOD and LOQ of 0.76 µg/L and 2.31 µg/L, respectively. GAPI assessment confirmed high environmental sustainability. This approach is suitable for routine regulatory monitoring, WSP implementation, and sustainable desalination management in hypersaline waters.

Introduction:

Cd is a toxic, persistent, and bioaccumulative heavy metal increasingly detected in marine ecosystems due to industrialization, urbanization, and desalination discharges (Kim et al., 2017). Accurate monitoring in hypersaline waters is essential for environmental protection and compliance with WSP. Conventional trace metal methods are challenged by matrix effects such as spectral interference and non-specific absorption, while GFAAS provides high sensitivity but requires optimization for high-TDS matrices (Nriagu & Pacyna, 1988). This study addresses these challenges through furnace program optimization, Zeeman background correction, sample dilution and producing a reliable, green protocol for Cd monitoring in Northern Sri Lanka.

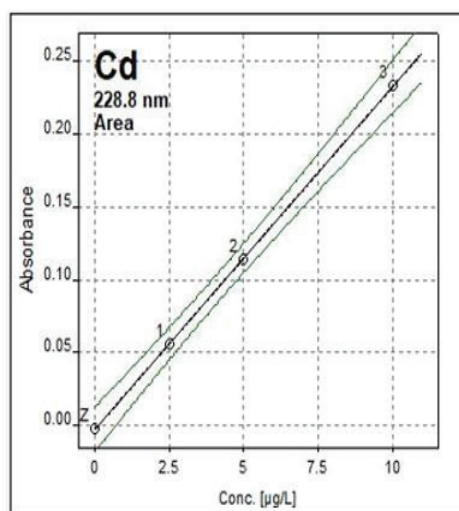
Methodology:

Cd analysis was performed using an Analytik Jena ZEEnit 700P GFAAS (228.8 nm) with 3-field Zeeman background correction. Calibration employed Certified Reference Materials and ultrapure water, while artificial seawater (ASW) and brine (ABW)

simulated hypersaline matrices. Furnace programs were optimized: P1 (110°C/600°C/1200°C, default programme) for low-matrix, P2 for ASW (150°C/800°C/1400°C), and P3 for ABW (up to 1500°C). External and matrix-matched calibrations evaluated and recovery tests with 10 ppb Cd spikes validated precision, while LOD and LOQ were determined per ICH Q2(R1). Method greenness was evaluated using the GAPI.

Results and Discussion:

Figure 01 represents the external calibration using CRMs under P1 showed excellent linearity ($R^2 > 0.999$) and low RSD, confirming precision for low-matrix samples. Matrix-matched calibration in ASW with Program P2 improved accuracy by compensating for salt-induced absorption. Zeeman background correction was essential, eliminating non-specific absorption that caused overestimation in ASW and ABW. Optimized furnace programs (P2 for ASW, P3 for ABW) ensured quantitative atomization and minimized matrix interference. Recovery studies demonstrated poor performance with P1 (<25%), improved recoveries with P2 (85–106%), and accurate ABW results with P3. Dilution effectively mitigated matrix suppression in high-TDS samples. LOD and LOQ in ASW were 0.76 and 2.31 $\mu\text{g/L}$ confirming suitability for trace-level monitoring. Figure 02 shows the GAPI assessment rated 12 of 15 parameters green, confirming high environmental sustainability.



S/No	Category	Parameter	Assessment	Color Code
1	Sample Preparation	Preservation	Simple storage, Dilute nitric acid	Green
		Transportation	Local analysis, minimal risk	Green
		Preparation complexity	Dilution/spiking only	Green
2	Reagents and Solvents	Reagent toxicity	Low-toxicity (Cd standard, no acids)	Green
		Solvent use	Milli-Q water only	Green
		Reagent amount	Microliter scale	Green
3	Instrumentation/ Energy	Instrument type	GFAAS (moderate energy)	Yellow
		Energy consumption	Moderate	Yellow
		Time requirement	Moderate (~2–3 min/sample)	Yellow
4	Waste Generation	Waste volume	Very low (~1 mL/sample)	Green
		Waste type	Non-hazardous	Green
		Waste treatment	Not required	Green
5	Safety and Hazards	Chemical hazards	Low	Green
		Environmental risk	Negligible	Green
		PPE requirements	Standard lab PPE	Green

Figure 01: External Calibration Curve Figure 02: GAPI assessment

Conclusions:

A robust and environmentally sustainable GFAAS method was developed for accurate cadmium determination in hypersaline waters. Owing to its low reagent consumption, minimal waste generation, and strong analytical performance, the method is well suited for routine regulatory monitoring, Water Safety Plan implementation, and long-term environmental surveillance of desalination-impacted coastal waters.

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IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

Spatiotemporal Dynamics of Dissolved Organic Matter (DOM) in Beira Lake, Sri Lanka

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Keywords: DOM; Urban Lakes; Beira Lake; Sri Lanka; Risk-based Monitoring

Abstract: This study uniquely analyzes the spatiotemporal dynamics of DOM in Beira Lake, Sri Lanka which has not been comprehensively studied. Sampling during wet and dry seasons utilized dissolved organic carbon (DOC) analysis and PARAFAC Analysis. Results showed significant seasonal variation, with higher DOC in the dry season (1.75–12.90 mg/L) than the wet season (2.75–3.67 mg/L). DOM composition shifted from terrestrial humics in the wet season to microbial fulvic acids and proteins in the dry season. These findings highlight distinct seasonal risk pathways and suggest that advanced DOM characterization is a sustainable and powerful tool for proactive risk identification and targeted water management in urban lakes worldwide.

Introduction

Urban lakes provide critical ecosystem services, yet their water quality is increasingly threatened by anthropogenic activities (Rahman et al., 2021). Pollution from untreated sewage and urban runoff introduces DOM, posing risks to human and ecological health. Despite its role in indicating pollution sources and biogeochemical processes, DOM dynamics are often overlooked in conventional water quality assessments. Beira Lake in Colombo, Sri Lanka, exemplifies these challenges, suffering severe degradation due to sustained urban pressures (Prasad et al., 2024). This study addresses a critical gap by conducting a spatiotemporal assessment of DOM to inform

pollution control and restoration strategies, directly linking DOM dynamics to water safety planning and targeted management interventions.

Findings/Results:

DOC levels were significantly higher and more variable in the dry season (1.75–12.90 mg/L) than in the wet season (2.75–3.67 mg/L). DOM composition shifted seasonally: wet-season DOM was dominated by terrestrial humic-like substances (39.15%), while dry-season DOM comprised microbial-derived fulvic acids (51.24%) and protein-like substances (48.76%). Fluorescence indices (FI > 1.9, BIX > 1.0, HIX < 0.8) indicated strong microbial dominance and low humification year-round (Figure 1).

PCA reinforced correlations between microbial-derived components and DOC. Beira Lake showed higher seasonal DOC variability and stronger microbial signatures, highlighting acute vulnerability to urban pressures.

Conclusions/Key Messages:

Beira Lake exhibits strong seasonal DOC dynamics and shifting DOM composition. Wet-season risks are driven by terrestrial runoff, while dry-season risks stem from internal microbial activity fuelled by sewage and nutrients.

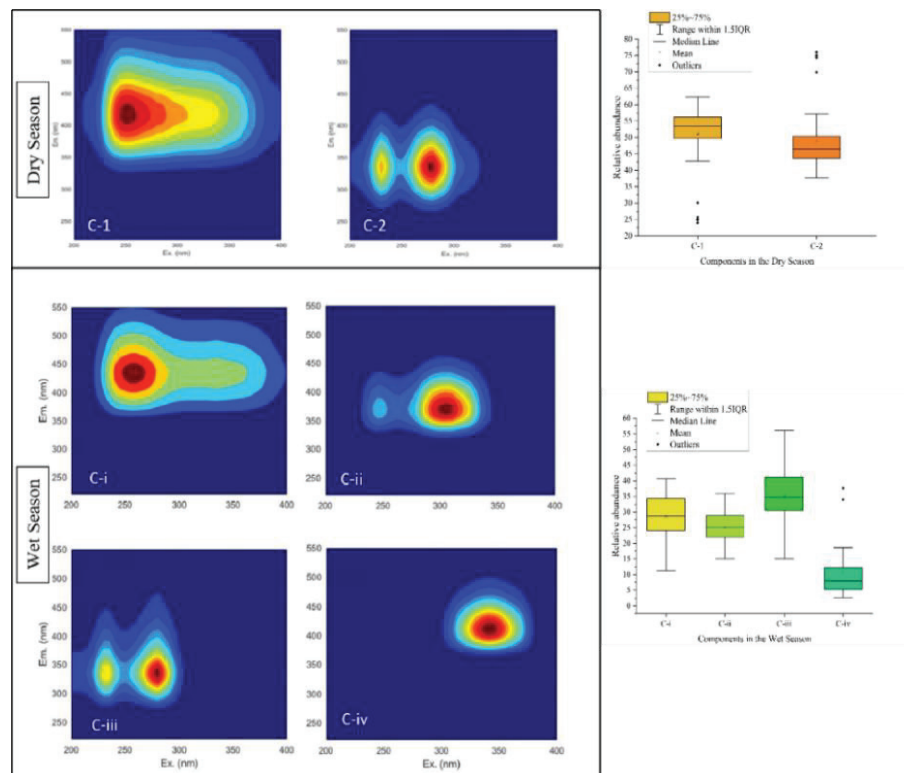


Figure 1 Distribution of Fluorescence Indices values of the Beira Lake

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IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

The Impact of Geological Features and Lithological Composition on Water Quality in the Upper Kelani River Basin

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Keywords: Chemical weathering; Geology; Kelani River basin; PHREEQC modeling

Abstract: The upper Kelani River basin and water quality, particularly upstream of Ruwanwella, is significantly influenced by natural factors such as lithology, soil, and vegetation. The river basin primarily consists of metamorphic rocks derived major minerals such as feldspar, quartz, and calcite. These minerals release Ca^{2+} , Mg^{2+} , K^{+} , and Na^{+} as major cations, along with CO_3^{2-} and HCO_3^{-} as major anions, into the water sources through weathering processes. The Ca-Mg- HCO_3 water type dominates the upper part of the Kelani River, suggesting the influence of rapid chemical weathering of marble and calc-silicate rocks, as indicated by the surface geology map. PHREEQC modeling predicts the dissolution of minerals including quartz, K-feldspar, albite, calcite, kaolinite, K-mica, gibbsite, and goethite indicating active chemical weathering.

Introduction:

The Kelani River is a member of the major 4 rivers in Sri Lanka and is the 4th longest river on the island. The river basin covers twenty sub-basins and seven districts, including several prominent towns in Sri Lanka, an area at high risk of river basin pollution due to substantial industrial and agricultural wastewater discharge (Mahagamage et al. 2006). Especially, the upper Kelani River water chemistry should be affected by natural factors (lithology, climate, topography, and recharge sources) and nutrients from croplands more than other anthropogenic activities according to the geographical setting. Geochemical weathering from minerals surrounding the bedrock of the river is one of the key mechanisms that might act on the river chemistry (Liu et al. 2001). Quantifying the factors that influence chemical weathering is complex; however, the process predominantly results from three principal sources: silicates, carbonates, and evaporites (White and Blum 1995). Identifying dissolved minerals and compounds in aquatic environments is essential for the advancement of innovative, customized water purification systems, which depend on the specific dissolved minerals present at each water intake location.

Methodology:

The methodology for this study was divided into five primary steps: desk studies, field sampling, laboratory analysis, data analysis, and chemical modeling. Water samples from the river were collected at 24 selected locations over about 75 km of the river. Sampling locations were selected based on geology, geomorphology, land use, and accessibility. Alkalinity and other physicochemical parameters were measured using an auto-titrator and multiparameter equipment. Major cations, trace elements, and anions were quantified using Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES) and High-Performance Liquid Chromatography (HPLC). The PHREEQC software is one of the modeling tools that can be used to simulate the river basin's rock-water interaction.

Results:

The element concentrations exhibit the following order: $\text{Ca} > \text{Si} > \text{Mg} > \text{K} > \text{Na}$, whereas the major anion concentrations demonstrate the $\text{HCO}_3^-/\text{CO}_3^{2-} > \text{NO}_3^- > \text{SO}_4^{2-} > \text{Cl}^-$ order. The Gibbs modeling diagrams indicate that the majority of river water samples are classified as rock-water interaction type, demonstrating the influence of watershed lithology on the water quality of the Kelani River. Surface geology maps show that the basin is covered by metamorphic rocks such as garnet-sillimanite-biotite gneiss, charnockitic gneiss, granitic gneiss, quartzite, hornblende-biotite gneiss, calc gneiss, and marble. According to hydrogeochemical modeling done based on Piper plots, the Ca-Mg- HCO_3 hydrochemical facies dominates the upper part of the Kelani River, suggesting the influence of rapid weathering of marble and calc-silicate rocks, as indicated by the surface geology maps. Stiff diagrams are also useful to visually categorize water samples based on their major chemical compound. There are three main types of water samples identified by stiff diagram shapes. Fifteen samples out of twenty-four samples belong to one category. PHREEQC modeling predicts the dissolution of secondary minerals, including K-mica, kaolinite, gibbsite, hematite, goethite, and Ca-montmorillonite, suggesting the potential for chemical weathering of primary rock-forming minerals, including silicate minerals such as feldspars.

Conclusion/ Key Messages:

In conclusion, the hydro-geochemical modeling indicates that rapid weathering of marble and calc-silicate rocks, along with the dissolution of silicate-bearing secondary minerals, plays a significant role in shaping the water chemistry of the upper Kelani River. Determining the minerals dissolved in the upper part of the Kelani River is crucial for developing novel purification techniques, including membrane filtration, precipitation, ion exchange, and adsorption, customized for mineral removal.

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Machine-Learning Prediction of DOM Composition and Disinfection By-Products Formation Potential in Seawater-Intruded Groundwater in Coastal areas.

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Keywords: Coastal aquifers; DBP precursors; Explainable machine learning; Optical indices

Abstract: Seawater intrusion modifies dissolved organic matter (DOM) composition in coastal aquifers, increasing the potential for disinfection by-product (DBP) formation during drinking-water treatment. This study evaluates the efficiency of widely used machine-learning (ML) models for predicting DOM reactivity and trihalomethane formation potential (THM-FP) using routine groundwater quality indicators. Groundwater samples from 56 wells in a coastal aquifer in Sri Lanka were analyzed for hydrochemical parameters, optical DOM indices, and molecular composition. Random Forest, XGBoost, and Partial Least Squares Regression models were developed and compared. Ensemble ML models achieved high predictive accuracy ($R^2 > 0.85$) and identified SUVA₂₅₄, chloride, sodium, and pH as dominant predictors. The results demonstrate the suitability of ML-based approaches for efficient DBP risk screening in seawater-intruded groundwater systems.

Introduction

Seawater intrusion is an increasing threat to coastal groundwater resources due to excessive abstraction and sea-level rise. Beyond salinity increases, intrusion alters the composition and reactivity of dissolved organic matter (DOM), which can significantly enhance the formation of disinfection by-products (DBPs) during drinking-water treatment. Monitoring DBP formation potential traditionally relies on advanced analytical techniques, such as FT-ICR-MS, GC-MS which are costly and not routinely available. Recent studies indicate that machine-learning (ML) models, particularly ensemble methods, can efficiently capture nonlinear relationships between water quality parameters and DBP formation (Weng et al., 2024; Khoi et al., 2022b).

Methodology

Groundwater samples were collected from 56 shallow and tube wells in the Mannar coastal aquifer, Sri Lanka, during wet and dry seasons. Major ions, pH, and optical DOM indices (SUVA₂₅₄, humification index, biological index, and fluorescence index) were measured, while DOM molecular composition was characterized using FT-ICR-MS. Random Forest, XGBoost, and Partial Least Squares Regression models were trained to predict DOM molecular fractions and THM formation potential. Model performance was evaluated using cross-validation, and feature importance was assessed using SHapley Additive exPlanations analysis (Wang, Peng and Liang, 2021).

Results

FT-ICR-MS results showed enrichment of aromatic and nitrogen-containing DOM components in seawater-intruded wells, indicating elevated DBP precursor abundance. Random Forest and XGBoost models demonstrated higher predictive efficiency than PLSR, achieving R^2 values between 0.86 and 0.89. Feature-importance analysis consistently ranked SUVA₂₅₄, chloride, sodium, and pH as the most influential predictors. Scenario simulations indicated that a 10% increase in salinity could increase predicted THM formation potential by approximately 20%, highlighting the sensitivity of DBP risk to seawater intrusion.

Conclusion

This study demonstrates that efficient machine-learning models using routine hydrochemical and optical parameters can reliably predict DBP formation potential in seawater-intruded groundwater. The approach reduces reliance on costly molecular analyses and provides a practical screening tool for identifying DBP-prone water sources

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Session 03

Regulatory Approches, Water Safety Plan Auditing and Safety in Distributions and Building

Session Chair	Prof. Mahesh Jayaweera
Session Co-chair	Mr. Ruwan S. Liyanage
Rapporteur	Mr. H.D.S. Piyathilaka



IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

A systems approach to risk-based regulation for safe drinking water

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Keywords: Drinking water; Regulation; guidance, STPA, Risk Management

Abstract: Safe drinking water is essential for public health and depends on a robust regulatory framework. The regulator collaborates with water service providers to implement effective risk management programs, advising on site-specific ambiguities. Although most guidelines focus on water suppliers' responsibilities, regulators must interpret the implementation efficacy. The study's findings yield a set of regulatory requirements, with sample criteria for preventing illness and death from unsafe drinking water.

Introduction:

Safe drinking water is essential for protecting public health; achieving this outcome requires support from an appropriate legislative and regulatory framework. The health regulator plays a crucial role in establishing a regulatory framework that ensures water service providers implement effective risk management programs to ensure the safety of drinking water. Also plays a role in collaborating with key stakeholders to support the water supplier's success in producing safe drinking water.

Most guidelines and risk management frameworks predominantly focus on the role of the water provider for managing the safety of drinking water. From that information, the health regulator is expected to interpret the efficacy of implementation in regulated entities. For example, the 2011 Australian Drinking Water Guidelines direct drinking water suppliers to defer to their health regulator for advice where there is potential ambiguity in deciding the most appropriate course of action under site-specific circumstances (NHMRC & NRMMC, 2011).

The research proposes requirements for a risk-based regulatory framework. This method supports the modelling of the various processes and flows of information in the regulatory processes. From the model, it is possible to identify potential ways in which safety constraints that control regulatory processes may fail to protect the safety of drinking water and establish countermeasures.

Methodology:

The study employs System Theoretic Process Analysis (STPA) to analyse the sociotechnical structure of the regulatory processes and environment involved in delivering safe drinking water, as illustrated in Figure 1. The STPA methodology is a

hazard analysis approach based on an expanded model of accident causation. Besides component failures, STPA assumes that accidents can also result from unsafe interactions between system components, even if none of them has failed yet. The analysis process will be informed via information collected from published information describing previous drinking water quality incidents and literature on good water quality practices. The countermeasures identified can then be used to develop guidance for regulators to ensure the safe delivery of drinking water.

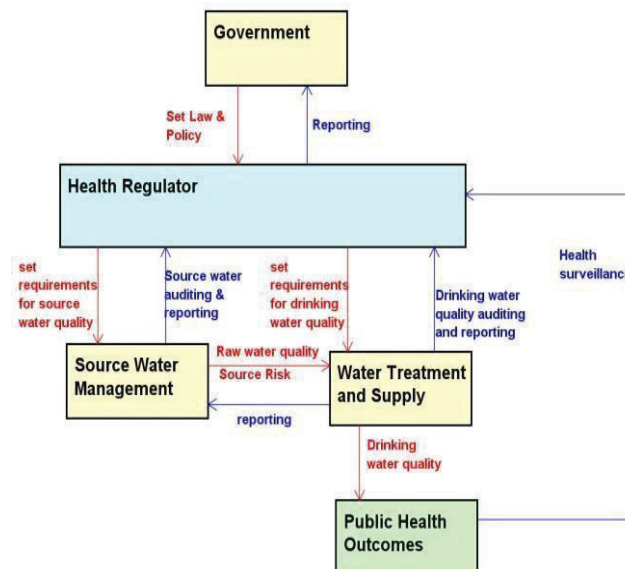


Figure 1: Diagram representing the regulatory environment for ensuring safe drinking water. Downward red arrows represent the control actions, while upward blue arrows indicate the flow of feedback.

Findings/Results:

The STPA results provide a detailed set of requirements for guiding regulators. The key loss considered was the illness or death caused by unsafe drinking water. Table 1 presents a sample of the risk-based regulatory requirements developed through this process.

Table 1: Example of countermeasures for risk-based regulation

Unsafe control action	Causal Scenario	Countermeasure
Regulatory actions are ceased before water safety issues are resolved	Insufficient information for a complete risk assessment	understand the whole situation of both compliance and potential harms before ceasing regulatory actions

Conclusions/Key Messages:

Providing guidance to strengthen the role of the health regulator is critical for protecting public health. The proposed risk-based requirements provide a basis for developing criteria that enable regulators to operate effectively and collaborate with water suppliers and other stakeholders to ensure the safety of drinking water supplies.

References:

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IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

Implementation Guidance for German Catchment Risk Management Regulation

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Keywords: Germany; policy; regulation; catchment; risk management; WSP

Abstract: The German ordinance TrinkwEGV sets out requirements for the assessment and risk management in drinking-water catchment areas. Its implementation is supported by comprehensive implementation guidance for the responsible authorities, which was published step-by-step. The guidance gives recommendations on the assessment of the documentation submitted by the water suppliers, and on risk management by the authorities, and is provided free of charge online.

Introduction

The national transposition of the risk-based approach of the European Drinking-Water Directive (EC 2020) happened in Germany for drinking-water catchment areas through the Ordinance on Catchment Areas of Abstraction Points for Drinking Water Production (TrinkwEGV 2023). The TrinkwEGV sets out requirements for the assessment and risk management to protect raw water, groundwater and surface water in order to avoid and reduce contamination and thus reduce the necessary drinking-water treatment. The new extension of the scope of application of the Drinking Water Directive towards the catchment risk management necessitated transposition into German law not only by the Federal Ministry for Health (BMG), but also by the Federal Ministry for the Environment, Climate Action, Nature Conservation and Nuclear Safety (BMUKN). The respective ministries of the 16 federal states were involved, and responsibility is partly with the local water authorities who initially were not yet very familiar with the Water Safety Planning (WSP) approach.

Methodology

According to the TrinkwEGV, water suppliers had to risk assess their catchments by 12 November 2025, and the water authorities have to establish risk management measures based on the risk assessments by 12 May 2027. A working group was established in 2025 as part of the already existing working group of the Federal States' ministries for water (*Bund/Länder-Arbeitsgemeinschaft Wasser, LAWA*) to develop implementation guidance for the water authorities. The working group included members from the BMUKN, the German Environment Agency (UBA), and the environment ministries of the federal states, as well as representatives from the BMG

and the health ministries of the federal states, and a representative of the German technical and scientific association for gas and water.

Findings/Results

The working group gradually published its results in three batches.

In the first batch in 11/2024, guidance was published on how to delineate the catchment areas as a basis for all following steps of the risk-based approach. This should happen according to the generally accepted codes of practice. However, given the relatively short timeframe, guidance is also provided for a simplified approach that can be taken in the first implementation cycle (November 2025) in cases in which there is not sufficient hydrogeological data available for a thorough delineation.

The second batch (03/2025) focused on hazard analysis and risk assessment, and monitoring programmes to be drafted by the water suppliers. The guidance is for the water authorities who receive the documentation from the water suppliers and who then have to assess if the documentation is complete, plausible and in accordance with their knowledge of the drinking-water catchment. Therefore, the emphasis of these guidance elements is on the documentation, rather than the procedure of the water suppliers' implementation.

The last batch (12/2025) consists of the main guidance document for the implementation of the TrinkwEGV by the water authorities, as well as guidance for their risk management measures. The main document provides recommendations on additional elements to be checked, checklists for completeness and plausibility, describes possible outcomes of these checks and the resulting need for action.

Conclusions/Key Messages

While water catchment protection zones have a long tradition in Germany, introducing the risk-based approach in catchments with the TrinkwEGV was a new aspect. The regulation strengthens cooperation between environmental authorities, health authorities and water suppliers. The implementation guidance is a helpful instrument for water authorities' new tasks, which helps unifying the implementation across the 16 federal states. The guidance is available free of charge online to facilitate its application. In order to allow for adaptations based on the experiences made with implementing this new approach, the working group will continue to meet regularly, and adapt the guidance if required.

References

European Drinking-Water Directive 2020 (EU) 2020/2184 of the European Parliament and of the Council of 16 December 2020 on the quality of water intended for human consumption (recast) (EC 2020)

Implementation guidance for German catchment risk management regulation available at [Publikationen / Aktuelle Veröffentlichungen - Bund/Länder-Arbeitsgemeinschaft Wasser - LAWA](#)

Ordinance on drinking water catchment areas; *Verordnung über Einzugsgebiete von Entnahmestellen für die Trinkwassergewinnung (Trinkwassereinzugsgebieteverordnung – TrinkwEGV)* of 04 December 2023 (Federal Law Gazette 2023 No. 346). BMUV



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Strengthening Aquatic Biosecurity: Comparative Policy Lessons from South and Southeast Asia

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Keywords: Invasive Aquatic Plants; Environmental Governance; South and Southeast Asia; Biosecurity Policy; Comparative Law

Abstract: This study compares regulatory frameworks for managing invasive aquatic plant species in seven South and Southeast Asian countries: Sri Lanka, Malaysia, Singapore, Bangladesh, Vietnam, Thailand, and India. Using qualitative analysis of legislation and biodiversity strategies, it assesses prevention, control, and coordination. Malaysia and Singapore demonstrate advanced legal systems. Sri Lanka's Water Hyacinth Ordinance (1909) reflects early recognition, while the 2016 National Policy on Invasive Alien Species provides a broader framework. Bangladesh and Vietnam show partial alignment with international biosecurity standards. The study proposes a policy template emphasizing early detection, rapid response, and stakeholder coordination to strengthen aquatic biosecurity and ecosystem resilience across developing Asia.

Introduction:

Invasive aquatic plants such as *Pontederia crassipes* (formerly *Eichhornia crassipes*), commonly known as water hyacinth, and *Salvinia molesta* pose serious ecological and economic threats worldwide, with particularly severe impacts reported across Asia, where they degrade water quality, obstruct irrigation canals, and suppress native biodiversity (Cilliers et al., 2007). Dense mats of these weeds reduce light penetration, deplete oxygen, and alter habitat structure, leading to fish kills and loss of ecosystem services (Gettys et al., 2020). Although many countries recognize the problem, legal and institutional responses remain inconsistent, some rely on broad environmental statutes, while others adopt targeted invasive species laws.

With accelerating climate change and expanding trade, invasion risks are intensifying, demanding governance systems that are preventive and adaptive. Global reviews highlight that effective aquatic biosecurity frameworks combine prevention, early detection, and coordinated cross-sector management (Bray et al., 2024). This study fills a regional gap by comparing regulatory and institutional responses across seven South and Southeast Asian nations and develops a general policy/strategy template that developing countries can adapt to strengthen water ecosystem resilience and regional biosecurity.

Methodology:

A qualitative comparative policy analysis (QCPA) was used to review legislative acts, biodiversity strategies, and enforcement mechanisms in seven selected countries. Official government documents, peer-reviewed publications, and reports were analysed using five key dimensions: prevention, control and management, mitigation, enforcement, and institutional coordination. Data triangulation from legal sources and national biodiversity reports ensured reliability. Comparative synthesis was then used to highlight effective regulatory patterns and policy gaps across different governance systems.

Findings/Results:

The study finds substantial variation in national responses to aquatic invasive species. Malaysia demonstrates a robust but multi-sectoral system supported by the Environmental Quality Act 1974 and the National Action Plan on Invasive Alien Species 2021–2025. Singapore employs a centralized approach integrating biodiversity and waterway management under the Parks and Trees Act 2005 and Prevention of Pollution of the Sea Act 1990. Sri Lanka, despite its early Water Hyacinth Ordinance 1909, exhibits limited enforcement and coordination. Bangladesh and Vietnam show emerging but partial alignment with global biosecurity standards, while India and Thailand apply hybrid systems combining federal and national initiatives. Overall, the findings reveal fragmented institutional authority, overlapping jurisdictions, and limited public participation. Preventive border controls are generally stronger than domestic early detection and rapid response systems, and most countries rely on broad environmental statutes rather than dedicated aquatic invasive species legislation, resulting in reactive rather than proactive governance.

Conclusions/Key Messages:

Effective invasive plant management requires preventive, adaptive, and cooperative frameworks. The study recommends a general policy/strategy template that can be adapted, emphasizing (1) risk-based import control, (2) early detection and rapid response, (3) inter-agency coordination, and (4) community engagement. Aligning national efforts with global conventions and regional collaboration can help developing nations strengthen water security and biodiversity protection. These findings contribute to the evolution of next-generation regulatory strategies for resilient and sustainable aquatic resource governance in Asia.

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External assessment of drinking-water risk management in Germany

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Keywords: Germany; regulation; risk assessment; risk management; auditing

Abstract: The recast European Drinking-Water Directive (EC 2020, DWD) includes new requirements on risk assessment and risk management in drinking-water catchment areas and water supply systems. In Germany, external assessment of the new requirements is carried out by the competent health- and water authorities. To support the authorities in their auditing processes, guidance documents and recommendations as well as training materials are available. The new requirements on the risk-based approach include aspects of documentation and auditing.

Introduction:

To transpose the EU DWD requirements into German law, the ordinances TrinkwV and TrinkwEGV determine the scope and responsibilities for implementation and external assessment of the risk assessment (RA) and risk management (RM), see Figure 1.

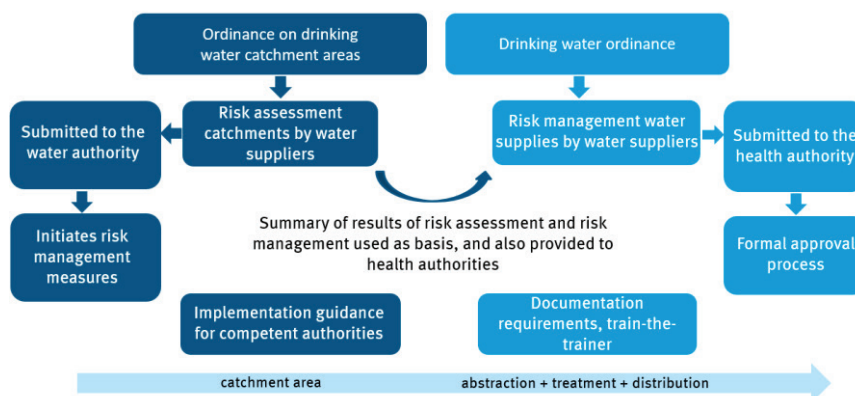


Figure 1: Overview legal requirements for the risk-based approach in Germany

The TrinkwEGV led to a legally anchored coordination of the requirements for drinking water protection with those for water protection. In drinking-water catchment areas, water suppliers are responsible for the system description, RA, and proposing a programme for raw water analyses, and competent water authorities need to provide them with required information. The water supplier submits the documentation to the competent authority, who checks it for plausibility and

completeness. In the drinking-water supply systems, water suppliers implement both RA and RM, considering the results from the catchments, and propose a drinking-water testing plan stipulating the scope of parameters and testing frequencies.

Methodology:

For the RA in the catchment areas, the auditing process started for the first time in November 2025 and result, in the establishment of RM measures by May 2027. The documentation of the RA and RM in water supply systems has to be submitted by January 2029. In both cases, the authorities check for completeness and plausibility. To support auditing, implementation guidance for water authorities and recommendations for the documentation to be checked by health authorities were published.

Findings/Results:

The new requirements of the TrinkwV and TrinkwEGV imply additional auditing tasks for the competent authorities. The responsible German ministries, supported by the UBA, representatives of the health- and environment ministries of the federal states and associations facilitate implementation of auditing through guidance and recommending documents. For the catchment areas, detailed guidance was developed for the water authorities. There is no official approval, however, the water authorities check the documentation for completeness and plausibility, and it has to be of a sufficient quality for the authorities to establish effective RM measures. The documentation needs to be provided to the health authorities as well. The auditing of the RA and RM in the water supply systems is more extensive and includes checking the documentation submitted for its plausibility and completeness, as well as checking for plausibility of the proposed testing plan. The result of the auditing process is granting approval or determining a deviating scope and frequency of the testing plan proposal. A detailed list of the scope and an exemplary documentation to be submitted by water suppliers to local health authorities has been published, extensive training materials are provided free of charge, facilitators have been trained, and an e-learning course for local health authorities is available. The whole process will need to be reviewed at six-year intervals at most, and if RM no longer ensures that the drinking water quality requirements are met.

Conclusions/Key Messages:

The auditing of RA and RM, which is new to local authorities, builds on existing structures of responsibilities for catchments and drinking-water supply systems, as well as drinking-water surveillance, and official permitting is included at a limited scope. At the outset of legally requiring these new approaches, auditing is rather flexible and focuses on the most important components. It is supported by extensive guidance materials and capacity building. Overall, the implementation is expected to improve the collaboration between water suppliers, water- and health authorities.

References:

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Successes and Challenges of Internal Formal Auditing of Water Safety Plan for Climate Resilience Water Supply

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Keywords: Climate Resilience; WSP Auditing; WSS

Abstract: Water Safety Plan (WSP) auditing is a mandatory process to assess the completeness and effectiveness of WSP implementation. The National Water Supply & Drainage Board (NWSDB) conducted Internal Formal Audits (IFAs) across 156 Water Supply Systems (WSSs); however, implementing Climate-Resilient WSPs (CRWSPs) remains challenging. Audit scores from 2021–2024 were analyzed and categorized as Excellent, Very Good, Good, Average, Below Average, and Priority Attention Needed to identify successes and challenges for CRWSP development. 36 out of the 156 WSPs obtained scores above 103 out of 120 indicating successful implementation, while the rest identified areas for improvement. It is recommended to incorporate research findings to ensure a sustainable and resilient water supply.

Introduction:

Safe and reliable drinking water is vital for public health, and as climate variability intensifies, integrating climate resilience into existing WSPs is essential to ensure a sustainable water supply (Pham & Dam, 2024). However, progress in this area within the NWSDB has been limited, highlighting the need for stronger action and accelerated implementation. WSP auditing helps to evaluate their effectiveness and identify areas for improvement, providing a foundation for developing CRWSPs. IFAs were conducted for 156 out of 362 WSPs in NWSDB during the period 2021–2024.

Methodology:

The analysis was based on WSP IFA reports from NWSDB WSSs for the period 2021 to 2024. The study analyzed Internal Formal Audit scores out of 120 for 156 WSSs conducted by the NWSDB (table 1). Audit scores were categorized as Excellent (≥ 115), Very Good (103–114), Good (91–102), Average (79–90), Below Average (61–78), and Priority Attention Needed (≤ 60) to identify system performances, successes, and challenges. The scores obtained for each year were tabulated and analysed graphically to assess an appropriate score to evaluate whether successes or challenges in CRWSPs. Furthermore, the average scores for each year were calculated, tabulated, and illustrated in the graph to identify the trend and determine the success of WSP Auditing.

Verification was carried out by comparing results with WSP External Formal Audit scores for the same period.

Table 1: Details of Audits

Year	Categorisation of Audit Scores						Total
	Priority Attention Needed	Below Average	Average	Good	Very Good	Excellent	
2021	-	5	2	10	2	-	19
2022	-	-	8	22	8	-	38
2023	-	3	8	32	7	-	50
2024	-	-	5	23	21	-	49

Findings/Results:

This analysis carried out for 156 WSPs with respect to the two score levels of 90 and 103. According to the figure 1, score level of 90 elaborates 80% (125) of successes and 20% (31) of challenges. The score level of 103 indicates only 23% (38) of successes and 77% (118) of challenges. By analysing these two levels of 90 and 103 with respect to the WSP audit criteria, it was identified that 103 is the most suitable score level of WSP audit to determine successes and challenges in WSPs.

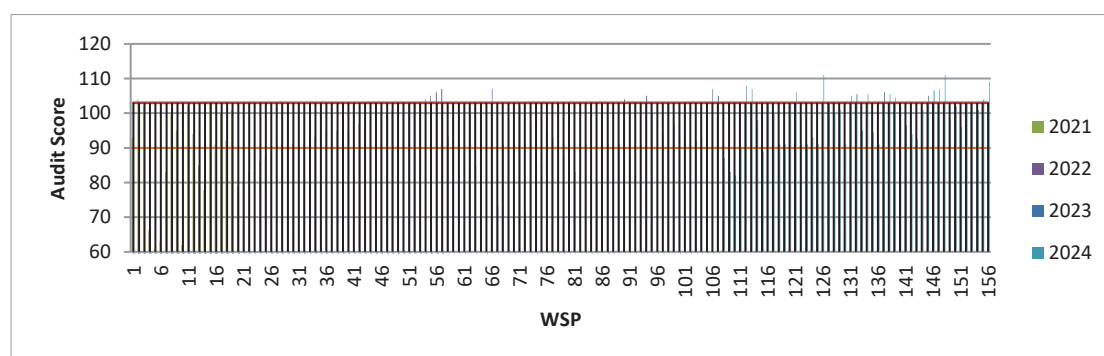


Figure 1: WSP Internal Formal Audit Scores 2021-2024

Analysis indicated that 36 WSSs scored above 103 demonstrating successful WSP implementation and the remaining 120 WSSs fell below this threshold, highlighting areas needing improvement. A positive gradient of trend line (figure 2) shows the success of WSP auditing towards the effectiveness of WSP implementation.

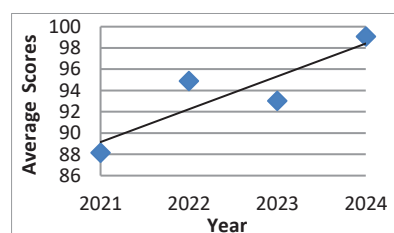


Figure 2: Trend line

Conclusions/Key Messages:

Achieving 103 score level which is Very Good status in WSP auditing confirms to cope up possible climate impacts of WSSs. Successes and challenges in WSP auditing were identified, and the results were verified using the WSP External Formal Audit scores for the same systems. WSP audit findings, including identified areas requiring improvement, are used to upgrade the status of WSPs and support the development of CRWSPs.

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Session 04

Innovations and Technological Advancements in Water Reclamation and Sustainable Reuse Practices

Session Chair	Prof. Thomas Pettersson
Session Co-chair	Prof. Rohan Weerasuriya
Rapporteur	Mrs. M.K.J. Prabodini



IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

Urban Stormwater Disinfection, Storage Quality Change and Influence on Microalgae: Implications for Reuse Safety

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Keywords: Stormwater disinfection; Stormwater storage; Stormwater reuse

Abstract: Stormwater reuse requires disinfection to address microbial risks. This study examined chlorination for urban stormwater containing *E. coli* and *S. aureus*. Disinfection efficiency depended on bacteria type, not water quality. During storage, *S. aureus* regrew significantly, worsening water quality, while *E. coli* did not. Dissolved components promoted algal growth, but particulates (including bacteria) required filtration before reuse. Findings guide safe stormwater reuse.

Introduction:

Stormwater reuse mitigates water shortages but poses microbial risks. If they are not properly treated, reusing stormwater would be highly risky. Therefore, the disinfection must be undertaken. Although disinfection has been widely conducted in the drinking water and even reclaimed water, it is rarely carried out for stormwater. Due to difference on sources and pathways, stormwater might have a very different quality from other conventional water resources.

This study focused on stormwater disinfection using a common approach, chlorination. Two typical bacteria were selected in this study, namely *Escherichia coli* (*E. coli*, Gram-negative bacteria) and *Staphylococcus aureus* (*S. aureus*, Gram-positive bacteria). The research outcomes can provide useful insight to effective stormwater disinfection and ensure reuse safety.

Methodology:

Stormwater was collected from a building roof in Xihu Campus, Shenzhen University and went through chlorination processes. After disinfection, the stormwater was stored for 12 days. Then, the stormwater was divided into filtrates and filter residues. A typical freshwater microalgae species, *Chlorella pyrenoidosa* (*C. pyrenoidosa*) was selected to test the stored stormwater toxicity.

Findings/Results:

Difference in stormwater quality did not significantly influence the disinfection results while bacteria species present in the stormwater might have an important effect.

Stormwater storage experiments revealed significant differences between *S. aureus* and *E. coli* containing samples. While both showed water quality variations, *S. aureus* samples exhibited higher coefficient of variation (CV) for water quality parameters (though lower CV for bacterial reactivation ratios: 95.4% vs *E. coli*'s 121.5%). This suggests *S. aureus* causes more pronounced water quality changes, likely due to its higher reactivation potential.

After 12-day storage, particulate matter (including reactivated bacteria) demonstrated greater inhibition on *C. pyrenoidosa* growth than dissolved components. This microbial reactivation poses ecological risks when stormwater is reused or discharged. The findings highlight the necessity for post-storage filtration to remove bacterial contaminants before water reuse, particularly for protecting receiving waters' ecological health. Figure 1 presents a comprehensive stormwater management framework addressing these storage-related quality variations and bacterial impacts, providing practical guidance for ensuring safe urban stormwater reuse while mitigating ecological risks associated with bacterial reactivation.

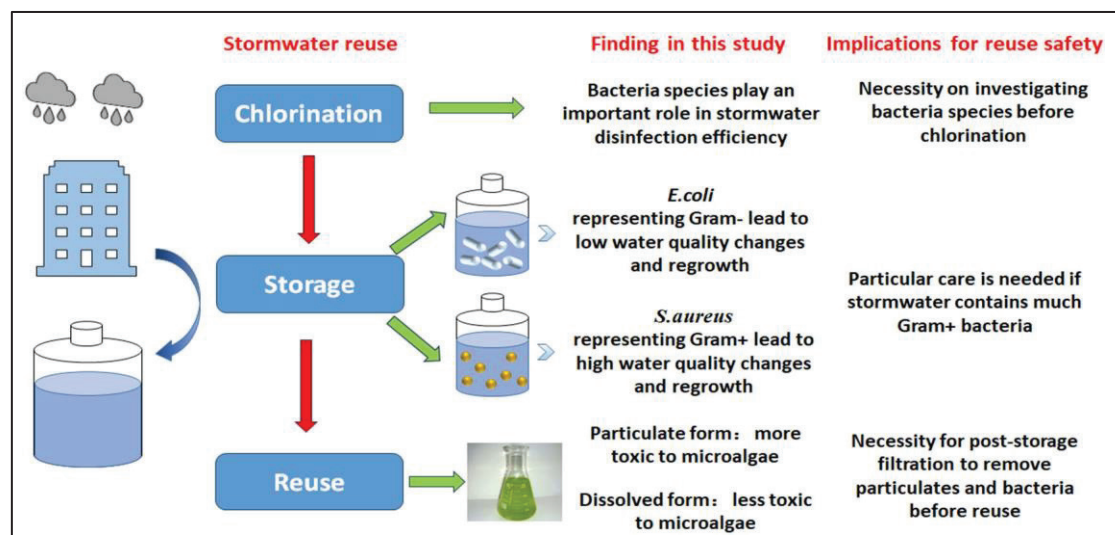


Figure1: Implications for urban stormwater reuse safety

Conclusions/Key Messages:

Bacteria species significantly impacts stormwater disinfection efficiency. Gram-positive *S. aureus* causes greater water quality variation and regrowth during storage than Gram-negative *E. coli*, posing ecological risks. Particulate form in the stormwater has more negative effect on *C. Pyrenoidosa* growth while dissolved form tends to improve their growth. This means that the urban stormwater undergoing the storage processes needs further treatment before reuse, such as filtration, to remove particulate matters.

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Quality Assessment of the First Full-Scale Direct Potable Reuse Scheme Using Treated Municipal Wastewater in Belgium and Europe

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Keywords: Flow cytometry; membrane filtration; multi-barrier; water reuse; WSP.

Abstract: This study presents a Direct Potable Reuse (DPR) scheme using municipal wastewater treatment plant (WWTP) effluent in Hofstade (Aalst, Belgium). The DPR plant produces 50 m³/h of drinking water (DW) using a multi-barrier treatment train consisting of ultrafiltration (UF), reverse osmosis (RO), UV disinfection, activated carbon filtration, and final disinfection by UV and chlorination. Microbial monitoring showed complete removal of bacterial, protozoan, and viral indicators. Flow cytometry (FC) and phenotypic fingerprinting confirmed the RO membrane integrity, and the final DW quality is monitored by online FC. Significant reductions in turbidity, organic carbon, (in)organic parameters, metals, and organic (micro) pollutants (OMPs) were observed and the final DW meets all norms.

Introduction:

Water scarcity occurs globally, even in regions considered water-rich such as Flanders (Belgium). To cope with these challenges, the WWTPs could be regarded as part of DW production process. To demonstrate the potential of using non-traditional water sources, a new DPR scheme was set up by the water utility Waterunie in Hofstade (Aalst, Belgium). The design of the multi-barrier treatment concept is based on a WSP, and allows 50 m³/h potable water reuse from municipal WWTP effluent. This study provides a technical description of WPC Hofstade. Extensive microbial monitoring was conducted on each step of the multi-barrier treatment using flow cytometry (FC) to assess total (TCC) and intact (ICC) bacterial cell counts and phenotypic fingerprints.

Methodology:

In the project, the DW utilities Farys and De Watergroep collaborate (as Waterunie) with Aquafin, which is responsible for the WWTPs in Flanders. Part of the effluent of

the WWTP Aalst (100.000 IE) is treated by a membrane filtration plant with a net capacity of 50 m³/h or 1200 m³/d. After prefiltration over self-cleaning mechanical sieves (500 and 300 µm), the water is treated by UF hollow fiber membranes with a pore size of 30 nm (Dupont), built in two trains to allow continuous production during backwash. The following RO step is built in a 2-stage configuration using brackish water membranes (Dupont), with an integrated energy recovery (Energy Recovery). As an extra safety barrier for organic (micro)pollutants (OMPs), activated carbon filtration (Chemviron) is integrated into the treatment, according to the WSP. UV disinfection, pH correction and post-chlorination of the water allows DPR by pumping the final reuse water directly into Farys' high-pressure (HP) water mains. This is part of the large transport infrastructure for DW, and distributes DW throughout Flanders.

Findings/Results:

The design of the multi-barrier treatment scheme of WPC Hofstade (Aalst) was based on a WSP made by Waterunie, following the guidelines of the WHO. Attention was given to the efficient use of energy, chemicals, and other resources. The plant operates at an overall recovery of 63% and an energy consumption of 0.63 kWh/m³ DW produced, rising to 0.98 kWh/m³ when including pumping to the HP network (8 bar). During the stepwise commissioning of the plant, a detailed quality and performance evaluation was conducted, and samples for in-depth microbial analyses (HPC, total coliforms, *E. coli*, Enterococci, *C. perfringens*) were taken at each step of the process. In summary, all obligatory microbial parameters measured in the final reuse water complied with regulatory standards. Furthermore, the WWTP effluent and final DW were also analyzed for *Giardia* cysts, *Cryptosporidium* oocysts, *Campylobacter* spp., and somatic coliphages as indicators to assess the overall treatment process. None of the latter were detected in the final reuse water, thus showing complete removal. In addition, FC and phenotypic fingerprinting was used to confirm RO membrane integrity. An extensive quality assessment was conducted to show that the DPR plant fully meets the DW standards. According to the Flemish DW directive, this includes a risk analysis based on the WSP and a monitoring strategy. In this study, significant reductions in turbidity, organic carbon, (in)organic parameters, nutrients, and metals were demonstrated, and the final reuse water complied with all.

Our research goes beyond the compliance with DW standards alone, since other OMPs and emerging contaminants were also measured, incl. pesticides, PFAS, pharmaceuticals, personal care products, and metabolites. A significant removal was observed: either the concentration in the final reuse water was below the detection limit, or well below the DW norm. In addition, the physical and chemical water quality is also controlled online by spectrophotometry using a Microstation (Badger Meter), and the outgoing DW is monitored using an online FC (Bactosense, bNovate) for bacterial quality control. The FC allows to trend the normal and historical baseline of TCC in real-time. The parameter is programmed in the PLC to automatically stop the DPR plant in case of an abnormal change. In addition to the frequent bacterial analyses by the drinking water lab, FC further helps to safeguard the outgoing microbial water quality and to foster confidence in DPR as a safe DW source. This study demonstrates the safety of DPR for DW production, and the opportunity to use WWTP effluent as an alternative source to make the DW supply more climate-resilient.

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Full-Scale Operation of Hybrid CW for HCH Treatment

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Keywords: Hexachlorocyclohexane; lindane; Fe(0); biodegradation; natural based solution; constructed wetland

Abstract:

Although production and application of γ -hexachlorocyclohexane (γ -HCH, lindane) is globally banned, there is between 1.7 and 4.8 million tons of HCH isomers improperly disposed worldwide and many HCH-contaminated sites remain unresolved. A hybrid-constructed wetland system Wetland+[®] has been built and have operated on a full scale at Hajek (Czechia), where several thousand tons of HCH were historically deposited. The system consists of a PRB with Fe(0) chips, a biosorption/biodegradation module, and an free surface aerobic wetland with a phytoremediation function. Over 40 months, the system demonstrated an average HCH removal efficiency over 85%. The system released approximately 8 g of HCH a day in winter and below 1 g/day in summer, compared to 23 g/day in the inflow, as an average.

Introduction:

Since 2007 γ -hexachlorocyclohexane (γ -HCH, lindane) is globally banned on the production and use, but during its historical production 1.7 – 4.8 millions of its isomers (α , β , δ , ϵ) were considered waste and deposited in landfills or uncontrolled dumps. Natural based solution (NBS) based on constructed wetlands (CW) using the chemical processes of natural or added substances and the biological processes of plants and root microbiomes for degradation, immobilization, and/or accumulation of selected contaminants. The reactivity of individual HCH isomers is affected by structural differences in their molecules, namely in the axial and equatorial orientation of the chlorine substituents.

Methodology:

The system Wetland+[®] comprises three subsequent modules – a permeable reactive barrier PRB (module B), consisting of three parallel branches filled with Fe(0) chips; two parallel biosorption/biodegradation modules (C); and an free surface aerobic

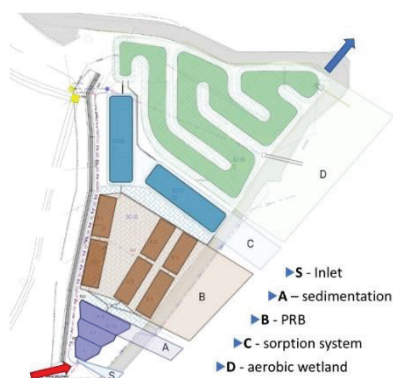


Figure 1: The system Wetland+®

wetland system (D). In module B, drainage water undergoes an HCH dichlorination. The biosorption module C was filled with a mixture of peat, crushed stones (30%), loamy soil, and birch wood chips and planted with reed canary grass and common reed. The aerobic wetland module D, filled with a mixture of crushed stones, loamy soil, birch wood chips, and compost, serves as the final biotic treatment stage. The residence time designed based on a maximum flow of 3 L/s is 15, 10 and 65 hours for modules B, C, D, respectively.

Findings/Results:

The system demonstrated an average overall efficiency of 83 %. Comparing the efficiencies for individual isomers, the highest overall efficiency was recorded for δ -HCH (89 %), α -HCH (79 %) and γ -HCH (79 %), and the lowest for β -HCH (51 %) and ϵ -HCH (45 %). The module's efficiency varies during the year, depending on water temperature (Fig. 1). At temperatures $>5^{\circ}\text{C}$ (days 150 – 300) the system exhibited a very high removal efficiency of 95%. During the low-temperature period, and HCH removal was reduced, which was previously found in the literature. The efficiency dropped to around 75% (days 0-60, January- February).

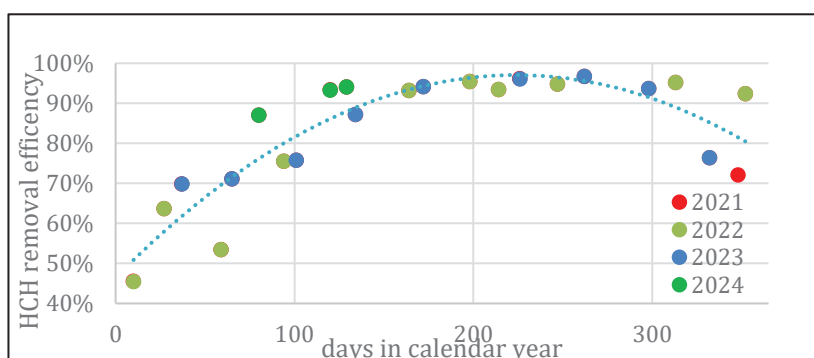


Figure 2: HCH removal efficiency of the whole system during the year

Conclusions/Key Messages:

The CW-based NBS system was applied on a full scale at the Hájek site (CZ) to remove HCH pesticides. Long-term results show high efficiency, which depends on the season (temperature) and averages $> 85\%$. The results were obtained as part of the LIFEPOPWAT project (No. LIFE18 ENV/CZ/000374), which received the LIFE Award 2025.

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IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

A Novel Pulse Aerator for Membrane Module by Coupling Converging-Diverging Nozzle and Tidal Flow

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Keywords: Membrane bioreactor; pulse aerator; fouling mitigation

Abstract: A novel pulse aerator was developed to generate large, single pulse bubbles (150 mL–500 mL) for effective submerged membrane scouring, addressing the limitations of existing bubble swarm systems. This durable, elegant system combines a siphon mechanism with a Venturi-inspired converging-diverging (CD) nozzle to achieve automatic pulse aeration: stable air is released as a large impulse bubble when the siphon breaks. Optimized through CFD and high-speed imaging (with optimal nozzle parameters of 1:3 CD ratio, 1:1 angle, and 36 mm diameter), the system uses the Venturi structure to accelerate air, causing smaller bubbles to coalesce into a single large pulse bubble ranging from 170 mL to 310 mL, which significantly boosts membrane cleaning shear stress compared to conventional methods.

Introduction:

Membrane bioreactors (MBRs) have been used more to upgrade and retrofit existing wastewater treatment plants, where Membrane fouling and high operational energy consumption continue to be important hurdles for MBR sustainability (Wang, *et.al*, 2022). Air scouring or aeration is the most effective way to reduce membrane fouling. Nonetheless, pulse aerators remain in the early development period, with a dearth of dependable pulse aerators and appropriate scientific structures for improving air scouring efficiency in MBR processes (Herrada and Eggers, 2023).

The current study objectives aim to optimize the aerator design to reduce operating complexity and improve energy efficiency, encompassing gas holdup, uniform velocity, and shear stress. This study employed the integration of computational fluid

dynamics (CFD) modelling research approaches, with high-speed imaging experimental investigation and validation.

Methodology:

In this study, the flow field structure and effect was compared in three different aerators, including: (i) the classic perforated pipe; (ii) the first-generation novel box aerator; (iii) the second-generation novel box aerator, where air distribution also improved from tube to side channel and guide sleeve improved from box to cylinder to mitigate sludge blockage; and (iv) the second-generation novel box aerator with CD nozzle.

Findings/Results:

Integrated air chamber per the siphon mechanism, transformed aeration into pulse bubbles. The Venturi converging-diverging nozzle was refined for accelerating subsequent bubbles. Optimized CD ratio 1:3 and angle 1:1 by CFD formed large pulse bubble instead of swarm. The large bubble created by coalescence was distinctly recorded by high-speed imaging.

Conclusions/Key Messages:

The novel pulse aerator significantly improved membrane module performance compared to perforated pipes, enhancing gas holdup (21.3%), velocity distribution (43%), and shear force (84.9%), offering a clear optimization pathway for intermittent aeration in membrane and bubble column systems.

Figures and Tables

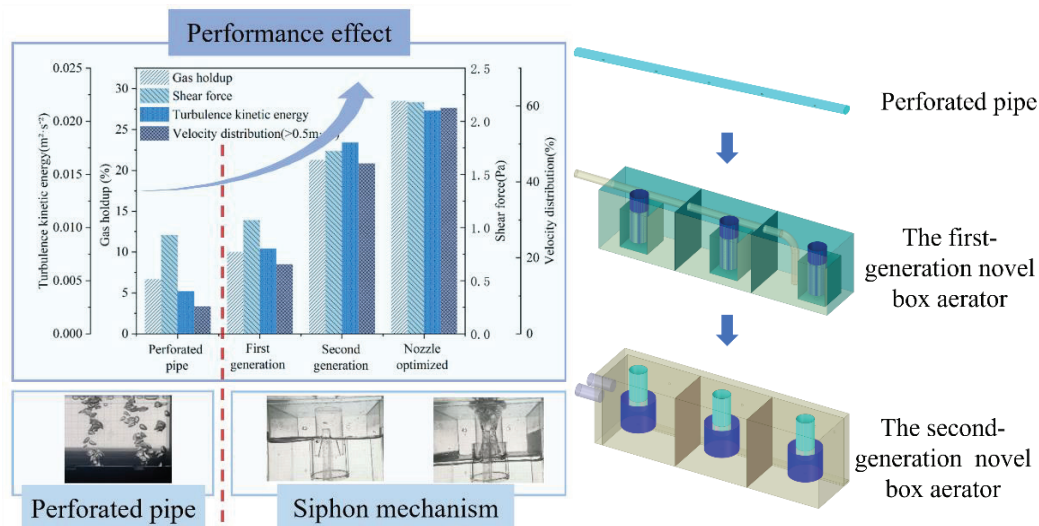


Figure 1: Comparison of three different type of aerator

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Assessment of Phytotoxicity and Growth-Promoting Potential of Fresh and Washed Hydrochar Using Seed Germination Index

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Keywords: Hydrochar; Phytotoxicity; Germination Index (GI); Soil Amendment; Seed Germination

Abstract: Hydrochar produced via hydrothermal carbonization of organic waste can contain toxic compounds such as PAHs, phenolics, quinones, N-heterocycles, furanics, and phthalates, which may affect plant growth. This study evaluated the phytotoxicity of fresh and washed hydrochar applied at 1%, 3%, and 5% (w/w) in soil using seed germination index (GI) tests. Fresh hydrochar showed GI values of 95% (1%), 72.2% (3%), and 54.4% (5%), indicating non-to-moderate toxicity, increasing with higher doses. Washed hydrochar exhibited significantly higher GI values (103–149%), demonstrating removal of toxic compounds and enhanced germination. These results suggest that washing hydrochar mitigates phytotoxicity and improves its potential as a soil amendment for sustainable agriculture.

Introduction

Hydrochar, produced via hydrothermal carbonization of organic waste, is a potential soil amendment due to its nutrient content and carbon-rich structure. However, it may contain toxic compounds, including PAHs (Liu et al., 2021), alkyl-PAHs, phenolics, quinones, N-heterocycles, furanics, and phthalates, which can inhibit seed germination, root elongation, and seedling growth. Therefore, assessing hydrochar phytotoxicity is essential before agricultural use. The germination index (GI) test is widely used to evaluate its toxicity and growth-promoting potential (Busch et al., 2013).

Methodology

Fresh hydrochar (FHC) was created by hydrothermally carbonizing dewatered sludge for 90 minutes at 200 °C. After being oven-dried for three to four hours at 100 °C, the product was cooled, crushed, and sieved (0.5 mm). FHC was combined with distilled water (1:10 w/v) to create washed hydrochar (WHC), filtered, and then rinsed six times before being dried at 60 to 80 °C, crushed, and sieved (0.5 mm). After 0.5 mm sieving of the soil and hydrochar, 45 g of the mixture was put into Petri dishes. After being labeled, the samples were left in the dark for seven days to equilibrate. Following equilibration, ten seeds were planted in each plate and allowed to germinate in a

controlled environment. The impact of hydrochar on seed germination was evaluated by recording the germination rate and seedling growth while maintaining moisture levels.

Findings/Results

Table 1: Seed germination, root elongation, and germination index for soil–hydrochar mixtures with Fresh (F) and Washed (W) hydrochar. (here G=No of seeds germinated in hydrochar mix, g= No of seeds germinated in control, R=Mean root length in hydrochar soil mix, r= Mean root length in control)

	Seed germination $SG(\%) = (G/g) \times 100$	Root Elongation $RE(\%) = (R/r) \times 100$	Germination index $GI(\%) = SG \times RE/100$
F1	93.0%	102.0%	95%
F3	87.0%	83.0%	72.2%
F5	80.0%	68.0%	54.4%
W1	113.0%	132.0%	149.2%
W3	100.0%	109.0%	109.0%
W5	93.0%	111.0%	103.2%

Germination index (GI) values indicate hydrochar phytotoxicity: >80% is non-toxic, 50–80% moderate, and <50% strongly toxic. Fresh hydrochar showed GI of 95% (F1), 72.21% (F3), and 54.4% (F5), indicating non-to-moderate toxicity, increasing with higher application. Washed hydrochar greatly improved GI: 149.16% (W1), 109% (W3), and 103.23% (W5), suggesting removal of toxic compounds and possible growth promotion. Overall, washing hydrochar mitigates toxicity and enhances seed germination, while high doses of fresh hydrochar may inhibit growth. (Tiquia, Tam, & Hodgkiss, 1996)

Conclusions/Key Messages

Fresh hydrochar exhibited moderate phytotoxicity at higher application rates, while washed hydrochar significantly enhanced seed germination, with GI values exceeding 100%, indicating a stimulatory effect on plant growth. This demonstrates that washing effectively removes soluble toxic compounds, such as PAHs and phenolics, and improves the suitability of hydrochar as a soil amendment. Overall, the study highlights that properly treated hydrochar can be a safe and beneficial additive for sustainable agriculture, promoting seed germination and early plant development.

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Session 05

Water Safety in Rural and Community Based Water Supply Systems

Session Chair	Prof. Lalith Rajapakse
Session Co-chair	Dr. Ayomi Witharana
Rapporteur	Ms. T.K.N.K. Kumari



IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

Household Treatment System for Safe Water in Coastal Bangladesh

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Keywords: salinity; household RO plant; water safety; coastal Bangladesh

Abstract: Shallow aquifer in coastal areas of Bangladesh presents salinity, also iron and arsenic and water is not safe to drink without treatment. Community options like PSFs and desalination systems suffer from operation and maintenance issues. DPHE installed 35 household reverse osmosis (RO) salinity removal units (SRUs) in four coastal districts to meet their daily safe water demand. Mixed method (qualitative and quantitative) evaluation found treatment units 100% effective in removing salinity (Conformity with Chloride and TDS tests) and iron and arsenic. Users' satisfaction with functionality (operation) and output of the system (quantity and quality) was 100%, but 11% were not satisfied with O&M service of suppliers. All users are willingness to pay for O&M, but local level supply chain for parts and institutional fund to cover major periodic replacement costs need to be ensured for long term sustainable operation.

Introduction:

Towards meeting the SDG 6.1, Bangladesh has achieved 98.5% improved water coverage, but only 47.9% is "safely managed" [1, 2]. Conditions are worse in the 19 coastal districts due to groundwater salinity, iron, arsenic, and faecal contamination [3, 4]. Community options like PSFs and desalination systems many fail due to poor operation and maintenance; as of 2019, 10% of government-installed public water sources were non-functional [5]. Hence, DPHE installed 35 household reverse osmosis (RO) salinity removal units (SRUs) in four coastal districts to provide safe, affordable drinking water. Each unit can treat 60 gallons water per day. This study evaluates their technical performance and user feedback after 7–9 months of operation.

Methodology:

Qualitative (user and caretaker feedback) and quantitative (census survey using questionnaire) data were collected. The functionality of SRU was physically examined. Raw and SRU treated water were analyzed for salinity (two times) and one time for iron and arsenic following standard protocols and checked against GoB standards.

Findings/Results:

100 of % SRU were found to be functional during physical inspection. 97% raw water is abstracted from groundwater by using No.6 handpump. 94% users reported to suffer from water quality problems before installing SRU. Exceedance of salinity (chloride), iron

and arsenic standards in raw water was 74%, 68% and 7%, respectively. 100% users opined that the SRU has solved their drinking water problem fully, and the water quality analysis confirmed that 100% of SRU are found able to treat salinity (up to 4840 mg/l), iron (up to 14.9 mg/l) and arsenic (up to 0.141 mg/l) within their standards (Concentrations: 1000 mg/l, 1.0 mg/l and 0.05 mg/l, respectively for salinity/TDS, iron and arsenic). After 7-9 months of operation, field kit-based monitoring (TDS) showed that the TDS value for 100% water samples (n=31) was within permissible limits (<1000 mg/L).

The survey found that SRU treated water was used for drinking (60%) and both drinking and cooking (40%). 100% of survey respondents opined to get good quality (no odour, no visible impurities, no iron and good test) enough water daily (range: 15-200 L) meeting their drinking and cooking demands. They do not see deterioration of treated water quality with time. Supplier is bound to provide operation and maintenance (O&M) service for two years and in 83% cases, users were happy with their O&M service, but 11% were not satisfied with O&M service and in 6% cases, O&M service was not required yet.

Conclusions/Key Messages:

Household RO based SRUs effectively remove salinity, iron, and arsenic from groundwater in coastal Bangladesh. While all users are willing to bear O&M costs after two-year warranty, long-term operation requires a local supply chain for parts and technicians. Additionally, according to national policy, DPHE should establish an institutional fund to cover major periodic replacement costs.

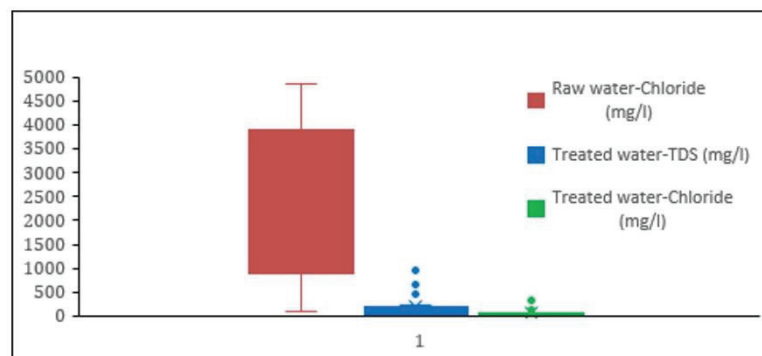


Figure 1: Water quality test results

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IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

Decentralized Safe Drinking Water Supply for Rural Community of Sri Lanka Using Nano-Filtration Membrane Technology: From Laboratory to Practice

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Keywords: Chronic kidney disease of unknown etiology; Nanofiltration; Drinking water; Decentralization.

Abstract: Decentralized nanofiltration (NF) plants offer a cost-effective solution for providing safe rural drinking water. Following groundwater quality assessments and tests of ten commercial membranes, the DF-90 membrane was selected for its superior removal of dissolved organic carbon (DOC) and hardness. Operating since September 2018, the pilot plant effectively eliminates DOC, TDS, hardness, fluoride, and pathogens. This customized system has gained strong community acceptance by consistently delivering high-quality permeate that meets local needs.

Introduction:

Safe drinking water is essential for well-being, yet rural Sri Lanka faces challenges due to scattered residences and the CKDu epidemic. Traditional centralized treatments are often impractical (Foster et al., 2021), making automated, decentralized systems a priority for achieving SDG 6.

Nanofiltration (NF) is an ideal alternative to RO, offering high-quality permeate and lower energy use while retaining natural mineral signatures. This study details the fabrication and one-year performance of a pilot NF plant in a CKDu-affected zone (Cooray et al., 2019), using a membrane specifically selected from ten commercial brands for its superior TDS and DOC rejection.

Methodology:

Table 1. Characteristics of the tested NF 1812 spiral wound membranes.

No.	Model/type	Manufacturer	Material	MWCO
1	DK1812	GE	Polyamide	150-300
2	DL1812	GE	Polyamide	150-300
3	NFX-1812	Synder	Polyamide	150-300
4	NFG-1812	Synder	Polyamide	600-800
5	NF4-1812	Nanostone	Polysulfone	~150
6	NF8-1812	Nanostone	Polysulfone	~300
7	DF-90-1812	Origin Water	Polyamide	~400
8	NF1-1812-75	Keensen	Polyamide	
9	JCM-1812-75N	HN-JCM	Polyamide	
10	GL-1812-75N	Gallon	Polyamide	

Ten NF 1812 series commercial spiral wound membranes (Table 1) were used in a laboratory setup to test the salt and DOC rejection. Experiments were carried out in cross flow mode circulating both concentrate and permeate back to the feed tank.

Findings/Results:

After testing ten commercial membranes, the DF-90 was selected for its superior hardness and DOC rejection. To prevent fouling, a 20 \$m^3\$/day pilot plant was built in Rajanganaya (2018) featuring sand, carbon, and resin pre-filtration. The plant remains stable due to automated cleaning, meeting SLS 614:2013 standards. Unlike RO, which produces acidic, mineral-poor water, the NF permeate retains essential ions (Na, K, Ca, Mg) and a neutral pH. This maintains the "water signature," resulting in high palatability and strong community acceptance.

Conclusions/Key Messages:

Ten commercially available NF membranes were tested for the rejection efficiency of hardness and DOC by the membranes, and the DF-90 membrane was selected due to its highest removal of DOC and hardness for the construction of a pilot drinking water treatment plant. The pilot drinking water treatment plant equipped with the DF-90 membrane was installed and in the stable operation in a village of the CKDu affected area of Sri Lanka since September 2018. This is the first time to use NF membrane technology to treat groundwater in Sri Lanka, and the removals of hardness, fluoride, and DOC by the NF pilot treatment plant is satisfactory. The permeate water quality of the NF plant meets the Sri Lankan drinking water standards (SLS 614: 2013) and is well accepted by the stakeholders of the society.

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A Rapid In-Situ Cleaning Method for Slow Sand Filters to Enhance Water Production

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Keywords: Slow sand filter; sand cleaning equipment; in-situ washing; water treatment; rural water supply

Abstract: Slow sand filters (SSFs) are widely used in potable water production for their simplicity and high efficiency, particularly in rural areas. Conventional SSF cleaning is labor-intensive, time-consuming, and interrupts water supply for several days. This study introduces a rapid in-situ cleaning method that isolates a sand bed section within a cylindrical form and flushes the top layer using pressurized water from a rotating sprinkler. The apparatus, featuring 45° nozzles and a bearing axle for easy transfer, enhances cleaning efficiency and mobility. Applied to a 30 m² SSF, cleaning time was reduced from 3 days to 5 hours, saving about 1860 m³ of water. The method increases filter availability, reduces downtime, and provides a cost-effective, resource-efficient solution for rural water treatment.

Introduction:

Slow sand filters (SSFs) are among the oldest and most reliable drinking water treatment technologies, widely used due to their simplicity, high treatment efficiency, and low energy requirements. They are particularly suitable for small-scale rural water supply systems because of their low infrastructure and operational costs [Logsdon, 2008]. A biologically active layer, known as the *schmutzdecke*, develops on the surface of the filter bed and plays a key role in treatment. As raw water percolates through the fine sand layer, turbidity, suspended solids, and microorganisms are effectively removed. Over time, the accumulation of debris and organic matter in the upper sand layer leads to clogging, reducing filtration rates and performance. Conventional cleaning methods, such as air drying, scraping, washing, and backfilling are time-consuming and may cause water supply interruptions and material losses [Madugalla et al., 2014]. This study investigates an *in situ* cleaning technique in which a section of the sand bed is isolated using a cylindrical casing and flushed with a rotating pressurized water system, while wash water is discharged through an outlet pipe. Compared to conventional methods, this approach comparatively minimizes disturbance to the biological layer, thereby preserving treatment efficiency [Maiyo et al., 2023].

Methodology:

The experiment was conducted in a 30 m² slow sand filter to evaluate the rapid in-situ cleaning process. A 1.3 m diameter cylindrical structure was installed in the sand bed to isolate a section for targeted cleaning. Pressurized water was applied through a rotating sprinkler fitted with multiple 45° nozzles, providing both vertical and lateral washing for efficient cleaning. A bearing axle at the base enabled easy manual movement of the unit across the sand bed after each cycle. Wash water was drained via an outlet pipe, and cleaning progress was monitored by observing water clarity. The design and arrangement of the rapid in-situ cleaning apparatus are illustrated in demonstrates the compact structure, uniform washing mechanism, and practical portability of the apparatus used in this study. Cleaning time, water use, and filter recovery were recorded and compared with conventional methods to assess efficiency and resource savings.

Findings/Results:

The rapid in-situ cleaning method reduced the cleaning time of a 30 m² SSF from nearly 3 days to 5 hours. Approximately 1860 m³ of water was saved compared to conventional cleaning, and filter productivity was maintained throughout the operation. The clarity of the wash water effectively indicated the end point, confirming efficient removal of fouling and debris from the sand surface. The method proved practical, cost-effective, and minimally disruptive to continuous water production.

Conclusions/Key Messages:

The proposed in-situ cleaning method greatly reduces downtime and water loss while maintaining filter performance. The addition of angled nozzles and a bearing axle improves cleaning efficiency and portability, making the system suitable for field and small-scale use. It offers a practical, sustainable solution to ensure continuous safe water supply in rural slow sand filter operations.

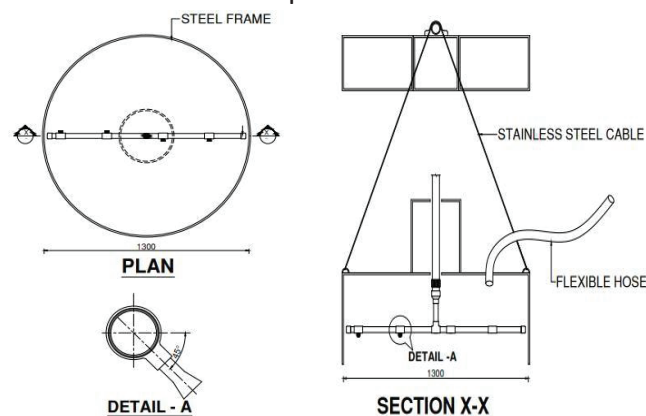


Figure 1: Design of the Rapid In-situ Cleaning Apparatus

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IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

A Collaborative Approach for Transforming Rural Water Supply Schemes into Sustainable Systems: A Case Study in Kandy District of Sri Lanka

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Keywords: Rural WSS; Sustainability; Safe Water; Kandy; NWSDB; CBO; DNCWS

Abstract: 123 rural water supply schemes registered under Department of National Community Water Supply (DNCWS) and National Water Supply & Drainage Board (NWSDB) are operated in Kandy district. Most of these schemes have failed due to financial, technical, legal challenges. Study reveals that, overall conditions and performance levels of the schemes are ‘very weak’ in overall condition/ performance level and 55 (45%) schemes have intention to hand over the schemes to NWSDB. More than 23 (19%) schemes are abandoned or withdrawn the registration from DNCWS. Due to assessed negative operation ratios, taking over of those schemes to NWSDB is financially not viable. Thus, a collaborative approach is proposed where DNCWS integrates with the NWSDB to create a more sustainable systems similar to NWSDB.

Introduction:

Rural water supply systems are vital for providing safe drinking water in remote areas of Sri Lanka. They are managed by Community Based Organizations (CBOs), under the oversight of the DNCWS (D.M.C.S. Mimrose, 2011). These schemes face financial, technical and legal support challenges, thereby often lead to compromised water quality, poor service level and entire system failures. Hence, this study aims to propose a collaborative approach to transform rural water supply schemes into sustainable and safe water supply systems.

Methodology:

123 community-based rural water supply schemes registered under DNCWS & NWSDB were considered for the study. The methodology involves interview-based questionnaire survey from all respective CBO officers; present conditions and performance levels, intention of handing over the scheme to NWSDB, registration withdrawn, abandoned schemes etc. five-point Likert scale (1-totally failed, 2-very weak, 3-moderately weak, 4-performing well, 5-performing extremely well) were used to assess the performance level. Based on the outcome, proposals were made to transforming into sustainable system.

Findings/Results:

Study reveals that, overall conditions and performance levels of the schemes are ‘Very Weak’ (2.44) in overall condition/ performance level and 55 (45%) schemes have intention to hand over the schemes to NWSDB. Also, more than 23 (19%) schemes are abandoned or withdrawn the registration with DNCWS. Refer Table 1 for analysed outcomes

Table 1: Condition & Performance Level of Kandy District Rural Water Supply Schemes Operating Under CBOs

DS Division	Number of CBO schemes registered under DNCWS & NWSDB	Condition & Performance Level of the Scheme (Shown in 5 Point Likert Scale)					Number schemes intending to hand over the scheme to NWSDB	Abandoned & Registration Withdrawn Schemes
Kandy North Region								
Patha Dumbara	6						4	2
Panwila	9							
Harispattuwa	6						4	
Poojapitiya	20						14	4
Akuran	3						2	1
Thumpane	6						2	1
Hatharaliyadda	7						2	
	57					2.75	28	8
Kandy South Region								
Gangawata Korale	1						1	
Ganga Ihala Korale	12						4	3
Pasbage Korale	8						3	
Udu-Nuwara	3						3	
Yati-Nuwara	1						1	
Uda-Palatha	8						4	2
Doluwa	16						3	3
Deltota	4							3
	53					2.15	19	11
Kandy East Region								
Patha Hewaheta	14						1	1
Udu-Dumbara	7							1
Meda-Dumbara	7						2	
Minipe	22						4	2
	50					2.42	7	4
Kandy District	<u>123</u>					<u>2.44</u>	<u>55</u>	<u>23</u>
Overall Condition & Performance Level of Kandy District CBO Schemes		Very Weak					45%	19%

Conclusions/Key Messages:

Results indicates that, it is crucial time to find a solution to transforming these schemes to a sustainable and well performing systems. Due technical, geological, operational, policy and financial viability issues, taking over of these schemes to NWSDB are not viable. Thus, a collaborative approach is proposed where DNCWS integrates with the NWSDB to create a more sustainable operational framework similar to NWSDB to transforming them into a sustainable system.

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Sustainability of Water Management in Rural Sri Lanka: A Multidimensional Assessment of Community-Based Water Supply Schemes in the North Central Province, Sri Lanka

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Keywords: Sustainability Assessment; Community-Based Water Supply Schemes; Rural Water Management; Sustainability Index; North Central Province

Abstract:

Ensuring sustainable and reliable water supply in rural Sri Lanka depends not only on water quality but also on the long-term performance of management and maintenance systems. This study evaluates the sustainability of 27 Community-Based Water Supply Schemes (CBWSS) in the North Central Province (NCP) using a multidimensional framework comprising 22 sustainability indicators under four dimensions: technical, social, economic, and environmental. The findings reveal that technical indicators particularly preventive maintenance, record-keeping, and water quality monitoring exhibited the strongest correlation with overall water safety and reliability of water supply. The developed Sustainability Index provides a diagnostic and monitoring tool for identifying weaknesses and prioritizing improvements. Its adaptable and replicable structure supports the global pursuit of Sustainable Development Goal 6 (Clean Water and Sanitation).

Introduction:

Rural communities in Sri Lanka, especially in the North Central Province (NCP) where Chronic Kidney Disease of unknown etiology (CKDu) and prolonged dry spells are prevalent, face increasing challenges in maintaining sustainable and safe water supplies. CBWSS have been introduced as decentralized management models to empower local communities in water management. However, many schemes suffer from technical failures, financial constraints, and a gradual decline in community participation over time. These challenges directly affect water quality, reliability, and sustainability, creating an urgent need for a comprehensive evaluation mechanism. Although previous studies in Sri Lanka examined isolated sustainability aspects, few have adopted an integrated framework linking technical reliability, community participation, financial transparency, and environmental protection. Addressing this gap, this study developed a Sustainability Index (SI) to assess and compare the performance of 25 CBWSS in the NCP, generating actionable insights for sustaining water safety and resilience amid climate challenges.

Methodology:

A mixed-method assessment was adopted, combining quantitative surveys with qualitative stakeholder engagement.

- Sample: 27 CBWSS across NCP (25 functional and 2 non-functional schemes) were selected, representing diversity in schemes, regional relevance, operational status, community participation and limited access to piped quality water.
- Framework: 22 sustainability indicators were selected and linked to four dimensions of sustainability; Technical, Social, Economic, and Environmental.
- Data Collection: Primary data were obtained through Likert-scale questionnaires, field observations, Focus Group Discussions (FGDs), Key Informant Interviews (KIIs)
- Analysis: Indicator scores (1–5) in the Likert Scale were normalized to develop a SI for each scheme. Descriptive statistics and correlation analysis examined the relationships between indicators and sustainability of CBWSS. Internal reliability was verified through Cronbach's Alpha ($\alpha = 0.8454$); strong internal consistency.

Findings/Results:

The results of this study revealed that the overall SI of functional CBWSS ranged between 2.55 and 4.14, positioning most schemes as moderately sustainable. Apart from the prominence of technical sustainability as the most influential dimension, Social sustainability outcomes, particularly high women's participation but weak capacity-building, echo (Ekanayake, 2018), though this study found slightly stronger community engagement than previously reported. Economic and environmental weaknesses; poor source protection and limited financial reserves mirror the vulnerabilities noted by (Senaratne & Pathmarajah, 2012). However, this study advances the discourse by integrating all four sustainability dimensions with climate resilience, demonstrating that long-term water safety and reliability.

Conclusion:

This study confirms that the sustainability of CBWSS management in rural Sri Lanka are multidimensional and interdependent, with technical performance and community participation as strongest determinants. The SI provides policymakers and practitioners an evidence-based replicable, data-driven framework for continuous monitoring to identify weaknesses and design targeted interventions. This study recommends strengthening preventive maintenance through continuous National Water Supply and Drainage Board (NWSDB) support, institutionalizing transparent financial audits, and introducing climate adaptation strategies to align with earlier calls by (UNDP, 2020) and (ADB, 2017). By linking technical reliability, socio-economic equity, and environmental sustainability, this contributes in achieving long term sustainability and provide a scalable model for rural water management.

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Session 06

Advancements in Sustainable Water Quality Monitoring, Smart Analytics and Reporting

Session Chair	Prof. Tushara Chaminda
Session Co-chair	Mr. Deepthi U. Sumarasekara
Rapporteur	Ms. Upeksha De Silva



IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

Integrating *Eichhornia crassipes* for Sustainable Water Quality Monitoring: A Case Study on Major Urban Wetlands in Colombo

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Keywords: Urban wetlands; Heavy metal contamination; *Eichhornia crassipes*; Bioindicator; Colombo

Abstract:

Urban wetlands in the Colombo District play a significant role in maintaining ecosystem balance yet are highly threatened by anthropogenic pollution. This study assessed heavy metal contamination (Cr, Cd, Pb, and Hg) in water and roots of *E. crassipes* from Beira, Boralesgamuwa and Thalangama wetlands. Results revealed that all metals were below detection limits in water but accumulated significantly in the plant roots. The highest concentrations were recorded for Cr and Pb as 15.57 mg/kg and 12.43 mg/kg respectively, particularly in Boralesgamuwa and Beira Lakes, indicating strong urban and industrial influence. Lower accumulations were observed in Thalangama Lake, showing its semi-rural setting. The study supports the suitability of using *E. crassipes* for sustainable water quality monitoring in wetland ecosystems.

Introduction:

Urban wetlands in Colombo District play a vital role in flood mitigation, biodiversity conservation, and water regulation (Mitsch et al., 2013). Rapid urbanisation, however, has increased pollutant loading, particularly heavy metals, posing ecological and public health risks (Akhtar et al., 2021). Traditional water quality monitoring may fail to detect metals present in sediments or suspended particles. Aquatic macrophytes such as *Eichhornia crassipes* can bioaccumulate heavy metals and therefore serve as effective bioindicators of long-term contamination. This study addresses whether *E. crassipes* can reliably indicate heavy metal contamination in urban wetlands where dissolved concentrations remain undetectable.

Methodology:

Three wetlands (Beira Lake, Boralesgamuwa Lake, and Thalangama Wetland) were selected based on urbanisation intensity and presence of *E. crassipes*. Three sampling

sites were established per wetland. Surface water and fresh plant samples were collected during a single sampling event in August 2025. Roots were separated and analysed for Cr, Cd, Pb, and Hg. Water samples followed standard APHA methods, while plant samples were analysed using ICP-MS.

Findings/Results:

Table 1. Mean concentrations ($\pm$ SD) of heavy metals in surface water (mg/L) and

Heavy Metal	Wetland					
	Beira Lake		Boralesgamuwa Lake		Thalangama Lake	
	Water (mg/L)	Root of <i>E. crassipes</i> (mg/kg)	Water (mg/L)	Root of <i>E. crassipes</i> (mg/kg)	Water (mg/L)	Root of <i>E. crassipes</i> (mg/kg)
Cr	ND	5.6 $\pm$ 0.10	ND	15.57 $\pm$ 4.24	ND	5.57 $\pm$ 3.34
Cd	ND	0.16 $\pm$ 0.04	ND	0.23 $\pm$ 0.03	ND	0.4 $\pm$ 0.30
Hg	ND	0.107 $\pm$ 0.02	ND	0.09 $\pm$ 0.02	ND	0.02 $\pm$ 0.02
Pb	ND	12.43 $\pm$ 4.67	ND	11.77 $\pm$ 2.68	ND	2.90 $\pm$ 1.11

Eichhornia crassipes roots (mg/kg dry weight).

***Note** = ND - Not Detected (limits of detection for Cr and Pb = 0.01 mg/L, Cd = 0.001mg/L, Hg = 0.0005 mg/L)

Conclusions/Key Messages:

Despite non-detectable metal concentrations in surface water, significant accumulation in *Eichhornia crassipes* roots indicates the presence of heavy metals in non-dissolved forms. Elevated Cr and Pb levels in Beira and Boralesgamuwa Lakes reflect strong urban and industrial pressures, while lower concentrations in Thalangama Wetland correspond with its reduced urban influence. This study is limited by one-time sampling and does not capture seasonal variability or metal mobility. Future monitoring should therefore include seasonal and sediment-based assessments. Integrating *E. crassipes* into wetland monitoring programs offers a low-cost and effective approach for long-term pollution surveillance, provided that harvested biomass is safely managed. Overall, the findings confirm *E. crassipes* as a reliable bioindicator, strengthening conventional monitoring and supporting improved management of Colombo's urban wetlands.

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IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

Assessment of Groundwater Quality in Sri Lanka Using Spatial and Statistical Analysis

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Keywords: Groundwater; Sri Lanka; Spatial Analysis; Statistical Analysis

Abstract: Groundwater serves as a major source of potable water in Sri Lanka to around 40% of the population. This study assessed groundwater quality across Sri Lanka using data from 3,339 locations. ArcGIS 10.4 was used to develop spatial maps and determine the spatial variation. The Correlation analysis and Water Quality Index (WQI) were developed to identify the key parameters and affected areas. Results indicate that Total Hardness, Total Dissolved Solids (TDS), and Alkalinity exceed the SLS 614:2013 standard in 63%, 47%, and 46% of the country, respectively. Critical contamination zones were identified as the Northern and Southern dry zones. The correlation matrix reveals strong relationships ($r > 0.8$) among TDS, Total Hardness, Cl^- , EC, and Na^+ , with the strongest correlation between EC and Cl^- ($r = 0.970$).

Introduction:

Groundwater is a vital freshwater resource and a primary source of drinking water in Sri Lanka (Imbulana & Oguma, 2021). This study assesses groundwater quality across Sri Lanka using GIS-based spatial analysis, multivariate statistical methods, the Water Quality Index (WQI), and correlation analysis to identify regions that exceed the standards outlined in SLS 614:2013 (Sri Lankan Standards Institution, 2013).

Methodology:

Groundwater data from the DNCWS, WRB, and the 1985 Groundwater Atlas were analysed for 15 physicochemical parameters across 3,339 locations. Spatial variations were mapped using ArcGIS 10.4 based on administrative, soil, and land-use factors following SLS 614:2013 standards (Sri Lankan Standards Institution, 2013). The Weighted Arithmetic WQI method was applied to assess drinking water suitability, and parameter correlations were evaluated using IBM SPSS Statistics 27.0.1.

Findings/Results:

Spatial analysis revealed significant heterogeneity in groundwater quality across the island. Spatially Interpolated Maps for selected Parameters are included in Figure 1. Parameters such as Total Hardness, TDS, and Alkalinity exhibited the highest exceedance percentages (63%, 47%, and 46%, respectively) compared to SLS 614:2013 standards. Critical exceedance zones were identified in the northern and southern Dry Zones. Land use analysis showed elevated TDS and TH in agricultural and barren lands, while soil-based analysis revealed high contamination in reddish-brown earths and calcic red-yellow latosols. High F^- and Cl^- levels in coastal areas indicate seawater intrusion and the influence of geological processes. The correlation matrix reveals strong relationships ($r > 0.8$) among TDS, Total Hardness, Cl^- , EC, and Na^+ , with the strongest correlation between EC and Cl^- ($r = 0.970$).

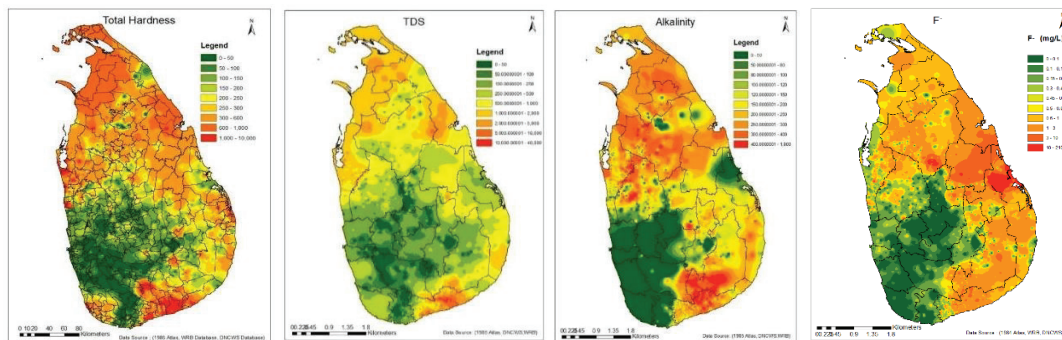


Figure 1 : Spatially Interpolated Maps for Groundwater Quality Parameters

Conclusions/Key Messages:

This study provides a comprehensive spatial and statistical assessment of groundwater quality across Sri Lanka, revealing significant heterogeneity and highlighting the Dry Zone's vulnerability to contamination. Analysis of 3,339 samples showed exceedances of Total Hardness (63%), TDS (47%), and Alkalinity (46%) beyond SLS 614:2013 limits, with critical zones in the Northern and Southern Dry Zones. These issues are linked to lithology, seawater intrusion, and agriculture-induced mineralization. Soil and land-use analyses identified reddish-brown earths, calcic red-yellow latosols, and agricultural/barren lands as high-risk areas. Strong correlations ($r > 0.8$) among TDS, hardness, Cl^- , EC, and Na^+ , especially EC- Cl^- ($r = 0.970$), confirm dominant hydrochemical controls. GIS-based mapping and WQI analysis effectively identified high-risk zones for evidence-based management.

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Review of Optimization Approaches in Conventional Water Treatment with Reference to the Diyathalawa Water Treatment Plant

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Keywords: Rapid mixing; hydraulic jump; coagulation; floc formation; turbulence

Abstract: Both coagulation chemistry and hydraulic conditions govern conventional water treatment performance. This study reviews optimization approaches at the Diyathalawa Water Treatment Plant, where an additional hydraulic disturbance exists between rapid mixing and flocculation. Jar tests using an optimized alum dose of 10 mg/l showed effective floc formation and turbidity reduction below 1 NTU at pH 8.0, while poor floc development and limited turbidity removal occurred at pH 5.5, highlighting the importance of pH control alongside hydraulic optimization.

Introduction:

Coagulation and flocculation control the removal of colloidal and suspended impurities in conventional water treatment and depend on coagulant dosage, hydraulic mixing, and raw water quality. At the Diyathalawa Water Treatment Plant, an additional hydraulic jump between the rapid mixer and flocculator may affect floc formation. This study evaluates the impact of existing hydraulic conditions and explores optimization using jar test simulations.

Methodology:

The study was conducted in three stages. First, a literature review was performed to assess the influence of pH, hydraulic energy, velocity gradients and detention time on coagulation efficiency. And Standard design guidelines were studied to identify acceptable ranges for mixing intensity and detention time. Second, the existing Diyathalawa WTP was hydraulically assessed using site data and drawings, focusing on flow conditions, HRT, and velocity gradients, followed by jar tests simulating existing conditions at pH 8.0 and 5.5. Finally, process modifications were proposed and simulated using jar tests. Raw water was used throughout, with an optimum alum dose of 10 mg/l selected based on minimum residual turbidity. Treated samples were analyzed for turbidity, TOC, TDS, and THM.

Results:

The raw water had an initial turbidity of 21.5 NTU and TOC of 1.19 mg/l, and all jar tests were conducted using an optimized alum dose of 10 mg/l. At pH $\approx$ 8.0, effective floc formation achieved residual turbidity of 1.75 ($\pm$ 0.16) NTU and 0.87 ($\pm$ 0.07) NTU for the existing and modified configurations, corresponding to removal efficiencies of 91.9% and 96.0%, respectively. The existing configuration used four flocculation stages ($G = 86\text{--}22\text{ s}^{-1}$, HRT = 10 min), while the modified configuration employed eight stages with lower velocity gradients ($G = 80\text{--}13\text{ s}^{-1}$) and a longer HRT of 21 min.

At pH 5.5, floc formation was poor, resulting in higher residual turbidity of 17.08 ($\pm$ 0.24) NTU and 14.23 ($\pm$ 0.60) NTU for the existing and modified configurations (20.6% and 33.8% removal, respectively). In contrast, organic matter removal improved at lower pH, with TOC reduced to 0.95 mg/l (20.2%) and 0.72 mg/l (39.4%) for the existing configuration, and to 0.93 mg/l (21.5%) and 0.68 mg/l (42.1%) for the modified configuration at pH 8.0 and 5.5, respectively

Conclusions:

Based on literature, rapid mixing and hydraulic jumps provide the turbulence required for effective coagulant dispersion, governed by velocity gradient (G) and detention time [Amirtharajah and Mills, 1982]. For alum coagulation, pH controls floc formation through aluminium hydrolysis, with enhanced organic matter removal expected at lower pH ($\approx$ 5.5–6.5) [McGraw-Hill, AWWA, 2011]. Accordingly, optimum performance was initially hypothesized at pH 5.5.

However, jar tests showed contrasting behaviour. By using an optimized alum dose of 10 mg/l, at pH 8.0 effective floc formation could be observed and turbidity below 1 NTU were achieved, while poor floc formation and high residual turbidity occurred at pH 5.5. Although lower pH improved TOC removal, turbidity control was governed by the combined effects of pH, coagulation mechanism, and hydraulic mixing. Improved performance under the modified flocculation configuration. Overall, the findings emphasize that water treatment plant optimization should be based on actual raw water quality.

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Methods comparison in determining organic carbon in surface and ground water

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Keywords: Organic carbon; Water quality; UV254; TOC; COD

Abstract: Understanding the concentration and composition of organic carbon in natural waters is crucial for assessing water quality and environmental impact. Conventional chemical methods like chemical oxygen demand (COD), total organic carbon (TOC), permanganate index (PI) and humic acid concentration are widely used in water quality monitoring. Therefore, this study aimed to evaluate the potential of ultraviolet (UV254) absorbance as a rapid indirect method for estimating organic carbon in water and to establish correlations among these methods. It is revealed a strongest correlation between UV254 absorbance and COD (closed reflux) and TOC, followed by COD (microfluidic) and PI. Therefore, UV254 can be used as a valuable and rapid tool for estimating general organic carbon content in water.

Introduction:

Organic carbon in natural waters include both naturally occurring and man-made organic compounds. While most natural compounds are harmless, many man-made contaminants cause serious risk to water quality and ecosystem health (Shetty & Goyal, 2022). The content of organic carbon in a certain amount can be useful for aquatic biota, but if the amount of organic carbon has exceeded the assimilation ability of waters, it can cause disturbances. The disturbance can be in the form of a decrease in water quality due to the decomposition process of organic matter (Albrektienė et al., 2012). The process of aerobic decomposition of organic matter can cause the content of dissolved oxygen to be low or even depleted.

Due to the need for trace organic carbon analysis in water, and the concern about organic pollution of drinking water and various types of environmental water, a sensitive and an accurate method for the determination of organic carbon content in water is needed. This study specifically investigates the utility of UV254 as a relatively less sophisticated and faster method for estimating general organic content compared to traditional, more complex, more time-consuming methods available.

Methodology:

Water samples were collected from surface and ground water (lakes, rivers and deep well) sources across Sri Lanka between March to July 2024. Sampling bottles were cleaned with nitric acid, rinsed with deionized water, and air-dried to prevent contamination. Physical parameters including temperature and pH were measured following standard procedures. TOC was determined using CHNS/O Elemental Analyzer after acidification and membrane filtration. The PI was analysed through oxidation with potassium permanganate (KMnO_4) in acidic medium, followed by titration with standard potassium permanganate solution. UV254 absorbance was measured using a UV-Vis spectrophotometer with 10mm quartz cuvette cells. Humic acid concentrations were determined using maximum absorbance at 204 nm. COD was analysed using both the standard closed reflux colorimetric method and a microfluidic approach utilizing potassium dichromate, mercury sulphate, and silver sulphate catalysts. The resulting data from all analytical methods were statistically analysed using correlation analysis to assess the relationships of TOC, COD (closed reflux and microfluidic), PI, and humic acid levels with UV₂₅₄ absorbance.

Findings/Results:

It is revealed that there is a strong correlation between TOC and UV254 with $R^2 = 0.9865$. Similarly, COD determined by the closed reflux method and UV254 show a strong correlation coefficient of determination with $R^2 = 0.9936$. The correlation between COD determined by the microfluidic method and UV254 shows an R^2 value of 0.9655. The relationship between UV254 absorbance and the PI shows a R^2 value of 0.8825. Further, there is no correlation between UV254 value and humic acid concentration.

Conclusions/Key Messages:

The study revealed a strongest correlation between UV254 absorbance and COD (closed reflux) and TOC, followed by COD (microfluidic) and PI. The significant relationships among these methods indicate consistent linear behaviour across diverse water samples. This confirms that UV254 absorbance can effectively estimate the total organic content in water. However, it fails to correlate UV254 absorbance reliably with humic acid concentration. Therefore, UV254 can be used as a valuable and rapid tool for estimating general organic content in water. And it should be used with caution when attempting to quantify specific organic fractions such as humic substances. A combined analytical approach is recommended for comprehensive evaluation of organic matter in natural and treated waters.

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IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

Impact of Low Langelier Saturation Index Waters on the Durability and Sustainability of Grade 25 Concrete Water Retaining Structures

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Keywords: Langelier Saturation Index (LSI), Water Retaining Structures, Concrete Deterioration

Abstract: Concrete water retaining structures constructed with Grade 25 concrete in water treatment and distribution systems are vulnerable to chemically aggressive, low Langelier Saturation Index (LSI) waters. Low LSI water is undersaturated with calcium carbonate, promoting calcium leaching from the concrete matrix and weakening its microstructure. This study investigates the mechanisms of deterioration, influencing factors, mitigation strategies, and includes a field-based case study at the Muthukandiya Water Treatment Plant (WTP). The findings confirm that waters with LSI below -0.8 are chemically aggressive and can significantly accelerate degradation in concrete structures, emphasising the importance of early detection, water chemistry control, and protective measures to extend structural service life.

Introduction:

Water retaining structures, particularly those built with Grade 25 concrete, often face premature deterioration due to environmental and material factors. The problem becomes more severe when exposed to low LSI waters, which are aggressive toward calcium-based compounds in concrete. Such deterioration compromises structural performance, and escalates maintenance costs. Studies by Poukhonto (2003) and Sarray (2013) indicate that deterioration often begins long before visible damage appears, highlighting the importance of early detection and preventive design. A site inspection at Muthukandiya WTP, revealed surface erosion and scaling on concrete walls below the waterline, evidence of chemical attack from water. Findings suggested that aggressive, low LSI water is the dominant cause. Understanding these mechanisms are essential for developing effective mitigation strategies and ensuring long term sustainability of water infrastructure.

Methodology:

This study employed a qualitative and multidisciplinary approach combining literature review, field investigation, and water quality analysis. Field inspections were conducted at key treatment unites of the Muthukandiya WTP, to visually document the extent and pattern of concrete deterioration. Several hypotheses covering potential causes such as construction defects, chemical, biological, and physical

impacts were evaluated using field evidence and reference studies. Monthly raw and treated water data of 2024 and 2025, obtained from the Monaragala Regional Laboratory, were analysed to assess parameters influencing concrete degradation, with a focus on the LSI and solubility characteristics. The results were compared against international standards (Dutch G.L.) and previous studies on low LSI environments. Finally, potential mitigation and neutralisation measures were reviewed, including lime or soda dosing, limestone filtration, and aeration, to propose practical strategies for improving water stability and reducing concrete deterioration.

Findings/Results:

Field inspections at the Muthukandiya WTP revealed that concrete degradation was concentrated below the waterline, while external surfaces showed minimal deterioration. This indicated that deterioration is primarily driven by chemically aggressive water contact. Of the five hypotheses assessed, two were validated: chemical attack from low LSI water causing calcium leaching, and localized reactions with treatment chemicals (PACl) near dosing points. Biological impacts, construction defects, and hydraulic erosion were excluded based on normal pH, moderate flow velocities, and absence of external damage. Water quality analysis confirmed strong under saturation with calcium carbonate, with LSI values of -0.82 (raw) and -1.01 (treated). Secondary factors such as Sulfate attack, Grade 25 concrete used during the construction might accelerate this process. To mitigate these effects, neutralisation methods such as chemical addition, and limestone filtration can be applied to increase alkalinity and stabilize water pH. Preventive strategies including high strength coatings and proactive maintenance are essential to reduce long term structural deterioration and ensure sustainable operation of the WTP.

Conclusions:

The study confirms that low LSI water is the principal factor accelerating the deterioration of Grade 25 concrete in Muthukandiya water retaining structures. Negative LSI values indicated undersaturation with calcium carbonate, promoting structural concrete strength. To mitigate these effects, the study recommends: 1) Chemical neutralisation through lime or soda ash dosing or limestone filtration to stabilise LSI, 2) Protective surface treatments for enhanced durability, 3) Routine monitoring of LSI and corrosion indices as part of WTP operations, and 4) Design modifications in future WTPs to ensure resistance against chemically aggressive water. Overall, addressing low LSI aggressiveness through water chemistry control, durable materials, and proactive maintenance is essential to extend service life, reduce costs, and ensure the long-term sustainability of water retaining structures.

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Session 07

Regulatory Approaches, Water Safety Plan Auditing and Safety in Distributions and Building

Session Chair	Mr. Sajjan Jayasiriwardhana
Session Co-chair	Dr. Chandima Gunawardhana
Rapporteur	Ms. Sumudu Ranaweera



IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

Assessing the Robustness of Water Safety Plans through Internal Audits: Evidence from Vavuniya District, Sri Lanka

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Keywords: Water Safety Plan; Robustness Analysis; WHO Guideline; Internal Audit

Abstract: The effectiveness of a Water Safety Plan (WSP) relies on its capacity to maintain safe water supply operations under changing conditions. This study assesses the robustness of the WSP implemented at the Vavuniya Water Supply Scheme (VWSS), which draws water from the Per Aru reservoir, through an internal informal audit. A 25-question survey rated the WSP's adaptability on a 5-point scale, scoring 91 out of 125 (73%), showing the WSP is moderately robust and functional under most conditions but needs improvements in resilience and adaptive control. The assessment found strong management and monitoring but weaknesses in emergency readiness and financial planning. Recommendations focus on staff retention, monitoring systems, financial plans, and climate risk integration for sustainable WSP.

Introduction:

The WHO Water Safety Plan (WSP) framework ensures safe drinking water through hazard identification, risk assessment, operational control, and continuous monitoring (WHO, 2004; 2017). Robustness—the ability to maintain effectiveness under staff turnover, technological changes, or environmental stressors—is a key feature (Howard & Bartram, 2020). In Sri Lanka, the NWSDB has implemented WSPs across urban and rural schemes. The Vavuniya Water Treatment Plant (12,000 m³/day), sourcing from the Per Aru Reservoir, faces seasonal scarcity, agrochemical runoff, high turbidity, algal blooms, and elevated iron and manganese (WHO, 2015). Assessing WSP robustness helps identify system strengths, adaptive capacity, and areas for improvement to ensure sustainable safe water delivery.

Methodology:

A 25-question internal audit, based on the WHO (2015) WSP framework, assessed five dimensions: institutional/personnel continuity, financial/managerial support, operational adaptability, risk/hazard management, and emergency preparedness with learning integration. Data were collected via document review, staff interviews, and verification of operational, audit, and maintenance records, alongside laboratory results from the ISO 17025-accredited Regional Laboratory, Vavuniya. Each question was scored 1–5, with total robustness classified as Red (<75, weak), Yellow (76–99, moderate), or Green (100–125, highly robust).

Results and Discussion

The internal audit evaluated the robustness of the WSP implemented at the VWSS across five dimensions in accordance with WHO (2015). The assessment produced an overall

robustness score of 91 out of 125 (73%), categorizing the WSP as moderately robust (Yellow). This indicates that the system functions effectively under routine operating conditions but exhibits vulnerabilities when exposed to prolonged stress or non-routine events.

Institutional and Personnel Continuity showed relatively high robustness, with scores mainly between 4 and 5. Clearly defined roles, comprehensive SOPs, and documented workflows ensure continuity during staff absence (score 4), while structured documentation supports rapid adaptation of new or reassigned staff (score 5). However, reliance on the Officer-in-Charge and frequent turnover of contract staff introduce moderate vulnerability (score 3–4), indicating the need for permanent staffing and succession planning. Financial and managerial support demonstrated moderate robustness (score 3–4). Senior management shows consistent commitment to WSP implementation and corrective actions (score 4). In contrast, procurement delays and the lack of a dedicated contingency budget constrain financial resilience (score 3), potentially delaying emergency repairs and rapid mitigation during critical events.

Operational and technical adaptability achieved moderate robustness (score 3–4). Updated system diagrams, operational procedures, and SCADA-based controls support plant-level adaptability and response to raw water quality fluctuations. However, the absence of online monitoring in the distribution network limits system-wide visibility (score 3), affecting early detection of water quality deterioration. While control measures are generally flexible and effective (score 4), systematic validation remains limited. Risk and hazard management showed moderate robustness (score 3–4). Major hazards like seasonal turbidity, algal blooms, agrochemical runoff, and high iron/manganese levels are well-identified, with routine preventive maintenance in place. Risk assessments aren't regularly updated for emerging threats like climate variability and catchment changes (score 3). Limited sensor backups and calibration delays also affect data reliability. Emergency preparedness demonstrated relatively strong performance (score 4), supported by defined response procedures and effective communication. However, learning integration scored lower (score 3) due to limited emergency drills and insufficient documentation of lessons learned, constraining institutional learning and long-term resilience.

Conclusions and Recommendations

The VWSS WSP is moderately robust, effectively delivering safe water despite challenges like staff turnover and limited resources. It excels in management, documentation, and monitoring but needs improvement in hazard identification, emergency preparedness, and financial planning. Strengthening resilience involves stable staffing, dedicated funding, equipment maintenance, climate risk assessment, emergency drills, and staff training to ensure sustainable water supply.

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Two Decades of Preventive Water Quality Management: The Evolution of the Water Safety Plan at Águas do Algarve, SA

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Keywords: Water Safety Plan; Risk Management; ISO 22000; Resilience; Water Quality

Abstract: Águas do Algarve, SA implemented its Water Safety Plan (WSP) in 2005, years before it became a legal requirement in Portugal. Based on WHO guidelines, the WSP established a preventive approach to water quality management, integrating risk assessment across all operational stages. Over two decades, it has evolved into a core management system, aligned with ISO 22000:2018 and supported by continuous monitoring, auditing, and improvement. This paper presents the company's experience, highlighting lessons learned and the WSP's contribution to resilience amid climate challenges, emerging contaminants, and cybersecurity risks.

Introduction:

In 2005, Águas do Algarve, SA (AdA) took a pioneering step by implementing a Water Safety Plan (WSP) inspired by World Health Organization recommendations, well before national legislation mandated such an approach. The initiative was launched alongside ISO 22000 certification, aiming to apply a preventive and risk-based framework covering the entire water supply chain — from abstraction to consumer delivery.

Over twenty years, this methodology has evolved into a central component of the company's culture, emphasizing continuous improvement, data-driven decision-making, and close coordination with the Portuguese Water and Waste Services Regulatory Authority (ERSAR) and the Regional Health Authority (ARS Algarve).

Methodology:

The WSP is structured around ISO 22000:2018 principles, distinguishing Critical Control Points (CCP) and Operational Prerequisite Programs (OPRP). Implementation involves multidisciplinary teams, risk assessment matrices, and continuous process verification. The system's improvement cycle is supported by over 20 external audits, an equal number of internal audits, and approximately 150 internal verifications.

Findings/Results:

The long-term application of the WSP has yielded significant operational, regulatory, and resilience outcomes. Preventive management practices have improved water quality assurance, optimized resources, and enhanced transparency. Furthermore, the system has effectively adapted to new challenges such as extreme droughts, cybersecurity threats, and the monitoring of emerging contaminants, aligning with the requirements of Decree-Law No. 69/2023 (transposing Directive (EU) 2020/2184).

Conclusions:

The experience of Águas do Algarve demonstrates that long-term investment in prevention, technical rigor, and continuous improvement leads to robust and sustainable results. The WSP has become a model of integrated risk management and resilience for the water sector, providing a foundation for future adaptation and innovation in the face of evolving environmental and technological challenges.

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Perceived Water Quality, Household Practices, and Consumer Satisfaction under a Water Safety Plan: A Case Study

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Keywords: Water Safety Plan; Consumer Satisfaction; Water Quality Perception; Distribution System; Kilinochchi Water Supply Scheme

Abstract: This paper explores the link between customer satisfaction and household water consumption practices, which were investigated in the Kilinochchi Water Supply System in Sri Lanka. A survey of 190 households was conducted using a clustered sampling technique. Consumer perceptions of water and usage practices were analyzed using Spearman's rank correlation test. The analysis showed that there are moderate positive correlations between customer satisfaction and certain water quality characteristics, i.e., odors, tastes, color, and the presence of dust particles, while household cleaning practices and purpose of water use showed very weak correlations. These findings indicate that consumer satisfaction is more strongly shaped by perceptible water quality attributes than by behavioural factors.

Introduction:

Access to drinking water is one of the basic public health needs that must be met and is one of the basic goals that can be achieved by a sustainable water supply. The process of water treatment is meant to achieve drinking water quality standards, but the quality of water can also vary during supply and at household levels due to factors affecting water infrastructure and the behavior of consumers. According to the World Health Organization, contamination of water after treatment may result from various factors like pipe leaks, inadequate residual disinfectants, or unhygienic storage at household levels.

To overcome these risks, the Water Safety Plan (WSP) approach advocates systematically undertaking risk management from catchment to consumer (Cotruvo, 2017). The NWSDB in Sri Lanka has already implemented WSPs under many water supply schemes, including those in the Northern Province. Literature has proved that consumer satisfaction with drinking water is strongly influenced by perceived water quality, taste, odour, and colour. Moreover, studies have proved that even when the water supply quality is adequate, improper household storage and handling will compromise the safety of water (Mcguinness et al., 2020). Accordingly, this study aims at evaluating consumer satisfaction and household water usage practices in relation to water quality attributes in the Kilinochchi water supply scheme.

Methodology:

In total, 190 households using the Kilinochchi Water Supply Scheme were selected for a clustered random sampling method and a questionnaire-based survey. The structured questionnaire was made up of 54 questions that ranged from demographic information on the household to perceived changes in water quality and overall consumer satisfaction. Water usage practices included the frequency of cleaning storage tanks or containers and the primary purpose of water use. Perceived water quality attributes included odour, colour, taste, and presence of dust particles. The consumer satisfaction was measured on a five-point ordinal scale ranging from dissatisfied to satisfied. Data analyses were done using the SPSS Version 27. Spearman's rank correlation coefficient has been applied to test the relationship of consumer satisfaction with the mentioned above variables.

Results:

The cleaning practices indicates, more than 52.63% of households reported never cleaning their storage tanks or containers, while smaller proportions cleaned annually, semi-annually, or quarterly. Regarding water usage, most households primarily used supplied water for drinking (57.89%), followed by cooking, bathing, and other domestic purposes, reflecting a general level of trust in the supplied water. Most respondents rated water quality as “better” for colour (89.48%), odour (78.96%), taste (81.59%), and turbidity (89.48%). And overall consumer satisfaction was high, with more than 78% of respondents reporting satisfaction or high satisfaction, and no respondents indicating dissatisfaction. Correlation analysis results show very weak relationships between satisfaction and cleaning practices ($p = 0.08$) and purpose of water use ($p = 0.07$). In contrast, perceived water quality attributes exhibited moderate positive correlations, particularly odour ($p = 0.52$) and dust particles ($p = 0.52$), followed by taste ($p = 0.46$) and colour ($p = 0.43$).

Conclusions:

The study also corroborates the finding that consumer satisfaction is more significantly affected by the perceived characteristics of water quality when compared to their practices. Storage and cleaning practices, despite affecting water safety, do not have a significant impact on satisfaction. This calls for the involvement of additional factors, such as supply reliability, pressure, cost, seasonality, service responsiveness, and consumer trustworthiness, to possibly have a more significant effect on satisfaction. Henceforth, this study calls for a more holistic approach by future research in uniting service quality and operational performance measures with consumer perceptions under the Water Safety Plans approach.

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IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

Removal of Manganese from Drinking Water Using A Pilot-Scale Biological Trickling Filter

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Keywords: Batch mode; Biological trickling filter; Continuous flow mode; Hydraulic retention time; Manganese removal

Abstract: Manganese (Mn) contamination in drinking water is both an aesthetic and public health concern. Long-term exposure to elevated concentrations has been linked to neurological and respiratory issues. Sri Lanka Standards (SLS 614) set a maximum permissible limit of 0.1 ppm for Mn, yet trace Mn level is often detected within distribution networks(>0.1ppm). This study investigated a pilot-scale biological trickling filter (BTF) with consistent aeration, operated under continuous flow and batch modes to reduce Mn (II) level to below 0.02 ppm to avoid Mn discoloration. Trials were conducted with synthetic water (0.1 & 0.2ppm) and raw water (0.24 ± 0.1 ppm). Continuous flow mode consistently achieved >95% removal at 50mL/min flow rate with 90 minutes hydraulic retention time (HRT) and >91% at 100mL/min with 40 minutes HRT, while batch mode averaged 75–85% removal. The findings confirm BTF as cost-effective and scalable technology for decentralized drinking water treatment in Mn-affected communities.

Introduction

Mn is a naturally occurring element in groundwater and surface waters, mobilized through geological weathering, mining, and industrial activities. While Mn is an essential micronutrient, elevated levels in drinking water present challenges. Aesthetic concerns include discoloration, precipitation, scaling, and staining. Beyond aesthetics, long-term exposure can cause neurological & respiratory issues. Persistent Mn residuals in drinking water distribution systems are common, even when initial treatment meets regulatory limits. Therefore, reducing Mn (II) concentration to below 0.02 ppm prior to distribution is recommended to ensure water safety (Gouzinis *et al.*, 1998; Walkerton Clean Water Centre, 2018)

Methodology

A pilot-scale BTF was designed using a cylindrical column packed with gravel as the supporting medium and provided consistent aeration using an air pump. The column was seeded with Mn-oxidizing bacteria & added KMnO_4 to ensure their biofilm growth. The influent was supplied to the column through a peristaltic pump. Continuous flow & batch modes were used for operational trials. Experiments were conducted for both synthetic water (0.1 & 0.2 ppm Mn (II)) and raw water containing 0.24 ppm (± 0.1) Mn (II). Flow rates were varied at 50, 100, and 150 mL/min, corresponding to HRTs of 90, 40, and 32 minutes respectively, derived using $\text{HRT} = (\text{media volume} \times \text{porosity}) / \text{flow rate}$ (Maiyo & Dasika, 2023).

Findings/Results

Continuous flow mode achieved Mn (II) removal efficiencies greater than 95% and 91%, consistently at 50mL/min flow rate (90 minutes HRT) and 100mL/min flow rate (40 minutes HRT) respectively, lowering Mn (II) concentrations below 0.02 ppm. In contrast, batch mode trials showed 75–85% removal efficiencies with higher variability. Extended HRTs improved removal rates in both modes, with continuous flow stabilizing biofilm activity and ensuring oxygen availability, support for Mn-oxidizing bacteria.

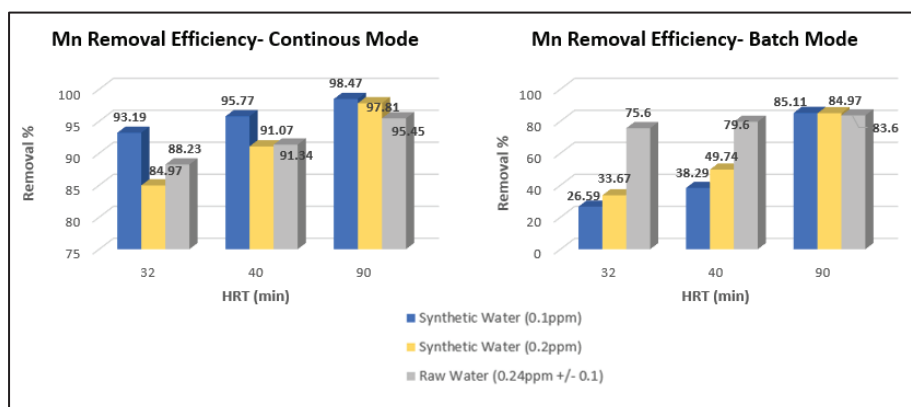


Figure 1: Manganese Removal Efficiency by Pilot- Scale BTF

Conclusions/Key Messages

BTF operated in continuous flow effectively reduce Mn to below standard limits, providing a viable solution for decentralized water treatment in affected areas. Their cost-effectiveness, sustainability, and scalability make them practical for community-scale use, while optimizing flow and retention time is crucial for maximum removal and stable biofilm activity.

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Bacterial Water Quality Issues and Societal Challenges Associated with Intermittent Water Supply in Sri Lanka: Preliminary Findings and Research Needs

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Keywords: Intermittent water supply; supply resumption phase; bacterial water quality; societal impacts; public health risks

Abstract: Intermittent Water Supply (IWS) is commonly used in rural Sri Lanka to address water scarcity, yet its water quality and social impacts are poorly understood. This preliminary study evaluated bacterial water quality in an intermittently supplied network in the Kandy region and assessed community experiences through a survey. The results show significant bacterial water quality deterioration and multiple social challenges associated with IWS.

Introduction:

Intermittent water supply is widely practiced in developing countries to manage water scarcity but it is associated with various water quality issues [Kumpel et al., 2016; Simukonda et al., 2018]. Global studies have reported health risks associated with opportunistic bacteria in IWS systems [Kumpel et al., 2013; Bivins et al., 2017]. This preliminary study examines bacterial water quality deterioration and related societal challenges, aligning with the conference theme of Water Safety in Distribution Systems and Buildings and contributing to SDGs 3 and 6.

Methodology:

Water samples ($n = 30$) were collected from directly connected household taps in an IWS system in the Mudunekade area of Kandy during both the supply resumption and continuous supply phases. Bacterial communities were analyzed using Illumina MiSeq sequencing of the 16S rRNA (V4 region). A questionnaire survey was conducted alongside sampling.

Findings/Results:

No samples were positive for total coliforms or *Escherichia coli*, but heterotrophic plate counts (HPC) were significantly higher during the supply resumption phase. Sequencing data showed that different bacterial genera were dominant during the supply resumption phase of IWS and the continuous supply phase, as shown in Figure 1. Survey results showed that 73% of households faced inconvenience and added costs from water storage, 60% reported high chlorine levels, and 23% noticed turbidity during supply resumption. Technical staff also indicated increased maintenance demands under IWS.

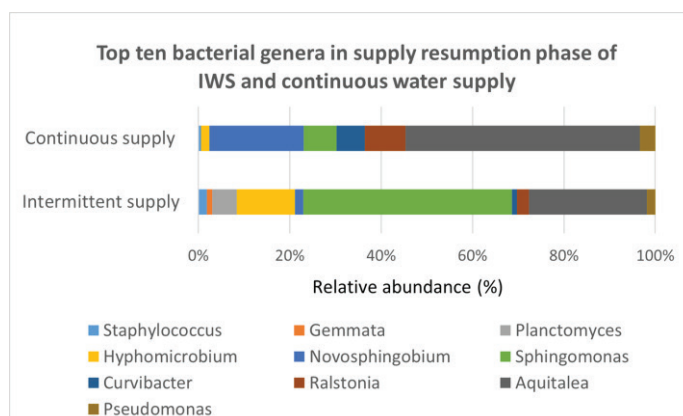


Figure 1: Top ten bacterial genera in the supply resumption phase of IWS and the continuous supply phase.

Conclusions/Key Messages:

This preliminary study underscores the need for comprehensive research on bacterial risks, operational issues, and societal impacts to support safer and more sustainable water supply systems where continuous supply is not feasible.

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Session 08

Innovations and Technological Advancements in Water Reclamation and Sustainable Reuse Practices

Session Chair	Prof. Nadeeshani Nanayakkara
Session Co-chair	Dr. I.M.W.K. Illangasinghe
Rapporteur	Ms. G.G.S. Lekha



IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

Comparative Study on the Effect of Atmospheric Air Plasma Treatment on Coconut Coir Biochar for the Adsorptive Removal of Nitrate and Ammonium Ions

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Keywords: Ammonium; Nitrate; Atmospheric air plasma; water remediation

Abstract: This study investigates the comparative adsorption performance of coconut coir biochar and plasma-functionalized biochar (PFBC) for the removal of ammonium and nitrate ions from aqueous media. Biochar was modified using Atmospheric Air Plasma Treatment (AAPT). The study demonstrates that while AAPT effectively enhances biochar for nitrate removal, it is less suitable for ammonium adsorption due to the degradation of essential surface functionalities.

Introduction:

Water pollution, caused by contaminants such as Nitrate and Ammonium, poses a critical global environmental and public health challenge. While various conventional treatment methods exist, they often suffer from limitations. In response to the urgent need for more sustainable solutions, biochar has emerged as a promising, cost-effective, and eco-friendly adsorbent. However, unmodified biochar often exhibits limited adsorption capacity for efficient binding of contaminants. To overcome these limitations, surface modification techniques are essential. This research addresses this gap by introducing a chemical-free surface modification approach utilizing Atmospheric Air Plasma Treatment (AAPT). AAPT introduces oxygenated and nitrogenated functional groups onto the carbon surface (Jayasinghe et al., 2024). This functionalization is designed to enhance the biochar's physicochemical properties and critically enhance its capacity to absorb a broad spectrum of pollutants. The study synthesizes plasma-activated coconut coir biochar and evaluates its efficiency in removing ammonium and nitrate ions, offering insights for sustainable biochar-based water purification.

Methodology:

Coconut coir dust was pyrolyzed at 300 °C, 500 °C, and 700 °C for 3 h under nitrogen to produce biochar (BC). Atmospheric Air Plasma Treatment (AAPT) was applied for 30

minutes using a double-arc generator to obtain plasma-functionalized biochar (PFBC). Characterization included iodine and methylene blue numbers, ash and moisture contents, and point of zero charge (PZC), with FTIR, SEM, N₂-BET, and XRD analyses assessing functional, morphological, and structural features. Batch adsorption studies evaluated nitrate and ammonium removal at 30 °C and 200 rpm, varying pH (2–8), contact time (5–120 minutes), and initial concentration (5–100 mg L⁻¹). Nitrate and ammonium were quantified by ion chromatography and the Direct Nesslerization method, respectively, with all tests performed in triplicate for reproducibility.

Findings/Results:

The comparative study investigated the adsorption performance of coconut coir biochar (CCBC) and PFBC for the removal of both ammonium and nitrate ions, revealing contrasting results dependent on the target contaminant. Among the prepared biochar samples, the 300 °C sample exhibited the highest ammonium adsorption capacity, while the 700 °C biochar performed best for nitrate removal. This contrasting behavior can be attributed to the progressive reduction of surface hydroxyl groups with increasing pyrolysis temperature, which decreases the number of active sites favorable for ammonium adsorption but enhances nitrate uptake by promoting a more positively charged surface. Biochar produced at 300°C (300CCBC) exhibited a maximum ammonium adsorption capacity of $14.5 \pm 0.9 \text{ mg g}^{-1}$ at the optimal pH of 8. However, plasma-treated biochar (300PFBC) showed lower adsorption capacity than untreated 300CCBC. This diminished performance was attributed to the reduction of beneficial hydroxyl functional groups and a less favorable surface charge profile in 300PFBC due to its higher PZC of 8.1 (compared to 7.2 for 300CCBC). Ammonium adsorption was best described by the Elovich kinetic model and the Sips isotherm, indicating heterogeneous chemisorption with active involvement of hydroxyl groups. The process was confirmed to be spontaneous and highly endothermic ($\Delta H^\circ 124 \pm 9 \text{ kJ mol}^{-1}$), characterized by strong chemical interactions. Conversely, for nitrate removal, 700PFBC demonstrated significantly enhanced efficiency compared to untreated 700CCBC. The optimal performance occurred under acidic conditions (pH 2), where the plasma-induced incorporation of nitrogen-containing functional groups imparted a positive surface charge below the elevated PZC (from 7.2 to 8.1), favoring anion binding through electrostatic attraction. Kinetics were best represented by the Pseudo-Second-Order model, and equilibrium data strongly fit the Langmuir isotherm, indicating monolayer adsorption with a maximum capacity of $6.4 \pm 0.8 \text{ mg g}^{-1}$. The nitrate removal process was also confirmed to be spontaneous and endothermic.

Conclusions/Key Messages:

AAPT successfully tailored CCBC for enhanced nitrate removal by optimizing surface charge for anion uptake, but it was less favorable for ammonium adsorption due to the loss of key functional groups.

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IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

Insight into the Magnetic Coagulation Separation for Black-Odor Water Restoration

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Keywords: Magnetic coagulation; DOM; black-odor water; water body restoration

Abstract: Black-odor water is still a world challenge, especially in developing countries. This study investigated the performance and DOM removal mechanism of Magnetic Coagulation (MC) for water reclamation. MC showed excellent removal efficiency in different scenarios, microbial-derived tryptophan-like, tyrosine-like, and humics, and aromatic DOM with high MW and polarity were preferentially removed. PAC was pivotal for dissolved pollutant removal, while the mix stage facilitates low-MW or humic-like DOM removal via PAM-promoted floc formation. This study provides theoretical support for its application in natural water protection.

Introduction:

The wastewater treatment industry advanced remarkably worldwide, but the black-odor water is still a global challenge. Coagulation is widely used for wastewater treatment and pollutant reduction, while MC forms high-density magnetic flocs and boosts highly efficient solid-liquid separation. However, the removal efficiency and mechanism of DOM, a key contributor to water blackening, odor, and eutrophication, are still understudied. The spectroscopic technologies are widely applied for DOM study, but are rarely used in black-odor water restoration. It was believed to provide new insights for wastewater DOM transformation.

Methodology:

This study investigated 3 MC stations with distinct water qualities; samples were collected at each stage of the MC process. Basic water parameters (pH, EC, turbidity, COD, TOC, N, P) were measured using standard methods. Colored dissolved organic matter (CDOM) was characterized via UV-Vis spectroscopy, with absorbance indices calculated and 2D-COS applied to resolve spectral peaks. Fluorescent dissolved organic matter (FDOM) was analyzed by 3D-EEM; FRI and peak-pick methods were used for composition analysis, and PARAFAC was employed for DOM fractionation.

Findings/Results:

MC removed 52.54–79.55% of TCOD and 18.35–50.21% of TOC in all 3 MC stations. SCOD/TCOD rose to ~76%, showing preferential removal of suspended/colloidal organics. PAC was the key for DOM removal via the hydrolyzed Al adsorption. TP and PO_4^{3-} -P removal rates were 82–87% and 71–94%; dissolved P was removed via coprecipitation/adsorption. UV-Vis spectra revealed the DOM difference in different stations: A had peaks at 197/226 nm; B showed a peak at 195 nm and a shoulder at

211 nm; C had peaks at 196/224 nm, which was similar to A. 2D-UV-COS identified an auto-peak at 230 nm, revealing that the conjugated DOM with high MW and hydrophobicity is the target DOM. The PCMW2D spectra showed that DOM removal stages varied by station; the mix stage is the key

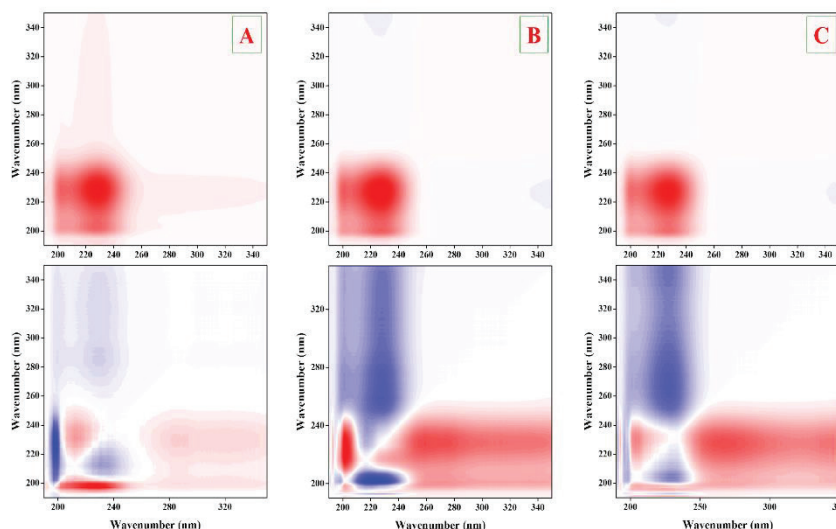


Figure 1: The 2D-UV-COS spectra of the wastewater during MC processes in three stations (above: synchronous spectra; bottom: asynchronous spectra)

process for DOM removal of wastewater with high COD. The FRI results showed that tyrosine-like and tryptophan-like DOM were the dominant DOM in MC. Three DOM components were identified by PARAFAC: C1 (tryptophan-like, microbial), C2 (tyrosine-like, high aromaticity), and C3 (humic-like). C2 was preferentially removed by PAC. However, the recycled seeds and residual PAM affected the DOM content, thus optimization of MC was needed for different application scenarios.

Conclusions/Key Messages:

MC exhibited excellent performance and strong adaptability in rural and non-pipeline-covered areas. The key DOM components were identified as tryptophan-like, tyrosine-like, and humic substances, while MC primarily targets C2. PAC is critical for removing dissolved pollutants via adsorption, and the mix stage facilitates the removal of DOM with low-MW and high humidification degree by PAM. However, the residual PAM and redissolved DOM from recycled magnetic seeds should be modified to optimize the operation, thus exploiting potential of MC in natural water protection and expand its practical application.

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IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

Development of a Gel Flow-Electrode Microbial Fuel Cell for Efficient Wastewater Treatment and Energy Recovery

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Keywords: Microbial fuel cell; Flow electrode; Fe–C gel; Wastewater treatment

Abstract: A novel microbial fuel cell (MFC) integrating gel flow-electrodes was developed to enhance wastewater treatment efficiency and energy recovery. Fe–C hydrogel particles were used as flow-electrodes, offering high surface area, excellent conductivity, and biocompatibility. Laboratory tests using synthetic wastewater demonstrated that the Fe–C gel electrodes achieved COD and phosphate removal rates up to 4 and 8 times higher than those of conventional carbon fiber electrodes, respectively. Open-circuit voltage increased by 1.5 times, while XPS confirmed the $\text{Fe}^{3+} \rightarrow \text{Fe}^{2+}$ conversion, evidencing active electron mediation. This technology offers a scalable and sustainable strategy for carbon-neutral wastewater management and is expected to overcome the long-standing technological bottlenecks of MFCs.

Introduction:

Microbial fuel cells (MFCs) have emerged as a promising technology for simultaneous wastewater treatment and energy recovery, directly converting the chemical energy of organic pollutants into electricity via the metabolic activity of electroactive microorganisms. However, despite decades of research, MFCs still face significant challenges, including low power output, high internal resistance, and limited microbial attachment on conventional fixed electrodes, which have hindered their large-scale application and commercialization.

To address these limitations, this study introduces a flow-electrode microbial fuel cell that replaces solid anodes with flowing Fe–C/activated carbon hydrogel particles. The flow-electrodes integrate the high conductivity of Fe–C materials, the capacitive behaviour of activated carbon, and the bioelectrocatalytic activity of electrogenic bacteria. This configuration enhances the reaction surface area, facilitates efficient electron transfer, and maintains long-time power output under continuous operation. The objectives of this research are to: (1) Compare the electrochemical characteristics of various self-synthesized flow-electrode materials; (2) Characterize the physicochemical properties of the flow-electrode materials; (3) Conduct mini-cell experiments using the flow-electrodes.

Methodology:

The gel, Fe–C materials, and powdered activated carbon were mixed at a 9:1 mass ratio and fabricated into gel electrode particles via jet extrusion molding. The particles were mixed with *Shewanella* spp. suspension and anaerobically co-cultured at 35 °C for 5 days before electrochemical testing. Cyclic voltammetry (CV) and SEM–EDS were used to compare the morphology and electrochemical behaviour of different flow-electrode particles, while changes in surface functional groups, crystal structures, and valence states before and after use were characterized by FTIR, XRD, and XPS.

In the mini-cell system, the anode was a 4 × 2 cm titanium plate (chamber 5 × 5 × 2.5 cm), and the cathode was a platinum-coated titanium plate under aerated conditions (Fig. 1-A). The system operated continuously for 10–12 h with real-time OCV recording. Ammonium, phosphate, COD, BOD, and TOC concentrations in synthetic wastewater were analyzed before and after operation to assess pollutant removal performance.

Findings/Results:

According to the results from the mini-cell operation, the Fe–C gel electrode exhibited the highest removal efficiency for all pollutants except ammonium (Fig. 1-B). Because the anode operates under anaerobic conditions, it is unfavorable for ammonium removal. As a solution, a cascade treatment combining the anode and cathode is being considered as a solution. During 10 hours of continuous operation, the Fe–C gel electrode exhibited the second-highest OCV, following the Fe–C particle electrode (Fig. 1C). The voltage increase observed in the later stage was reproducible, although its underlying cause requires further investigation. The current output was lower than that of the carbon fiber electrode, due to higher internal resistance.

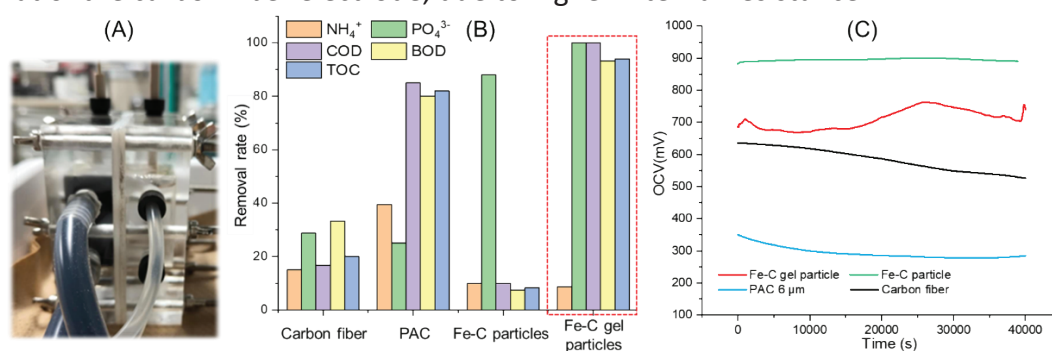


Figure 1: Pollutant removal rates (B) and OCV (C) of the mini-cell operation (A).

Conclusions/Key Messages:

1. This study successfully synthesized and demonstrated the feasibility of gel-based flow-electrodes integrated into wastewater treatment microbial fuel cells (MFCs).
2. The gel flow-electrodes exhibited superior removal performance for all tested pollutants except for ammonia nitrogen.

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Lime sludge as a sustainable alternative for soil pH correction in agriculture

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Keywords: Lime sludge; pH correction; Soil acidity; Dolomite; Calcined dolomite

Abstract: Hydrated lime is used in water treatment plants to adjust the pH in drinking water. At the National Water Supply and Drainage Board (NWSDB), hydrated lime is produced from calcined dolomite, which generates lime sludge as a by-product. This study examined the potential use of lime sludge to correct soil pH in agricultural lands and compared its effectiveness with dolomite and lime. Soil pH correction is necessary in agricultural lands for efficient nutrient absorption. A soil incubation study was carried out using soil from Udardella. Treatments with lime sludge, calcined dolomite, and dolomite were applied, and soil pH was monitored over time. Results showed that lime sludge improved soil pH more effectively than dolomite and calcined dolomite.

Introduction:

Soil acidity is a common problem in Sri Lankan agriculture specially in wet zone, as it limits nutrient availability and reduces crop yields. Farmers usually apply dolomite, while some use lime for faster pH correction. The production of hydrated lime at NWSDB water treatment plants creates large amounts of lime sludge as a by-product and it is an environmental problem. To solve this issue in a sustainable way, lime sludge is used for soil pH correction in the agricultural lands. This sludge contains calcium and magnesium, two key elements that help neutralize soil acidity and act as a plant nutrient⁽¹⁾. The objective of this research is to study the use of lime sludge to correct the soil pH and compare it with the present recommendations of the Department of Agriculture.

Methodology:

Laboratory tests were conducted to analyse lime sludge composition. The red-yellow podzolic is the type of soil which used for this study. Soil samples were collected from Udardella. The initial pH of the soil is 4.3. The soils were sieved and placed in polythene bags with 6-inch x 15-inch. Different rates of lime sludge, lime and dolomite

were used for this study. The Department of Agriculture recommendation for dolomite is 2000 kg/h. Based on that rate following treatments were applied: the Department of Agriculture (DOA) recommended rate(T1), 0.5 × DOA rate(T2), 1.5 × DOA rate(T3), 2 × DOA rate(T4), and a control with no amendments(T5). Moisture was maintained, and pH was measured in every two weeks.

Findings/Results:

Lime sludge showed 14.36 % of calcium and 16.42 % of magnesium contents, which suitable for correcting pH in agricultural lands. Heavy metal contents of Pb, Cr, As, Cd were below the permissible limits established by EU for liming materials - fertilizers, ensuring safety ⁽²⁾. The initial soil pH was 4.3. All treatments increased soil pH compared to the control, which continued to decline. Lime sludge achieved the highest pH (5.3), followed by lime (5.2) and dolomite (4.8). The pH increased rapidly in the 2-4 weeks and remained above the control for all treatments.

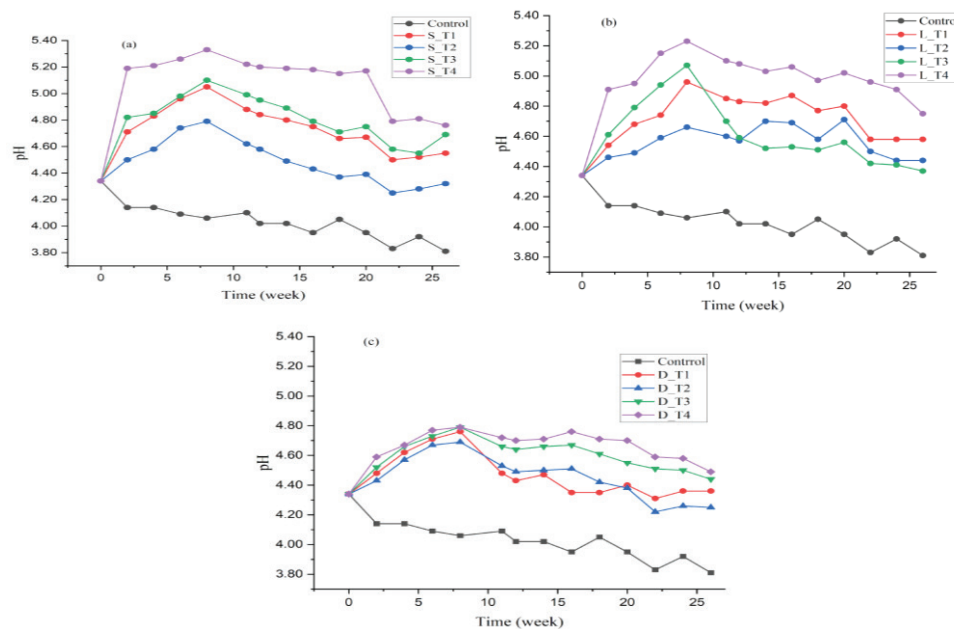


Figure 1: pH data in Udaradella soil with (a) Sludge, (b) Agricultural Lime, (c) Dolomite as soil amendment

Conclusions/Key Messages:

This study confirmed that lime sludge from water treatment is the safer, more effective, and more sustainable amendment for soil pH correction. Lime sludge reduces soil acidity more effectively and efficiently than dolomite or lime. As a low-cost by-product, lime sludge reduces waste disposal problems while supporting agricultural productivity and environmental sustainability.

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Co-Hydrothermal Carbonization of Sewage Sludge with Biomass Additives for Improved Solid Fuel Production

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Keywords: Hydrothermal carbonization; Sewage sludge; Hydrochar; Calorific value; Renewable solid fuel

Abstract: The growing generation of wastewater sludge poses environmental and economic challenges, with six major wastewater treatment plants under the NWSDB producing about 53 MT/day of dewatered sludge. Hydrothermal carbonization (HTC) offers a sustainable method to convert this waste into energy-dense hydrochar. In this study, sludge-derived hydrochar produced at 200 °C for 90 min achieved a gross calorific value (GCV) of 14.31 MJ kg⁻¹. To enhance its energy quality, it was blended with *Gliricidia sepium*, *Panicum maximum*, and *Eichhornia crassipes*. The resulting blends recorded GCVs of 21.08, 17.19, and 17.05 MJ kg⁻¹ respectively. Co-hydrothermal carbonization thus improves hydrochar energy density, making it a viable renewable solid fuel for heat and power applications.

Introduction

Wastewater sludge management has become a major environmental issue, as conventional disposal methods such as landfilling and incineration are costly and unsustainable. Hydrothermal carbonization (HTC) provides a promising alternative, converting wet biomass into carbon-rich hydrochar without the need for drying (Funke & Ziegler, 2010). Although sludge-derived hydrochar shows improved properties (Zhou et al., 2021), its energy quality remains moderate. Co-hydrothermal carbonization (Co-HTC) with lignocellulosic biomass has been found to enhance calorific value and combustion performance (Liu et al., 2021). This study explores Co-HTC of wastewater sludge with locally available biomass to improve its fuel characteristics.

Methodology

The primary wet feedstock was dewatered sludge collected from the Kandy City Wastewater Treatment Plant. Gliricidia, Panicum, and Water Hyacinth were among the lignocellulosic biomass additives that were chopped, allowed to air dry, and weighed. Dewatered sludge and biomass were combined in a 1:3 (w/w) ratio for each experiment, and the final mixture was sized to fit the 350 mL reactor chamber. Under autogenous pressure, the mixes were placed in a stainless-steel batch reactor and heated to 200 °C for 90 minutes to undergo hydrothermal carbonization. Following the reaction, the reactor was allowed to cool to ambient temperature, and the resulting hydrochar was filtered out of the liquid phase. After the hydrochar was oven-dried at 100°C, standard analytical techniques were used to ascertain its fuel characteristics, including its calorific value.

Findings/Results

Hydrochar derived solely from sludge showed a GCV of 14.31 MJ kg⁻¹. Co-HTC with lignocellulosic biomass significantly improved energy content, with Gliricidia sepium yielding the highest GCV of 21.08 MJ kg⁻¹, followed by Panicum maximum (17.19 MJ kg⁻¹) and Eichhornia crassipes (17.05 MJ kg⁻¹). The enhancement is attributed to higher fixed carbon and lower ash content contributed by biomass materials.

Table 1.1: Calorific value of enhanced hydrochar with different biomass additives

Additive	Gross Calorific Value (MJ kg ⁻¹)
Panicum maximum	17.19
Gliricidia sepium	21.08
Eichhornia crassipes	17.05

Conclusions/Key Messages

Hydrothermal carbonization effectively converts wastewater sludge into a solid fuel with moderate calorific value. Co-hydrothermal carbonization with lignocellulosic biomass, particularly Gliricidia sepium, significantly enhances energy potential. These findings support Co-HTC as a sustainable option for wastewater sludge management and renewable solid fuel production.

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Session 09

Water Safety in Rural and Community Based Water Supply Systems

Session Chair	Mr. Sajjan Jayasiriwardhana
Session Co-chair	Dr. Madhusa Sudasinghe
Rapporteur	Mr. D.N.P. Welikala



IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

Functionality of Arsenic-Iron Removal Plants in Water-Challenged Rural Areas of Bangladesh

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Keywords: Arsenic-Iron Removal Plants (AIRPs); functionality; multivariate regression; sustainability

Abstract: Arsenic-Iron Removal Plants (AIRPs) are vital for safe drinking water in rural Bangladesh but often face operational failures. This study surveyed 190 villages across 11 districts to identify factors affecting AIRP functionality. Multivariate regression revealed that system age, water source reliability, and user financial contributions significantly influence performance. AIRPs with professional maintenance, good water quality, and community support were more likely to remain functional. Findings highlight the need for durable design, financial sustainability, and community engagement to ensure the long-term success of AIRPs and similar decentralized water systems.

Introduction:

Ensuring a sustainable drinking water supply remains a significant challenge in rural regions of Bangladesh. The complex and interconnected relationships among technical, social, financial, institutional, and environmental factors influence the functionality of rural water infrastructure in developing countries (Walters and Javernick-Will, 2015). Community-level Arsenic-Iron removal plants (AIRPs), a nationally promoted option for treating arsenic-contaminated groundwater, are experiencing operational problems and frequent malfunctions, often leading to abandonment. Maintenance costs, suboptimal system design, component failure, and scarcity of available groundwater could have contributed to service dysfunction. This study aims to determine the linkages between the functionality of the AIRPs and these factors, and to identify and prioritize factors associated with their long-term sustainability.

Methodology:

A conceptual framework was developed to identify the various factors that may have a reasonable association with the functionality of an AIRP. A questionnaire survey was administered to collect information on installation age, well yield, tariff contribution, willingness-to-pay, repair responsibility, O&M, and external support received by the community. A multivariate regression analysis was performed, and only those factors exhibiting a statistically significant ($p < 0.05$) association with the outcome were included in the final interpretation.

Results:

AIRPs installed more than 8 years ago were found to be 10 times less likely to remain functional than those installed 4-8 years ago (adjusted odds ratio (AOR)=0.1; 95% confidence interval (CI)=0.0-0.4). AIRPs serving water for drinking and cooking were over 6 times more likely to be functional than those used solely for drinking (AOR=6.2; CI=1.1-33.9). AIRPs are 10 times less likely to remain functional when alternative water sources are available (AOR=0.1; CI=0.0-0.7). The absence of earthworms and/or insects in the AIRP aeration chamber and filter media has higher odds of being functional than in systems where they are present (AOR=14.3; CI=2.2-95.2). AIRPs connected to reliable wells were over 6 times more likely to remain functional than those connected to wells with insufficient yield (AOR=6.4; CI=1.1-36.6). AIRP systems that incorporate user tariff contributions were 13 times more likely to be functional than those that do not (AOR=13.2; CI=2.2-79.8). Functional AIRPs were also associated with users having a high willingness-to-pay (AOR=6.9; CI=1.1-42.1), AIRPs delivering water with good physical properties (AOR=8.9; CI=1.6-48.9), AIRPs with a professional cleaning team (AOR=6.9; CI=1.4-34.2), and users receiving regular capacity-building support from external agencies (AOR=4.7; CI=1.0-22.1).

Conclusions:

Functionality of AIRP was found to be closely tied to multiple interrelated factors. Older systems tend to be less reliable, underscoring the importance of durable construction and timely upgrades. Financial contributions through user tariffs provide maintenance resources and promote a sense of ownership. Professional cleaning and technical maintenance significantly enhance performance, while community training and involvement foster local capacity for sustainable operation. This study offers valuable insights into the underlying factors influencing AIRP functionality and provides guidance for enhancing existing AIRP interventions with broader applicability to other decentralized water systems.

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Promoting Active Youth Participation in Water Safety Plans in Community Based Organizations through Digitalization and the Clean Sri Lanka Initiative

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Keywords: Water Safety Plan; Youth Participation; Digitalization; Community-Based Organizations; Clean Sri Lanka Initiative

Abstract: Community-Based Organizations (CBOs) are essential for safe rural water supply in Sri Lanka, yet low youth engagement and limited technical capacity constrain their effectiveness. This study examines how digitalization and the Clean Sri Lanka Initiative can strengthen youth participation in Water Safety Plans (WSPs). Based on field visits to five rural CBOs, findings show that mobile applications, online training, and social media improve transparency, efficiency, and accountability while motivating youth through digital engagement and incentives, supporting sustainable and modernized community water governance.

Introduction

Community-Based Organizations (CBOs) play a central role in rural water management in Sri Lanka under the Department of National Community Water Supply (DNCWS). However, nearly 50% face financial and technical constraints that limit effective Water Safety Plan (WSP) implementation. A major gap is low youth participation due to migration and lack of incentives. This study examines how digitalization and the Clean Sri Lanka Initiative can strengthen youth engagement and improve the sustainability of CBO-led water management.

Methodology

This study used a qualitative approach with five rural CBOs in Badulla, combining field visits, document reviews, and interviews with staff and youth. It explored barriers to youth participation, evaluated existing Water Safety Plan practices, and assessed digital tools—such as mobile apps, GIS mapping, online training, and social media—to enhance engagement. The Clean Sri Lanka Initiative provides a national framework promoting transparency, accountability, and community-driven water management. By integrating digital tools with this initiative, youth can actively participate in

monitoring, reporting, hazard identification, and awareness campaigns, motivated by recognition and incentives, strengthening sustainable rural water governance.

Findings / Results

Through the Field observations and discussions from five rural CBOs in Badulla show that youth engagement will be increased significantly when activities are modernized and skill-oriented. As a case study it has observed that the Bill system in Meedumpitiya CBO in passara, has boosted reporting by 40%. A mobile-based incident reporting system can replace manual logbooks, reducing response delays and increasing reporting frequency. Youth participants valued real-time updates and digital dashboards, which strengthened transparency, accountability, and their sense of ownership. GIS-based mapping of water sources and distribution systems will be attracted technically interested youth, particularly school leavers and diploma holders. Their involvement will be improved hazard identification and risk mapping while providing practical skills relevant to employment. Social media-based awareness campaigns further will be enhanced youth visibility and improved community communication. Participation will be increased by approximately 20%–30% by introducing incentives such as training certificates, digital recognition, and leadership roles. These experiences align with the digital governance framework of the Clean Sri Lanka Initiative, demonstrating that digital integration can strengthen accountability, efficiency, and sustainable youth participation in rural water management.

Conclusions / Key Messages

Digital transformation offers a powerful mechanism to modernize rural water governance and encourage youth participation in Water Safety Plans. By leveraging mobile technology and online education, CBOs can enhance efficiency, reduce administrative burdens, and increase youth engagement. The Clean Sri Lanka Initiative serves as a national platform to integrate these innovations, supporting transparent, inclusive, and sustainable community-based water management. Ultimately, empowering youth through digital tools ensures the long-term success of WSPs and contributes to Sri Lanka's vision for a clean and resilient future.

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IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

Improving Water Safety in Rural Community-Based Water Supply Systems: Evidence from Trincomalee District, Sri Lanka

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Keywords: Water Safety Plans; Community-managed water supply; Rural water safety; Microbial contamination; Sri Lanka

Abstract: Access to safe drinking water remains a major challenge in rural Sri Lanka, where many communities rely on community-managed water supply systems (NWSDB, 2019). These systems often face infrastructure limitations, weak monitoring, and inadequate risk-based management, resulting in microbial contamination and inconsistent water quality (WHO, 2017). This study assesses water safety risks and evaluates the effectiveness of WSP implementation in selected rural schemes in the Trincomalee District using sanitary inspections, water quality testing, and stakeholder interviews. Previous studies have identified similar risks in small-scale water supplies across Asia (McIntosh, 2003). The results indicate that implementing a simplified and context-appropriate WSP improved chlorination practices, record keeping, and microbial compliance, thereby strengthening community capacity and contributing to Sustainable Development Goal 6.1.

Introduction

Approximately 30% of Sri Lanka's rural population relies on community-managed water supply systems. While these systems play a critical role in improving rural water access, they frequently operate with limited technical capacity, inadequate monitoring, and weak documentation. National and international studies have identified microbial contamination, inconsistent chlorination, and poor risk management as persistent challenges. This study addresses these issues by examining water safety practices and the applicability of Water Safety Plans in rural community-managed systems.

Methodology

A mixed-method approach was adopted across ten community-managed water supply schemes located in Kuchchaveli, Gomarankadawala, and Kinniya in the Trincomalee District. Quantitative data were collected through sanitary risk inspections and microbial and physico-chemical water quality testing. Qualitative data were gathered via semi-structured interviews with Community-Based Organization representatives, Public Health Inspectors, and beneficiary households.

Findings / Results

Results showed that 70% of water sources were physically protected, yet 65% of schemes lacked regular chlorination and 45% of household samples tested positive for *E. coli* contamination prior to intervention. Approximately 80% of schemes had inadequate operational record keeping and no formal WSP procedures. Following the introduction of a simplified low-cost WSP toolkit and capacity-building activities, microbial compliance improved by 30% within six months. Chlorination frequency increased from 35% to 80%, while record completeness improved from 20% to 75%.

Table 1: Summary of Key Findings

Indicator	Before WSP	After WSP
Chlorination frequency	35%	80%
<i>E. coli</i> contamination	45%	15%
Record completeness	20%	75%

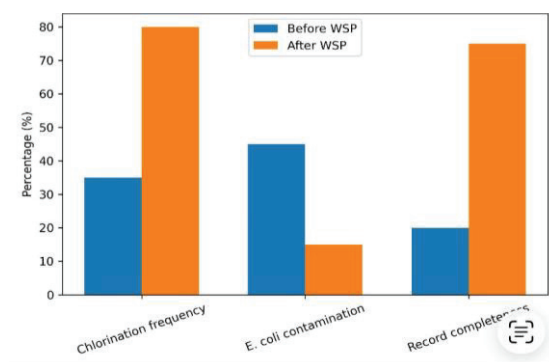


Figure 1: Trends in Key Water Safety Indicators Following WSP Implementation.

Conclusions / Key Messages

The study demonstrates that context-appropriate Water Safety Plan implementation can significantly improve water quality management and sustainability in rural community-managed water supply systems. Strengthening community capacity, routine monitoring, and institutional collaboration is essential for scaling up rural water safety interventions and achieving national and global water safety targets.

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Modified Biosorbents for the Removal of Hardness from Groundwater

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Keywords: Adsorption; Biosorption; Hardness removal; Sustainability

Abstract: Reverse Osmosis (RO) is effective for hardness removal but limited by high energy demand, brine disposal and mineral loss. This study investigates fruit peel biosorbents as sustainable alternatives for groundwater hardness reduction. Groundwater from the University of Vavuniya had an initial hardness of 650 ± 20 mg/L. Five peels—beetroot, lemon, orange, banana and pomegranate were tested in raw and phosphoric acid-activated forms. Lemon and pomegranate peels showed the highest hardness removal. Batch experiments revealed optimum doses of 5 g/L and 8 g/L with 67% and 73% removal respectively. Adsorption followed Freundlich isotherm and pseudo-second-order kinetics. Column studies confirmed batch findings with appropriate models. Phosphoric acid activation enhanced adsorption significantly.

Introduction:

Groundwater hardness, caused by calcium and magnesium ions, is a major concern in Vavuniya, Sri Lanka, where levels often exceed 600 mg/L as CaCO_3 , above WHO guidelines (Pradip et al., 2019). Hard water causes scaling, reduces soap efficiency, increases energy use, and prolonged consumption may contribute to kidney stones and CKDu.

Biosorption using agricultural waste, especially phosphoric acid-treated lemon and pomegranate peels, offers a low-cost, eco-friendly alternative (Darajeh et al., 2021). This study evaluates their effectiveness for hardness removal, improving water quality, reducing health risks and promoting sustainable rural water management.

Methodology:

Groundwater from the University of Vavuniya was analyzed within 24 hours. Lemon and pomegranate peels were washed, dried, ground, sieved and chemically treated with phosphoric acid. Preliminary tests identified the most effective biosorbents and total hardness was measured by EDTA titration. Batch experiments studied isotherms and kinetics, while fixed-bed columns were run for 24 h. Post-treatment with GAC reduced organics. Removal efficiency and adsorption capacity were modeled using standard isotherms, kinetics and breakthrough models (Saad et al. 2010).

Findings/Results:

Optimal dosages were 5 g/L for lemon peel and 8 g/L for pomegranate peel, achieving hardness removal of 66.7% and 71.3%, respectively, with adsorption capacities of 97.4 mg/g and 64.1 mg/g. Maximum removal occurred in 5 h for lemon peel and 4 h for pomegranate peel, with Elovich and pseudo-second-order models fitting the kinetics best. Adsorption equilibrium followed the Freundlich isotherm, while column breakthrough curves aligned with the Thomas model, indicating chemisorption. Combining both biosorbents effectively reduced total hardness and maintained other water quality parameters within SLS 614:2013 standards.

Conclusions/Key Messages:

This study demonstrates that lemon and pomegranate peels are effective, eco-friendly biosorbents for groundwater hardness removal. Also, pre-boiling further improved efficiency.

Figures and Tables

Table 1: The batch and column adsorption results for hardness removal

Type of adsorbent	Freundlich	Pseudo second order	Yoon-Nelson
Modified Lemon peel	$R^2 = 0.78079$	$R^2 = 0.87809$	$R^2 = 0.98617$
Modified Pomegranate peel	$R^2 = 0.81506$	$R^2 = 0.91988$	$R^2 = 0.98912$

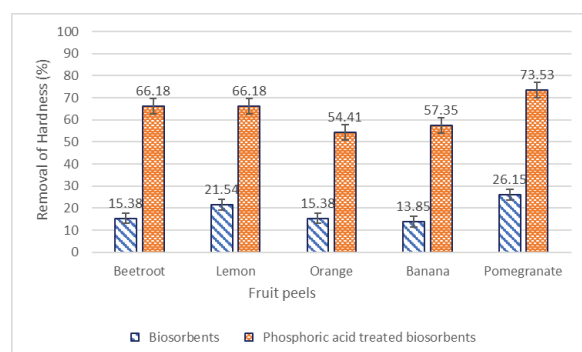


Figure 1: Comparison of raw and modified (phosphoric acid treated) fruit peels on the removal of Hardness (%) from groundwater

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Integrating Policy Coherence and water safety plan: A Conceptual Framework for Sustainable Water Governance

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Keywords: water safety plan; Policy Coherence; Sustainable Water Management

Abstract: Water resources management in developing countries often suffers from fragmented decision-making and inconsistent institutional responsibilities. The WSP framework provides a structured, risk-based tool to ensure drinking water safety through preventive management. However, without policy coherence and institutional collaboration, even technically sound WSP requirements face major implementation challenges. This study proposes a conceptual integration of Policy Coherence and WSP as an operational framework for water quality and safety management.

Introduction

Sustainable drinking water supply systems are a global priority. WSPs provide a preventive risk management approach for drinking water safety (WHO, 2023), but their effectiveness is often limited by fragmented governance and overlapping responsibilities. Policy coherence, a key governance principle for complex environmental and water challenges (Nilsson et al., 2012; OECD, 2019; Siitonen, 2016), emphasizes coordination among institutions and alignment of legal frameworks (Reyes-Mendy et al., 2014; Reyes-Mendy & Arriagada, 2018; Nilsson et al., 2020). little attention has been given to integrating policy coherence into WSPs. This study proposes a conceptual framework integrating policy coherence with WSPs to strengthen governance and long-term effectiveness.

Methodology

This study adopts a qualitative descriptive research design to develop a conceptual model integrating policy coherence with the WSP framework (Ghasem Sharabiani et al., 2018). A structured review of WSP guidelines and water governance literature identified core constructs. (WHO, 2023; Nilsson et al., 2012). Analysis was used to derive the key dimensions of policy coherence systematically. These dimensions were analytically mapped onto the principal components of the WSP to examine enabling relationships and structural linkages. The model was iteratively constructed and assessed for consistency with WHO and IWA principles.

Findings / Results

The analysis indicates that policy coherence serves as an enabling governance layer that strengthens WSP implementation. Institutional coherence clarifies roles and accountability; legal coherence ensures enforceable mandates for corrective actions. Informational coherence supports data integration, and technological coherence aligns treatment and monitoring with operational requirements (Nilsson et al., 2020; Reyes-Mendy et al., 2014). These dimensions enhance risk control and system resilience. The model highlights a feedback mechanism where operational outcomes inform policy, institutions, and technology, fostering continuous improvement and enabling sustainable WSP implementation.

Conclusions / Key Messages

Integrating policy coherence with WSPs strengthens both governance and operational performance in drinking water systems. Aligning institutional, legal, informational, and technological dimensions with WSP components enables consistent risk control, accountability, and continuous improvement. Coherent policies enhance coordination, data sharing, and technology alignment (OECD, 2019; Nilsson et al., 2012). The conceptual model's novelty lies in structurally integrating policy coherence as an enabling governance layer with the operational cycle of WSPs, highlighting its value for sustainable and resilient WSP management (WHO, 2023; Nilsson et al., 2020). The key message is clear: policy coherence is essential for sustainable, resilient, and effective WSP implementation.



Figure 1: A Conceptual Framework integrating policy coherence with WSP components.

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Session 10

Advancements in Sustainable Water Quality Monitoring, Smart Analytics and Reporting

Session Chair	Prof. Gamini Rajapakse
Session Co-chair	Mr. R.R.P.N. Rathnayaka
Rapporteur	Ms. Geethanjalee Gunathilake



IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

Optimization of Electrocoagulation Process Parameters for COD Removal from Selected Industrial Wastewater in Colombo, Sri Lanka

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Keywords: Aluminum electrodes; ferrous electrodes; sustainable wastewater treatment; current densities; electrocoagulation

Abstract: Industrial wastewater, characterized by high Chemical Oxygen Demand (COD) and complex pollutants, poses a significant environmental challenge. This study assesses the effectiveness of electrocoagulation (EC) in treating high-COD industrial wastewater from selected industries in Colombo. Using aluminium and iron electrodes at current intensities of 25 A and 50 A for 15–30 minutes, the EC process achieved COD removal efficiencies of 61.8% and 95.0%. Aluminium electrodes at 50 A for 30 minutes produced the best results, particularly in pharmaceutical wastewater. EC also reduced TSS, TDS, and conductivity, while a natural media-based filter effectively stabilized pH. The findings highlight EC's potential as a sustainable, low-sludge, and cost-effective solution for industrial wastewater treatment in Sri Lanka.

Introduction:

Industrial wastewater management is a major environmental challenge in developing countries due to the discharge of high-COD effluents from industries such as textiles, pharmaceuticals, food processing, and tanneries. In Sri Lanka, many industrial discharges exceed Central Environmental Authority (CEA) standards for COD and total dissolved solids, necessitating more efficient and sustainable treatment technologies. Conventional biological and physicochemical methods are often ineffective for high-strength wastewater because of long retention times, high chemical demand, and sludge management issues. Electrocoagulation has emerged as an effective and environmentally friendly alternative, offering high removal efficiency with low sludge generation and minimal chemical use (Mao et al., 2023). This study assesses the potential of EC for COD removal from industrial wastewater in Colombo and identifies optimal operating conditions.

Methodology:

Industrial wastewater samples were collected from selected pharmaceutical, food processing, cable manufacturing, service center, and university facilities in Colombo. Each 30.00 L batch was treated in a laboratory-scale electrocoagulation reactor equipped with interchangeable aluminum (Al–Al) and iron (Fe–Fe) electrode pairs. The reactor was

operated at current intensities of 25.00 A and 50.00 A for treatment durations of 15.00 minutes and 30.00 minutes, respectively. Electrodes were connected in monopolar mode, and gentle mixing was maintained throughout the process to ensure uniform reaction conditions. The physicochemical characteristics of influent and treated wastewater were analyzed using the APHA (2017) standard methods. Parameters measured included pH, electrical conductivity (EC), total dissolved solids (TDS), total suspended solids (TSS), and COD. COD removal efficiency (%) was calculated as $\text{COD removal efficiency} = \frac{(\text{Initial COD} - \text{Final COD})}{\text{Initial COD}} \times 100$, with removal classified as Very High ($\geq 85.00\%$), High (70.00–84.00%), Moderate (50.00–69.00%), Low (30.00–49.00%), and Very Low ($< 30.00\%$). A natural media-based polishing filter was also introduced post-treatment for pH stabilization and further solid removal. Energy consumption was determined as $E = VIt/1000$ (kWh). Specific energy consumption per treated volume (kWh m^{-3}).

Results:

The electrocoagulation process significantly improved wastewater quality across all tested industrial samples. COD removal efficiencies ranged from 61.80% to 95.00%, depending on the electrode type, current intensity, and treatment time. The pharmaceutical wastewater showed the highest COD reduction (95.00%) using Al electrodes at 50.00 A for 30.00 minutes, due to the formation of $\text{Al}(\text{OH})_3$ flocs that effectively adsorb organic contaminants (Khandegar & Saroha, 2019). Fe electrodes performed better for service center and university wastewater, achieving COD reductions above 85.00%, indicating their suitability for low- to medium-strength effluents. The efficiency of the process increased with higher current intensity and longer treatment time, as these conditions enhanced coagulant formation and pollutant removal. However, energy consumption also increased, with SEC ranging from 4.17 kWh m^{-3} to 16.67 kWh m^{-3} , highlighting the need to balance efficiency with operational cost. Post-treatment natural filtration further stabilized pH and reduced residual TSS, improving overall water clarity. Overall, Al electrodes were more effective for high-strength effluents, while Fe electrodes performed better for lower-strength wastewater, consistent with previous studies (Mokhtari et al., 2020).

Conclusions:

This study demonstrates that electrocoagulation is an efficient and sustainable method for treating industrial wastewater in Sri Lanka. The process achieved up to 95.00% COD removal and significantly reduced TDS, TSS, and electrical conductivity. The most effective condition was Al electrodes operated at 50.00 A for 30.00 minutes. Due to its low sludge production, simple operation, and scalability, electrocoagulation is suitable for small- and medium-scale industries. Regular electrode maintenance and integration with natural filtration can further improve performance. Future studies should focus on pilot-scale applications, energy optimization, and life-cycle assessment (LCA) to evaluate practical feasibility. Overall, electrocoagulation shows strong potential as a sustainable solution for industrial wastewater pollution control.

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Competitive Adsorption and Mathematical Modelling For Micropollutant Removal in Drinking Water Treatment

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Keywords: Competitive adsorption; Activated carbon; Micropollutants; Mathematical modelling

Abstract: Understanding competition during adsorption is crucial to predict the removal of organic micropollutants (MPs) in drinking water treatment. This study combines batch adsorption experiments and mathematical modelling to evaluate competitive behaviour between solutes of different charge and polarity. Tests were performed with model organic compounds on activated carbons (AC) of contrasting surface chemistry. Experimental results reveal clear displacement effects and highlight the influence of surface charge on selectivity. Modelling using extended Langmuir-type formulations accurately described equilibrium data, providing a consistent predictive framework to anticipate adsorption efficiency under variable raw-water conditions.

Introduction

Trace organic contaminants such as pesticides, fragrances, and antimicrobial agents are frequently detected in drinking water sources. Although typically present at nanogram-to-microgram levels, their persistence and potential toxicity make their removal essential to guarantee water safety. Activated carbon adsorption remains a key barrier technology, but its efficiency is highly sensitive to the composition of the water matrix.

In natural waters, multiple pollutants coexist and compete for adsorption sites. This competition depends on molecular properties such as hydrophobicity, aromaticity, and charge, as well as on the surface chemistry and pore structure of the carbon. Predicting these interactions is crucial to optimize adsorbent use and prevent premature saturation or breakthrough (Ben Amar et al., 2024).

While traditional isotherm models (Langmuir, Freundlich) provide valuable insight for single-solute systems, they fail to capture the displacement and selectivity that occur in complex mixtures (Calvo-Schwarzwalder et al., 2025). Extended formulations introduce interaction terms that better describe multicomponent equilibria while maintaining physical interpretability. By coupling these models with batch experiments under controlled conditions, it is possible to extract adsorption parameters representative of real treatment scenarios and later translate them into column-scale simulations.

This study aims to experimentally investigate competitive adsorption between two model compounds of opposite charge and to evaluate the capacity of mathematical models to reproduce observed behaviour. The combination of experimental and modelling approaches

provides mechanistic insight into how molecular properties and surface chemistry govern adsorption selectivity, contributing to the optimization of activated carbon use in drinking water treatment.

Methodology

Three commercial powdered activated carbons (two coal-based and one biomass-derived) were selected to cover a broad range of textural and chemical properties. Two sets of batch adsorption experiments were performed: (1) under environmentally relevant conditions, using five organic micropollutants at trace concentrations (in the $\mu\text{g}\cdot\text{L}^{-1}$ range) in the presence of natural organic matter (NOM), and (2) under elevated concentrations to evaluate equilibrium behaviour and derive adsorption parameters for model calibration. Experiments were conducted in 2 L glass reactors using $100\text{ mg}\cdot\text{L}^{-1}$ of activated carbon at ambient temperature and natural pH. Samples were periodically collected over 24 hours to ensure equilibrium conditions, filtered ($0.45\text{ }\mu\text{m}$), and analysed for micropollutant quantification. NOM was measured as by UV–Vis absorbance at 254 nm to assess its potential competition for adsorption sites. Adsorption kinetics was evaluated by monitoring the concentration decay over time. Equilibrium data were obtained from both single-solute and competitive systems. The equilibrium concentration (C_e) and the corresponding adsorbed amount (q_e) were calculated from mass balances.

Results

Kinetics and selectivity: Adsorption kinetics confirmed a two-stage behaviour, with a rapid uptake during the first 30–60 min followed by a slower diffusion-controlled phase. Figure 1 shows the time-dependent removal of atrazine on two activated carbons (AC1 and AC3) in ultrapure (DI) and NOM-containing water. The faster decay observed for AC1 reflects its higher surface oxygen content and larger external area, while NOM consistently reduced adsorption rates by occupying surface sites and partially blocking pores.

Model development and validation:

Experimental data were used to calibrate a competitive Langmuir-type model formulated from site-balance considerations. The model assumes shared active sites among coexisting solutes and accounts for the decrease in affinity due to surface occupation. Parameter estimation was performed simultaneously for single and multicomponent datasets using nonlinear regression.

Conclusions

- The mathematical model developed reproduced the relative displacement trends observed in mixtures.
- The resulting parameters are physically interpretable and will be used for subsequent column-scale models
- That can support process optimization and the design of resilient activated carbon filters.

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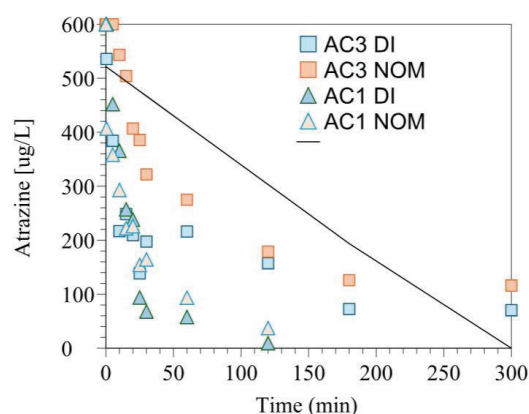


Figure 1: Adsorption of atrazine ($C_0=600\text{ }\mu\text{g}\cdot\text{L}^{-1}$) on two activated carbons ($100\text{ mg}\cdot\text{L}^{-1}$, AC1, AC3) in ultrapure (DI) and NOM-containing water.



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Development of Oyster Shell-Based Filtration Systems for the Removal of Specific Heavy Metals (Pb and Fe) from Drinking Water

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Keywords: Drinking Water; Heavy Metals (Pb, Fe); Oyster Shell; Rural Water Quality; Sustainable Water Treatment

Abstract: Access to safe drinking water remains a global challenge, particularly in rural and low-income areas where heavy metal contamination poses health risks. This study developed a low-cost, sustainable oyster shell-based filtration system for removing lead (Pb) and iron (Fe) from drinking water. Oyster shells, a seafood industry byproduct, were characterized by X-ray diffraction (XRD), confirming aragonite-rich crystalline structures ideal for adsorption. Batch adsorption and column filtration study using oyster shell media demonstrated over 95% Fe removal and moderate Pb reduction. Adsorption followed the Langmuir model ($R^2 > 0.998$), indicating monolayer adsorption. The system proved efficient, eco-friendly, and suitable for decentralized water treatment in underserved communities.

Introduction:

Access to safe drinking water is increasingly challenged by heavy metal contamination, with lead (Pb) and iron (Fe) posing serious health and aesthetic concerns (Collin et al., 2022; Abbaspour et al., 2014). Conventional treatment methods are often unsuitable for rural and low-income communities due to high costs and technical complexity. In Sri Lanka, the seafood industry generates several thousand tonnes of oyster shell waste annually, which could potentially supply enough material to support decentralized filtration systems for treating drinking water in rural areas (International Collective in Support of Fishworkers, 2021; Uresha et al., 2021). This study investigates the valorization of waste oyster shells as a low-cost adsorbent for heavy metal removal, aligned with circular economy principles and the Sustainable Development Goals (SDG 6 and SDG 12). The research aims to characterize the material, assess its adsorption performance, and develop a practical filtration prototype.

Methodology:

Oyster shells (*Crassostrea sp.*) were collected, cleaned, and processed into two forms: Full Oyster Shell (FOS) and the inner Calcium Carbonate Layer (COS). Their mineral

composition was characterized using X-Ray Diffraction (XRD). Batch adsorption studies were conducted using synthetic water contaminated with Pb (3-5 mg/L) and Fe (5-16 mg/L), testing FOS, COS, red clay, silica sand, and activated carbon. Adsorption data were fitted to Langmuir and Freundlich isotherm models. A small-scale column filtration prototype with eight different media configurations was operated continuously for 108 hours. Effluent water samples were analysed using Atomic Absorption Spectroscopy (AAS) to determine contaminant removal efficiency (CRE).

Results:

XRD Analysis: Confirmed both FOS and COS are primarily composed of aragonite (CaCO_3), with FOS exhibiting higher crystallinity and structural stability. **Batch Adsorption:** Oyster shells (FOS and COS) showed high removal efficiencies for both Fe and Pb. As shown in Table 1, the adsorption data fitted the Langmuir isotherm model best ($R^2 > 0.998$), indicating monolayer adsorption on homogeneous surfaces. As shown in Table 2, Freundlich model shows weaker fit, indicating limited multilayer adsorption and surface heterogeneity. **Column Study:** Configurations incorporating oyster shells with other media achieved >95% Fe removal, consistently reducing concentrations below the WHO limit of 0.3 mg/L. Pb removal improved over time but did not meet the stringent WHO guideline of 0.01 mg/L. A visible brown layer of ferric hydroxide formed on oyster shell surfaces, confirming Fe oxidation and deposition.

Table 1: Langmuir isotherm parameters for Fe adsorption on Full Oyster Shell (FOS)

Intercept	Slope	q _{max} (mg/g)	R ²	KL (L/g)
-0.02698	6.48627	0.154	0.9999	6.49

Table 2: Freundlich isotherm parameters for Fe adsorption on Full Oyster Shell (FOS)

Intercept	Slope	1/n	K _f	R ₂
-1.81205	-0.01441	-0.01441	0.015415	0.91154

Conclusions:

Oyster shells are a highly effective, low-cost, and sustainable filtration medium for iron removal, making them suitable for simple, decentralized water treatment systems. While Pb removal was significant, it requires enhancement, potentially through media blending or shell modification. The visible iron deposit on the shells serves as a useful indicator for filter maintenance. This approach offers a dual benefit of improving water safety and repurposing seafood industry waste.

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Pre-Ozonation as an Advanced Oxidation Process for Algal Control and Water Quality Improvement

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Keywords: Pre-ozonation; Algae removal; Surface water treatment; Water quality

Abstract: The Kilinochchi Water Treatment Plant (KWTP) treats surface water for potable supply; however, excessive algal concentrations (40,000–250,000 cells mL⁻¹) limit treatment performance. This study evaluates pre-ozonation for algal control using an ozone dosage of 0.4 mg L⁻¹ at a flow rate of 200 m³ h⁻¹. During June–August 2025, total algal removal ranged from 63–99%, with complete removal of colonial algae (100%) and high removal of filamentous algae (96–100%), while unicellular algae showed lower removal (average 62%). Total coliforms were reduced by 59.5%, and *Escherichia coli* was almost completely removed. Total iron was fully removed, while manganese, nitrite, and ammonia showed removal efficiencies of 29%, 38%, and 34%, respectively. Colour and turbidity were reduced by 87%. Pre-ozonation also enhanced coagulation and DAF efficiency.

Introduction:

The KWTP, treats surface water from the Dry Aru Reservoir using aeration, pre-ozonation, coagulation–flocculation, Dissolved Air Floatation (DAF), Filtration through Rapid Sand Filtration (RSF) and then Granular Activated Carbon (GAC), and finally through post-chlorination. Among these processes, pre-ozonation represents the first large-scale application of ozone in an NWSDB surface water treatment plant. Ozonation, a powerful advanced oxidation process, decomposes organics, oxidizes metals, and inactivates microorganisms. This study evaluates the performance of pre-ozonation at KWTP with particular emphasis on algal control, physicochemical improvements, microbial reduction, and compliance with drinking water standards.

Methodology:

Ozone was generated using a corona discharge ozone generator with a production capacity of 80 gh⁻¹ and applied at a dosage of 0.4 mgL⁻¹ to a treatment flow of 200 m³h⁻¹. Pre-ozonation was introduced immediately after aeration and prior to coagulation–flocculation. The study was conducted during the dry season from June to August 2025, a period characterized by elevated algal concentrations. Water samples were collected from raw water, post-DAF, post-RSF, and treated outlets and analyzed for physicochemical parameters and microbiological indicators. Algal identification and enumeration were performed microscopically using a haemocytometer. All analyses followed APHA Standard Methods (24th Edition).

Results and discussion:

Algal Removal Performance: Raw water algal densities ranged from 4×10^4 to 20.25×10^4 cells mL⁻¹, dominated by unicellular (*Anacystis*, *Merismopedia*), colonial

(*Gloeocapsa*), and filamentous (*Oscillatoria*) genera. Following pre-ozonation and DAF, total algal removal efficiencies ranged from 63–99%, with a mean removal of 81%. Algal removal strongly depended on morphological characteristics. Colonial algae were completely removed (100%), while filamentous algae achieved removal efficiencies of 96–100%. In contrast, unicellular algae exhibited lower removal efficiencies ranging from 18–82% (mean 62%). The reduced removal of unicellular algae is attributed to their small size, limited ozone exposure time, and relatively higher resistance to oxidative stress. Pre-ozonation significantly enhanced algal flocculation and sedimentation by rupturing colonial and filamentous cell walls, thereby improving DAF performance. However, smaller unicellular algae displayed persistence, potentially due to lower ozone exposure and resistance to oxidative attack. This finding aligns with Li et al. (2017), who reported that pre-chlorination can achieve up to 95% algal removal under optimal conditions, particularly for filamentous and colonial species.

Microbiological Removal: Pre-ozonation resulted in a 59.5% reduction of total coliforms, while *Escherichia coli* was almost completely eliminated (100%). Although ozone alone did not ensure full microbial compliance, it substantially reduced microbial loading, thereby enhancing the effectiveness of downstream chlorination.

Physicochemical Improvements: Colour decreased from 76–215 Pt-Co to 0–68 Pt-Co, achieving 59–100% removal (mean 87%), while turbidity was reduced from 7.36–20.3 NTU to 0.93–8.09 NTU (mean 87%). Total iron was completely removed (100%), demonstrating the strong oxidative capacity of ozone. In contrast, manganese removal was limited to 29%, suggesting the need for higher ozone doses or longer contact time. Nitrite and ammonia removals were 38% and 34%, respectively, indicating partial oxidation of nitrogenous compounds.

Regulatory Compliance and Treatment Integration: Pre-ozonation improved raw water quality but full WHO and SLS 614:2013 compliance was achieved only after DAF, RSF, GAC, and post-chlorination, confirming its role as a supportive pre-oxidation step.

Operational Cost, Energy Use, and Scalability: Pre-ozonation required moderate energy input for ozone generation but delivered operational benefits such as improved coagulation efficiency, reduced chemical consumption, and enhanced filter performance, partially offsetting energy costs. With optimized ozone dosage, the process is operationally stable, scalable, and suitable for application in other NWSDB surface water treatment plants facing algal challenges.

Conclusion:

Pre-ozonation at KWTP effectively improved water quality, reduced microbial load, and enhanced downstream process stability. While unicellular algae showed partial resistance, integrating optimized pre-ozonation with conventional treatment supports regulatory compliance. Further refinement of ozone dosage and contact time is recommended for better algal removal and cost-efficiency.

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IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

Assessment of groundwater quality status in Gal Oya river basin, Sri Lanka

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Keywords: groundwater; Gal Oya river basin; water quality; major ions

Abstract: The Gal Oya river basin is a major intensive agricultural region in the southeastern dry zone of Sri Lanka, which has a strong correlation to groundwater as a consequence of the flat morphology. This study assessed the physicochemical status of groundwater through the analysis of 50 water samples collected from dug wells and tube wells within the basin. In situ parameters (pH, salinity, total dissolved solids, and electrical conductivity), major cations and anions, nutrients, and heavy metals were measured using multi-parameter probes, UV-Vis spectrophotometry, titration, and atomic absorption spectrophotometry. GIS was used to visualise the spatial distribution patterns of the measured parameters. Results revealed that most parameters complied with Sri Lanka Standards (SLS 614:2013); however, elevated iron, phosphate, and chloride concentrations were detected locally, associated with natural lithology, seawater intrusion, and agricultural runoff. Calcium chloride was the prevalent water type in the region. Groundwater presently is safe for human utilization; however, anomalies indicate the necessity for sustained monitoring of groundwater, particularly in agricultural and coastal areas.

Introduction:

The Gal Oya river catchment is the primary water supply catchment for Southeastern Sri Lanka, supporting irrigation, agriculture, and domestic consumption. Groundwater is also extracted on a large scale with dug wells and tube wells; however, no detailed basin-scale quality analysis had been documented prior to this study. Most of the case studies have highlighted groundwater quality concerns linked to health issues such as chronic kidney disease of unknown etiology (CKDu) in the Sri Lankan dry zone (Udeshani et al., 2022). Hence, the groundwater quality must be checked to avoid health issues when used for human consumption. On this background, this study

aimed at conducting a quality assessment of baseline levels in the Gal Oya catchment with a focus on major ion and nutrient distribution.

Methodology:

Fifty groundwater samples were taken at a systematic grid spanning the basin, including 42 dug wells and 8 tube wells. pH, TDS, electrical conductivity, and salinity were measured using a calibrated multi-parameter. Nutrients (NO_2^- , PO_4^{3-} , SO_4^{2-}) were determined using UV-Vis spectrophotometry. Concentrations of Cl^- , CO_3^{2-} and HCO_3^- were estimated by standard titrimetric methods (APHA, 2017). Major cations (Ca^{2+} , Mg^{2+} , Na^+ , K^+) and trace metals (Fe, Mn) were estimated with atomic absorption spectrophotometry (AAS). Spatial variability of parameters was plotted in a GIS environment. A Piper diagram was used to delineate groundwater types.

Findings/Results:

The groundwater at the basin as a whole shows a chemical quality that is appropriate under SLS criteria for drinking water. Elevated Fe levels ($>0.3 \text{ mg/L}$) were noted in the north-central basin, possibly due to weathering of the lithology (Cooray, 1961). Elevated levels of phosphate ($>2.0 \text{ mg/L}$) were detected in some farmed areas, referring to agrochemical application. High levels of chloride were encountered in coastal and lowland areas due to seawater infiltration and leaching caused by agrochemicals (Chandrajith et al., 2014). Classification based on hydrogeochemical facies characterized the prevalence of Ca–Cl facies.

Conclusions/Key Messages:

Groundwaters throughout the Gal Oya basin are mostly compatible with human consumption, as most physicochemical parameters meet the Sri Lanka Standards (SLS 614:2013); nevertheless, localized anomalies in iron, phosphate, and chloride identify rising contamination potential. This study emphasizes a long-term monitoring system of groundwater, mainly for the intensive agricultural areas and along the coastal margin.

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Session 11

Effectiveness of Emergency and Incident Management in Water Supply and Sanitation Systems

Session Chair	Ms. Bettina Rickert
Session Co-chair	Prof. Bandunee Attapattu
Rapporteur	Mr. T. Suthakaran



IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

Analysis of Deflections of Reinforced Concrete Walls of Sedimentation Tank of Ranna Water Supply Scheme

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Key Words: Deflection; Sedimentation; Reinforcements; Crack Widths.

Abstract: The presented analysis concerns deflection of one of the water retaining structure walls in Ranna Water Supply Scheme, namely the Sedimentation Tank. When the water is filled into the tank, the reinforced concrete walls are deflected and it was clearly noticed at their upper most levels. It is required to find out the causes of the scenario, to manage the incident in the long run although at present they uses good operational management techniques to continue.

Introduction:

As per Cho (2023) maintenance of water retaining structures involves evaluating their performance against current and future water levels. The sedimentation tank of Ranna Water Supply Scheme, which retains water during the required detention time, is poorly performing causing non acceptable deflections in some walls (Figure1), against water loads. This research paper discusses the causes for excessive deformations of walls and will help the designers to manage the present situation ensuring safety and avoid such situations in future.

Methodology :

To identify the reasons for above deflections, a series of site visits were done to the Ranna Water Supply Scheme to identify the problem, to collect data and to carryout necessary field tests. In this process only non destructive tests were performed at site (Figure 2 & 3) to avoid any risk of further failure of the tank, if took place will affect the continuous water supply to the area. Then a numerical model was prepared using SAP 2000 analysis software to simulate the actual scenario before the design works. As per Donduren (2012) design of structures is an iterative process where the designers assume a design and then go through the analysis process. The analysis and the numerical model was done using fixed actual dimensions and unfactored loads under serviceability limit state.



Figure 1: Deflected Wall



Figure 2: Rebound Hammer Test



Figure 3: Cover meter Test

Results and Discussion:

The analysed moments of deflected walls generated by the SAP 2000 analysis software using the measured concrete strength of 27 N/mm^2 and actual dimensions of tank are presented in the Figure 4 (Analysed Moments of Deflected Wall), to be used for long term repair solutions.

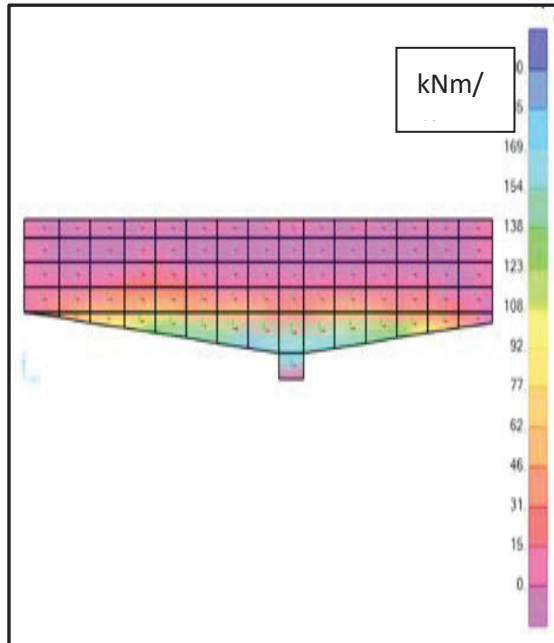


Figure 4: Analysed Moments of Deflected Wall

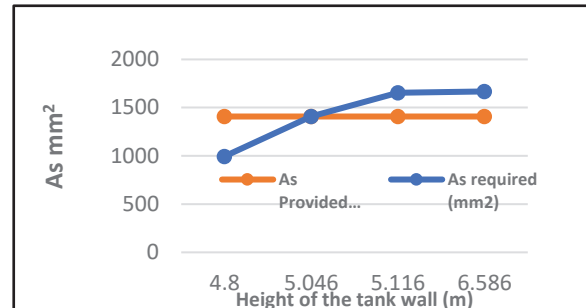


Figure 5: As required Vs Provided.

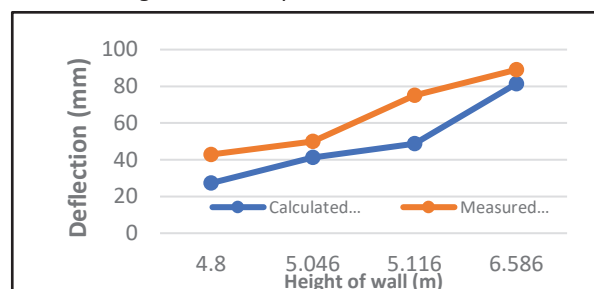


Figure 6: Calculated Vs Measured Deflections

The required steel area calculated as per BS8110 to withstand the moment at bottom in critical areas, using the actual dimensions of the structure, is much higher than the steel area provided in the given actual section of wall as described in Figure 5 (As required Vs Provided). The shear check is also not satisfactory in some area sections as per BS8110. The actual steel stresses are well above the yield stress at some places. Due to inadequate steel area and wall thickness, the calculated actual deflections of walls are excessive than calculated allowed deflections for the given actual dimensions of some tank elements. (Figure 6: Calculated Vs Measured Deflections).

Conclusions.

As per the above results, it could be concluded that the structure has permanently deformed and the concrete sections can be weaker in the bottom zones where cracks could occur. At the moment incident is well managed and using the results, a long term proposal could be given.

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Source-Specific Efficiency of Pre-Ozonation and Pre-Chlorination for Turbidity Control in Surface and Groundwater to Support Sustainable Water Safety in Northern Sri Lanka.

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Keywords: Turbidity; Pre-chlorination; Pre-Ozonation; Surface water; Groundwater.

Abstract: This study assessed the source-specific performance of pre-ozonation and pre-chlorination for turbidity reduction in selected surface and groundwater sources of Northern Sri Lanka. Surface waters (Dry Aru, Iranamadu, Paliyaru) and groundwaters (Valipuram, Manakadu, Mullaithivu) were treated with ozone (0.1–0.5 mg/L) and chlorine (0.2–4.0 mg/L) under controlled laboratory conditions. Ozonation at 0.5 mg/L achieved turbidity reductions of 38.5–92.3% in surface waters and 19.2–78.6% in groundwaters, with highest efficiencies observed in organic-rich sources. Chlorination at 4.0 mg/L provided more consistent turbidity removal (69.7–85.3% in surface water; 30.1–83.2% in groundwater) across varying water chemistries. Ozone was more effective where organic colloids dominated, while chlorine performed reliably in inorganic- and metal-rich waters. These findings show that source-specific pre-oxidation enhances turbidity control and ensures reliable water treatment.

Introduction:

Turbidity, caused by suspended organic colloids, minerals, and metals, affects water aesthetics, filtration, and disinfection efficiency, posing health risks. Pre-oxidation using chlorine or ozone is applied to reduce turbidity before filtration. Chlorination, widely practiced by the National Water Supply and Drainage Board, effectively oxidizes organic and inorganic matter but may form harmful disinfection by-products. Ozonation, a faster and stronger oxidant, was introduced at the Kilinochchi Water Treatment Plant to address these issues. This study evaluates the source-specific efficiency of ozone and chlorine in surface and groundwater to optimize treatment and promote sustainable water quality management.

Methodology:

Surface and groundwater samples from six sources in Northern Sri Lanka were treated with ozone (0.1–0.5 ppm, 15 min contact) and chlorine (0.2–4.0 ppm, 30 min contact) under controlled laboratory conditions. Turbidity was measured using a HACH 2100Q nephelometric meter, and removal efficiency was calculated as the percentage reduction from initial values. Dose–response trends were analysed to assess oxidant performance, and comparative evaluations were made between turbidity from organic-rich and inorganic-dominated waters.

Findings/Results:

Pre-oxidation with ozone and chlorine exhibited distinct turbidity removal patterns in both surface and groundwater sources. In surface waters (Figure 01), ozonation at 0.5 ppm reduced turbidity by 38.5–92.3%, with the highest efficiency observed in Paliyaru due to its high organic colloid content, while lower removal in inorganic-dominated waters like Dry Aru was attributed to limited reactivity and rapid ozone decay. Chlorination at 4 ppm achieved 69.7–85.3% turbidity reduction, maintaining more consistent performance across inorganic-rich matrices due to slower reaction kinetics and longer contact time (Torabian et al., 2007). In groundwater, ozone achieved 19.2–78.6% removal, and chlorine 30.1–83.2%, with peak efficiency in Mullaithivu, where initial turbidity and iron concentrations were elevated. Reduced ozone performance in Valipuram and Manakadu reflected the predominance of inorganic particulates, whereas chlorine's broader reactivity with both organic and inorganic constituents, including Fe and Mn oxides, enhanced overall removal (Temesgen et al., 2023). Ozone is more effective in organic-rich waters. Chlorine ensures consistent turbidity control, showing the need for source-specific pre-oxidation.

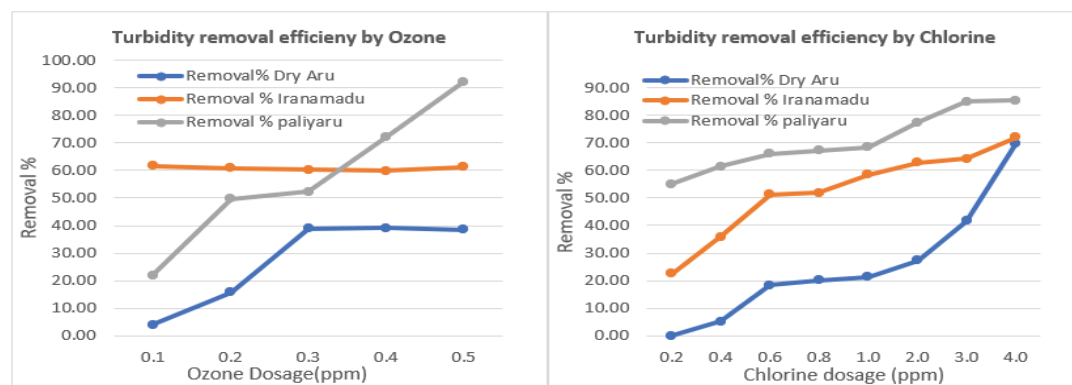


Figure 01: Turbidity removal efficiency of ozone and chlorine.

Conclusions/Key Messages:

Both pre-ozonation and pre-chlorination are effective for turbidity reduction; however, their performance is strongly source-dependent. Ozone is recommended for organic-rich surface waters and for rapid response during emergency or incident scenarios such as algal blooms or sudden runoff events. Chlorine is more suitable for inorganic- and metal-rich waters, providing stable performance and operational reliability under routine conditions. Adoption of source-specific pre-oxidation strategies, supported by continuous turbidity monitoring and integration with coagulation or filtration, can enhance treatment resilience, minimize operational risks, and strengthen sustainable water safety management in Northern Sri Lanka.

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Household Water Vulnerability and Equity across Diverse Accessibility Contexts in Sri Lanka

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Keywords: Household water vulnerability; Water equity; Socioeconomic disparities; Sustainable water management

Abstract: Access to safe and reliable water remains central to human well-being and sustainable development. Despite high national water access in Sri Lanka, local disparities persist due to variations in income, education, and several other factors. This study assesses the household water vulnerability and equity across five Grama Niladhari Divisions (GNDs) in Sri Lanka: Nawela, Suruvila, Cheddipalayam-North, Pattanichchipuliyankulam, and Pallekubura. Household Water Vulnerability Index (HWVI) was developed using survey data, integrating indicators of accessibility, affordability, adaptability, and conservation practices. Results revealed marked spatial disparities, with Suruvila (HWVI = 0.98) showing the highest vulnerability due to low income and poor water access, while Pallekubura (HWVI = 0.05) recorded the lowest vulnerability. The findings highlight that household water insecurity is driven more by socioeconomic inequality than resource scarcity, emphasizing the need for targeted policy interventions and community-based water management to achieve SDG 6 and strengthen resilience in Sri Lanka.

Introduction:

Access to safe and reliable water remains central to sustainable development and human well-being (UNESCO, 2023). Although Sri Lanka maintains high national water access, local disparities persist, particularly in rural and peri-urban regions where income, education, and infrastructure vary (ADB, 2021). Water vulnerability extends beyond physical scarcity it reflects the capacity of households to access, afford, and manage water sustainably (Sullivan, 2002; Giné-Garriga et al., 2021).

This study develops a Household Water Vulnerability Index (HWVI) to assess disparities in five Grama Niladhari Divisions (GNDs) in Sri Lanka. By integrating indicators of accessibility, affordability, adaptability, and conservation, the study identifies household-level inequities that hinder progress toward SDG 6 (Clean Water and Sanitation).

Methodology:

A structured household survey was conducted across five selected GNDs in Sri Lanka representing varied climatic and socioeconomic contexts. Thirty households from each GND were selected using stratified sampling to ensure a representative sample. The survey gathered data on Household income (monthly average), Education level of

the household, Water consumption (liters per person per day), Water supply method (piped, well, or shared source), Water conservation practices (presence or absence of water-saving behavior). After collection of the primary data each variable was normalized between 0 and 1 using the min–max normalization technique. To ensure consistency, variables where higher values represent lower vulnerability (e.g., income, education, conservation) were inverted using. Finally, the Household Water Vulnerability Index (HWVI) was then calculated as the means of five equally weighted dimensions which are stated in Equation 1.

$$HWVI = \frac{(V_{income} + V_{education} + V_{usage} + V_{supply} + V_{conservation})}{5} \quad (\text{Equation 1})$$

Depending on the HWVI values obtained the values are categorized into three classes as High Vulnerability (0.67–1.00), Moderate Vulnerability (0.34–0.66) and Low Vulnerability (0.00–0.33).

Results and Discussion:

The observed spatial variation in HWVI highlights pronounced socioeconomic disparities in household water vulnerability across the study areas. Suruvila (HWVI = 0.98) and Pattanichchipuliyankulam (0.70) emerge as highly vulnerable communities, indicating that households in these areas experience compounded challenges related to low-income levels, limited educational attainment, and restricted access to reliable and affordable water services. In contrast, Pallekubura (0.05) and Cheddipalayam-North (0.20) demonstrate strong resilience, likely reflecting higher socioeconomic capacity, better infrastructure, and greater adaptive ability at the household level. Nawela, with a moderate HWVI of 0.66, represents a transitional context where partial access to water resources exists, but socioeconomic constraints continue to influence vulnerability. Importantly, these contrasts suggest that water vulnerability in the study area is driven more by social and economic determinants than by physical water scarcity, supporting findings by Jepson et al. (2017) and Brewis et al. (2020). This underscores the need for targeted, context-specific interventions that address income security, education, and governance of water access rather than focusing solely on supply-side water availability

Conclusions:

Findings highlight that socioeconomic inequality is the key driver of household water insecurity in Sri Lanka. Strengthening adaptive capacity through equitable pricing, community education, and decentralized management can enhance water resilience (Perera & Pathirana, 2022; UNDP, 2022). The HWVI framework provides a practical tool to locate vulnerable hotspots and guide policy interventions toward achieving equitable and sustainable water access.

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Flood Hazard Potential Mapping Using GIS in Southern Province, Sri Lanka.

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Keywords: Flood hazard mapping; GIS; AHP; Southern Province Sri Lanka

Abstract: The Southern Province, Sri Lanka is particularly vulnerable for flooding due to its physiographic complexity, river basins, and exposure to the Southwest Monsoon. The aim of this study was to develop a comprehensive flood hazard potential map for Southern Province using Geographic Information Systems (GIS) combined with multi-criteria analysis. The methodology incorporated diverse datasets, including high-resolution Digital Elevation Model (DEM) data for slope and drainage density, and the rainfall data over a ten-year period of time (2014–2024) was provided by the Department of Meteorology in Sri Lanka. Proximity-based hazard indicators were generated using road and river vector datasets. These thematic layers were systematically combined using the weighted overlay technique and the analytic hierarchy process (AHP) to generate a composite flood hazard potential map using ArcGIS 10.8 software. The resulting map categorized into very low, low, moderate, high, and very high hazard zones and reveal that approximately one-third of the Southern Province lies within moderate to high hazard zones. The Nilwala and Gin Ganga basins were identified as the areas at the highest risk of flood vulnerability. Future research work in potential flood hazard mapping can incorporate seasonal and extreme rainfall events, high-resolution remote sensing data, hydrological flood modelling and projections into future climate change scenarios to enhance the accuracy while reducing the temporal dynamics and uncertainties. Overall, this study provides valuable insights to enhance resilience and sustainable development in the Southern Province of Sri Lanka.

Introduction:

Flooding is one of the most destructive natural disasters, affecting millions worldwide and causing severe environmental and socioeconomic damage, particularly in monsoon-influenced regions. The Southern Province of Sri Lanka is especially vulnerable due to the influence of the Southwest Monsoon, complex topography, and major river systems such as the Nilwala and Gin Ganga. Traditional flood management in Sri Lanka remains reactive, with limited use of spatially integrated tools. GIS models, predict and map flood hazard potential by combining various spatial datasets using analytical techniques and integrating multiple flood-conditioning factors, including rainfall, slope, drainage density, land use, and proximity to water bodies (Ahmed et al., 2022; Al-Omari et al., 2024). This study develops a GIS-based flood hazard potential map for Sri Lanka's Southern Province using a multi-criteria analysis approach to support evidence-based disaster preparedness, land-use planning, and flood risk mitigation.

Methodology:

The study used multiple datasets, including a Digital Elevation Model (DEM) from USGS Earth Explorer, to analyze slope, drainage density, and other hydrological features. Rainfall data from the Sri Lanka Department of Meteorology, verified with secondary sources for 2014–2024, and road and river vector data were also used as proximity indicators. Thematic maps of drainage density, slope, distance to rivers and roads, and rainfall were created to represent key flood risk factors. These maps were integrated using the Weighted Overlay tool in ArcGIS 10.8 and the Analytic Hierarchy Process (AHP) to produce a composite hazard map. Finally, regions were categorized by flood risk level.

Findings/Results:

The flood hazard map of Sri Lanka's Southern Province, developed using multiple thematic layers of drainage density, slope, distance to rivers and roads, and rainfall categorized the region into five hazard levels: very low, low, moderate, high, and very high. About one-third of the province falls under moderate to high hazard zones, mainly around the Nilwala and Gin Ganga basins. These low-lying floodplains with gentle slopes and high rainfall are most vulnerable, while upland and steep areas show low hazard due to rapid runoff. Rainfall and drainage density were key factors influencing flood risk, as higher precipitation and dense stream networks increased flooding potential.

Conclusions/Key Messages:

Flood-prone zones in the Southern Province are mainly in low-lying areas near the Nilwala and Gin Ganga basins, where rainfall, topography, and drainage density heighten risks. Strengthening early warning systems, enforcing land-use regulations, and improving GIS-based mapping can enhance flood resilience and support sustainable development.

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IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

Seasonal Effects of Rainfall on Nitrogen Removal, Sludge Yield and Energy Consumption in an Oxidation Ditch System: Kandy City WWTP, Sri Lanka

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Keywords: Oxidation ditch; Rainfall; Nitrogen removal; Sludge yield; Energy consumption

Abstract: This study evaluates the influence of seasonal rainfall on nitrogen removal efficiency, sludge yield, and energy consumption at the Kandy City WWTP, Sri Lanka. The system consists with the oxidation ditch with the sludge treatment by gravity thickener, screw press and drying beds. Monthly averaged operational data from 2021–2025 were analyzed together with rainfall records using correlation analysis and linear regression (Excel). Results show that monsoon rainfall increased influent flow by approximately 35–40%, leading to influent COD dilution 10–20% ($r = -0.4$) and a reduction in total nitrogen (TN) removal efficiency by about 40% during peak wet months. Sludge yield showed a strong positive correlation with rainfall ($r = 0.70$, $p < 0.01$), while energy consumption was more strongly correlated with rainfall-induced flow variation than organic loading. The findings highlight the need for rainfall-responsive operational strategies to improve energy efficiency and treatment stability in tropical OD systems.

Introduction:

Rapid urbanization in South Asia has intensified wastewater-related environmental impacts. In Sri Lanka, centralized wastewater treatment remains limited, making the performance of existing plants critically important. The Kandy City WWTP, employs an oxidation ditch system, which is robust but sensitive to hydraulic and organic load variations (Liu et al., 2025). Seasonal monsoon rainfall causes infiltration and inflow, resulting in influent COD dilution, biomass washout, and fluctuating aeration demand (Jessica Lawrence, 2024). Quantitative evidence linking rainfall with nitrogen removal, sludge yield, and energy consumption Sri Lanka is limited. This study addresses that gap using long-term operational data.

Methodology:

Monthly averaged data (2021–2025) on influent flow, COD, effluent NH_3N , sludge yield, and energy consumption were obtained from plant records. Daily Rainfall data were

collected from the Peradeniya meteorological station located approximately 500m away from the WWTP. Seasons were defined as Southwest Monsoon (May–September), Northeast Monsoon (December–February), and Inter-monsoon periods (March–April and October–November). Statistical analysis included regression analysis, correlation matrices for to determine the strength and nature of relationship among parameters.

Results and Discussion

During monsoon periods, rainfall-induced inflow and infiltration generate short-term hydraulic surges that may temporarily approach or exceed process design limits, even when average flows remain below capacity. This interaction between gradual connection growth and episodic rainfall-driven flow variability explains the observed influent COD dilution, biomass washout, reduced nitrogen removal efficiency, increased sludge production, and elevated energy demand.

Linear regression analysis confirmed significantly higher influent flows during monsoon seasons, with rainfall showing a strong positive correlation with flow ($r = 0.9$, $p < 0.0001$). Influent COD concentrations decreased during the first monsoon rainfall period, with mean reductions of approximately 10–20% observed in 2021, 2022, 2023, and 2025, whereas COD variations during the second monsoon period were comparatively minor and not statistically significant. Monthly COD variability was also influenced by differences in rainfall duration and sampling timing.

Regression analysis indicated a weak negative relationship between influent flow and TN removal efficiency ($b = -5 \times 10^{-5}$, $R^2 = 0.08$), suggesting reduced nitrogen removal performance at higher hydraulic loading rates, although flow alone could not explain the observed variability. In contrast, sludge yield increased significantly with rainfall ($b = 0.067$, $R^2 = 0.7$), while energy consumption correlated more strongly with rainfall and flow ($r = 0.55$) than with organic loading, confirming rainfall-driven aeration and pumping demand

Conclusions

Seasonal rainfall significantly influences oxidation ditch performance at the Kandy City WWTP. Monsoon-driven flow increases reduce nitrogen removal efficiency while increasing sludge yield and energy consumption. Incorporating rainfall forecasting into operational control, particularly for aeration and sludge handling, can improve treatment stability, energy efficiency, and climate resilience of wastewater infrastructure in Sri Lanka.

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Session 12

Innovations and Technological Advancements in Water Reclamation and Sustainable Reuse Practices

Session Chair	Prof. E.P.N. Udayakumara
Session Co-chair	Mr. D.N.De.S. Gunathilake
Rapporteur	Ms. D.G.N. Kumari



IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

Integration of Novel Suspended Bio-S⁰ Filters for High-Performance and Short-Process Sulphur Autotrophic Denitrification from Low-Wastewater C/N

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Keywords: Elemental sulphur; suspended filters; autotrophic denitrification

Abstract: Sulphur-based autotrophic denitrification (SAD) is an alternative for eliminating N from COD deficient wastewater; however, it extends process. Herein, novel suspended bio-S⁰ filters embedding S⁰ and bacteria were devised. These filters removed 65.79% - 74.09% NO₃⁻-N via SAD at a stoichiometric ratio of 5.59 mg SO₄²⁻/mg NO₃⁻-N, simultaneously with 25% -35% by heterotrophic denitrification. A 30-d lifespan of those filters was indicated by high NO₃⁻-N removal in sequencing batch reactors simulating the anoxic zone of A2/O process. Increased abundance of dominant SAD genera, *Thiobacillus* and *Ferrirophilum*, and unclassified f PHOS-HE36 suggests their key role in mixotrophic denitrification. Moreover, the lignin addition enhanced the filters stability, as revealed by reduced pore volume and TOC release. The suspended filters realize high denitrification performance, showing promising application prospects in fluidized bed wastewater treatment systems.

Introduction:

Elemental sulphur (S⁰) is non-toxic, easily available, cost-effective, and stable, garnering wider attention in real-world applications to treat low C/N ratio wastewater. However, use of S⁰ directly or in column (Ma et al., 2024) generally produces a large quantity of SO₄²⁻ by product and extends process flow. Therefore, to avoid these bottlenecks novel suspended bio-S⁰ filters were constructed via chemical modification and applied in the simulated anoxic zone of anaerobic-anoxic-oxic reactors to shorten the traditional SAD treatment process and reduce byproduct production through synergistic autotrophic-heterotrophic denitrification.

Methodology:

The immobilization of the S^0 and bacterial cells was performed using the common boric acid cross-linkage method using PVA and sodium alginate (SA) and named as suspended bio- S^0 filters. To modify the suspended bio- S^0 filters, glycerol and lignin were added to the solution of PVA/SA before autoclaving. The stability of filters were determined by measuring total organic carbon (TOC). To study morphology, pore volume/size and chemical composition of filters, SEM, BET, FTIR, and XPS, respectively were conducted. To demonstrate autotrophic-heterotrophic denitrification, batch experiment was conducted. Likewise, to determine the working life of suspended bio- S^0 filters, four sequencing batch reactors of 1 L working volume and suspended with different types of suspended bio- S^0 filters were operated. Sludge and suspended bio- S^0 filters samples from each reactor were collected for microbial community and function analysis using illumina sequencing for 16s rRNA.

Findings/Results:

The results reveal that the novel suspended filters can remove 65.79% - 74.09% NO_3^- -N via SAD at a stoichiometric ratio of 5.59 mg SO_4^{2-} /mg NO_3^- -N, while heterotrophic denitrification simultaneously removes 25% -35% (Koju et al., 2025). A 30-d working life was indicated for the filters was based on their high removal of nitrate through fluidization in sequencing batch reactors simulating the anoxic zone of the A2/O process. An increase in the abundance of two dominant and positively correlated genera associated with SAD, *Thiobacillus* and *Ferritrophicum* ($R=0.8$, $P < 0.05$), and the abundance of heterotrophic denitrifiers such as unclassified f PHOS-HE36 were evidenced by 16s rRNA sequencing. Moreover, the addition of lignin improved the stability of lignin (L)-modified suspended bio- S^0 filters compared to Glycerol (G)-modified suspended bio- S^0 filters, as revealed by the reduced in volume ($0.009 \text{ cm}^3 \text{ g}^{-1}$) and lower release of total organic carbon (TOC).

Conclusions/Key Messages:

Novel chemically modified suspended bio- S^0 filters were successfully prepared, demonstrating highly efficient denitrification contributing to 65.79 - 74.09% to SAD. The filters can be continuously used for long durations without a decline in efficiency for the removal of NO_3^- -N under fluidization and anoxic conditions in SBR, which resembles the anoxic stage of the A2/O process. The production of SO_4^{2-} was less than the theoretical value (stoichiometric ratio of 5.59 mg SO_4^{2-} /mg NO_3^- -N), supporting reduction in the production SO_4^{2-} as a result of SAD followed by heterotrophic denitrification. These results were assisted by the abundance of two dominant SAD bacteria (*Thiobacillus* and *Ferritrophicum*) and heterotrophic bacteria (*Candidatus competitor*, and *unclassified f Comamonadaceae*). Therefore, these novel suspended filters can be applied in the anoxic stage of A2/O process to treat low C/N ratio municipal wastewater and shorten the treatment process in practice.

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Institution-Led Integrated Water Supply Model for Climate-Stressed Regions of Bangladesh

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Keywords: climate resilience; salinity intrusion; integrated water supply; reverse osmosis; rainwater harvesting

Abstract: The southern region of Bangladesh faces severe freshwater scarcity due to salinity intrusion, arsenic contamination, and climate-induced hazards. Chandkhali Union in Paikgacha Upazila exemplifies this crisis, where traditional water sources have failed, leaving communities dependent on seasonal rainwater and unsafe surface water. To address this challenge, an integrated water supply system was implemented at an educational institute specifically at madrassa, combining a 1,000 L/hr Reverse Osmosis (RO) plant, rainwater harvesting, and a smart card-operated water ATM. The system is operated and managed by the institute authority under an institution-led model, where revenue from water sales supports operation and maintenance (O&M) and institutional welfare. The system serves 1,770 people, including 300 households and 319 students and staff, ensuring year-round access to safe drinking water. The total initiative cost was USD 16,925, with institutional co-financing covering 15% of the cost. Post-intervention, water quality improved significantly, meeting national standards. Improved water quality contributes to reducing waterborne diseases, increasing school attendance, and enhancing gender equity. This case demonstrates a sustainable, scalable, and climate-resilient water solution for climate-stressed regions of Bangladesh.

Introduction:

Chandkhali Union, the largest in Paikgacha Upazila of Khulna District, lies in Bangladesh's vulnerable southern belt and faces chronic freshwater scarcity due to salinity intrusion, arsenic and iron contamination, and seasonal rainfall variability. WaterAid studies show that deep tube wells have failed, while shallow wells contain unsafe levels of salt, iron, and arsenic. Groundwater is heavily polluted with high salinity, iron, and turbidity, and no functional tube well exists within a 2 km radius. An existing PSF (Pond Sand Filter) was found to be old and ineffective, creating the need for an alternative solution. Rainwater remains the only safe water source, with annual rainfall of about 1,711 mm in Paikgacha, though it is insufficient during the dry season. As a result, women and children often travel long distances to collect water from unsafe ponds, causing health risks, time loss, and disruption to education. To address

this, a targeted community-inclusive intervention was introduced to ensure year-round access to safe drinking water.

Methodology:

The integrated water system installed at a madrassa combines groundwater treatment with rooftop rainwater harvesting to reduce salinity and pressure on aquifers. The institute authority manages the system, while trained teachers oversee daily operations, maintenance, and recordkeeping. Revenue generated through a smart card system is deposited into a joint account and used for operation and maintenance, filter replacement, electricity, and minor repairs. This model financially sustains the system while benefiting the institution and 300 surrounding households.

Results:

The initiative benefits 1,770 people, including 300 households and 319 students and staff, by ensuring year-round safe drinking water. Water quality has improved significantly, achieving zero faecal coliform contamination and complying with national standards. The intervention reduced turbidity, iron, and arsenic by 100% and chloride by 95.4%, resulting in overall water quality improvement exceeding 97%. These improvements reduced waterborne diseases, improved school attendance, and decreased household time and financial burdens related to water collection by 60%. Since groundwater in the area contains high salinity, treatment produces brine. When only groundwater is treated, about 50% becomes usable drinking water, while 50% is brine. With rainwater, about 80% becomes usable with only 20% wastage. When mixed, the system produces 65-70% usable water. Rainwater use also protects the filtration system and extends its lifespan while reducing the workload of women and girls.

Conclusions:

This intervention shows that institution-led integrated water systems can effectively address freshwater scarcity in southern Bangladesh. By combining RO technology, rainwater harvesting, and institution-based management, the system ensures sustainability, transparency, and climate resilience. Educational institutions can serve as sustainable service providers, improving community welfare and institutional stability. With strong local ownership and significant contaminant reduction, the model can be scaled across saline-prone southern regions through partnerships with local governments, NGOs, and the private sector, and integrated into national climate-resilient water programs.

Figures and Tables

Table 1: *Changes in Water Quality through Treatment*

Parameters	Before scenario	After scenario	Standard
pH	6.9	6.8	6.5-8.5
Turbidity	85.8NTU	0 NTU	10 NTU
Iron	5.0mg/l	0 mg/L	0.3-1.0 mg/L
Chloride	1950mg/l	90 mg/L	250 mg/L
Arsenic	0.25mg/l	0.0 mg/L	0.05 mg/L

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Adsorption & Kinetic Studies of Clay- Biochar Composite in treating Laboratory Wastewater

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Keywords: Adsorption; Isotherm; COD; Composite

Abstract:

Laboratory wastewater is frequently underrepresented in wastewater management strategies despite its high pollution potential. This study evaluates the feasibility of using clay–biochar composites as adsorption media for laboratory wastewater treatment and constructed wetland design. Composite ratios of clay to biochar (1:1, 1:3, 1:5, 3:1, and 5:1) were initially assessed based on COD removal efficiency. Adsorption and kinetic studies were conducted for Clay-Neem biochar and Clay-Cinnamon biochar composites. The Freundlich isotherm model best represented the adsorption behavior, with R^2 values of 0.9931 and 0.9917, respectively. Kinetic studies indicated that adsorption capacity of 1.868mg/g and 1.624mg/g was achieved at a detention time of 2880 minutes for Clay-Neem biochar and Clay-Cinnamon biochar composites respectively. COD removal efficiency of 82% for Clay-Neem biochar (1:1) and 71% for Clay-Cinnamon biochar (1:1) was observed. The study demonstrates that clay–biochar composites provide an economically viable and environmentally sustainable option for laboratory wastewater treatment.

Introduction:

Laboratory wastewater contains chemical, physical and biological contaminants that leads to detrimental effect to the environment. Heavy metal such as As, Pb, Cd, Ni, Hg, Cr, Co, Zn, & Se are highly toxic even in minor quantities leads to kidney dysfunction, renal dysfunction, bone defects & potential long-term health effects. This study aims to design a Horizontal flow constructed wetland treatment using clay-biochar composite in treating laboratory wastewater.

Methodology:

Composite sample of a university laboratory wastewater underwent characterization, adsorption & kinetics studies. Caly sample collected from Gaint tank-Murunkan, Cinnamon biochar is a byproduct of gasification process from a hotel-Kandalama, Neem biomass from Vavuniya-underwent thermochemical processing in a brick furnace. Both the biochar, clay grinded with mortar & pestle and sieved through 150µm sieve. Clay-biochar were mixed by 1:5, 1:3, 1:1, 3:1, 5:1 mass ratios, prepared small threads and then allowed to undergo slow pyrolysis at 400°C in muffle furnace Model No Sx2-5-12.

30g of clay-biochar composite pallets prepared and stirred continuously with 1500ml laboratory wastewater. 100ml of samples were withdrawn at time 0, 3, 5, 7, 15, 30, 60, 120, 240, 480, 720, 1440, 2880 min. Then Supernatant was collected at a particular time interval and passed through a 0.45µm Nylon filtration membrane to find m/v ratio and COD testing purpose.

Results and discussions:

Influent parameter of composite sample shows pH-3.5, Electric Conductivity - 1294ms/cm, BOD₅ -16,000 mg/l, Dissolved oxygen -256mg/l, TDS -773g/l, Turbidity – 940 NTU, Fluorite – 106mg/l, COD – 27,000 mg/l. The BOD₅ removal described by First-order reaction model $C_e = C_i e^{-K_T t}$. First-order temperature dependent rate constant (K_T) was calculated using the following equation. $K_T = K_{20} (\theta)^{(T-20)}$, $K_{20}=1.35$ [Crities et al., 1994, Subalakshmi et al., 2015) Temperature=30°C, $\theta=1.06$ Hydraulic detention time (t) $= (\ln C_i - \ln C_e) / K_T$ (Reed & Brown, 1992). Among tested various proportions, 1:1 Clay–Neem and Clay–Cinnamon composites showed the highest COD removal efficiency and were chosen for further analysis. Fitting order of kinetic model is determined to be Freundlich Isotherm > pseudo first order > pseudo second order for Neem Biochar and Freundlich Isotherm > Pseudo Second Order > Pseudo First Order for Cinnamon BC-Clay composite. The data best fitted with Freundlich model with $R^2= 0.9931$ for Clay-Neem BC and $R^2= 0.9917$ for Clay - Cinnamon BC, The effect of reaction time of adsorption in to Clay-BC composite, demonstrated in Figure 1. The adsorption by the Clay Neem BC composite was better than that by the Clay-Cinnamon BC Composite. These composites exhibited a gradually increasing adsorption more than 24 h and was able to remove around 71% of COD and 82% of COD by Clay-Cinnamon BC composite and Clay-Neem BC composite respectively.

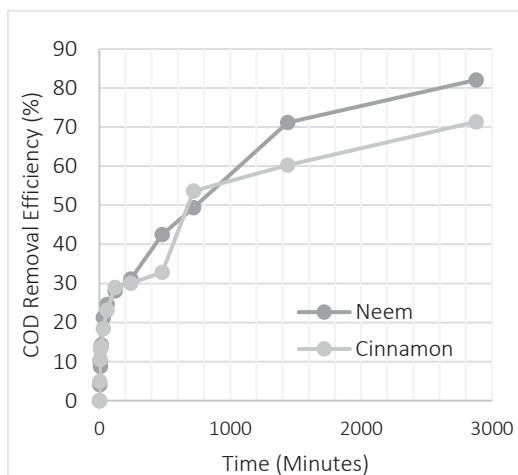


Figure 1: COD Removal Efficiency

Conclusions:

Clay: Neem BC (1:1) and Clay: Cinnamon BC (1:1) composites results higher percentage of COD removal efficiencies than other composites (1:3,1:5, 3:1, 5:1). Freundlich Isotherm model best fit for Clay: Neem BC and Clay: Cinnamon BC. These composites describe adsorption occurring on heterogeneous & amorphous surfaces. Kinetic studies express detention time of 2880 minutes takes to reach adsorption capacity of 1.848mg/g and 1.624mg/g for Clay: Neem BC and Clay: Cinnamon BC respectively.

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Evaluation of Hydrogen Sulphide Removal Efficiency of Sponge and Coconut Husk in a Biofilter when Treating Hydrogen Sulphide Generated from Sewage Treatment Plant

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Keywords: sponge; biofiltration; H₂S; removal efficiency; durability

Abstract: Two identical pilot-scale biofilters packed with sponge and coconut husk were operated for 90 days to evaluate hydrogen sulfide (H₂S) removal. The sponge biofilter showed a shorter start-up period (17 days) compared to coconut husk (23 days). Complete H₂S removal was achieved on day 29 for the sponge and day 41 for the coconut husk. The sponge maintained 100% removal efficiency throughout the study. The coconut husk achieved an average efficiency of 91% from day 41 to day 83 but declined afterward, reaching 50% by day 90 at an inlet concentration of 6 ppm. Overall, the sponge biofilter demonstrated better long-term performance and durability under a mass flux of 24.5 kg/m²·h.

Introduction:

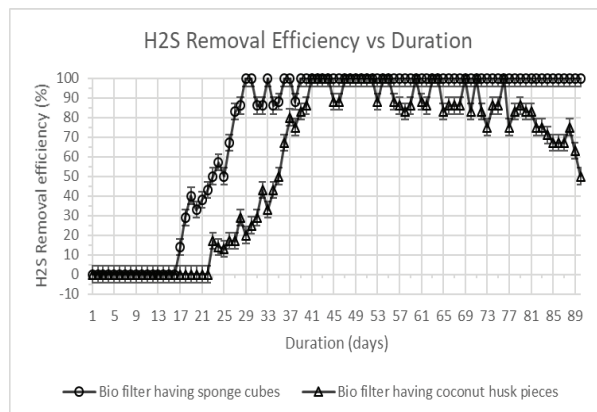
Coconut husk pieces are currently used as biofilter media at the Ratmalana Moratuwa Wastewater Treatment Plant because they are inexpensive and readily available. However, their major drawback is inconsistent performance due to low durability, requiring replacement every 3–4 months as the material decomposes. Previous studies have shown that synthetic sponge (Polyurethane Foam) possesses favourable properties as a biofilter medium. Therefore, this study evaluates the H₂S removal efficiency and durability of sponge compared with coconut husk.

Methodology:

Two transparent acrylic biofilter columns (95 mm internal diameter, 1005 mm length) with a 900 mm media height were used. One column was packed with 37.5–50.0 mm coconut husk pieces and the other with 20 × 20 × 20 mm sponge cubes. Both media were inoculated with bacteria from an existing biofilter. Odour gas from the HDPE transmission pipe was supplied through two tapping points. Humidification was maintained by intermittent spraying of treated wastewater, and inlet and outlet H₂S concentrations were measured daily for 90 days.

Results:

The variation of H₂S removal efficiency of both biofilter models against operating period is shown in the Figure 1.



Start-up time was 17 days and 23 days for sponge and coconut husk media, respectively. High surface area of sponge due to its high porosity (0.95) than the coconut husk pieces (0.62) allowed effective and efficient adsorption of H₂S prior to the biodegradation. It resulted an enhanced microbial growth and subsequently, reduced the start-up time in sponge media.

Figure 1 - H₂S Removal Efficiency

High porosity in sponge media promoted faster microbial colonization and rapid biofilm formation. It also enabled uniform airflow and improved diffusion of oxygen, water, and nutrients throughout the media. These conditions resulted in earlier H₂S removal and quicker achievement of 100% efficiency. The large pores allowed biodegradation by-products to be easily washed away during intermittent spraying, giving the sponge biofilter a longer steady-state H₂S removal period than coconut husk. The inconsistent performance of the coconut husk biofilter may be due to reduced porosity caused by accumulation of H₂S biodegradation by-products, which limited microbial attachment sites. This also trapped sulphuric and nitric acids within the media, creating toxic conditions for sulphur-oxidizing bacteria. Reduced porosity further led to uneven distribution of odorous gases, oxygen, nutrients, and water, collectively hindering microbial activity and reducing H₂S removal efficiency to 50% by the end of the experiment.

Conclusion:

The sponge media showed much higher porosity (95%) than coconut husk (62%), enabling better microbial growth and more uniform distribution of air, oxygen, water, and nutrients. Biodegradation by-products of H₂S were also more easily washed out from the sponge during intermittent spraying of treated wastewater. Its lower density helped prevent compaction and maintained adequate void spaces for airflow. As a result, the sponge biofilter achieved earlier H₂S removal, reached 100% efficiency faster, and maintained complete removal throughout the experiment at a high mass flux of 24.5 kg/m²·h. The study confirms that sponge media can effectively treat 4–8 ppm H₂S concentrations with better long-term durability than coconut husk.

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Acceptance and Demand of Non - Domestic Customers towards Treated Wastewater Reuse

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Keywords: Acceptance; Reclaimed water; Reuse; Sustainable Water Management

Abstract: With rising water scarcity, reclaimed wastewater provides a sustainable alternative for industrial, commercial, and construction uses. This study explores acceptance and demand for reclaimed water reuse among non-domestic customers in the Ratmalana/Moratuwa Wastewater Treatment Plant service area, Sri Lanka through literature review, questionnaire survey, statistical analysis, and financial analysis. Key concerns identified were water quality, health risks, reliability, and infrastructure changes. Industries with higher water demand showed greater willingness to adopt reuse. The study concludes that the industrial adoption of reclaimed water can significantly reduce freshwater demand, contributing to sustainable water management.

Introduction:

Water scarcity is a pressing global issue, intensified by population growth, climate change, and irregular rainfall. Reclaimed water is increasingly recognized as a sustainable alternative, reducing reliance on freshwater while supporting the circular economy and climate commitments (Baghapour et al., 2017; Akpan et al., 2020). Though many countries successfully implement wastewater reuse for non-potable purposes, Sri Lanka has yet to realize its full potential. Currently, the National Water Supply and Drainage Board operates 10 wastewater treatment plants, discharging approximately 80,500 m³/day of treated effluent without reuse. At the Ratmalana/Moratuwa plant, 8,000 m³/day of reclaimed water is released to the sea, representing a significant missed opportunity. This study examines acceptance, demand, and potential barriers to reclaimed water reuse among non-domestic customers, generating insights essential for sustainable water management and national climate goals.

Methodology:

A questionnaire survey was carried out to assess the acceptance and demand for reclaimed water reuse among non-domestic customers near the Ratmalana/Moratuwa Wastewater Treatment Plant. Details of type of industry/commercial institute, brief description of business, product or service, consumption, processes within industries, type of wastewater, willingness to use reclaimed water, purpose to expect using reclaimed water, wastewater discharge information, reclaimed water quality requirement and any other information were obtained during the survey. Survey data were digitized and analyzed using SPSS (version 26). Descriptive statistics were applied to assess consumption and acceptance levels, while Pearson's chi-square test identified

associations between variables such as industry type, usage, and willingness to adopt reclaimed water. Results were presented using graphs, charts, and tables using thematic analysis.

Financial feasibility was evaluated by comparing a hypothetical 500 m³/day reclaimed water project with an equivalent water supply treatment plant, considering investment, operation, and maintenance costs. For reclaimed water, only upgrading of existing wastewater treatment facilities was required, while the water supply project required new intake and treatment infrastructure.

Findings/Results:

High water-consuming sectors show greater interest in reclaimed water, recognizing its potential to reduce their operational costs and environmental impact.

Financial analysis showed that upgrading the Soysapura plant to produce reclaimed water is more cost-effective than building a new water treatment plant. Since reclaimed water relies on quality improvement of existing effluent, both capital and operational costs are significantly lower than developing new intake and treatment systems.

Overall, findings highlight strong potential for wastewater reuse projects. By addressing concerns of quality and reliability, NWSDB can foster reclaimed water adoption, support industrial demand, and strengthen Sri Lanka's climate-resilient water management. 53% of customers raised concerns on quality, health risks, complexity, and reliability. 86% of customers are willing to adopt reuse. Preferred Contract Type is Long-term agreements. Potential reclaimed water reuse applications are manufacturing industries (textiles, food processing, plastics, chemicals, painting, and concrete): prefer reclaimed water for process needs & production-line washing. Service institutions (vehicle services, hotels, packaging, soap & detergent): prefer reclaimed water for toilet flushing, landscaping, vehicle washing. Reclaimed Water Quality Expectations are 47% for drinking water quality, 30% for lower standards and 23% no preference.

Conclusions/Key Messages:

To promote reclaimed water reuse in Sri Lanka, further studies and awareness programs should be undertaken, focusing on quality, safety, and financial viability. Supportive policies, incentives, infrastructure development, and sector-specific reuse plans are essential. Long-term agreements, monitoring systems, and collaboration with local/international experts will ensure reliable supply, stakeholder confidence, and alignment with climate-resilient water management goals.

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Session 13

Climate Resilient Water Supply System

Session Chair	Prof. Thammarat Koottatep
Session Co-chair	Dr. Manjula Wijesinghe
Rapporteur	Mr. G.K. Nimalsiri



IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

Assessing the Sustainability of CBO Managed Rural Water Supply Systems in the Context of Climate Change in Sri Lanka

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Keywords: Community-Based Water Supply Systems; Climate Resilience

Abstract: Community-based organizations (CBOs) are the backbone of rural water supply in Sri Lanka's dry zone, yet their resilience under increasing climate variability remains poorly understood. This study investigates how shifting rainfall patterns influence CBO-managed water systems by analyzing consumption data (2023-2024), a decade of rainfall records (2015-2024), and household surveys. Results show that over 75% of rainfall occurs in two main seasons, with demand strongly linked to recharge dynamics ($r = -0.466$ to -0.524 in 2023), but weakening in 2024. Despite limited adoption of rainwater harvesting, natural infiltration sustained supply, while 48% of households depended on private wells. These findings suggest that strengthening artificial recharge to offset rainfall variability, upgrading infrastructure to enhance supply reliability, and improving community awareness to promote safe water use are critical steps toward building climate-resilient rural water systems.

Introduction:

Sri Lanka's dry-zone regions are increasingly vulnerable to water scarcity due to erratic rainfall and intensifying climate variability (Herath et al., 2023; Eriyagama et al., 2022), affecting groundwater recharge, tank storage, and rural water reliability (Fernando et al., 2024). Community-based water schemes and household storage are vital for coping with supply uncertainty, especially where piped networks do not reach. Although previous studies discuss governance and institutional aspects (NWSDB, 2022), few explore how rainfall variability influences demand or users' treatment awareness (Daluwatte et al., 2022). This study addresses these gaps by integrating consumption data, rainfall records, and user perceptions.

Methodology:

In the water-scarce Mahawa Pradeshiya Sabha dry-zone, four CBO-managed schemes sourcing well-water near tanks with differing treatment practices were studied. Data collected from March to May 2025 included 2023-2024 household consumption and 2015-2024 rainfall. Two surveys were conducted: 5% of households (water use, perceptions, coping) and operators (yield, treatment, drought response), which were analyzed descriptively, while rainfall and demand underwent statistical analysis.

Findings/Results:

Rainfall Patterns and Recharge: Over 75% of annual rainfall occurs during two periods (April-May, September-December), sustaining aquifers through dry months. High inter-annual variability indicates strong climatic influence.

Rainfall-Demand Relationship: A strong inverse Pearson correlation observed in 2023 ($r = -0.466$ to -0.524) weakened in 2024 ($r = -0.105$ to $+0.227$, Table 1), suggesting shifting usage patterns or climate impacts and underscoring the need for artificial recharge, demand management, and infrastructure upgrades.

Table 1: Rainfall vs. Household Demand Correlation (r) in CBO Areas (2023–2024)

Year	Avg. Monthly Rainfall (mm)	CBO1 (r)	CBO2 (r)	CBO3 (r)	CBO4 (r)
2023	170.4	-0.466	-0.524	-0.103	-0.330
2024	154.2	-0.105	-0.213	+0.227	-0.189

Indirect Recharge and Field Evidence: No households practice rooftop rainwater harvesting, but 48% use private wells. CBOs rely entirely on passive recharge (infiltration and bank filtration) near reservoirs, preventing source failure during droughts.

Implications for Water Security: Enhancing passive recharge (e.g., percolation ponds, infiltration trenches, and catchment management) significantly improves aquifer resilience. Limited user awareness regarding water treatment requires urgent education and monitoring to support health outcomes and climate adaptation.

Conclusions/Key Messages:

Seasonal rainfall is crucial for sustaining CBO-managed water supplies in Mahawa, with infiltration and bank filtration acting as passive recharge mechanisms. Increasing rainfall variability highlights the importance of artificial recharge, infrastructure investment, and community awareness. Strengthening these measures is essential to ensure reliable, climate-resilient water services in Sri Lanka's dry zone.

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IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

Impact of the Managed Aquifer Recharge (MAR) through Roof Harvested Rainwater Systems in the Dry Zone of Sri Lanka: A Case Study at Ekiriyankumbura, Rideemaliyadda

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Keywords: Groundwater; Recharge; Rainwater; Abstraction; MAR

Abstract: Groundwater depletion is a critical issue in Sri Lanka's dry zone due to increasing demand and low rainfall. Since Managed Aquifer Recharge (MAR) has been identified as a sustainable solution to restore groundwater. This pilot study assessed the effectiveness of a MAR system using roof-harvested rainwater at Ekiriyankumbura Base Hospital, Rideemaliyadda and the injection well, constructed by the Water Resources Board in 2024, directly recharges the deep fractured aquifer. Monitoring over nine months (Jan 2025 – Sep 2025) analyzed rainfall, harvested volume, and groundwater response. A total of 371.76 m³ of rainwater was injected over 9 months, suggesting a positive recharge effect. High daily abstraction (81.2 m³/day) likely masked significant level rises.

Introduction:

Managed Aquifer Recharge (MAR) offers a sustainable solution to restore groundwater levels. Ekiriyankumbura, Rideemaliyadda was selected for the study where people depend on groundwater and experience dry out of the well in during the dry season. As a solution the Water Resources Board implemented a pilot MAR project implementing an injection well at Ekiriyankumbura Base Hospital, Rideemaliyadda, Mahiyangana in December 2024 to recharge the deep fractured aquifer with roof-harvested rainwater. This study investigates the effectiveness of the MAR system in recharging the groundwater aquifer (WRB, 2024).

Methodology:

There has been a Community-Based Water Supply Project '*Puraneguma CBO*' since 2017, which extracts groundwater via a tubewell with an average daily extraction of 81.2 m³/day, located adjacent to the hospital. A monitoring well has been constructed in the Ekiriyankumbura Base Hospital. Real-time groundwater level, conductivity, and temperature data were recorded at one-hour intervals for nine months using a Van Essen CTD Diver. Precipitation was monitored through a tipping bucket rain gauge. Correlation analysis was performed to examine relationships between rainfall, recharge volume, and groundwater level variations during the study period. Stakeholder interviews were conducted with the members of the local authority, Officials from the CBO, staff of the hospital for data validation.

Groundwater pumping data was collected from the CBO records. Recharge volume was estimated using rainfall data collected over nine months (January 2025 to September 2025).

Findings/Results:

It was calculated that the total rainwater harvested from the roof is 371.76 m³ over nine-months duration and total collected volume was fed into the groundwater aquifer through the injection well. Although the prior studies clearly verify that direct rainfall has a significant effect in groundwater recharge (Hsu and Li, 2020) it was observed statistically 'No significant correlation' between precipitation and groundwater depth ($R = 0.0012$). The daily groundwater abstraction is very high (81.2 m³/day) compared to the accepted rate (32 m³/Day) and there has been a limited rainfall during the study period which also could be a reason for this observation.

Depth of the monitoring well fluctuated in between 128.09 mMSL to 144.34 mMSL. Average conductivity has been recorded 0.333 mS/cm (varying between 0.448 mS/cm to 0.284 mS/cm) (Figure 01).

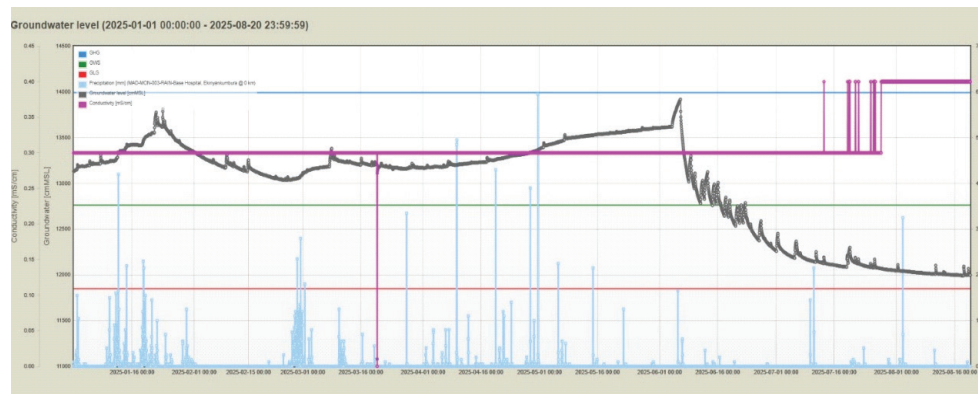


Figure 01: Variation of the groundwater level against precipitation (Jan 2025-Aug 2025)-after construction of the injection well

Based on calculations and observations, it can be indicated that the injection well has a positive impact on groundwater recharge. Unlike previous years, both the community water supply beneficiaries and the hospital met their dry-season water needs without experiencing water scarcity.

Conclusions/Key Messages:

As a pilot study it is evident that the injection well has positive impact on the groundwater level through aquifer recharge by the roof harvested rainwater. The groundwater recharge through the roof harvested rainwater systems can be introduced to public buildings to meet additional demand during the dry periods. However, the data collection period of this study can be extended to collect data over a long period of time to validate the groundwater level enhancement.

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Real-time monitoring and fuzzy control for adaptive water treatment under variable NOM and DBP risk

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Keywords: Fuzzy logic; Ozonation; Disinfection by-products; Drought resilience

Abstract

A data-driven fuzzy control strategy was developed and validated for the ozonation stage of the Figueres Drinking Water Treatment Plant (Catalonia, Spain). The system combines on-line UV254 and temperature measurements with historical operational data to optimize ozone dosage under variable raw water quality. The fuzzy inference system (FIS) translates these parameters into operational decisions using expert-based rules. After full-scale validation (2019–2025), the model achieved consistent oxidation efficiency with 8–10% lower chemical and energy use. During the 2024–2025 drought, a second fuzzy module (FIS n°2) extended the control range to address extreme increases in natural organic matter (NOM). Results demonstrate that fuzzy logic enables adaptive and interpretable control aligned with Water Safety Plan principles, ensuring water safety and minimizing disinfection by-products (DBP) risk under climate-driven variability.

Introduction

The ozonation unit of the Figueres DWTP represents about 30% of total electricity consumption. Historically, ozone dosage was adjusted empirically, with limited correlation to raw-water quality and no consistent operational criteria. As Mediterranean catchments experience increasing droughts and episodic rainfall, strong fluctuations in NOM composition challenge the stability of oxidation and disinfection processes. This study aimed to design a real-time FIS integrating sensor data (UV254, temperature) and operator expertise to optimize ozone dosage. The goal was to minimize energy and reagent consumption while maintaining oxidation efficiency and regulatory compliance for DBP precursors (Golea et al., 2017). The approach supports Water Safety by embedding adaptive, interpretable, and preventive process control.

Methodology

The controller was implemented in MATLAB using a Mamdani-type inference model with two input variables (UV254 and temperature) and one output (ozone dose). Three linguistic categories were defined for each input and five for the output. Triangular and trapezoidal membership functions were derived from 135 historical operational records (2019–2021) and refined using expert judgement from plant operators. Monte Carlo uncertainty propagation (NMC=600) quantified model robustness, while sensitivity indices following the methodology of (Godo-Pla et al., 2019) assessed input relevance. Validation combined historical replay and field testing over more than 1500 operational days, including standard and drought conditions.

Results

Data analysis and model behaviour: Figure 1 illustrates the resulting fuzzy response surface, showing how ozone demand increases non-linearly with UV254 and temperature. The surface provides a clear, interpretable representation of the controller's reasoning. Historical data showed moderate correlation between ozone dose and UV254 ($r=0.64$) but weak correlation with temperature ($r = 0.23$), indicating intuitive but unsystematic dosing. The FIS provided smoother and coherent dose predictions than historical operation, with reductions of up to 34% in ozone demand while maintaining oxidation efficiency. Monte Carlo analysis confirmed stability against moderate input noise ($\sigma = 0.002 \text{ cm}^{-1}$ for UV254, $\sigma = 0.2 \text{ }^{\circ}\text{C}$ for temperature), with narrow prediction intervals and deviations below $\pm 10\%$. Sensitivity indices attributed 54% of variability to UV254 and 46% to temperature, validating the balanced contribution of both inputs to ozone demand.

Validation under standard and drought conditions: Under normal operation (FIS n°1, 2022–2023), the controller maintained stable oxidation, reducing PAC consumption by 8% and NaClO by 9% compared to the pre-control baseline. Specific energy demand remained constant ($\sim 31 \text{ Wh}\cdot\text{m}^{-3}$) but with reduced variability. During the 2024–2025 drought, extreme reservoir drawdown (Darnius–Boadella, 11% capacity) caused a doubling of UV254 ($0.049 \rightarrow 0.114 \text{ cm}^{-1}$) and a compositional shift toward humic–fulvic fractions, determined by EEM fluorescence. The updated FIS n°2 restored adequate control, achieving UV254 reductions $> 40\%$ despite elevated NOM loads (Figure 2). Sensitivity analysis showed UV254 dominance (82% of output variance) under these conditions, confirming its role as the key supervisory parameter.

Water quality outcomes: Throughout all phases, finished trihalomethane (THM) concentrations remained well below $100 \mu\text{g}\cdot\text{L}^{-1}$, averaging $17\text{--}24 \mu\text{g}\cdot\text{L}^{-1}$. THM-FP after ozonation ranged $56\text{--}185 \mu\text{g}\cdot\text{L}^{-1}$, with peaks during drought reflecting NOM composition shifts rather than control inefficiency. The fuzzy framework successfully maintained compliance while minimizing over-dosage.

Conclusions

The fuzzy system provided interpretable and data-driven ozone control integrating operator's expertise.

Energy and reagent use were reduced without compromising regulatory water quality targets.

The dual configuration ensured adaptability under extreme drought and changing NOM conditions.

UV254 and temperature proved robust proxies for real-time process supervision.

Future work will focus on closed-loop automation and AI-based retraining to enhance autonomy.

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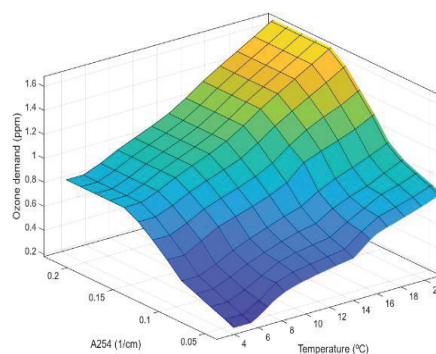


Figure 1. Response surface of the FIS showing the combined influence of UV254 absorbance and temperature on the predicted ozone dose.

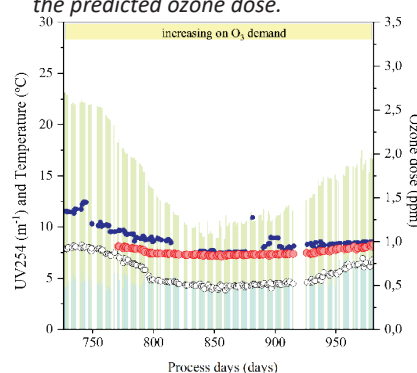


Figure 2. Field validation of the fuzzy control system. Vertical bars indicate temperature (green) and UV254 absorbance (blue). Black points show the applied ozone dose, white circles the FIS recommendation



IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

From policy to Practice: Aquatic Invasive Plants and Climate-Resilient Water Systems in Sri Lanka.

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Keywords: Biodiversity; Freshwater ecosystem; Socio-economic; Water security; Wetland management.

Abstract: Aquatic invasive plants (AIPs) are degrading Sri Lanka's freshwater and wetland systems, threatening biodiversity, water security, and livelihoods. The paper presents a narrative review of ecological, hydrological, and governance evidence on AIPs in Sri Lanka. Ten significant invasive species, including floating, submerged, and emergent forms, were identified from literature and case studies. The review highlights hydrological disruption, reduced dissolved oxygen, increased evapotranspiration, sedimentation, and reinvasion in canals, tank systems, and urban wetlands. Although biological control and mechanical removal show partial success, long-term effectiveness is constrained due to gaps among the institutions. Science-based management integrating early detection, targeted control, and ecosystem restoration is essential to strengthen climate-resilient water systems.

Introduction:

Sri Lanka's freshwater and wetland ecosystems are essential for food security, biodiversity conservation, flood mitigation, and climate resilience. However, these systems face increasing pressure from aquatic invasive plant species (AIPs) now widespread in irrigation canals, reservoirs, tank cascade systems, rivers, and urban wetlands. Early introductions of *Eichhornia crassipes* (1904–1905) and *Salvinia molesta* (1939), initially for ornamental or research purposes, have developed into persistent ecological challenges, intensified by nutrient enrichment, hydrological modification, urbanization, and climate variability. These rapidly spreading plants form dense stands that reduce light penetration and dissolved oxygen, obstruct water conveyance, accelerate sedimentation, and increase evapotranspiration, undermining irrigation efficiency, fisheries, and flood-buffering capacity. Despite national policy frameworks, including the National Invasive Alien Species Policy (2016) and National Wetland Policy (2006), management remains fragmented and largely reactive (Ministry of Mahaweli Development & Environment, 2016; Auditor General's Department, 2020). This paper identifies major AIPs in Sri Lanka, examines their ecological and hydrological impacts, synthesizes evidence across water systems, and evaluates governance constraints relevant to climate-resilient water management.

Methodology:

A structured systematic narrative review (2001–2025) synthesized ecological, hydrological, socio-economic, and governance evidence on aquatic invasive plants in Sri Lanka. An initial 1,020 records were identified from peer-reviewed and institutional sources; after duplicate removal and staged screening, 52 studies were retained for qualitative synthesis. Species were classified by growth form, and thematic analysis was conducted to identify recurrent system-scale impacts and governance gaps.

Findings/Results:

Ten aquatic invasive plant species of national significance were identified (Wijesundara, 2010). Floating species (*Eichhornia crassipes*, *Salvinia molesta*, *Pistia stratiotes*, *Ludwigia sedoides*) were linked to surface mat formation, hypoxia, canal blockage, and increased evapotranspiration. Submerged species (*Hydrilla verticillata*, *Egeria densa*, *Myriophyllum aquaticum*) reduced conveyance efficiency and altered underwater light and oxygen regimes, while emergent and semi-aquatic invaders (*Annona glabra*, *Colocasia esculenta*, *Typha* spp., *Alternanthera philoxeroides*) narrowed channels, trapped sediments, and displaced native vegetation. Case studies from the Moragoda Canal, Nachchaduwa Tank Cascade System, Metro Colombo Wetland Complex, and Muthurajawela Wetland show consistent hydrological disruption, reduced storage and flood-buffering capacity, and rapid reinvasion after mechanical removal. Biological control agents (*Cyrtobagous salviniae*, *Neochetina* spp.) have achieved partial success, though outcomes remain context-dependent and require monitoring. Invasion severity is amplified by nutrient enrichment, hydrological connectivity, and climate variability, while management effectiveness is limited by fragmented institutional responsibilities and weak early detection.

Conclusions/Key Messages:

Aquatic invasive plants represent a persistent and escalating threat to Sri Lanka's freshwater ecosystems and water security. Species-specific traits, combined with anthropogenic pressures and climate variability, drive widespread hydrological and ecological disruption. Although Sri Lanka has a relatively strong policy framework, implementation gaps and reactive control approaches limit long-term effectiveness. Effective management must move beyond site-specific clearance toward coordinated, ecosystem-based strategies integrating early detection, biological and mechanical control, hydrological restoration, and community participation. Aligning invasive plant management with irrigation planning, wetland restoration, and climate-adaptation agendas is essential to strengthen the resilience of Sri Lanka's water systems under accelerating environmental change.

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IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

Climate Mitigation through Energy Management in Water Supply - Net-Zero Transition at Ambathale Water Treatment Plant

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Keywords: Climate mitigation; net-zero; ISO 50001; Water Safety Plan; NDC targets

Abstract: Climate change demands resilient and energy-efficient water supply systems in developing nations. This study demonstrates climate mitigation benefits through reduced energy consumption and carbon emissions via implementation of the ISO 50001:2018 Energy Management System (ISO,2018), aligned with WHO Water Safety Planning principles (WHO,2017), at Sri Lanka's largest water treatment facility Ambathale Water Treatment Plant. This initiative advances climate mitigation and supports the country's national net-zero commitments (Ministry of Environment, 2021). Three years period of systematic energy management (Jan 2023 - Dec 2025), the plant achieved cumulative energy savings of 15.03 GWh, avoiding 6,104.35 tCO₂e emissions and saving LKR 354.31 million.

Introduction:

The global drive toward net-zero emissions by 2050 under the Paris Agreement presents major challenges for developing countries with limited technical and financial capacity. In Sri Lanka, the National Water Supply and Drainage Board (NWSDB) water sector is among the country's largest energy consumers.

The Ambathale Water Treatment Plant (WTP), with a design capacity of 550,000 m³/day, operates 38 high-capacity pumps consuming about 62.23 GWh annually (2022), with energy accounting for nearly 54% of operational expenditure. This makes the plant a critical target for energy efficiency and carbon mitigation.

Methodology:

The study employed ISO 50001:2018 framework (ISO, 2018) of PDCA implementation over three years (Jan 2023 - Dec 2025) at Ambathale WTP. The methodology integrated WHO WSP principles by incorporating water quality monitoring (WHO,2017) and operational control requirements into the energy management system, ensuring that energy efficiency measures did not compromise water safety.

Key methodological steps included:

1. Energy Baseline: A regression model was developed to correlate electricity consumption with water production, establishing a 2022 performance baseline.
2. SEU Identification: Nine Significant Energy Users were identified, representing 86.4% of total energy use, mainly pumping systems.
3. Performance Monitoring: Energy Performance Coefficient (EnPC) and CUSUM methods were applied for continuous monitoring and verification.
4. Operational Optimization: Low-cost measures included optimizing pump combinations, impeller trimming to reduce throttling losses, and operating pumps near the Best Efficiency Point (BEP).
5. Climate Adaptation: Seasonal river levels and raw water quality variations were incorporated into normalized energy performance evaluation.

Findings/Results:

- Total Energy Savings: 15.03 GWh & Financial Savings: LKR 354.31 million
- Specific Energy Consumption: Reduced from 0.3504 kWh/m³ (2022 baseline) to 0.2932 kWh/m³ (Dec 2025)
- Carbon Emission Reduction: 6,104.35 tCO₂e

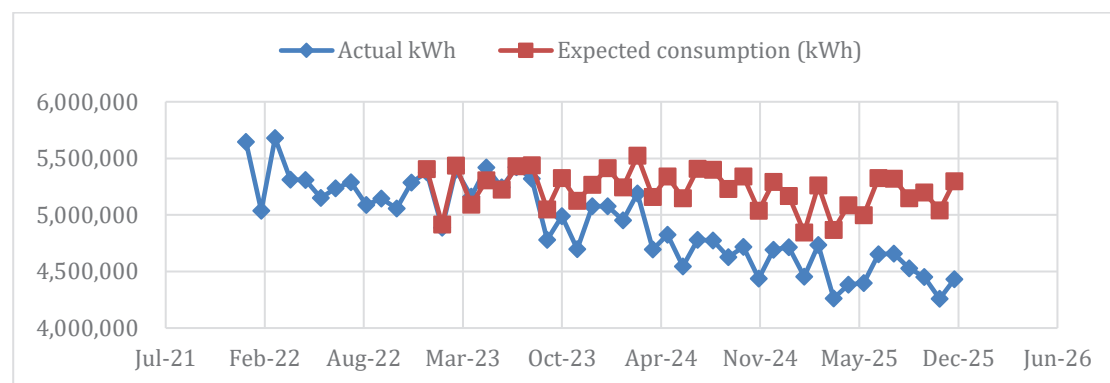


Figure 1: kWh Difference (Actual - Expected) from Jan 2022 to Oct 2025

Conclusions/Key Messages:

This study provides empirical evidence that developing countries can progress toward net-zero targets through structured energy management without relying solely on capital-intensive renewable infrastructure. The Ambathale case shows that pumping system efficiency improvements offer the most practical, high-impact pathway for water utilities. These gains create a stable foundation for future renewable integration and are now considered for replication across NWSDB systems.

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Session 14

Outcome Based Innovations in Water Supply and Sanitation Systems

Session Chair	Prof. J.M.A. Manatunga
Session Co-chair	Mr. L.K.M.C.B. Jayawardene
Rapporteur	Ms. Anparasi Sivabalan



IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

Engineering the Cognitive Orientation for NRW Reduction: Integrating Technical and Behavioural Frameworks - Murunkan Case Study

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Keywords: Non-Revenue Water; Cognitive Orientation; Behavioural Framework; Water Utility Management; Field Engineering

Abstract: Non-Revenue Water (NRW) reduction initiatives commonly focus on technical interventions such as leak detection, pressure management, and metering improvements (Farley, M et al., 2008). Field experience indicates that such measures rarely deliver sustained outcomes without corresponding behavioural alignment among operational teams. This paper presents a hybrid technical-behavioural framework implemented at the Murunkan Water Supply Scheme (WSS), Sri Lanka, where NRW was reduced from 45.7% to 12.4% within nine months. The framework integrates a structured six-step technical process with cognitive elements related to data interpretation, communication, and ownership. Results show that aligning engineering controls with behavioural reinforcement improves fault localisation, billing accuracy, and decision-making efficiency. The proposed model provides a replicable approach for small- and medium-scale water utilities seeking sustainable NRW reduction beyond purely technical solutions.

Introduction:

High levels of Non-Revenue Water remain a persistent challenge for water utilities in developing regions due to infrastructure deterioration, operational inefficiencies, and weak organisational practices. Conventional NRW reduction strategies often achieve short-term gains but fail to sustain performance over time (Liemberger, R., & Wyatt, A. 2011). Recent utility management research highlights the importance of behavioural factors such as staff ownership, data literacy, and accountability in achieving operational effectiveness. Engineering cognitive orientation extends technical optimisation by shaping how operational teams perceive, analyse, and act upon system data. This approach was applied at the Murunkan WSS, Sri Lanka, comprising a 225 m³ overhead reservoir and approximately 103 km of distribution mains, providing a practical case to examine the impact of behavioural alignment on NRW performance.

Methodology:

A six-step hybrid technical-behavioral model was developed and implemented between November 2024 and August 2025. Each technical intervention was intentionally paired with a cognitive element to reinforce behavioral change:

1. **Meter Management and Accessibility** – Physical relocation and standardization of meters combined with clear assignment of staff responsibility.

2. **Data-Driven Monitoring and Analytics** – Regular reconciliation of bulk inflow, distribution, and billing data to build confidence in data accuracy.
3. **Operational Controls and Leak Management** – Valve isolation, step testing, and targeted repairs designed to encourage investigative and analytical thinking.
4. **Customer Engagement and Compliance** – Awareness programmes and field interaction to strengthen communication skills and customer cooperation.
5. **Institutionalization and Replicability** – Integration of NRW reviews into routine operational meetings to embed practices into organizational culture.
6. **Data Integrity and Renumbering** – Systematic customer renumbering and database alignment to reinforce accuracy and consistency as operational norms. Performance was monitored through monthly NRW calculations, daily production and billing reconciliation, customer account audits, and qualitative assessments of team engagement and decision-making practices.

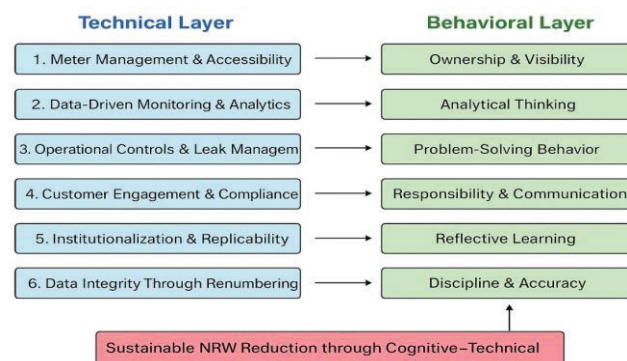


Figure 1. Six-Step Technical–Behavioural Integration Model for NRW Reduction

Findings/Results:

Implementation of the hybrid model reduced NRW from **45.7%** (November 2024) to **12.4%** (August 2025). Average daily NRW volumes declined from approximately **574 m³/day** to **124 m³/day**. Active customer accounts increased from **1,304** to **1,392** following renumbering and verification exercises. Improved meter accessibility and data reconciliation enhanced fault localisation efficiency, while behavioural reinforcement resulted in faster response times and improved billing accuracy. Each step of the framework contributed incrementally, with data integrity and operational controls producing the most immediate quantitative gains, and cognitive alignment sustaining performance improvements over time.

Conclusions/Key Messages:

The Murunkan case study confirms that technical interventions alone are insufficient to achieve durable NRW reduction. Prior to implementation, conventional technical measures were present but inconsistently applied due to weak data confidence and limited staff ownership. Embedding cognitive orientation alongside engineering controls transformed how data were used, how decisions were made, and how accountability was exercised. While the study is limited to a single scheme, the findings suggest that integrating behavioural alignment with technical practice offers a replicable and resilient model for NRW management. Future work should examine long-term sustainability and adaptation of the framework across diverse utility contexts.

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IWA Water Safety Conference & Exhibition
23-25 March 2026, Sri Lanka

Optimization of Vermifiltration Process for Dairy Effluent Treatment Using Earthworms

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Keywords: Vermifiltration; Dairy Effluent; COD Removal; Vermicompost

Abstract: Dairy industries generate high-strength wastewater containing elevated organic matter and nutrients that require effective treatment prior to discharge. This study evaluates a horizontal subsurface flow vermifilter using *Eisenia fetida* for dairy effluent treatment. Process optimization was performed using Response Surface Methodology with Box–Behnken Design considering Earthworm Density (ED), Hydraulic Loading Rate (HLR), and Organic Loading Rate (OLR). Optimized conditions (ED 3 kg/m³, HLR 0.3 m³/m²·day, COD 1481.89 mg/L) achieved 85.1% COD removal ($R^2 = 0.986$). At 26 h HRT, COD, TAN, and TP removals reached 94.68%, 88.8%, and 53.64%, respectively. BOD and TSS reductions exceeded 85%, indicating strong organic stabilization. Results demonstrate vermifiltration as a sustainable, low-energy alternative suitable for decentralized dairy wastewater management.

Introduction:

The dairy industry produces wastewater rich in COD, BOD, TSS, fats, oils, nitrogen, and phosphorus. Untreated discharge causes eutrophication and oxygen depletion. Conventional treatment systems require high energy and operational costs. Vermifiltration offers a nature-based, low-energy solution where earthworms and microorganisms synergistically degrade organic pollutants while improving aeration and nutrient stabilization. While COD was the primary optimization parameter due to its rapid analytical response and representation of total oxidizable load, additional indicators including BOD, TSS, TAN, and TP were monitored to evaluate overall treatment performance.

Methodology:

A laboratory-scale horizontal subsurface flow vermifilter (85 cm × 20 cm × 25 cm) was fabricated using transparent acrylic. The bed consisted of coarse gravel (support layer), garden soil and compost (4:1 ratio), and inoculated *Eisenia fetida*. A charcoal polishing layer was provided at the outlet for adsorption of residual phosphorus and fine solids. Dairy wastewater was collected from NSR Dairy, Warangal District,

Telangana, India. Experiments were designed using RSM–Box Behnken Design with three variables: Earthworm Density (3–7 kg/m³), Hydraulic Loading Rate (0.3–0.9 m³/m²·day), and Organic Strength (800–1900 mg/L COD). Seventeen experimental runs were conducted. COD, BOD, TSS, TAN, TP, DO, and pH were analysed according to standard methods.

Results:

The RSM model showed high predictive accuracy ($R^2 = 0.986$). Under optimized conditions, COD removal reached 85.1%. Extending HRT to 26 hours improved COD (94.68%), TAN (88.8%), TP (53.64%), BOD (>90%), and TSS (>85%) removal. DO increased from 3.29 to 5.26 mg/L, indicating enhanced aeration. Compared to conventional activated sludge systems (85–95% COD removal), vermifiltration achieved comparable efficiency with lower energy demand and reduced sludge production.

Conclusions/Key Messages:

Vermifiltration is suitable for decentralized dairy units and small-scale industries due to low operational energy, minimal sludge production, and resource recovery through vermicompost. Operational challenges include maintaining moisture balance, preventing worm washout, and temperature sensitivity. The system supports SDG 6 and SDG 12 by integrating wastewater treatment with circular economy principles. The optimized vermifiltration system achieved high organic and nutrient removal efficiencies while generating nutrient-rich vermicompost. The vermicompost obtained demonstrated balanced nutrient content (N, P, K), suitable for agricultural applications, and no toxic effects were observed on germination tests using fenugreek seeds (Figure 1). Performance is comparable to conventional systems with significantly lower energy requirements, supporting sustainable and decentralized dairy wastewater treatment.

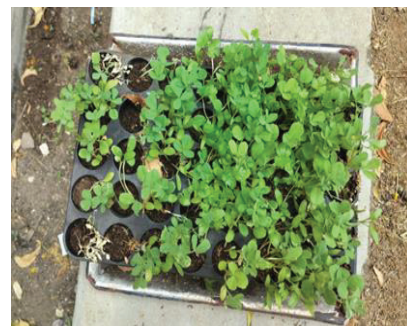


Figure 1. Growth of fenugreek and corianders @20th day

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Outcome-Based Optimization of Electrocoagulation-Flotation for Sustainable Sewage Wastewater Reclamation and Reuse

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Keywords: Electrocoagulation; Sewage wastewater; Response surface methodology; Optimization

Abstract: This study investigates electrocoagulation-flotation (ECF) using stainless-steel electrodes as an energy-efficient treatment method for sewage wastewater. The operational parameters pH, applied current, and electrolysis time were optimized using Response Surface Methodology with a Central Composite Design to enhance treatment performance. The objective was to maximize pollutant removal while minimizing resource consumption and operational cost. Optimal conditions were determined as pH 8.5, current 1.5 A, and electrolysis time 15 minutes. Under these settings, the process achieved 87.57% COD removal efficiency. The specific energy consumption was recorded as 13.44 kWh per cubic meter. Overall, the findings highlight ECF as a promising sustainable technology.

Introduction

Rapid population growth and industrialization have led to an alarming increase in sewage wastewater generation, with only a fraction being effectively treated before discharge. Untreated wastewater contributes to severe environmental pollution and poses serious health risks. Traditional physical, chemical, and biological treatment methods suffer from high operational costs, energy consumption, and limited removal efficiency for refractory pollutants. Electrocoagulation has emerged as an alternative electrochemical treatment process that uses sacrificial metal electrodes to generate coagulants in situ. This method offers low sludge generation, reduced maintenance, and high treatment efficiency. However, its effectiveness depends strongly on parameters such as pH, current density, and electrolysis time, which require optimization for maximum performance.

Methodology

Sewage wastewater was collected from the treatment plant at IIT Tirupati. A batch electrocoagulation reactor of 1 L capacity was fabricated using stainless-steel electrodes,

having dimensions of 70 mm × 120 mm and thickness of 3 mm and an effective surface area of 70 cm² connected to a DC. Three independent variables, pH (4.5–8.5), applied current (1–1.5 A), and electrolysis time (5–15 min) were optimized using a Central Composite Design in MATLAB software. Experimental responses measured were COD removal efficiency, specific energy consumption (SEC), and treatment cost. Data were analyzed using regression modeling and ANOVA to develop and validate predictive equations.

Results

COD removal efficiency increased with pH, applied current, and electrolysis time up to their optimal levels. At pH 8.5, trivalent hydroxide species $M(OH)_3$ formed, promoting effective coagulation and pollutant removal. Higher current density accelerated coagulant generation, while extended electrolysis time improved floc formation. The optimized conditions (pH 8.5, 1.5 A, 15 min) achieved 87.57% COD removal, SEC 13.44 kWh/m³, and cost 1.61 \$/m³.

Conclusions

The results demonstrate that electrocoagulation-flotation is an effective and sustainable treatment technology for sewage wastewater, capable of delivering measurable performance outcomes in line with next-generation water supply and sanitation objectives. Optimization through RSM ensured energy-efficient operation, achieving high pollutant removal with reduced cost. The process enables high-quality effluent suitable for non-potable reuse applications such as landscape irrigation and industrial cooling, thus promoting circular water management practices. Overall, this study reinforces the role of electrochemical treatment technologies as outcome-based innovations for advancing water reclamation and sustainable reuse, aligning with global goals for smart, resilient, and resource-efficient urban water systems.

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IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

Evaluating the effect of CWIS adaptation on National Regulatory Guidelines for Sanitation: Insights from Six Cities

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Keywords: Citywide Inclusive Sanitation; Fecal Sludge Management; Urban Sanitation

Abstract: Citywide Inclusive Sanitation is one of the novel approaches which guides the service delivery institutions through its holistic framework and inclusive principles. This study explores how the strategic adoption of CWIS has enabled municipalities in Bangladesh to institutionalize the provisions of the national regulatory framework- Municipal Fecal Sludge and Sanitation Management Guidelines, 2023 (MFSSMG-2023). The findings reveal that CWIS adoption has strengthened institutional compliance across the sanitation service chain, enhanced governance, monitoring system and enforcement mechanism in line with the directives of MFSSMG-2023.

Introduction:

To achieve universal, safely managed sanitation in urban Bangladesh, some municipalities adopted the Citywide Inclusive Sanitation (CWIS) approach since 2020 through Gates Foundation-supported initiatives led by the Department of Public Health Engineering. This approach strengthens sanitation service delivery mechanism through three system functions- responsibility, accountability and resource planning to achieve three service outcomes- safe, equitable and sustainable sanitation (Schrecongost et al. 2020). Recently, the Local Government Division of Bangladesh introduced the Municipal Fecal Sludge and Sanitation Management Guidelines (MFSSMG-2023) to provide guidance for urban sanitation. So far, no studies have been undertaken to investigate the municipal compliance with this guideline. Moreover, while prior CWIS studies examined planning frameworks, none assessed whether adoption supports municipal compliance with regulatory guidelines (Saker et al., 2022). This study addresses this gap, exploring CWIS's role in facilitating policy implementation.

Methodology:

This study employs a mixed method case study approach to examine how adoption of CWIS framework influences municipal compliance with the MFSSMG-2023. Six CWIS-adopting municipalities were purposively selected, and data were collected through 20 semi-structured KIs and 8 FGDs. A structured KPI scoring system was applied to quantify municipal performance under CWIS outcomes, while thematic analysis ensured systematic evaluation of compliance with the MFSSMG-2023. A limitation of the study is the potential for self-reporting bias from participants.

Findings/Results:

The MFSSMG-2023 provides a comprehensive framework for urban sanitation, structured around governance, technical interventions and capacity-building measures, with technical directives along the sanitation service chain: containment, collection, transportation, treatment, and safe disposal. Under the directives of containment, the guideline mandates monitoring of household sanitation containment to ensure safety. Findings show that all six municipalities monitor household containment to ensure building code compliance and presence of soak-pit, addressing the CWIS KPIs of Safety and Responsibility. High KPI scores for safety and responsibility in Kushtia, Shakhipur and Lakshampur (Table 1) correspond to strong compliance with the containment directive. For collection and transportation, MFSSMG-2023 prescribes mechanized FS emptying, pro-poor tariffs, and coordination with private operators. Through CWIS adoption in Responsibility, Accountability, Safety, and Equity, municipalities such as Kushtia, Faridpur, Shakhipur, Jhenaidah, and Saidpur operationalize and adhere effectively to these directives. In treatment, safe disposal, and end-use, FSTP operation, co-composting per national standards, and wastewater reuse are prescribed. CWIS Sustainability and Resource Planning adoption in Faridpur and Shakhipur reflects strong compliance. Finally, awareness programs, GESI-responsive action plans, inclusive sanitation services, and digital monitoring, guided by CWIS Equity, Sustainability, Responsibility, and Accountability, ensure adherence to governance and administrative provisions. Overall, the findings demonstrate that CWIS adoption systematically enhances municipal compliance with MFSSMG-2023 across the sanitation service chain.

Conclusions/Key Messages:

The study shows that CWIS adoption across municipalities has facilitated institutionalized governance, systematic monitoring, and strengthened accountability and community engagement. Overall, the findings indicate that CWIS provides a practical framework for translating sanitation policies into effective implementation, thereby enhancing governance, service quality, and public health outcomes.

Table 1: CWIS Scores (out of 100) of six CWIS-adopting municipalities

City	CWIS System Outcome			CWIS System Functions		
	Equity	Safety	Sustainability	Responsibility	Accountability	Resource Planning & Management
Lakshampur	73	57	65	56	49	61
Faridpur	76	46	80	45	49	64
Saidpur	86	59	67	71	8	53
Shakhipur	41	77	74	65	27	15
Kushtia	73	67	70	67	35	68
Jhenaidah	76	38	47	56	41	67

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IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

Outcome-Driven Water Quality Assessment for Sustainable Management in the Aththanagalu Oya and Maha Oya River Basins

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Keywords: CCME-WQI; Smart water monitoring; Water Safety Plans; Predictive analytics; Operational optimization

Abstract: This study evaluates water quality in Sri Lanka’s Aththanagalu Oya and Maha Oya basins using the CCME-WQI to enhance NWSDB operational decision-making. Analyzing 2022–2023 monitoring data across 16 sites, the research identifies localized deterioration at critical intakes like Kotugoda and Bambukuliya, especially during low-flow periods. The findings demonstrate that WQI outputs can optimize treatment processes, such as chemical dosing and filtration management, while identifying pollution hotspots for targeted catchment rehabilitation. By integrating WQI with predictive modeling, the study provides a scalable framework for Water Safety Plans (WSPs), improving cost-efficiency and ensuring long-term drinking water security through data-driven governance.

Introduction

Surface water quality degradation poses a major challenge to sustainable drinking water supply in Sri Lanka. The Aththanagalu and Maha Oya River basins support multiple National Water Supply and Drainage Board (NWSDB) intake schemes, yet are increasingly impacted by industrial effluents, agricultural runoff, sand mining, and untreated municipal wastewater (Fernando, 2005) (Pathirana et al., 2010). Conventional parameter-by-parameter assessment often fails to translate complex datasets into actionable information for operators and decision-makers. The Water Quality Index (WQI) provides an integrated metric that bridges technical monitoring data with operational decision-making and public communication. This study applies the Canadian Council of Ministers of the Environment (CCME) WQI framework to assess water quality trends and demonstrate its value as an outcome-driven tool for smart monitoring, treatment optimization, and catchment-scale management.

Methodology

Monthly sampling (2022–2023) across 16 key locations in the Aththanagalu Oya and Maha Oya basins assessed seasonal and anthropogenic impacts on water quality using APHA (2023) standards. Compliance for parameters including nutrients, BOD/COD, and microbiological indicators was evaluated against SLS and CEA (2019) regulations. The CCME-WQI was then calculated based on scope, frequency, and amplitude to identify operational risks and spatial trends.

Results and Discussion

Monsoonal rainfall at Karasnagala and Pasyala strongly correlates with elevated turbidity, color, and phosphates, confirming that runoff from agricultural and urban areas drives pollution (Auer et al., 1993) (Pathirana et al., 2010). While nutrient enrichment and high BOD/COD levels exceed CEA limits at various intake points, microbiological contamination peaks downstream of densely populated regions. CCME-WQI analysis reveals that Aththanagalu Oya shows localized improvements near managed intakes, whereas Maha Oya exhibits consistent water quality declines across all monitored locations. These findings highlight critical priority zones for intervention and provide a data-driven basis for implementing adaptive water treatment and catchment management strategies.

Conclusions

The CCME-WQI effectively transforms complex monitoring data into actionable health scores, supporting sustainable water management and early warning systems. By integrating these scores into Water Safety Plans, the framework strengthens governance and enables proactive risk management through spatial analysis and nature-based solutions. Operationally, WQI-informed decision-making improves public health protection while reducing treatment costs through optimized chemical dosing. Ultimately, this outcome-oriented approach provides a scientific basis for targeted catchment rehabilitation and smarter water network management.

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Session 15

Impact on Emerging Contaminants in Drinking and Reclaimed Water on Public Health

Session Chair	Prof. Tanvir Ahmed
Session Co-chair	Dr. Nandika Miguntenna
Rapporteur	Mr. S.M.S. Bandara



IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

Nitrate reduction in wastewater by [B]-Linda Type A-stabilized nanozero-valent iron: Effect of Initial pH

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Keywords: Green synthesis; Efficiency; Nanozero-valent iron; Nitrate; Stabilization

Abstract: Nano zero-valent iron (nZVI) is effective for removing nitrate from wastewater but suffers from oxidation and aggregation. In this study, nZVI was successfully stabilized using boron-modified Linde Type A zeolite ([B]-LTA) representing a novel use of boron incorporation to LTA Zeolites for enhancing nZVI stability and synthesized via a green method. PXRD, and Raman analyses confirmed the presence of Zero-Valent Iron (Fe^0) within the [B]-LTA framework. The prepared materials showed excellent nitrate removal efficiencies of 97.88%, 99.5%, 99.54%, 98.53%, and 96.99% at the optimum pH for 0%, 25%, 50%, 75%, and 100% [B]-LTA-nZVI, respectively. Nitrate reduction increased with rising pH in higher boron samples due to boron's weak acidity. Thus, [B]-LTA-nZVI demonstrates excellent potential as a sustainable and efficient material for nitrate removal.

Introduction:

Nitrate in water is a health concern, with WHO limiting it to 50 mg/L, necessitating effective removal [Ma et al., 2025]. Green-synthesized nZVI offers an eco-friendly reduction method, though aggregation limits efficiency [Zhang et al., 2023]. This study immobilized nZVI on boron-modified LTA ([B]-LTA) to enhance stability and nitrate removal performance.

Methodology:

[B]-LTA zeolites with varying Al/B ratios were synthesized via microwave-assisted hydrothermal method, and tea-extract-based nZVI stabilized by [B]-LTA was characterized and tested for nitrate reduction under varying pH using UV-Vis Spectroscopy.

Findings/Results:

Figures 1–2 confirm [B]-LTA-nZVI synthesis via PXRD, and Raman analyses. Nitrate removal was tested at pH 3.5, 5.5, 7 and 10 for various Al/B ratios, achieving NO_3^- -N removal efficiencies of 97.88%, 99.5%, 99.54%, 98.53%, and 96.99% were obtained at their respective optimum pH values (Figure 3). Higher boron content increased solution pH through enhanced nitrate reduction and iron corrosion. Boron substitution improved electron transfer from nZVI to NO_3^- , reducing acidity due to its higher electronegativity than Aluminium.

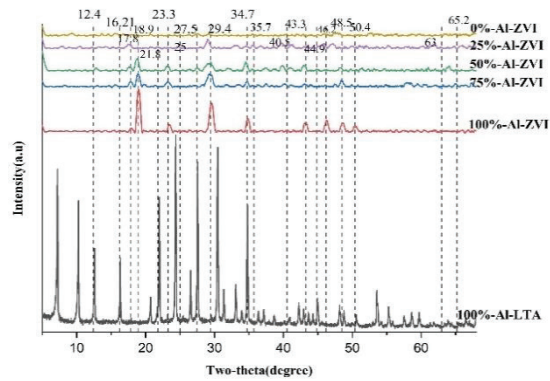


Figure 1: PXRD Patterns of prepared samples

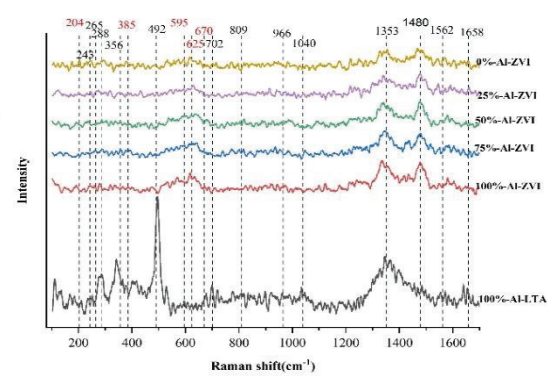


Figure 2: Raman spectra of prepared samples

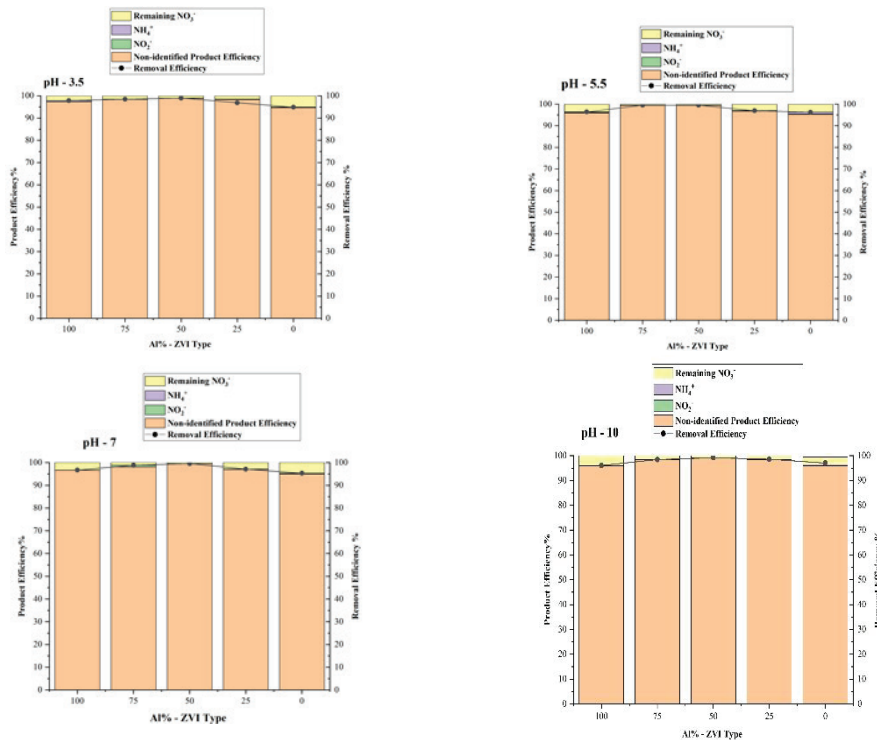


Figure 3: Effect of initial pH on nitrate removal and product formation.

Conclusions/Key Messages:

B]-LTA-nZVI composites were successfully synthesized for efficient nitrate removal, with Fe^0 confirmed and nitrate mainly reduced to ammonium and nitrite; maximum removal 97.88%, 99.5%, 99.54%, 98.53%, and 96.99% at optimum pH values of 3.5, 5.5, 7, and 10 for 0%, 25%, 50%, 75%, and 100% [B]-LTA-nZVI, respectively, highlighting pH as a key factor influencing nitrate reduction.

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IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

Distribution of per and poly fluoroalkyl substances (PFAS) in urban waterways

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Keywords: PFAS; stormwater pollution; urban waterways

Abstract: Per- and polyfluoroalkyl substances (PFASs) are persistent synthetic pollutants widely used in industrial and consumer applications. Their extensive use has resulted in widespread contamination of urban aquatic environments. This study investigates the occurrence and distribution of 8 PFAS compounds in surface waters across 19 urban creek sites located within three catchments draining to the Brisbane River, Australia. Samples were collected over four monitoring rounds under predominantly base-flow conditions. Samples were analysed using solid-phase extraction followed by liquid chromatography–tandem mass spectrometry (LC–MS/MS). Elevated PFAS concentrations were observed in catchments influenced by airports, industrial areas, and high-density residential land use. Short-chain PFASs were frequently detected in surface waters, while concentrations of long-chain PFASs were low. Comparison with revised Australian drinking water guidelines showed that PFOS exceeded the 8 ng/L guideline at 13 sites, while PFHxS exceeded the 30 ng/L guideline at two locations. These findings highlight potential risks to both human and ecological receptors and emphasise the need for targeted monitoring and specialised treatment technologies.

Introduction:

Per- and polyfluoroalkyl substances (PFASs) are environmentally persistent organic contaminants that pose increasing concern due to their mobility, bioaccumulation potential, and toxicity. Urban waterways are particularly vulnerable to PFAS contamination due to inputs from industrial discharges, wastewater treatment plant effluent, and diffuse stormwater runoff (Paige et al. 2024). Despite growing regulatory attention, there remains limited understanding of the spatial distribution of PFASs within urban creek systems and their relationship with land-use characteristics. This study aims to characterise PFAS distribution in urban surface waters and evaluate implications for urban water resource management.

Methodology:

The study was conducted across three major urban creek systems—Oxley Creek, Enoggera Creek, and Bulimba Creek—draining into the Brisbane River, Australia. Nineteen sampling sites were selected to represent a range of upstream and downstream land-use conditions. Surface water samples were collected over four monitoring rounds under predominantly base-flow conditions to minimise hydrological variability. Samples were extracted using solid-phase extraction and analysed for 8 PFAS compounds using LC–MS/MS (SCIEX QTRAP 6500).

Findings/Results:

Figure 1 summarises PFAS concentrations observed across all sites and sampling rounds. Boxplots represent median concentrations (ng/L). PFOS exceeded the Australian drinking water guideline of 8 ng/L at 13 sites, while PFHxS exceeded the 30 ng/L guideline at two sites. Several PFAS compounds were detected at concentrations below laboratory reporting limits, and therefore non-exceedance does not imply absence. Elevated concentrations were primarily associated with industrial land-use, wastewater infrastructure, and high-density residential catchments.

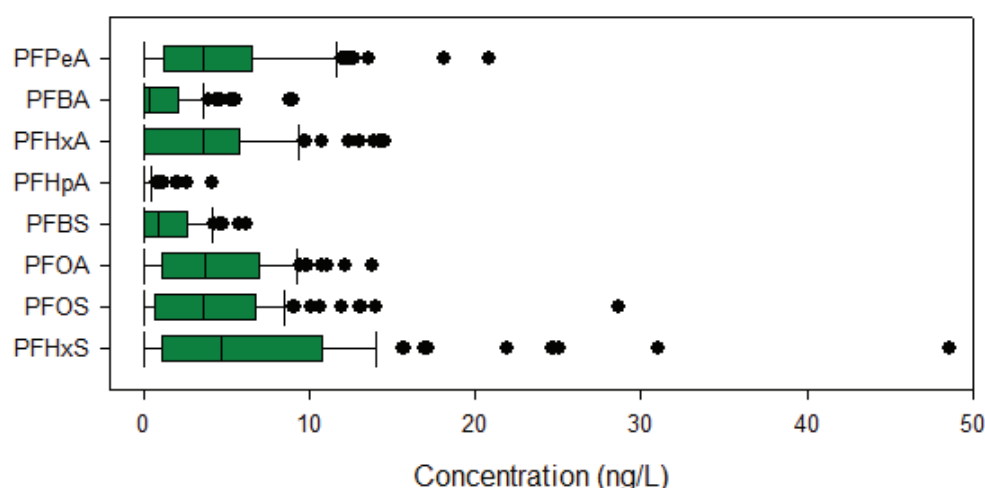


Figure 1: Distribution of PFAS concentrations (ng/L) in surface waters across three urban creek systems. Boxplots represent basic statistics across four sampling rounds.

Conclusions/Key Messages:

PFASs are widely present in urban surface waters, with PFOS and PFHxS exceeding Australian drinking water guideline values at multiple locations. The findings highlight the influence of land-use activities on PFAS distribution and the limitations of conventional treatment processes for PFAS removal. Enhanced monitoring, source control, and specialised treatment technologies are required to protect urban water resources and aquatic ecosystems.

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IWA Water Safety Conference & Exhibition 23-25 March 2026, Sri Lanka

Point-of-Use Electrodialysis as a Scalable Solution for Tackling Groundwater Quality Challenges in CKDu-Affected Areas, Sri Lanka

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Keywords: Electrodialysis; Fluoride removal; CKDu; Decentralized water treatment; Water Safety Plans

Abstract: Chronic Kidney Disease of Unknown Etiology (CKDu) remains a major public health challenge in Sri Lanka, linked to groundwater with elevated fluoride and hardness. This study evaluates electrodialysis (ED) as a low-energy, decentralized water treatment solution in CKDu-affected areas. Two systems were installed—a community-scale unit (30 m³/day) in Kahatagasdigiliya and a domestic-scale unit (50 L/day) in Padaviya. Fluoride and hardness removals ranged from 55–81% and 66–83% for the community unit, and 62–88% and 57–95% for the domestic unit, producing water within WHO and SLS standards. Specific energy consumption (0.0032–0.209 kWh/m³) was significantly lower than reverse osmosis or nanofiltration. The results confirm ED's scalability, solar compatibility, and integration potential with Water Safety Plans for sustainable, community-managed water systems.

Introduction:

Chronic Kidney Disease of Unknown Etiology (CKDu) has emerged as a critical health crisis in Sri Lanka's North Central and Uva Provinces, disproportionately affecting rural agricultural populations without traditional risk factors. Studies attribute its occurrence to groundwater enriched in fluoride and hardness, often exceeding WHO and SLS 614:2013 limits. Despite the use of reverse osmosis (RO) and nanofiltration (NF), their high energy demand, fouling, and brine disposal limit sustainability (Malalagama et al, 2024).

Electrodialysis (ED) offers a promising alternative by enabling selective ion removal using ion-exchange membranes (IEMs) under low voltage. It ensures fluoride and hardness reduction while preserving beneficial minerals. This work investigates field-installed ED systems at community and domestic scales in CKDu-endemic regions to assess performance, energy use, and alignment with decentralized Water Safety Plans (WSPs).

Methodology:

Two ED systems—a 30 m³/day community unit (Malalagama et al, 2024) in Kahatagasdigiya and a 50 L/day domestic unit in Padaviya (Malalagama et al, 2025)—were fabricated and tested. Each comprised alternating anion and cation exchange membranes (NEOSEPTA CMX/ACS for large-scale and HDX-100/200 for domestic units). Feed, concentrate, and dilute streams were analysed. Energy consumption was determined using measured current, voltage, and flow rate.

Findings/Results:

Both systems demonstrated strong performance with treated water meeting WHO and SLS drinking water standards. At community scale, fluoride and hardness removal efficiencies ranged from 55–81% and 66–83%; at domestic scale, 62–88% and 57–95%, respectively. ED outperformed conventional RO and NF systems with much lower energy use and minimal brine generation (<10% of feedwater).

Conclusions/Key Messages

Electrodialysis is a technically feasible, energy-efficient, and scalable solution for fluoride and hardness mitigation.

Both field systems produced water compliant with WHO and SLS 614:2013 standards. ED energy consumption (0.0032–0.209 kWh/m³) was markedly lower than RO/NF.

Solar-driven ED units enable sustainable, decentralized drinking water treatment. Integrating ED within WSPs strengthens rural water safety and community management.

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Computational Investigation of Dopant Location Effects on Band Gap Reduction in Nitrogen-Doped TiO₂ Anatase for Enhanced Photocatalytic Water Reclamation

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Keywords: TiO₂; Nitrogen Doping; Photocatalysis; Water Reclamation; DFTB+

Abstract: Titanium dioxide (TiO₂) is a widely studied semiconductor photocatalyst for water purification, but its wide band gap limits activity to the UV region (Cheng et al., 2012; Wahyuni et al., 2021). Nitrogen (N) doping can extend its response into visible light (Cheng et al., 2012; Wahyuni et al., 2021). This study used Density Functional Tight Binding (DFTB+) to examine how nitrogen dopant location in anatase TiO₂ affects the band gap and electronic structure. Using 2×2×3 anatase supercells, single (0.7%) and double (1.4%) N substitutions at different oxygen sites were simulated. Total Density of States (TDOS) and band structure analyses showed a slight but consistent band gap reduction, depending on dopant proximity and surface interaction. These findings show dopant site engineering tunes visible-light absorption in TiO₂, enabling high-performance photocatalysts for sustainable water reclamation.

Introduction:

Titanium dioxide (TiO₂) is a well-known photocatalyst widely used for environmental purification and water reclamation due to its high stability, strong oxidizing ability, and low cost (Cheng et al., 2012). However, its large band gap (~3.2 eV for anatase) limits light absorption to the ultraviolet region, which represents less than 5% of solar energy, restricting solar-driven applications (Cheng et al., 2012; The Wolfson Foundation). Among various band gap engineering strategies, nitrogen (N) doping has emerged as one of the most effective methods to extend TiO₂ activity into the visible-light region (Wahyuni et al., 2021). N atoms can substitute for oxygen or occupy interstitial sites, forming N 2p - O 2p hybridized states that shift the valence band edge and reduce the band gap (Khan et al., 2021).

Despite extensive research, the effect of dopant location on electronic structure and band gap narrowing remains insufficiently understood. Dopants positioned at different oxygen sites or near surfaces can modify local bonding and charge distribution, affecting visible-light activity (Khan et al., 2021). This study computationally investigates how the spatial position of N dopants influences the band gap of anatase TiO₂ using Density Functional Tight Binding (DFTB+). DFTB+ offers comparable accuracy with much lower computational cost, enabling efficient simulations of larger supercells (DFTB+ Developers' Group, 2025). The findings aim to

improve the understanding of dopant-site engineering for optimizing TiO₂-based photocatalysts in solar-assisted water treatment and reclamation systems.

Methodology:

The primitive anatase TiO₂ cell was built using the Atomic Simulation Environment (ASE) with lattice parameters $a, b = 3.784 \text{ \AA}$, $c = 9.514 \text{ \AA}$. A $2 \times 2 \times 3$ supercell (144 atoms) was constructed to simulate bulk-like conditions and accommodate low dopant concentrations (DFTB+ Developers' Group, 2025). Calculations were performed using DFTB+ with the matsci-0.3.0 Slater-Koster parameter set. The Self-Consistent Charge (SCC) method was used with a convergence tolerance of 1×10^{-5} . A Broyden mixer ensured charge stability, and spin polarization was included - assigning one and two unpaired electrons for single and double N-doped systems, respectively. Single N-doping (0.7%): One oxygen atom replaced by nitrogen at three distinct lattice positions. Double N-doping (1.4%): Two oxygen atoms replaced by nitrogen in four site combinations. The resulting electronic structures were analysed using Total Density of States (TDOS) and band structure plots. Band gaps were derived from the difference between conduction band minimum (CBM) and valence band maximum (VBM).

Findings/Results:

Pristine anatase TiO₂ showed a band gap of $\sim 3.19 \text{ eV}$, consistent with experiments. All single-doped models exhibited similar TDOS and similar reduced band gaps ($\sim 3.13 \text{ eV}$), confirming minor visible-light activation. Double-doped systems showed further narrowing ($2.88\text{--}3.09 \text{ eV}$) depending on dopant proximity, with surface or edge-site dopants showing stronger effects due to enhanced N - O orbital hybridization.

Conclusions/Key Messages:

N-doping enables visible-light activity in anatase TiO₂ by reducing the band gap and enhancing photocatalytic potential. Dopant-site position influences band gap reduction. DFTB+ is reliable and efficient for modelling large doped systems, reproducing realistic band gaps (DFTB+ Developers' Group, 2025). The study supports site-controlled doping as a design strategy for advanced photocatalysts in sustainable water reclamation.

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Health Risk Assessment on Climate Change Effects in Drinking Water Supply Systems

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Keywords: climate change effects; hydraulic modelling; quantitative microbial risk assessment (QMRA)

Abstract: Due to the effects of climate change, increased pathogen discharges from untreated wastewater through combined sewer overflows (CSOs) will contaminate raw water sources and may pose serious health risks to drinking water supply systems in the future. This study modelled future CSO discharges of pathogens into a raw water source using predicted rainfall data based on global climate models. A quantitative microbial risk assessment (QMRA) was employed to evaluate the associated health risks. The results indicate that climate change will significantly elevate the volume of CSO discharges into raw water sources, thereby increasing health risks for downstream drinking water consumers. The magnitude of these health risks depends on pathogen dilutions and the resilience of the drinking water treatment processes.

Introduction:

Climate change will lead to more intense and frequent storm events (IPCC, 2023), resulting in increased pathogen discharges from untreated wastewater through CSOs and the contamination of raw water sources. This could pose serious health risks to future drinking water consumers connected to downstream supply systems (Perry et al., 2024).

Methodology:

In this study, we modeled future CSO discharges of pathogens from a wastewater system using a hydrodynamic flow model (DHI, 2025). The wastewater system is located in a Swedish city near a raw water source, serving over 600,000 downstream drinking water consumers. Predicted rainfall events, used as input data for the hydraulic model, are based on global climate models that include different storm events with varying durations and intensities (Olsson et al., 2017). These models identified critical rain events for the sewer system in the present day, 2070, and 2100. A QMRA model developed in Sweden was employed to estimate the increased health risks for connected drinking water consumers. Pathogen concentrations of *Campylobacter*, norovirus, and *Cryptosporidium* were calculated in the raw water

source based on the CSO volumes generated by different storm events. These pathogen concentrations served as input data for the QMRA model. The health risks were then assessed for drinking water consumers connected to two different downstream water treatment plants (WTPs), including conventional treatment, activated carbon filtration, UV-disinfection, and chlorination (one plant without UV).

Findings/Results:

The results from the hydraulic modeling indicate that climate change will significantly increase CSO discharges in the future (Figure 1A). Both heavy and short (HS) storm events, as well as extreme and short (ES) storm events, are predicted to be the most critical, compared to longer but less intense rainfall events. Increased health risks are projected in the future; however, these risks are highly dependent on the dilution capacity of river flow during storm events. The findings also show that water treatment plants (WTPs) without UV treatment generally elevate health risks for consumers, particularly regarding infections with Norovirus and *Cryptosporidium* (see Figure 1B). This emphasizes the effectiveness and importance of UV treatment and highlights the need for robust and efficient treatment barriers in future WTPs.

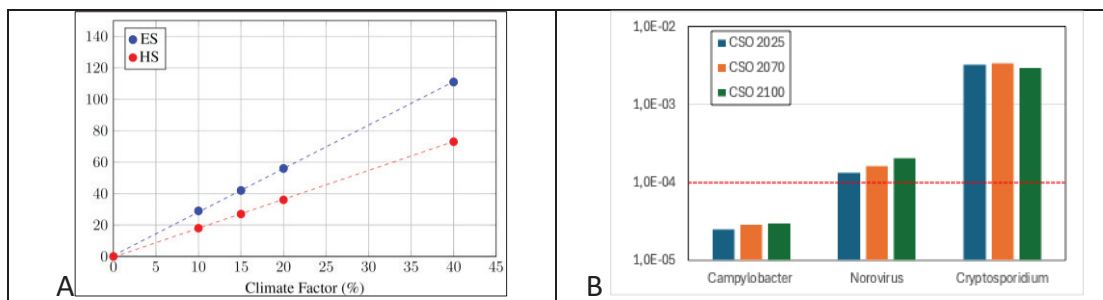


Figure 1: (A) Increase in CSO discharge volumes (in %) under different rain scenarios. (B) Estimated annual health risks for drinking water consumers at WTPs without UV disinfection, comparing CSO events in the present day, 2070, and 2100. The red dotted line in B represents the annual acceptable infection level of 10^{-4} .

Conclusions/Key Messages:

In the future, the elevated health risks from larger CSO volumes and higher pathogen levels in water sources must be addressed by greater redundant treatment capability.

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Session 16

Water Safety Plan Implementation

Session Chair	Mr. Asoka Jayarathne
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Rapporteur	Mr. Sugath Piyasena



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Integrating Preventive Oriented Control Measures into Climate Resilient Rural Water Safety Planning in Sri Lanka

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Keywords: Climate Resilience; Water Safety Plans; Community Managed Water Supply; Preventive Control Measures; Sri Lanka

Abstract: Safe and reliable drinking water remains a global challenge, especially in rural and underserved communities where water supply systems are often managed at the community level. To address these risks, the World Health Organization recommends Climate Resilient Water Safety Plans (CR-WSPs) as a preventive framework to safeguard public health. This study examined 465 Community Based Organizations to assess the integration of preventive control measures and quantitative analyses were conducted to interpret findings. The study revealed that only 30% of water users had adequate knowledge of WSPs, and just 35% of caretakers received training in preventive actions beyond routine repairs. Preventive practices included fencing and source protection in 43% of schemes, and chlorination in 48%. Major barriers included inadequate financial resources, weak infrastructure, and low technical capacity. Strengthening financial mechanisms, community engagement, and policy support is essential to embed preventive approaches and ensure safe drinking water in community managed systems.

Introduction:

This Ensuring access to safe drinking water is a continuing global priority, particularly in rural and underserved areas where water supply systems are community managed (Oliveira & Matos, 2022). In 2004, the World Health Organization introduced Water Safety Plans (WSPs) in its Guidelines for Drinking Water Quality, recommending that all water suppliers systematically assess and manage risks from catchment to consumer. Since then, governments, regulators, and water practitioners worldwide have increasingly adopted this preventive approach to ensure water safety (Studies, n.d.). In Sri Lanka, most rural water supply schemes are operated by Community Based Organizations (CBOs), which have been reported to face operational, technical, and financial limitations. While some studies have examined WSP adoption globally and in Sri Lanka, there is limited evidence of the extent to which preventive oriented control measures are integrated within community based WSPs in Sri Lanka, including the knowledge and training of caretakers, implementation of preventive practices, and the barriers that hinder effective operationalization. This study aims to assess the

current level of integration of preventive oriented control measures in relation to WSP knowledge within community managed water schemes in Sri Lanka and to identify key barriers to their effective implementation.

Methodology:

A quantitative methodological approach was used. Primary data were collected through structured questionnaires administered to CBO executive members and water users of 465 community based organizations registered under the Department of National Community Water Supply. Secondary data were reviewed from WSP manuals, national water policies, and related guidelines to evaluate the alignment of current practices with CR-WSP principles. Data were analysed using descriptive statistical methods, including frequency and percentage analysis.

Findings:

The study found that although several schemes had adopted preventive measures, implementation was inconsistent. Only 30% of users had an adequate understanding of WSPs, while 35% of caretakers had training beyond routine maintenance. Preventive actions such as source protection (43%) and chlorination (48%) were practiced irregularly. Major constraints included inadequate financial resources, limited access to treatment chemicals, insufficient technical skills, and poor infrastructure. These weaknesses significantly reduced the schemes' ability to adapt to climate related risks such as flood contamination and drought induced shortages.

Conclusions:

Strengthening preventive oriented approaches in rural WSPs requires enhanced financial mechanisms, continuous training for caretakers and CBO members, supportive policy frameworks, and stronger community participation. Promoting proactive rather than reactive measures will improve both water quality and climate resilience in community managed systems across Sri Lanka.

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Governance Success of the Risk-based Co-management of the Transboundary Dongjiang Water Supply from Guangdong to Hong Kong

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Keywords: water safety plan; risk-based; multi-barrier; water governance

Abstract: Severe droughts in the 1960s plunged Hong Kong (HK) into acute water shortages. Since 1965, the *Dongjiang (DJ; the East River)–Shenzhen Water Supply Scheme* (DS Scheme) has transferred DJ water from Guangdong to HK. Guided by the Water Safety Plan (WSP)’s risk-based and multi-barrier approach, the governments of Guangdong and HK have jointly identified risks, enacted regulations, enhanced infrastructure and established comprehensive water quality monitoring programmes to ensure a safe and sustainable supply. This co-management model, marking its 60th anniversary, serves as a global example of successful water governance.

Introduction:

Without reliable natural water resources, HK depended on erratic rainfall. The 1963 drought forced extreme water rationing with only 4 hours of supply every 4 days. In response, the Guangdong and HK governments, with Premier Zhou Enlai’s approval and funding from the Central People’s Government, completed the DS Scheme in just 11 months, with deliveries beginning in 1965 (Figure 1).

Methodology:

The management strategy adopts WSP principles to identify risks and implement control measures through infrastructure enhancements, regulations, and administrative protocols under extensive operational monitoring and verification: [WHO, 2023]

Guangdong Provincial Government – The primary risk along the over 500 km DJ River was industrial and domestic pollution. Mitigation measures included sewage interception/diversion, relocating intake points, and constructing sewage treatment works. A bio-nitrification plant and a dedicated aqueduct were also commissioned. In 2016, the River Chief System was introduced to unify leadership and coordinate conservation efforts. Legislation strictly prohibited industrial, farming, mining and other activities in the basin. Advanced technologies like drones and robots verified that the water meets *GB3838-2002*, the national standard for Type II waters (applicable to the abstraction for human consumption in first class protection area).

Additionally, the Xijiang (West River) was introduced in 2024 as an emergency backup to enhance climate resilience (Figure 2).

HK Government – Upon receiving the DJ water, HK implements a local WSP using online monitoring and laboratory analysis to safeguard water quality in the subsequent water supply chain. Monitoring data are regularly audited by experts and reported to an external advisory committee for endorsement and public release. HK also promotes education to curb water demand. Sustainable co-management relies on regular meetings between the two governments to exchange data and strategies, and a notification mechanism is in place for emergencies, such as flood discharges.

Findings/Results:

The quantity of supply has expanded from 68.2 million m³/year to a ceiling of 1,100 million m³/year under the 2023 agreement. Key water quality parameters, including ammoniacal nitrogen, biological oxygen demand, total phosphorus, dissolved oxygen and manganese, improved significantly especially following the 2003 commissioning of dedicated aqueduct. DJ water now provides 70-80% of HK's freshwater, effectively eliminating water scarcity and supporting sustainable development.

Conclusions/Key Messages:

The 60th anniversary in 2025 highlights the role of DJ water in HK's evolution into a world-class city. The WSP-based co-management between Guangdong and HK is a recognised model of regional water governance.

Figures and Tables



(Left) Figure 1: The Dongshen Water Supply System for supply of Dongjiang water from Guangdong to Hong Kong.

(Right) Figure 2: The Pearl River Delta Water Resources Allocation Project.

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São Paulo, Brazil Drought Plan

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Keywords: Drought Plan; risk assessment; regulatory experiment; regulatory agency; drought declaration

Abstract: The São Paulo State Water Agency (SP-Águas) developed the São Paulo Drought Plan, a technical and operational framework designed to strengthen water security and resilience to climate extremes. Grounded in international risk management frameworks, the Plan integrates continuous monitoring, vulnerability assessment, and contingency measures to guide state-level responses to drought. In 2025, the declaration of water scarcity in two major basins following significant reservoir declines. As the first initiative of its kind in Brazil, the Plan operates as a two-year regulatory experiment to test indicators, thresholds, and management actions, contributing to adaptive water governance.

Introduction:

SP-Águas is responsible for regulating and monitoring multiple water uses in São Paulo State, particularly during periods of drought or severe water scarcity. To support structured and proactive responses to these events, the agency developed the São Paulo Drought Plan, a technical-operational instrument that establishes procedures for drought risk assessment, continuous monitoring, and alert level definition. The Plan supports gradual demand management and supply preservation measures, enhancing preparedness and coordination during dry periods.

Methodology:

The Guidelines for Water Scarcity Management in the State of São Paulo are based on the Sendai Framework for Disaster Risk Reduction (UNDRR, 2015), the United Nations Convention to Combat Desertification (UNCCD, 2022), and the Integrated Drought Management Program (IDMP; WMO, 2014). These frameworks define water scarcity risk as the probability that an adverse event will negatively impact the availability and quality of water resources. The likelihood and severity of scarcity depend on the interaction among hazard (e.g., droughts, pollution, extreme climatic events), exposure, and vulnerability of affected regions (UNDRR, 2015).

The design of measures to minimize, mitigate, and reduce water scarcity impacts and is structured into three fundamental pillars:

The Plan is structured around three pillars:

- (i) Monitoring and Early Warning, using indicators such as SPI, SPEI, NDVI, the National Drought Monitor, and reservoir levels;
- (ii) Vulnerability and Risk Assessment, identifying areas most susceptible to scarcity based on water balance and socioeconomic factors; and
- (iii) Contingency Measures, including communication strategies, water use regulation, enforcement, and infrastructure actions.

Thresholds were defined for each drought stage, with progressively restrictive measures applied as water availability declines.

Findings/Results:

The Plan represents a shift from reactive crisis management to proactive risk management, improving anticipation and prevention of drought impacts. After its approval in September 2025, a state of water scarcity was declared in the Upper Tietê and Piracicaba river basins, triggered by reservoir storage reductions of approximately 30% in the Integrated Metropolitan System. Projections indicated that continued below-average rainfall could lead to emergency conditions during the subsequent dry season.

Conclusions/Key Messages:

The São Paulo Drought Plan establishes a risk-based governance model that enhances predictability, transparency, and coordination among water users and institutions. By integrating monitoring, vulnerability assessment, and contingency measures, it strengthens institutional preparedness for future droughts. As the first initiative of its kind in Brazil, the Plan serves as an innovative and replicable framework and operates as a two-year regulatory experiment to refine indicators, thresholds, and management actions.

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Evaluation of Water Safety Plan Outcomes and Impacts in Bushenyi-Ishaka Municipality, Uganda

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Key words: compliance; evaluation; monitoring; performance indicators; water safety plan

Abstract: Water Safety Plan (WSP) performance evaluation is necessary for water service delivery improvement. In this study, evaluation of the WSP implementation was done in Bushenyi-Ishaka Municipality, Uganda. Training of the WSP team and performance indicator data collected before, during and after 18 months of WSP implementation were done. Results showed that the WSP resulted in improvement of infrastructure, operational monitoring, customer engagement and training, but did not improve catchment management, standard operating procedures and internal meetings. Significant short-term impact improvement was realized for water quality standards, supply continuity and customer satisfaction, but not for Revenue-Cost ratio.

Introduction

Access to clean and safe water is a pre-requisite to a healthy population and therefore has a direct impact on the quality of life and productivity of the population. The most cost-effective means of consistently assuring safe water supply is the application of Water Safety Plans (WSP), defined as a risk based water supply system management approach, covering the whole system from catchment to consumer (WHO, 2023). In Uganda, WSP implementation has been carried out for about 20 years, in over 23 towns including Bushenyi-Ishaka Municipality, that receives its supply from a wetland source, surrounded by a cultivated catchment. Hazardous events relating to catchment management, inadequacies in the water treatment and distribution processes result in risks affecting the quality and quantity of water supplied in the municipality. This study evaluated the performance of the WSP in Bushenyi-Ishaka Municipality over a period of 18 months. The objective of the study was to evaluate the WSP in terms of: i) outcomes, and ii) short-term impacts, with the aim of achieving sustainable safe water supply (Kumpel *et al.*, 2018).

Materials and methods

WSP development: The WSP development process started in 2017 by selection and training of the WSP team. System description was carried out followed by hazard identification and risk assessment. Critical control points were identified and new control measures determined as an improvement strategy. A monitoring plan, WSP procedures and support programs were developed. A plan for periodic review and

revision of the WSP was documented. Selection of outcome and short-term indicators was done and semi-structured questionnaires designed for data collection. The outcome indicators selected were operational, institutional and financial change parameters. Short-term impact indicators selected were water supply continuity, non-revenue water, consumer satisfaction parameters and water quality parameters.

WSP implementation: This started in July 2018, by applying the WSP procedures in the entire water supply system. Monitoring of control measures was carried out using water quality parameters, namely pH, turbidity, residual chlorine and faecal coliforms (WHO, 2017) as short-term performance indicators. Meetings and training of consumers was done in a bid to avoid water re-contamination. WSP internal audit and consumer satisfaction surveys were conducted. The conceptual framework used in this study was the CDC concept with an evaluation methodology adapted from the impact assessment of WSP in the Asia-Pacific Region (Kumpel et al., 2018). The data collection road map for this study is given in Fig. 1.

Results and discussion

There was significant improvement in compliance with the national drinking water standards, attributed to the multiple barriers of source protection measures and monitored conventional treatment units and the distribution system. Application of O&M schedules and trained competent staff manning the systems also helped to achieve compliance. Significant improvement in supply continuity and customer satisfaction was also registered. The WSP did not result in improved catchment management, application of standard operating procedures, internal meetings and Revenue-Cost ratio, *i.e.* revenue generation compared to expenditure needs.

Conclusion

The WSP implementation positively resulted in immediate outcomes of infrastructure improvement, operational and compliance monitoring, application of procedures and training of staff and customers. Significant improvement in supply continuity, water quality compliance and consumer satisfaction signifies the need for WSP institutionalization and uptake not only in Uganda but in the rest of the developing world.

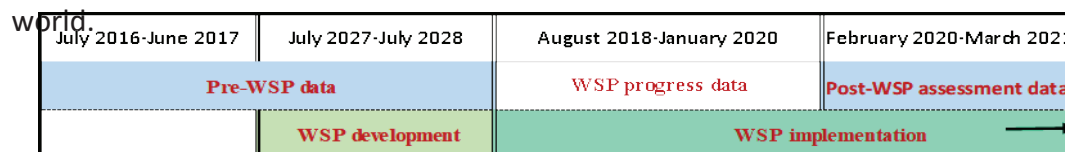


Figure 1: Data collection road-map for pre-WSP, during WSP implementation and post-WSP assessment period. (In all cases, monthly data sets were obtained during the periods mentioned and analyzed to monitor and evaluate the WSP performance).

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Implementing Water Safety Plans under Climate Change: case study in Badulla, Sri Lanka

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Keywords: Drinking Water; Safely Managed Drinking Water (SMDW); Rural water supply; Climate resilient

Abstract: Water Safety Plans (WSPs) are critical for securing Safely Managed Drinking Water (SMDW), yet their efficacy against climate change in rural Sri Lanka is insufficiently documented. Evaluating nine water treatment plants in Badulla, this study demonstrates how climate-induced rainfall and droughts exacerbate turbidity, color, and microbial contamination. Findings highlight that the Demodara plant suffers from manganese-sediment-related discoloration, while only 54% of household taps in the Badulla MOH area meet safety standards. Furthermore, CBO-managed systems lacking WSPs exhibit significant chemical and bacterial risks. Compounded by anthropogenic pressures, results indicate that climate change limits current WSP effectiveness, necessitating integrated climate-resilience measures to ensure sustainable water security.

Introduction: Access to Safely Managed Drinking Water (SMDW) is a fundamental right, vital for public health (WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene, 2018; Rheingans & Moe, 2005). In Sri Lanka's Badulla District, only 46% of residents have reliable access, facing bimodal rainfall and climate-induced stressors (Marambe et al., 2015). Dependency on vulnerable surface and spring sources compromises treatment efficacy. While Water Safety Plans (WSPs) provide a systematic risk-mitigation framework, implementation remains inconsistent. This study comparatively assesses nine treatment plants to evaluate WSP operational effectiveness against contamination and identifies strategies to enhance climate-resilient practices in rural systems.

Methodology:

Nine drinking water treatment plants were selected based on technology, scale, age, and data availability. The NWSDB manages five sites (Bandarapura, Demodara, Eladaluwa, Ettampitiya, Mahiyanganaya), while CBOs oversee four (Hopton, Rendapola, Yodunulpotha, Ranpokuna). WSP implementation was assessed via field inspections, document reviews, and interviews. Daily water quality parameters (2017–2021) were analyzed alongside rainfall and health data. Using linear regression and removal efficiency calculations, the study integrated spatial-temporal variations and onsite observations to evaluate operational performance and WSP efficacy.

Results:

Badulla faces significant water safety challenges due to rising demand and climate change, with peak rainfall (September–December) driving high turbidity and color. Assessment of NWSDB plants revealed that while WSPs exist, their effectiveness against extreme weather is limited. Specifically, Demodara's treated water frequently exceeded color standards (SLS 614:2013) due to rainfall-mobilized manganese sediments. Despite low disease rates in NWSDB areas, only 54% of household taps met microbiological standards, indicating distribution-stage contamination. CBO-managed systems showed critical failures; none implemented WSPs, resulting in poor turbidity removal. Ranpokuna recorded high hardness/TDS, while Yodunulpotha faced bacterial contamination due to weak oversight and insufficient treatment. Risks are exacerbated by anthropogenic pressures—sand mining, livestock, agriculture, and tourism—which increase sedimentation and microbial loads. Climate-induced rainfall fluctuations further strain treatment capacities and prolong service interruptions, highlighting the urgent need for climate-resilient management.

Conclusions/Key Messages:

This study demonstrates that while NWSDB-managed systems in Badulla have partially implemented WSPs, CBO-operated systems remain vulnerable without formal frameworks. Erratic climate patterns degrade water quality and reliability, particularly impacting CBOs due to inadequate treatment and catchment activities. A lack of alternative raw water sources further compromises climate resilience. Despite low disease rates, distribution-level microbial contamination persists. Strengthening water security requires expanded WSP integration, infrastructure upgrades, and localized climate projections to achieve universal access to safely managed water.

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Poster Presentations

Day 01



Smart GIS Analytics for Sustainable Water Quality Monitoring in the Upper Walawe Basin

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Keywords: InVEST Model; SDR Model; Soil Erosion; Watershed

Abstract: This study advances sustainable water quality monitoring by integrating the InVEST Sediment Delivery Ratio (SDR) model with GIS-based smart analytics and dung beetle bioindicators to assess watershed processes in the Upper Walawe Basin, Sri Lanka the first such application for this critical area. By combining rainfall, soil, topography, and 2022 land-use data, the model quantified soil erosion, sediment transport, and retention, revealing a mean annual soil erosion rate of $8.34 \text{ tons ha}^{-1} \text{ yr}^{-1}$, exceeding the national tolerance threshold of $5 \text{ tons ha}^{-1} \text{ yr}^{-1}$. Vegetated areas demonstrated strong retention ($281.75 \text{ tons ha}^{-1} \text{ yr}^{-1}$ avoided erosion), while agricultural zones showed hotspots, highlighting the framework's novelty for cost-effective, transferable sediment risk mapping in tropical data-scarce regions.

Introduction:

Water quality degradation in tropical catchments like the Upper Walawe Basin poses environmental challenges from rapid land-use changes, accelerating soil erosion and sedimentation that reduce water clarity and elevate treatment costs. Conventional field-based methods remain labour-intensive and spatially limited, while GIS-integrated InVEST SDR modeling with bioindicators offers quantitative, spatially explicit tools to identify sediment generation hotspots.

Methodology:

The InVEST SDR model (version 3.12.1) within a GIS environment estimated soil erosion and sediment export using Revised Universal Soil Loss Equation (USLE)

components: rainfall erosivity (R-factor via Roose equation), soil erodibility ($K=0.15-0.27$), DEM (SRTM), 2022 LULC, and biophysical C/P-factors from Piyathilake et al. (2021). Connectivity used $kb=2$, $IC0=0.5$; outputs validated against regional Sri Lankan datasets with $\pm 15-20\%$ uncertainty from rainfall/LULC variability. Framework transfers to similar basins (e.g., Uva Province) via local calibration.

Results:

The modeling outputs for 2022 clearly demonstrate the influence of land use and topography on sediment dynamics within the Upper Walawe Basin. The avoided soil erosion map (Figure 1.1) illustrates the vital role of vegetation in minimizing soil loss, particularly across forested and grassland zones. In 2022, the average avoided soil erosion was $281.75 \text{ tons ha}^{-1} \text{ yr}^{-1}$, demonstrating the strong retention capacity of vegetated surfaces in mitigating soil displacement. The total soil loss map (Figure 1.2) indicates a mean annual soil loss rate of $8.34 \text{ tons ha}^{-1} \text{ yr}^{-1}$, which exceeds the global soil loss tolerance threshold of $5 \text{ tons ha}^{-1} \text{ yr}^{-1}$.

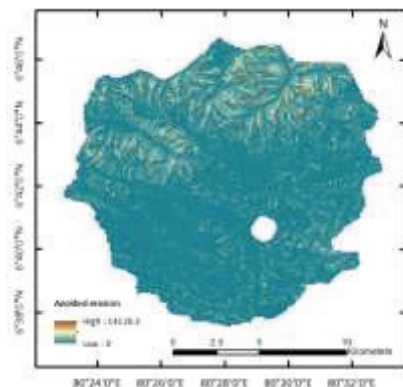


Figure 1.1: Avoided soil erosion map

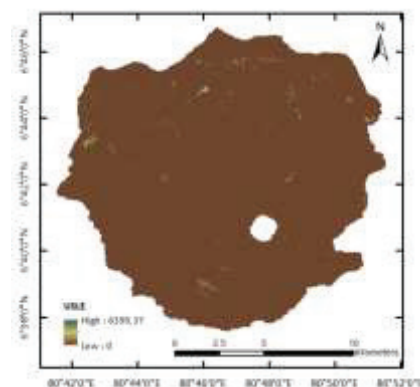


Figure 1.2: Total soil loss map (USLE map)

High soil loss values were concentrated in cultivated regions and areas with sparse vegetation, while forested zones exhibited minimal erosion. Therefore, vegetation not only reduces soil erosion but also enhances water infiltration and groundwater recharge, contributing to improved watershed stability and ecosystem resilience.

Conclusions:

Vegetated landscapes reduce sediment export, preserving downstream water clarity and groundwater.

GIS-InVEST framework enables proactive targeting of agriculture-driven risks, balancing development with conservation.

Scalable for Sri Lanka's tropics, validated across land uses for policy-relevant monitoring.

Reference

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Evaluation of Potential of Plant Residue Based Biocarrier for Nitrogen and Phosphorous Removal Using a Mesocosm Study

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Keywords: Floating wetlands, biocarrier, plant assimilation, nitrogen, phosphorous

Abstract: FWs (FWs) are effective nature-based systems for nutrient removal, but their performance is often constrained by limited plant biomass. This study evaluated plant residue-based biocarriers to enhance nitrogen and phosphorus removal by supporting plant growth and microbial activity. A mesocosm batch experiment at 7 days Hydraulic Retention Time (HRT) compared the performance of FWs with and without plant residues based biocarriers. Though the both systems showed non-significant improvement for NH_4^+ , NO_3^- and TP removal, root biomass (0.8 to 1.0 kg m^{-2}) and nitrogen (2718.8 to 3166.9 mg) and phosphorous (261.7 to 336.6 mg) contents of plant tissues significantly increased. This higher nitrogen and phosphorus accumulation in plant tissues confirmed the biocarriers associated enhanced whole-plant assimilation. Scanning Electron Microscopic (SEM) observations confirmed the biofilm development on biocarrier surfaces, indicating their role as biofilm carrier. The study concludes that the plant residue-based biocarriers have potential to enhance FWs performance primarily by improving plant growth and microbial attachment sites.

Introduction:

FWs remove nutrients through combined plant uptake, microbial transformation, and physicochemical processes. Whereas, plant biomass development is a key determinant of long-term nitrogen and phosphorus removal. However, limited biomass production often constrains system performance (Cao et al., 2016; Wang et al., 2018). Previous enhancement strategies have mainly focused on microbial transformation, while approaches that directly support plant-mediated assimilation remain underexplored. Plant residue-based biocarriers offer a biodegradable alternative that can function as both growth-supporting substrates and biofilm attachment media, improving rhizosphere conditions and plant-microbial interactions. Therefore, this study investigated the potential of plant residue-based biocarriers to enhance nutrient removal in FWs with emphasis on plant assimilation and nitrogen dynamics under mesocosm conditions.

Methodology:

A mesocosm batch experiment operated at 7-days HRT was conducted for 19 weeks using FWs with and without plant residue-based biocarriers. Biocarriers were

prepared from dried *Canna indica* root pieces and suspended beneath the floating mats below the water surface. Water samples collected weekly were analyzed for NH_4^+ , NO_3^- , and TP concentrations. At the end of the experiment, dry biomass (kg m^{-2}) and nitrogen and phosphorus contents in plant biomass were quantified. Selected biocarriers were examined using SEM ($\times 1000$ and $\times 3000$) for qualitative biofilm assessment. All results are presented as mean $\pm$ standard deviation (SD).

Results:

High nutrient removal efficiencies were observed in both systems. NH_4^+ removal increased slightly from 66.2% (without biocarriers) to 68.2% (with biocarriers), while NO_3^- removal improved from 20.8 % to 25.2%. Total phosphorus removal remained consistently high (>95%) in both treatments. The small differences in removal efficiency can be attributed to the already high baseline performance and the relatively long HRT (7 days), which likely masked observable treatment effects. Despite modest efficiency changes, biocarrier inclusion enhanced plant performance. Root biomass increased from 0.8 to 1.0 kg m^{-2} , accompanied by higher nitrogen (2718.8–3166.9 mg) and phosphorus (261.7–336.6 mg) accumulation in plant tissues, indicating improved whole-plant nutrient assimilation. Large standard deviations in nitrate removal reflect dynamic nitrogen transformations. Occasional nitrate increases suggest active nitrification in oxygenated root zones followed by delayed uptake or denitrification in localized microaerophilic regions. SEM images confirmed microbial colonization, particularly of microalgae and extracellular polymeric substances on biocarrier surfaces, demonstrating their effectiveness as biofilm carriers and supplementary growth substrates.

Table 1: Performance of FWs with and without carriers for plant growth and nutrient removal

	Shoot dry biomass (kg/m^2)	Root dry biomass (kg/m^2)	Nitrogen (mg)	Phosphorus (mg)
FWs (without biocarrier)	1.3 $\pm$ 0.02	0.8 $\pm$ 0.05	2718.8 $\pm$ 105.3	261.7 $\pm$ 13.51
FWs (with biocarrier)	1.2 $\pm$ 0.05	1.0 $\pm$ 0.03	3166.9 $\pm$ 91.8	336.6 $\pm$ 12.2

Conclusions

The plant residue-based biocarriers resulted in modest improvements in nitrogen removal efficiencies of FWs but a clear increase in root biomass and nutrient assimilation in biomass. These biocarriers have served not only a plant growth substrate but also a biofilm carrier by providing additional nutrients and attachment site, in turn enhanced the performance of FWs.

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Climate-Resilient Groundwater Management and Quality Adaptation Strategies in Manalkadu, Jaffna Peninsula, Sri Lanka

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Key Words: Groundwater quality; Climate resilience; Microbial contamination.

Abstract: Groundwater is a vital source of domestic water in rural Sri Lanka, particularly in the Jaffna Peninsula where surface water is scarce. Climate variability increases challenges in maintaining safe and reliable drinking water. This study assessed physicochemical, microbiological, and selected heavy metals in 76 groundwater wells from Kudaththanai, Manalkadu, and Karaiyoor during the dry season (September–November). Most physicochemical parameters complied with Sri Lanka Standards: pH (100%), nitrate and nitrite (100%), fluoride (96.1%), chloride (92.1%), phosphate (94.7%), sulfate (94.8%), total iron (85.5%), total alkalinity (79%), total hardness (73.7%), TDS (85.5%), and EC (85.5%). Turbidity (39.5%) and color (51.3%) occasionally exceeded permissible limits. Microbiological analysis detected total coliforms and *Escherichia coli* in all wells, while lead and cadmium were below detectable levels. Water Quality Index analysis indicated 18% of wells were chemically unsuitable, and 100% unsafe when microbiological contamination was included. Immediate disinfection measures and long-term strategies such as rainwater recharge, wellhead protection, and integrated catchment management are recommended to enhance groundwater resilience under climate stress.

Introduction:

Groundwater is the primary drinking water source in the Jaffna Peninsula, where low rainfall and limited surface water increase reliance on wells. Climate variability intensifies risks to water quality and availability, necessitating integrated, climate-resilient management (Rajasooriyar et al., 2013). Manalkadu village depends almost entirely on shallow wells and boreholes, yet data on chemical, microbial, and heavy metal contamination are limited. This study evaluates groundwater quality in Manalkadu, examining physicochemical parameters, microbial contamination, and selected heavy metals, and provides recommendations for adaptive, climate-resilient water supply strategies.

Methodology:

Seventy-six groundwater wells in Kudaththanai, Manalkadu, and Karaiyoor were sampled considering geological variation. Physicochemical parameters were analyzed following APHA (24th Edition), microbial contamination by the membrane filtration method, and lead and cadmium by atomic absorption spectroscopy. Sampling

coordinates were recorded using GNSS RTK, and spatial patterns were mapped in ArcGIS 10.8 using the Inverse Distance Weighted (IDW) interpolation method. Drinking water suitability was evaluated using the Weighted Arithmetic Water Quality Index (WQI) and Metal Index.

Results and Discussion:

Groundwater quality in Manalkadu showed notable spatial and compositional variation during the dry season. Color (0–274 Pt-Co), turbidity (0.4–70.8 NTU), and pH (6.73–7.69) met SLS 614:2013 limits in 49%, 61%, and 100% of samples, respectively. Electrical conductivity (178–13,650 $\mu\text{S}/\text{cm}$), TDS (114–8,736 mg/L), and chloride (15–3,870 mg/L) reflected geological diversity, with chloride exceeding limits in 12% of wells. Hardness (60–3,323 mg/L) and alkalinity (49–833 mg/L) were high in clay/silt aquifers, while nitrate, nitrite, and heavy metals remained within safe limits. Fluoride exceeded 1 mg/L in 4% of samples, and total iron was acceptable in 84%. However, microbiological contamination was widespread, with total coliforms in all wells and *E. coli* in 91%, making most sources unsafe for direct consumption despite generally acceptable chemical quality. Water Quality Index results classified 52% of wells as “excellent” chemically, but inclusion of microbial data rendered all wells unsuitable for drinking. Seasonal contamination may further increase during the rainy period due to runoff and infiltration (Mahagamage et al., 2019).

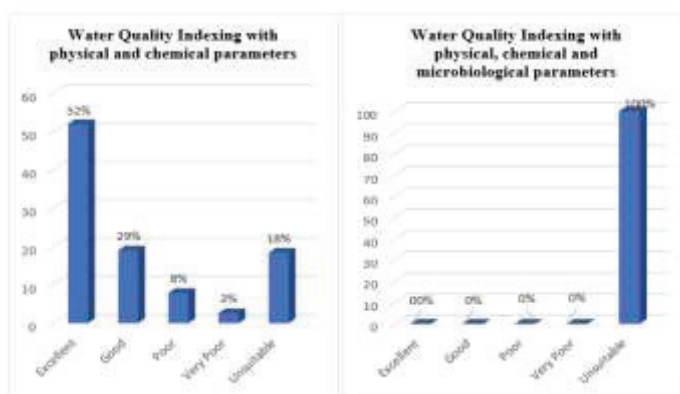


Figure 01: WQI with physiochemical and microbiological parameters

Conclusion and Recommendation:

Groundwater in Manalkadu shows significant spatial variability and widespread microbial contamination, making most sources unsafe for consumption. Climate variability, including saline intrusion and heavy rainfall, may further degrade water quality. Following the World Health Organization Water Safety Plan framework, this study provides hazard identification and risk assessment data to support climate-resilient groundwater management. Routine monitoring, wellhead protection, disinfection, rainwater harvesting, aquifer recharge, and integrated catchment management are recommended to ensure safe and sustainable groundwater use in the Jaffna Peninsula.

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Non-Revenue Water (NRW) Control Strategies for Kandy Municipal Council Area: A Case Study of Galagedara Billing Area, Kandy, Sri Lanka

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Keywords: Non-Revenue Water; Leakage Detection; Meter Inaccuracies Hydraulic Simulation; Water Utility Efficiency

Abstract: Non-Revenue Water (NRW) remains a major issue for water utilities globally, resulting in financial losses, wasted resources, and reduced operational efficiency. In Sri Lanka, NRW is about 25.7% (Swarnapali and Kumarage, 2020), considerably higher than in developed countries such as Germany (8.7%) (Covelli et al., 2016). This study evaluated NRW in the Kandy Municipal Council area, focusing on the Galagedara billing area under Katugasthota, using the International Water Association Balance Assessment framework. Recommended measures include meter replacement and pressure management in the short term, alongside pipeline upgrades, DMA establishment, and leak detection technologies for sustainable reduction.

Introduction:

This research focused on analysing Non-Revenue Water (NRW) in the Kandy Municipal Council area and developing technical strategies for minimize it. Throughout the IWABA analysis, and WaterGEMS simulation, the study identified major sources of water loss and proposed practical, sustainable strategies to reduce NRW while enhancing network efficiency, resource conservation, and the financial performance of the utility.

Methodology:

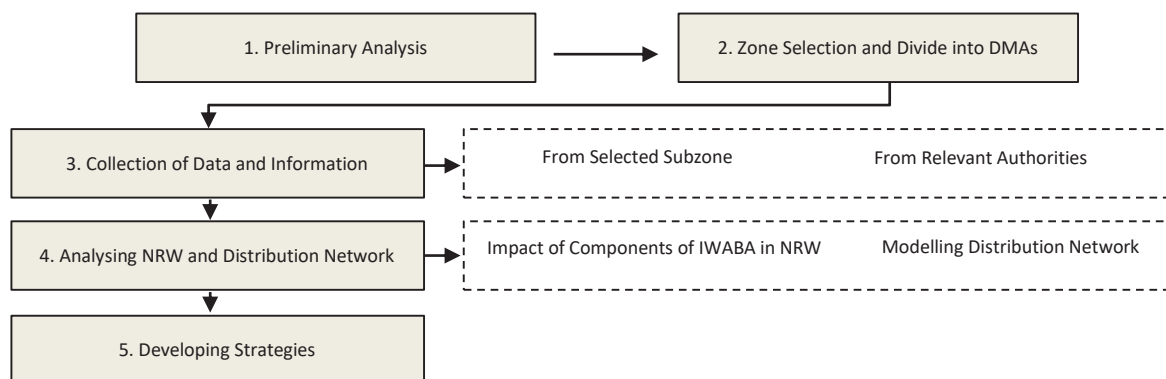


Figure 1: Flow Chart of the Methodology

The methodology involved preliminary assessment of the KMC supply system, selection of the Galagedara billing area and division into DMAs, data collection from subzones and authorities, NRW quantification using IWABA with network modelling, and formulation of short- and long-term reduction strategies.

Findings/Results:

The study revealed that the average Non-Revenue Water (NRW) level in the Kandy Municipal Council (KMC) area was 39.45%, resulting in an annual financial loss of approximately Rs. 127.8 million, while the Galagedara billing area indicated a higher NRW of 43.77%.

Table 1: IWA Balance Assessment Results for Galagedara Billing Area

System Input Volume	Authorized Consumption	Billed Authorized Consumption	Billed Metered Consumption	56.23%	Revenue Water 56.23%
			Billed Unmetered Consumption	0.00%	
		Unbilled Authorized Consumption	Unbilled Metered Consumption	0.09%	Non – Revenue Water 43.77%
			Unbilled Unmetered Consumption	0.00%	
	Water Losses	Commercial Losses	Customer Meter Inaccuracies	16.19%	
			Unauthorized Consumption	7.55%	
		Physical Losses	Leakages in Distribution Network	16.53%	
			Leakages and Overflows in Utility Storages	3.37%	
			Leakages in Transmission	0.04%	

In addition, WaterGEMS hydraulic simulation for the Galagedara distribution network highlighted high-pressure zones, especially in the Inigala Road DMA, that led to occur significantly higher leakages and physical losses.

Overall, aging meters, undetectable leakages, and pressure-related inefficiencies were identified as major NRW sources.

Conclusions/Key Messages:

The study recommends both short- and long-term strategies to reduce Non-Revenue Water (NRW). Short-term measures consist of replacing aged (more than 15 years) and inaccurate customer meters, which could save 14.94% of water monthly, and implementing active network monitoring with pressure management system to prevent leakages.

Long-term strategies suggest replacing outdated pipelines, controlling unauthorized consumption, establishing District Metered Areas (DMAs) for precise monitoring, and conducting regular audits with modern leak detection technologies to ensure continuous system efficiency and sustain NRW reduction efforts.

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Degradation of organic textile dye using Graphene Oxide and Graphitic Carbon Nitride composite (GO/g-C₃N₄) as a Photocatalyst

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Keywords: Graphene Oxide; Graphitic Carbon Nitride; Textile Dye; Photodegradation

Abstract: This study first time reports the degradation of effluent from textile industry using composite of graphene oxide (GO) and graphitic carbon Nitride (g-C₃N₄) under sunlight as a photocatalyst. GO/g-C₃N₄ composite was synthesized by sonication of GO with g-C₃N₄. In the preparation of GO from graphite powder, the duration of oxidation of graphite was critical to result GO with variable catalytic activity those were labelled as GO1, GO2, and GO3 based on oxidation time 1, 2, and 3d respectively. It was an adjustable parameter to control the reactivity of catalyst. Reactive Red123 dye was used as a model dye compound to optimize experimental conditions. Within 15 min and 60 min 77% and 95% of 20ppm dye was degraded by the lowest active GO1/g-C₃N₄ under solar illumination and it followed 1st order reaction kinetics. Catalysts GO/g-C₃N₄ were characterized by XRD and Raman spectroscopy and dye concentrations were detected by UV-Vis absorption. Waste effluent from textile industry was quantified by COD measurement and UV-Vis spectrum and 60% of COD decreased withing 1h duration by GO3-g-C₃N₄ and colour disappeared completely.

Introduction:

During last four decades' higher attention has been focused on the development of photo Fenton systems and semiconductor-based photo catalysts for advanced oxidation of dissolved organic wastes. However, due to certain inherent problems heterogenic photocatalyst systems such as TiO₂ and metal doped-TiO₂, and also other semiconductor metal oxide are still restricted in field applications. Catalytic activity of graphene-based systems has been identified as an excellent catalyst activated under the visible light. However, only very few studies have reported the application of activated graphene oxide for textile dye degradation and this study first time reports the degradation of textile effluent by using activated GO/g-C₃N₄ composite as a photo catalyst under solar illumination with adjustable catalytic activity based on the Graphite oxidation process during the GO formation.

Methodology:

Graphene oxide was synthesized via the Modified Hummers process using natural flake graphite powder as the starting material (Hummers and Offeman, 1957; Zhu et al., 2010). Depending on the time taken for Graphite oxidation (1-3 days), Go was

labelled as GO₁, GO₂ and GO₃ Graphitic carbon nitride (g-C₃N₄) was prepared using the thermal polycondensation of urea (Li et al., 2023; Niu et al., 2012). Both g-C₃N₄ and GO dispersions were sonicated for 1 hour separately to produce GO/g-C₃N₄ composite (Sun et al., 2017).

Findings/Results:

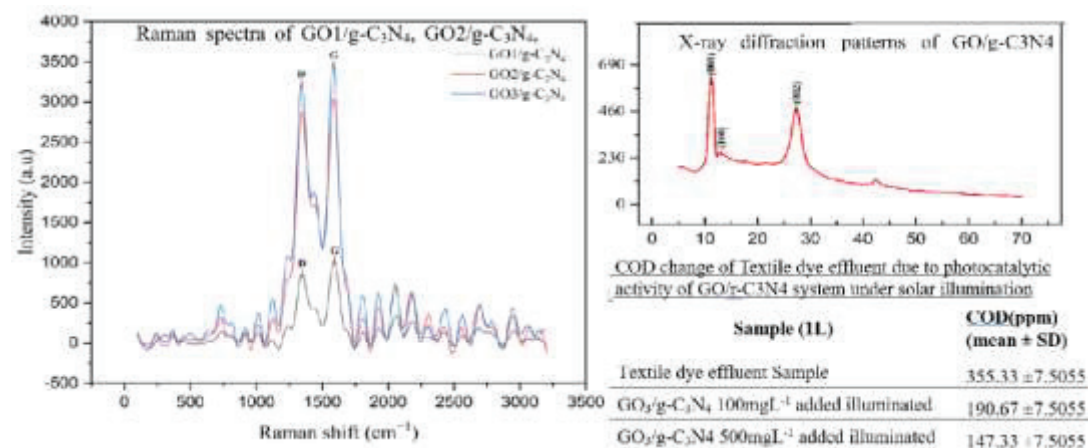


Figure 1: Raman spectrum, XRD pattern of GO/g-C₃N₄ composite photocatalyst and COD measurement of textile dye effluent.

Table 1: Degradation efficiency of Reactive Red123 textile dye (mean ±SD) at different in concentrations with catalytic activity adjusted GO/ g-C₃N₄ systems.

RR123 (ppm)	Time (min)	GO1/g-C ₃ N ₄ (Mean ± SD)	GO2/g-C ₃ N ₄ (Mean ± SD)	GO3/g-C ₃ N ₄ (Mean ± SD)
100	15	53.17 ± 0.4869	71.06 ± 0.8075	71.27 ± 0.3453
	60	88.03 ± 0.4443	93.59 ± 0.4219	96.08 ± 0.4219
80	15	51.13 ± 1.6778	51.79 ± 4.5802	52.54 ± 6.7400
	60	91.46 ± 1.6505	93.54 ± 1.9039	94.61 ± 1.8376
60	15	51.37 ± 0.8025	57.87 ± 0.7430	58.56 ± 1.5023
	60	94.07 ± 0.7036	96.34 ± 0.6697	97.38 ± 1.0681
40	15	55.03 ± 1.8745	68.30 ± 0.7917	75.96 ± 0.6062
	60	89.06 ± 0.7326	93.44 ± 0.0982	94.15 ± 2.0773
20	15	77.49 ± 0.6900	82.19 ± 1.4308	90.23 ± 0.3450
	60	96.09 ± 0.3450	96.20 ± 0.9988	96.89 ± 0.9930

Conclusions/Key Messages:

The heterojunction between GO and g-C₃N₄ was successful and could be confirmed by XRD, and Raman characterization results. The increase in binding groups in the catalyst was confirmed by the Raman spectrum. Remarkable enhancement of photocatalytic capability under ambient conditions was achieved by using a tuned GO/g-C₃N₄ hybrid and comparing reactivity of three type of catalysts, the best catalyst system was GO₃/g-C₃N₄. GO₃/g-C₃N₄ could be used to eliminate textile effluent.

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Rock–Water Interactions Driving Groundwater Composition in the Dry Zone, Sri Lanka: Identified By Inverse Modeling

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Keywords: Geochemical modelling; Metamorphic terrain; Dry zone; Sri Lanka

Abstract: Inverse geochemical modeling using PHREEQC was applied to groundwater and surface water samples from dry zone of Sri Lanka, revealing rock–water interactions controlling groundwater chemistry. Samples showed Ca-HCO₃ dominance in shallow wells (TDS ~344 mg/L, pH 6.5-7.4) evolving to Ca-Mg-Cl types in deeper wells (TDS up to 1035 mg/L), with elevated hardness (~600 mg/L as CaCO₃) posing scaling and health risks. Flow paths linked shallow recharge to deep discharge wells across Granitic Gneiss, Hornblende-Biotite Gneiss, and Charnockitic Gneiss zones. Modeling, constrained by mineralogical studies and saturation indices, showed feldspar, biotite dissolution forming kaolinite, montmorillonite in Granitic Gneiss; anorthite, hornblende weathering yielding kaolinite, montmorillonite and goethite in Hornblende-Biotite Gneiss; and pyroxene, feldspar alteration producing illite, gibbsite, calcite in Charnockitic Gneiss. These processes elevate Mg²⁺ and Cl⁻, impacting water safety for irrigation and potable use.

Introduction:

The inverse geochemical modeling of groundwater provides critical insights into subsurface water–rock interaction processes and their control on water chemistry. In crystalline metamorphic terrains of Sri Lanka’s dry zone, the groundwater system evolves along flow paths through varied lithological units such as granitic, hornblende-biotite, and charnockitic gneisses. The present study aims to interpret these hydrogeochemical processes using inverse modeling with PHREEQC, supported by mineralogical data and field-based chemical analysis. Groundwater in these terrains often reflects complex geochemical evolution governed by mineral dissolution, precipitation, and ion exchange processes. This study, therefore, links hydrochemical data with geochemical modeling to establish mineral weathering sequences and equilibrium conditions influencing groundwater composition.

Methodology:

69 groundwater and 11 surface water samples were collected from Netiyagama village across lithological zones. Major cations (Ca, Mg, Na, K) and anions (HCO₃, Cl, SO₄, NO₃) were analyzed via ICP-OES and IC, yielding averages of pH 7.1 ± 0.4, TDS 650 ± 350 mg/L, hardness 350 ± 150 mg/L as CaCO₃, and NO₃ up to 20 mg/L (below WHO 50 mg/L but notable). Mineralogy via SEM-EDX and XRD identified primary phases (K-feldspar, anorthite, biotite, hornblende, pyroxene) and secondary clays (kaolinite,

montmorillonite). Inverse modeling used PHREEQC v3.7.3 (PHREEQC.dat database), with shallow recharge (Ca-HCO₃) and deep discharge (Ca-Mg-Cl) pairs selected via ArcGIS 10.8 flow maps along hydraulic gradients. Phases were justified by: (1) petrographic/SEM/XRD abundance (>5% for primaries); (2) saturation indices (SI >0 for precipitation candidates like kaolinite; SI <0 for dissolution like feldspars); (3) charge balance (<5% uncertainty); and (4) literature (e.g., Appelo & Postma, 2005). Tolerance was 1E-10; models constrained to one dissolution/precipitation per phase per zone.

Findings/Results:

Inverse PHREEQC modeling quantified interactions along paths in Granitic Gneiss, Hornblende–Biotite Gneiss, Charnockitic Gneiss, with phases per XRD/SEM/SI. Granitic Gneiss (6 models): K-feldspar (3.82×10^{-4} mol/kg), anorthite (1.11×10^{-3} mol/kg), biotite (1.09×10^{-4} mol/kg) dissolution; kaolinite/montmorillonite precipitation (-9.52×10^{-4} mol/kg) indicating early weathering, moderate K⁺ risk with dominant silicate weathering and clay mineral formation typical of early-stage groundwater evolution (Appelo & Postma, 2005). Hornblende–Biotite Gneiss (12 models): anorthite (5.04×10^{-3} mol/kg), albite (1.04×10^{-3} mol/kg), biotite (4.96×10^{-4} mol/kg) dissolution; kaolinite (-6.61×10^{-5} mol/kg), montmorillonite, goethite, Fe/Mg rise, scaling risk (Drever & Stillings, 1997). Charnockitic Gneiss (12 models): feldspar/pyroxene alteration; kaolinite (1.57×10^{-4} mol/kg), calcite precipitation, gibbsite/illite formation indicating advanced aluminosilicate weathering under humid tropical conditions and show high TDS/Mg laxative risk.

Conclusions/Key Messages:

Rock-water interactions in Netiyagama area show silicate weathering dominating, with K-feldspar, anorthite, and biotite dissolution in Granitic Gneiss forming kaolinite, montmorillonite (low-risk, potable), yielding Ca-HCO₃ water. Hornblende–Biotite Gneiss exhibits anorthite, albite dissolution with goethite, hematite, also producing Ca-HCO₃ water (moderate hardness, scaling risk). Charnockitic Gneiss shows advanced weathering with calcite, gibbsite, illite precipitation, transitioning to Ca-Mg-HCO₃ water (high TDS/Mg, laxative, hypertension risks per WHO). These drive 30% samples exceeding TDS 1000 mg/L, urging blending, treatment for safety; findings inform metamorphic terrain management.

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Greywater Reuse and Rooftop Harvesting for Sustainable Water Management- Case Study in Kurunegala Municipal Area

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Keywords: Rainwater harvesting; Reuse of greywater; Sustainable Water management.

Abstract: Water shortage in urban areas in Sri Lanka is a rising problem especially in the fast-developing metropolis like Kurunegala (Vijitha, Sayanthan & Mikunthan, 2022). As pressure mounts on available drinking water resources, innovative ways to provide sustainable water sources, including greywater reuse and rooftop rainwater harvesting, become possible solutions to meet the water demand (Ariyananda, 2010; Lo & Koralegedara, 2015). The objective of the current study is to map and identify possible to implement community-level reuse systems based on the easily accessible spatial and demographic data. In the study, the data of building footprint is combined with the population density, household water consumption as well as land-use features to determine the appropriateness of reuse and harvesting (Ranasingha & Wattage, 2024). The findings present a spatial decision support tool to guide areas of priorities of decentralized water reclamation ventures under water safety planning frameworks (Vijitha, Sayanthan & Mikunthan, 2022).

Introduction

There is water stress in Sri Lanka which is a result of high rate of urbanization, climatic changes and inadequate water supply infrastructure (Lo & Koralegedara, 2015). The area of Kurunegala Municipal Council is a typical medium-sized urban centre which faces the growing water demand. Rooftop rainwater harvesting and water reuse are known to be effective, low cost and sustainable ways of reducing potable water demand, and assuring water security (Ariyananda, 2010). The practices can be integrated into water safety planning to enhance the aims of climate resilience and sustainability in urban areas (Vijitha, Sayanthan & Mikunthan, 2022).

This paper aims at mapping the candidate areas of Kurunegala MC to install greywater reuse and rooftop harvesting systems. The mapping is based on available data, and offer some useful information to local authorities (Ranasingha & Wattage, 2024).

Methodology

- Mapping (roof and impermeable surface area) to get a clue on the potential rain water yield.
- Superimposing water consumption and population density data to determine high-demand areas.
- The potential reuse of open spaces, home gardens, and irrigation demands can be identified.
- Prioritizing candidate zones based on the potential yield and reuse.

Findings / Results

The analysis resulted in a spatial map that indicates priority clusters in the Kurunegala MC area. The areas with high suitability were concentrated in the dense residential areas with big roof cover and increased water demand. The overall estimated rainwater harvesting potential was about 380,000 m³/year that easy covers 25-30 percent of non-portable water need. The potential of greywater generation was approximately 70 L/person/day in residential areas, which is promising enough to reuse locally.

These findings indicate that the introduction of community-scale rooftop rainwater harvesting, coupled with the introduction of simple greywater treatment facilities, can have a significant effect on reducing the pressure on the centralized water supply systems and improving the climate resilience.

Conclusions

This paper illustrates a low cost and fast way of mapping and prioritizing candidate regions where rooftop rainwater can be harvested and greywater can be reused in Sri Lankan urban settings (Ariyananda, 2010). The methodology can help local authorities, water utilities, and urban planners make pragmatic decisions by utilizing the available spatial and demographic data (Ranasingha & Wattage, 2024). The inclusion of water reuse strategies in the municipal water safety plans would also help in improving the level of water security, particularly in the face of rising climate variability (Vijitha, Sayanthan & Mikunthan, 2022).

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Factors Influencing the Continuance Intention to Use E-Payments: Evidence from Utility Bill Payments During the COVID-19 Pandemic

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Keywords: E-Payment; Utility bill payments; Continuance intention; COVID-19; Trust

Abstract: The COVID-19 pandemic accelerated the adoption of e-payments as a health-proactive behavior. This study examines the factors influencing consumers' continuance intention to use e-utility payment systems in Sri Lanka during the pandemic. The conceptual framework integrates elements from the HBM and the UTAUT2. A structured questionnaire was distributed and a convenience sampling method was utilized to collect data from 400 e-utility bill payers. Data were analyzed using SPSS, and the findings reveal that all factors significantly influence continuance intention to use e-payments, except for monetary value. 51.7% of the variation is explained by the integrated model. This study provides practical insights for utility service providers, policymakers to strengthen sustainable e-payment adoption.

Introduction:

E-payment systems have emerged as an inevitable consumer trend and a strategic business innovation in the twenty-first century. The COVID-19 pandemic significantly increased electronic transactions as travel restrictions and health concerns compelled customers to move from traditional physical payment methods to digital alternatives (Chana De Silva, 2021). E-utility bill payments in Sri Lanka increased dramatically in the early phases of the pandemic, suggesting a growing demand for contactless payment methods (Central Bank of Sri Lanka, 2021). Despite this initial acceleration, e-payment usage fluctuated over time without exhibiting steady growth. Consumer behavior is often unpredictable during times of crisis and may reflect transient shifts rather than enduring patterns (Daragmeh et al., 2021). According to Levinson (2024), such behavioral shifts in consumers lead to interim changes once perceived threats diminish. Most of previous studies have focused on adoption; however, the post-adoption behavior in a crisis-driven digital payment context remains limited. To address this gap, the current study examines the factors influencing continuance intention to use e-payment systems during the pandemic.

Methodology:

A quantitative research approach was adopted and data were collected through a self-administered online questionnaire from September 8 to December 1, 2021. 400

individuals who had previous experience in e-utility payments were selected as a sample using the convenience sampling method. Performance expectancy, effort expectancy, hedonic value, habit, social influence, facilitating conditions and monetary value were derived from UTAUT2. Trust was incorporated as a new variable, while perceived susceptibility and perceived seriousness from HBM were integrated into the conceptual framework. SPSS was used to analyze the data and the impact of the selected variables on continuance intention to use e-payment systems was examined through multiple regression analysis.

Findings/Results:

The sample consisted of 59% female and 41% male respondents, predominantly middle-class, well-educated, and employed. The findings revealed that monetary value was not significant ($p=0.065$) and perceived susceptibility ($\beta = 0.103$, $p = 0.006$), perceived seriousness ($\beta = 0.171$, $p < 0.001$), hedonic value ($\beta = 0.179$, $p < 0.001$), performance expectancy ($\beta = 0.137$, $p < 0.001$), effort expectancy ($\beta = 0.200$, $p < 0.001$), social influence ($\beta = 0.172$, $p < 0.001$), habit ($\beta = 0.098$, $p = 0.011$), Facilitating condition ($\beta = 0.116$, $p = 0.005$), and trust ($\beta = 0.105$, $p = 0.005$) significantly influenced continuance intention to use e-payment. The regression model explained 51.7% of the variance in continuance intention ($R^2 = 0.517$). Additional feedback from respondents revealed that network instability, user interface and system login issues acted as key barriers, while time-saving, convenience, and health concerns were identified as key motivators to sustain use of e-payment systems. Mobile banking apps and official utility websites were identified as the most frequently used payment platforms.

Conclusions/Key Messages:

Initial adoption of e-payments during the pandemic was largely driven by health-related threats. However, to encourage continuance intention to use of e-payment systems beyond the pandemic, utility service providers are recommended to improve user convenience through integrating real-time payment options (such as mobile wallets, QR codes), automated recurring payments, IVR and AI-based voice assistance facilities. Also, designing multilingual and user-friendly interfaces is equally important to improve the end-user experience. Biometric authentication, blockchain verification and robust cybersecurity measures can be utilized to strengthen the user trust. Developing digital infrastructure facilities, continued investment in community digital literacy, e-governance initiatives together with regulatory policy modernization will ensure sustained use of e-payment systems in Sri Lanka.

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Geogenic Adverse Groundwater Quality: Challenges and Cost-Effective Treatment for Safe Water Supply

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Keywords: Groundwater quality; Iron and manganese removal; Groundwater treatment; Climate-resilient water source

Abstract: Groundwater remains a relatively underutilized source within the National Water Supply and Drainage Board (NWSDB) due to prevailing water quality challenges. This study assesses groundwater quality in fourteen major supply schemes across Sri Lanka and proposes cost-effective treatment options. Elevated iron and manganese were detected in 64.3% of the schemes, while 35.7% showed hardness-related problems. Conventional treatment processes reduced iron from 5.3 to 0.1 mg/L, and pressure filtration further decreased iron to 0.05 mg/L and manganese to 0.01 mg/L. Blending with low-hardness sources was identified as an economical solution for hardness control. The findings demonstrate that, with appropriate treatment, groundwater can serve as a sustainable and climate-resilient water source.

Introduction:

Groundwater in many regions contains geogenic and anthropogenic pollutants, making it unsuitable for direct consumption without treatment (Islam and Mostafa, 2024). In Sri Lanka, the NWSDB operates about 75 groundwater-based water supply schemes (WSSs), mainly in areas lacking sufficient surface water. However, groundwater remains a less preferred source due to persistent quality issues. No comprehensive island-wide study has assessed these problems or evaluated suitable treatment strategies. This study identifies common groundwater quality issues in NWSDB-operated WSSs and proposes economically feasible treatment solutions to promote groundwater as a sustainable, climate-resilient supply source.

Methodology:

Fourteen major NWSDB groundwater-based WSSs with daily extraction exceeding 1000 m³ were selected for the study. Monthly raw water quality data were collected over one year, with some schemes having only two months of data. Raw and treated water parameters from Ankumbura, Rajapihilla, Hakmana, Pothuvil, and Naththandiya WSSs were analysed to assess the effectiveness of their treatment methods.

Results:

Among key parameters, iron (Fe), manganese (Mn), hardness, and turbidity frequently exceed the limits of Sri Lankan Drinking Water Quality Standards (SLS 614) (Figure 1). Elevated Fe is the dominant issue (35.7% of schemes), followed by combined Fe and Mn (28.6%) and hardness-related problems (35.7%). High turbidity is common and strongly correlated with Fe, suggesting that iron oxidation and colloidal formation contribute to turbidity.

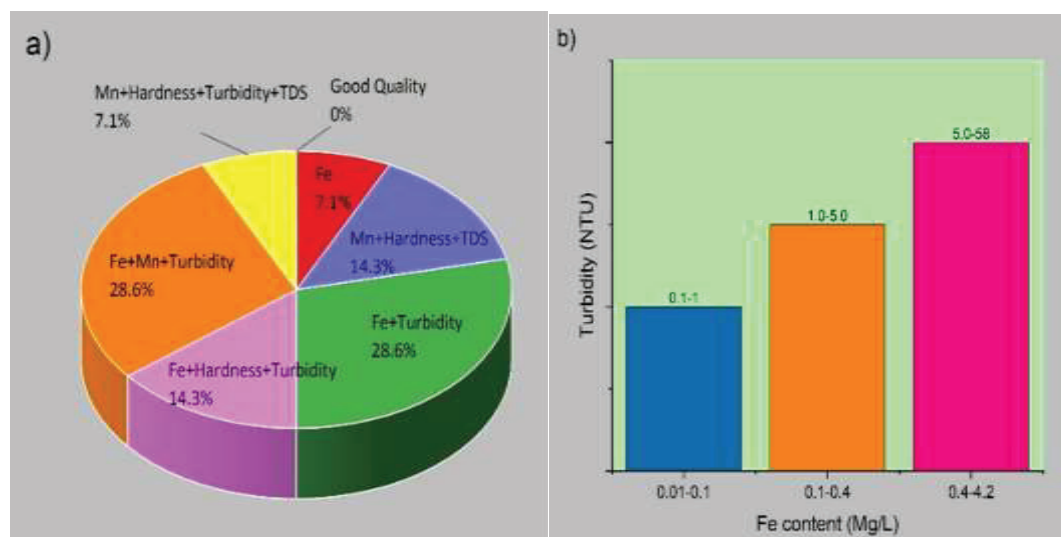


Figure 1: a) Distribution of major water quality issues as percentages, and (b) relationship between Fe concentration and turbidity observed in major WSSs.

Current treatment practices were evaluated for groundwater quality improvement. Oxidation followed by filtration is the most common and effective method for Fe and Mn removal (Vries et al., 2017). In Hakmana, Nattandiya, and Ankumbura WSS, aeration and filtration reduced Fe from approximately 5.3 to 0.1 mg/L. Pothuvil WSS achieved effective Fe and Mn removal with pressure filtration, lowering Fe from 4.2 to 0.05 mg/L and Mn from 0.7 to 0.01 mg/L. Hardness treatment is not currently practised by the NWSDB. Blending with treated surface water or low-hardness groundwater is proposed for selected schemes based on analyses of the Haragama and Rajapihilla sources, while pellet softening is recommended for large-scale schemes such as Murunkan, referencing the Cheng Ching Lake plant in Taiwan.

Conclusions/Key Message:

Elevated Fe and Mn constitute major groundwater quality issues but can be effectively removed through conventional or advanced pressure filtration. Hardness can be managed by blending or pellet softening. Groundwater can therefore serve as a sustainable and safe source for climate-resilient water supply systems in Sri Lanka.

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Developing a Policy Framework for Managing Microplastic Contamination in Drinking Water Supplies in Sri Lanka

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Keywords: Microplastics; drinking water; policy; monitoring; Sri Lanka;

Abstract: The public health risks of microplastics (MPs) in drinking water motivate this study to develop a monitoring policy framework for Sri Lanka. A literature-based analysis is used to assess MP contamination levels in sources, treatment practices, removal efficiencies, analytical methods, and regulatory gaps. The findings indicate moderate contamination compared to global trends, ranging from 11.76 to 23.5 MP/L, driven by industrial discharges, urban runoff, poor waste management, and agricultural activities in Sri Lanka. The conventional treatment plants achieve moderate removal efficiencies, while granular activated carbon (GAC) filtration provides higher removal. It underscores the need for robust mitigation measures to manage MP contamination effectively in Sri Lanka.

Introduction:

Drinking water has been identified as one of the major pathways for human exposure to microplastics (MPs), with estimated ingestion rates ranging from 11,845 to 193,200 particles per person per year, associated with potential adverse health effects (Senathirajah et al., 2021). Despite growing global concern, regulatory and monitoring frameworks for MPs in drinking water remain limited in Sri Lanka. This study aims to assess and develop an evidence-based policy framework for the monitoring, management strategies, mitigating measures and regulating MPs in drinking water supplies in Western Province in Sri Lanka, by integrating global best practices.

Methodology:

A comprehensive literature review compares MP levels in the Kelani River and Attanagalu Oya with global data and assesses sampling and analytical methods suitable for local conditions using the PRISMA review method. Spatial-temporal and land-use analyses identified pollution sources, seasonal variability, treatment removal efficiencies, and relationships between MP levels and water quality indices (WQI). Based on health risk assessments, a policy framework is proposed with benchmark thresholds for regulating MPs in drinking water. The study reviews global standards and best practices, identifies gaps in Sri Lanka's regulatory framework, and

emphasizes stakeholder engagement to support effective monitoring, management, and governance of microplastic contamination in drinking water supplies.

Findings/Results:

MP concentrations in global river waters ranged widely (0.038–6614 particles/L), while Sri Lankan levels were moderate (11.76–23.5 particles/L). Polyethylene (PE) and polypropylene (PP) were the dominant polymers, and fibres and fragments were the most common shapes. The Kelani River exhibited MP concentrations peaking during wet seasons (Dassanayake et al., 2023), while Attanagalu Oya showed higher values, particularly near the Raddolugama DWTP intake (Pathirana, 2022). Major pollution contributors included industrial effluents, urban runoff, agricultural waste, and poor solid waste management. Temporal variations indicated higher MP loads during monsoon periods due to surface runoff and resuspension of sediments.

DWTPs employing conventional water treatment show removal efficiencies ranging from 67.6% to 99.7%, with enhanced performance in plants using granular activated carbon (GAC). Regression analysis showed a strong correlation ($R^2 = 0.94$) between turbidity and MP concentration, confirming that MPs significantly affect physical water quality. However, MP presence was not directly correlated with the overall Water Quality Index (WQI).

Smaller MPs (<10 μm) pose greater health risks due to their ability to penetrate biological barriers. Based on European Commission guidelines, benchmark values of <1 particle/L for MPs <1 μm and 10–100 particles/L for MPs 1–100 μm are proposed for Sri Lankan drinking water. Current Sri Lankan regulations lack specific provisions for MPs in drinking water. Comparative analysis with WHO and EU guidelines indicates the need for national benchmarks, enhanced waste management, and integration of advanced treatment technologies. Effective policy implementation requires coordination among regulatory bodies, industries, and communities, alongside strengthened laboratory and monitoring capacity.

Conclusions/Key Messages:

Sri Lanka's moderate but concerning MP levels highlight an urgent need for improved water governance. While conventional DWTPs demonstrate effective removal, residual MPs persist, emphasising the importance of advanced treatment and continuous monitoring. The absence of standardised analytical protocols and data limits comprehensive policy formulation. Therefore, establishing a robust testing infrastructure and nationwide guidelines is essential for safeguarding public health.

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Evaluation of Water Quality and Sanitation Practices in Commercial RO Filtration Units: A Year-Long Study in Anuradhapura Town, Sri Lanka

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Keywords: RO water; water quality; hygiene practices; Total Dissolved Solids; public health

Abstract: The increasing use of commercially filtered Reverse Osmosis (RO) water in urban Sri Lanka reflects rising public concern over drinking water safety. In Anuradhapura, nearly 100 small-scale roadside RO units operate with varying operational and hygiene standards. This study systematically evaluated the physicochemical quality and sanitation practices of 50 selected RO units over a twelve-month period (September 2024–August 2025), with monthly Sunday morning sampling for consistency. Water quality parameters included pH, Total Dissolved Solids (TDS), and temperature, while hygiene assessments examined floor and ceiling conditions, tank coverage, RO membrane maintenance, bottle-cleaning procedures, and environmental cleanliness. Most units produced water with pH 5.0–6.0 and TDS below 20 mg/L, indicating very low mineral content. Five units showed slightly higher values due to mineral addition practices, although only one unit formally implemented supplementation. Hygiene deficiencies were observed in 15 units and others, increasing contamination risks. Results indicate non-compliance with national potable water standards and highlight the need for improved regulation, maintenance, and continuous monitoring.

Methodology:

Water quality was assessed through key physicochemical parameters to evaluate the safety and stability of treated RO water. pH measured acidity or alkalinity, influencing chemical stability and potential corrosiveness. Total Dissolved Solids (TDS) quantified dissolved minerals, reflecting nutritional value and water palatability. Temperature was recorded to monitor thermal conditions affecting chemical reactions and microbial growth. These parameters collectively provided insights into water quality, enabling comparison with Sri Lanka Standards Institution (SLS) drinking water standards and identification of deviations from safe potable water requirements.

Findings/Results:

Most units produced mildly acidic water (pH 5.0–6.0) with TDS <20 mg/L and temperatures 29–33°C; few mineral-added units showed improved values. Hygiene non-compliance was widespread, including poor infrastructure, inadequate membrane maintenance, and improper bottle cleaning. Findings highlight risks of mineral deficiency and microbial contamination, emphasizing urgent regulatory enforcement and operator training.

Conclusions/Key Messages:

This study reveals widespread non-compliance with national water standards among commercial RO units in Anuradhapura, posing risks of mineral deficiency and microbial contamination. It recommends strict hygiene protocols, routine membrane and tank maintenance, standardized bottle-cleaning, continuous monitoring, and appropriate mineral supplementation to improve water safety and protect public health.

Figures and Tables

Table 1: Hygiene and Water Quality Summary of Selected RO Units

Parameter	Observed Range	Notes
pH	5.0–7.0	Most units 5.0–6.0
TDS (mg/L)	<20	Higher in units with mineral addition
Temperature (°C)	29–33	Morning samples
Tiled Floors	12 units	Majority without tiles
Tank Coverage	Mostly uncovered	Dust accumulation
Membrane Maintenance	Rare	Few units maintained regularly
Bottle Cleaning	15 units inadequate	Potential contamination risk

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Spatial Variations of Sulphur Content and Algal Diversity: A Case Study of the Samanalawewa Dam Leakage Canal

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Keywords: Samanalawewa; sulphur analysis; karstification; water quality

Abstract: Benthic algal communities are widely recognized as reliable indicators of water quality and ecological conditions in freshwater environments. This study examined the water quality parameters and the relationship between sulphur-related water chemistry and benthic algal diversity within the Samanalawewa reservoir and its associated leakage canal. Particular attention was given to sulphate enrichment resulting from dam leakage through karst-influenced geological formations. The Samanalawewa leakage area exhibited high sulphate concentration as 427.84 ppm while reservoir water showed 80.80 ppm and the lowest benthic algae diversity and high dominance of filamentous cyanobacterial species such as *Spirogyra* sp, *Leptolyngbya* sp, *Limnothrix* sp.

Introduction:

Samanalawewa is one of Sri Lanka's largest and most significant reservoirs, contributing to the country's second-largest hydroelectric power scheme while supplying water to surrounding regions (Laksiri, 2007). Karstification, a geological process involving the dissolution of soluble rocks such as limestone, can significantly influence water characteristics by increasing the concentration of minerals, including Sulphur compounds (Laksiri, 2007).

Methodology:

The study was conducted at five sampling sites within the Samanalawewa reservoir and leakage canal system during the period from July to October 2025. Site 5 represented the reservoir upstream, while S1 marked the leakage starting point. Sites 2, 3 and 4 were located progressively downstream along the leakage canal. 3 replicate samples were collected from each site during a single visit, totaling 15 samples. All the data were measured in-situ using a portable multiparameter water quality meter. Sulphate content was measured using the Barium Chloride method. Benthic algae samples were collected

by scraping substrates from the sampling sites and preserved in Lugol's Iodine. Species identifications were done by light microscopic observations and identified using keys (Lund & Canter, 1995), (Entwisle, et al., 1997).

Findings/Results:

Figure 1 shows the pH changes in sampling sites within the range of 6.30 - 7.19. S1 had the lowest pH value, and the pH values across the sampling sites reveal a gradual increase from S1 towards the reservoir, alongside decreasing Sulphate concentrations from 427.84 ppm to 88.80 ppm. Figure 2 shows the Simpson index related to benthic algae variation among sampling sites. S1 exhibited the lowest value of 0.74 and reservoir exhibited the highest value of 0.88.

Conclusions:

The findings show that the leakage area is strongly influenced by seepage moving through fractured limestone and iron-bearing rocks than the reservoir area. These formations release sulphate and iron into the water, lowering the pH and producing the clear smell of H_2S at the leakage canal. Such conditions created a harsh environment where only a few tolerant filamentous cyanobacteria were able to grow, which explains the low diversity observed at leakage starting point (S1). As the water moved along the canal, natural dilution and buffering reduced the concentration of dissolved ions and raised the pH. These gradual chemical changes supported a steady increase in algal richness and evenness from S1 toward the downstream and reservoir.

Figures and Tables:

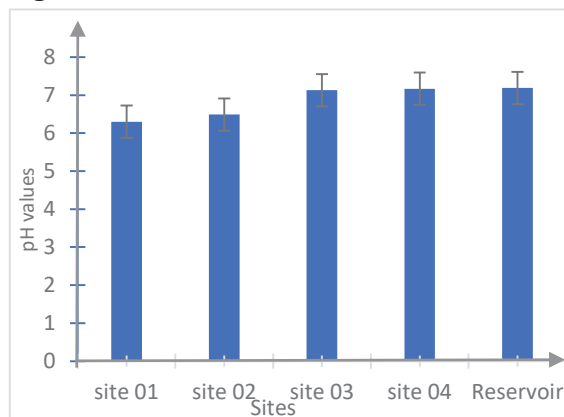


Figure 1: pH variation among sites

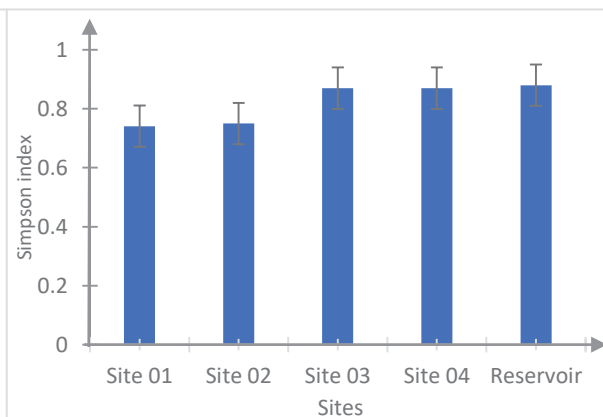


Figure 2: Simpson Index among sites

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Development of Water Quality Index for Mahaweli River

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Keywords: Water Quality Index; Mahaweli River; Canadian Council of Ministers of the Environment Water Quality Index; Weighted Arithmetic Index; Assigned Water Quality Index

Abstract:

This study assessed raw water quality in a 50 km section of the Mahaweli River upstream Meewathura Water Treatment Plant (WTP) using three Water Quality Indexes (WQIs): Canadian Council of Ministers of the Environment – Water Quality Index (CCME-WQI), Weighted Arithmetic Index (QAI), and Assigned Water Quality Index (AWQI). Data from eleven WTPs between 2021–2023 were analyzed. Results showed seasonal and spatial variations in water quality. Upstream stations mostly had “Good” quality, while Meewathura and nearby plants dropped to “Poor” in rainy seasons and improved to “Fair” in dry periods. The indices effectively simplified complex data and supported sustainable water management for the National Water Supply and Drainage Board (NWSDB).

Introduction:

The Mahaweli River’s water quality has declined due to pollution and environmental changes, affecting water used for treatment at plants like Meewathura WTP. Since testing many separate parameters is complex, the WQI provides a single, simplified measure to interpret overall water quality. This study used three models WAI, AWQI, and CCME-WQI to evaluate the river’s condition and identify seasonal and spatial variations (Brown et al., 1970; Canadian Council of Ministers of the Environment, 2001; Azman et al., 2015; Uddin et al., 2023).

Methodology:

A 50 km stretch of the Mahaweli River and its associated WTPs was analysed from January 2021 to December 2023, using data from eleven WTPs. Seven parameters

colour, turbidity, pH, TDS, total hardness, total iron, and total coliform were evaluated. Water quality was assessed using three indices: CCME-WQI, Weighted Arithmetic Index, and Assigned WQI, which facilitated classification of water quality, highlighted seasonal and spatial variations, and supported effective water resource management (Canadian Council of Ministers of the Environment, 2001; Brown et al., 1970; Azman et al., 2015; Uddin et al., 2023).

Findings/Results:

The Mahaweli River's water quality varied seasonally and spatially: upstream stations had good quality, while downstream areas near Meewathura experienced poor quality during rainy seasons, improving to fair levels in dry periods.

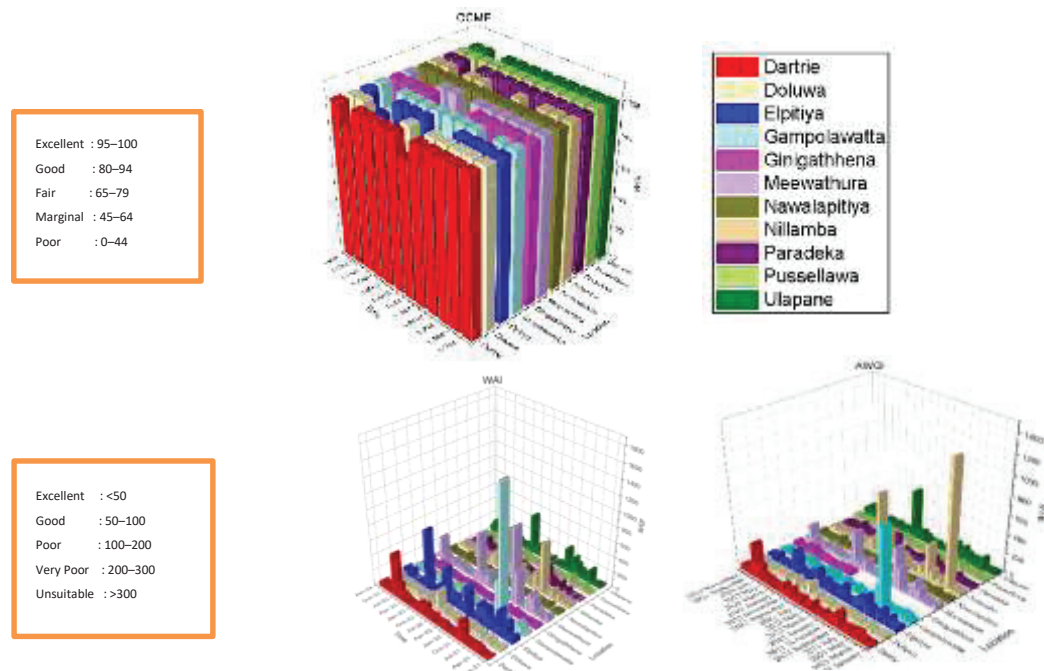


Figure 1: Comparison of Water Quality along the Mahaweli River using CCME-WQI, WAI, and AWQI Methods

Conclusions/Key Messages:

The CCME-WQI, WAI, and AWQI indices effectively revealed seasonal and spatial variations in the Mahaweli River's water quality. Meewathura and nearby plants showed poor quality during rainy seasons but improved in dry months, while upstream stations generally maintained good quality. These results offer the NWSDB practical tools for water management, with future studies suggested to improve index accuracy using larger datasets.

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Effectiveness of Control Measure of Roughing Filter Plant under the Water Safety Plan Framework: A Case Study of the Point Pedro Water Supply Scheme

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Keywords: Water Safety Plan; Roughing filter; Groundwater treatment; Iron and manganese removal; Water quality improvement

Abstract: The Point Pedro Water Supply Scheme (PWSS) abstracts 1350 m³/day of groundwater from four dug wells and six boreholes. Water quality assessments revealed elevated iron, manganese, turbidity, and colour exceeding SLS 614:2013 limits. Within the Water Safety Plan (WSP) framework, these were identified as significant source hazards. A cascade aerator followed by a vertical up-flow roughing filter with graded media was implemented to mitigate these risks. Monitoring showed effective reduction of turbidity (0.7–2.7 NTU; 32.9–79.0%; 92% compliance) and manganese (0.007–0.049 mg/L; 60.8–93.5%; 100% compliance). Iron (0.30–0.76 mg/L; 13.1–69.2%; 8.3% compliance) and colour (59–109 Pt/Co; 12.5–50.0%; 0% compliance) removal remained insufficient. Limitations were linked to uneven flow and lack of roofing. Recommended improvements include pre-chlorination, optimized media grading, roofing, and routine monitoring. Overall, the system improves water quality but requires further optimization for compliance and robust WSP implementation.

Introduction:

Groundwater from the PWSS has been found to contain elevated iron and manganese, high turbidity, and excessive colour, which reduce consumer acceptability and may pose health risks. Under the WSP framework (WHO, 2017), these parameters were identified as significant source related hazards. Risk assessment revealed that existing treatment practices were inadequate to consistently meet water quality standards, resulting in high residual risk scores. To mitigate these risks, the NWSDB implemented a cascade aerator followed by a roughing filter as a corrective and preventive control measure. This study aims to evaluate the system's effectiveness in removing turbidity, colour, iron, and manganese, verify compliance with SLS 614:2013 standards, identify limitations, and provide recommendations to enhance treatment performance. The findings are intended to support WSP improvement and strengthen control measures.

Methodology:

The system consisted of a cascade aerator (4 drops) followed by a vertical up-flow roughing filter (450 m³ capacity) with four media layers graded from 16–20 mm (bottom) to 4–8 mm (top). Each borehole was operated for 3 hours with a 30-minute rest period. Sampling was conducted during September which is the driest period in

Jaffna region. Water quality parameters turbidity, colour, total iron, and manganese were monitored in both raw and treated water over 48 hours. Removal efficiency and compliance with SLS 614:2013 standards were assessed.

Results:

Table 1: Removal Efficiency and Compliance of the Roughing Filter System

Parameter	Raw Water Range	Treated Water Range	Removal Efficiency (%)	Compliance with SLS 614:2013 (%)
Turbidity (NTU)	1.0-3.8	0.7 – 2.7	32.9 – 79.0	92
Manganese (mg/L)	0.079-0.188	0.007 – 0.049	60.8 – 93.5	100
Iron (mg/L)	1.08-1.42	0.30 – 0.76	13.1 – 69.2	8.3
Colour (Pt/Co)	71 – 156	59 – 109	12.5 – 50.0	0

The roughing filter system effectively reduced turbidity and manganese, achieving compliance in 92% and 100% of samples, respectively, through sedimentation, filtration, and partial oxidation with media adsorption. In contrast, iron and colour removal were inadequate, with treated water often exceeding standards. Low iron removal (13–69%) was attributed to insufficient oxidation and uneven flow distribution, while limited colour removal (12–50%) resulted from incomplete iron removal and the absence of roofing, which facilitated algal growth under sunlight exposure (Patil et al., 2012). These operational and design limitations indicate the need for targeted improvements. Within the WSP framework, the filter serves as a critical control point, but residual risks for iron and colour remain significant. Recommended measures include pre-chlorination, optimized media grading, roofing, and routine monitoring. Adoption of these interventions would strengthen control efficiency, reduce residual risk, and support sustainable safe water supply.

Conclusions and Recommendations:

The roughing filter system effectively reduced turbidity and manganese, achieving compliance with SLS 614:2013 standards, but iron and colour removal remained inadequate. Performance limitations were linked to uneven flow, insufficient oxidation, suboptimal media grading, and lack of roofing, which promoted algal growth. From a Water Safety Plan perspective, the filter serves as a critical control point, yet residual risks for iron and colour persist. Targeted interventions such as pre-chlorination, optimized media grading, roofing, and routine monitoring are recommended to enhance treatment efficiency, reduce residual risk, and ensure sustainable safe water supply.

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The Unseen World: Revealing the Microbial Dark Matter and Core Microbiome from a *Chironomus spp.* Contaminated Drinking Water Storage Tank.

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Keywords: Microbiome; Metagenomics; Opportunistic Pathogens; Water Storage Tank.

Abstract:

Drinking water storage tanks serve as the final barrier, ensuring safe water quality before consumption. Infestation by *Chironomus spp.* larvae introduce organic matter and microorganisms; therefore, shotgun metagenomics was employed to characterize bacterial communities within a contaminated drinking water storage tank. Over 1.3 million Kraken assigned reads revealed a microbiome dominated by *Pseudomonadota* (69.4%) and *Bacteroidota* (27.7%), with core genera including *Acidovorax*, *Acinetobacter*, and *Chryseobacterium*. Opportunistic pathogens such as *Acinetobacter junii*, *A. baumannii*, and *Stenotrophomonas maltophilia*. Notable levels of *Aeromonas* and the emerging pathogen *Elizabethkingia* were also detected. Storage tanks harbour microbes, posing potential health risks that demand urgent management.

Introduction:

Maintaining the microbiological integrity of drinking water from the treatment plant to the consumer tap is essential for public health. Storage tanks and service reservoirs play a key role in balancing supply but are also potential points of water quality degradation due to stagnation, disinfectant decay, and biofilm development (Ling et al., 2016). Among the underexplored contamination vectors are aquatic macroinvertebrates such as non-biting midge larvae (*Chironomidae*), which can colonize tanks and introduce complex organic substrates and associated microbiota (Failla et al., 2016). This study used shotgun metagenomic sequencing to analyze the microbial community of a consumer water storage tank contaminated with *Chironomus spp.* The objectives were to (i) determine the taxonomic composition of bacterial and viral communities, (ii) identify potential pathogens and indicator organisms as a public health concern.

Methodology:

Metagenomic Analysis and Bioinformatics: Biofilm DNA will be extracted using the DNeasy PowerSoil Kit (Qiagen, USA) following the manufacturer's protocol and stored at

–20 °C. Library preparation and paired-end sequencing will be performed using the Illumina TruSeq Nano DNA HT Kit on a HiSeq2500 platform. Read quality will be verified using FastQC, and assembly quality assessed with MetaQuast v5.0.2. (Wood et al., 2019).

Findings/Results:

Microbial Community Composition: The microbial community was overwhelmingly dominated by bacteria (99.9%). The predominant phyla were Pseudomonadota (69.2%) and Bacteroidota (28.5%). At the genus level, *Acidovorax*, *Chryseobacterium*, and *Acinetobacter* were most abundant, with *Acidovorax temperans* (33.0%), *Acinetobacter junii* (12.5%), and *Chryseobacterium aureum* (11.5%) as the dominant species.

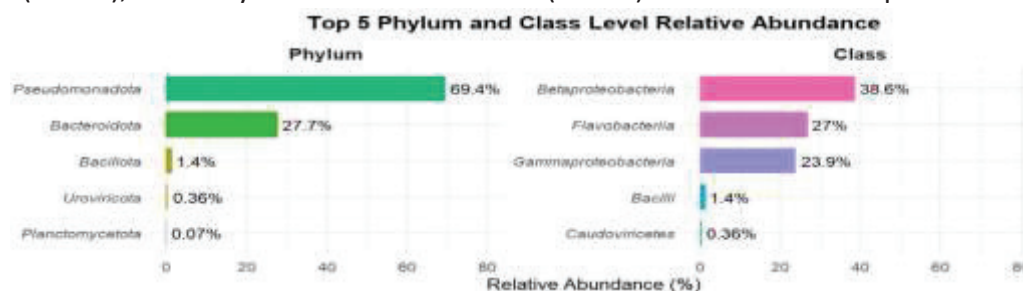


Figure 1: Dominant Phyla with class

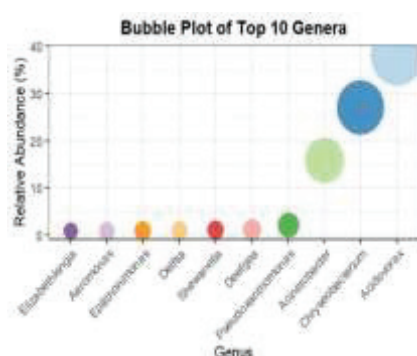


Figure 2: Top 10 Genera

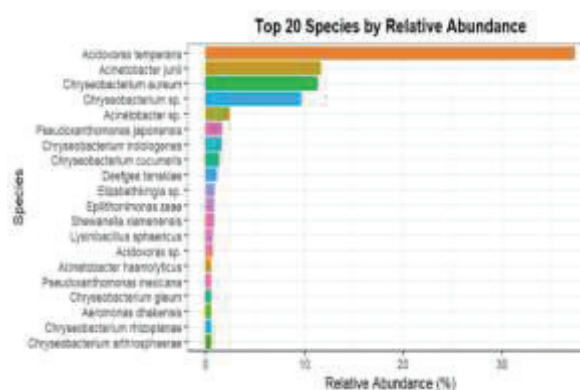


Figure 3: Top 20 Abundant Species

Conclusions/Key Messages:

The results show a dramatic shift toward communities dominated by organic-degrading and biofilm-forming bacteria, coupled with the presence of multiple opportunistic pathogens and faecal contamination indicators. Such conditions compromise water microbiological safety and demonstrate that macrofaunal contamination is not merely a nuisance but a serious health hazard.

References:

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Detection of Microplastics Present in Water Samples Using Modified Graphene Oxide Quantum Dots (GOQD)

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Keywords: Microplastics; Graphene Oxide Quantum Dots

Abstract: Presence and contamination of microplastics in drinking water is a growing concern for the environment and human health. For sampling and extracting microplastics, many methods have been developed. In this project, we aim to develop a method to detect microplastics using graphene oxide quantum dots, which were developed using citric acid, urea, and ammonia solution, making it a more cost-effective method. Using a standard digestion method, microplastics were functionalized, and quantum dots were bonded. As a result, it is capable of distinguishing microplastics when other substances, such as organic and sand particles, are present.

Introduction:

Use of Nile red as a fluorescent dye is a very common technique used to identify microplastics. This is a very costly method, as 500 mg of Nile red costs around Rs 350,000.00, and equipment such as FTIR, Raman, and GC-MS is costly as well, and they cannot be used in a regular manner, especially in 3rd world countries. Therefore, cost-effective methods are necessary to monitor microplastic variation more frequently (Wagner et al. 2014). Our objective here is to replace Nile red with modified GOQD for the detection of microplastics which will enable the identification and analysis of microplastics in a more cost-effective manner.

Materials and Methodology:

Materials: Citric acid crystals (BHD), Sodium Hydroxide (Sigma-Aldrich, 98%), Urea (Vel, 99%), NH₃ (25%), H₂O₂ (Chem labs, 30%), FeSO₄ (Chem labs, 99+%) were used in this study. All the reagents used in this study were used without further purification.

Graphene Oxide Quantum Dots (GOQDs) Synthesis: Graphene Oxide Quantum Dots were synthesized in atmospheric conditions where 4 g of citric acid was heated to 250 °C and was poured into a 200 mL solution containing 2g of NaOH.

Modified N-Doped GOQD Synthesis: 50 mL solution of GOQD was taken and 5 mL NH₃ solution was added and to another 50 mL solution urea was added and both solutions were heated to 180 °C in a Teflon lined autoclave for 8 hours.

Microplastic Detection: All plastic samples created using grinding and cutting of various plastics undergo a standard digestion procedure using Fenton's reagent (Tagg

et al. 2017) and density separation using NaCl. The samples were treated with 200 μL of GOQDs and was observed using a fluorescence microscope under blue and green light (description given in Table 01)

Findings/Results:

Microplastics coated with NGOQD exhibited significantly greater fluorescence compared to GOQD, indicating the importance of N-doping to GOQD in the field of microplastic detection. PVC and PS exhibited strong luminescence under blue and green light, while PE was detectable but did not show as strong a luminescence as Nile red.

Conclusions/Key Messages:

In conclusion, using this technique, we were able to detect microplastics far better compared to their natural fluorescence. Since the synthesis of these quantum dots involves only 3 compounds this already proves the cost effectiveness of this method. Quantum dots will be modified using different methods and microplastics will undergo a longer digestion which will enable more accurate detection of microplastics.

Figures and Tables

Table 1: Optical and fluorescence microscopic images of different microplastics (PS, PVC, and PE) treated with water, Nile red, GOQDs, and N-doped using NH_3 and Urea GOQDs under various illumination conditions (light (L) (White Light source, blue (B) (460nm – 465nm), and green (G) (510nm – 550nm)). ND indicates no detectable fluorescence signal.

	Water			Nile Red			GOQD			NGOQD from NH_3			NGOQD from Urea		
	L	B	G	L	B	G	L	B	G	L	B	G	L	B	G
P S			ND						ND			ND			
P V C			ND						ND			ND			
P E			ND						ND						

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Algal Blooms in Drinking Water Supply Reservoirs

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Keywords: Algal blooms; dry zone; reservoir; eutrophication; Sri Lanka

Abstract: Harmful algal blooms in drinking water supply reservoirs have the potential to cause human health risks, negative ecological and economic impacts and specifically water treatment challenges. We reviewed the status of algal blooms in Sri Lanka and critically evaluated the prevention, control and treatment strategies to manage algal blooms in reservoirs through an extensive literature review. Our study emphasized the need for an integrated approach for a continuous safe drinking water supply.

Introduction:

Climate change can influence the functioning of drinking water supply reservoirs through increasing temperature, altering precipitation patterns, and intensified nutrient loadings which favored algal bloom forming in reservoirs. Algal blooms degrade raw water quality, produce toxins, cause taste and odour problems, clog treatment process, frequent backwashing which leads to high operational costs and threatening the safety of drinking water supplies. Here we aim to: (i) review the significance of algal blooms in Sri Lankan context, (ii) summarize current algal treatment techniques practiced in Sri Lanka, and (iii) provide an overview of suitable solutions by evaluating techniques from other tropical countries and match them with the Sri Lankan context.

Methodology:

A comprehensive literature review was carried out using the advanced search function on Google Scholar™. Keywords such as “Algal bloom”, “Reservoir”, “Sri Lanka”, and “Potable water” were used, with the query set to search for keywords appearing “anywhere in the article” from 1902. Knowledge-sharing meetings were held with experts in relevant fields. Relevant studies data were gathered in a master document for further analysis.

Findings/Results:

Microcystis and *Cylindrospermopsis* are the most frequently reported bloom-forming cyanobacterial genera in drinking water supply reservoirs. Several treatment techniques designated for algae or algal toxin removal are implemented in existing water supply projects in Sri Lanka, such as micro strainers, granular activated carbon (GAC), powdered activated carbon (PAC), dissolved air floatation systems (DAF) and sonicators. Treatment techniques which are used in different stages of treatment process can be classified as biological (Gumbo et al., 2008) physical, chemical or physiochemical (Herman et al., 2017) treatment techniques (Figure 1).

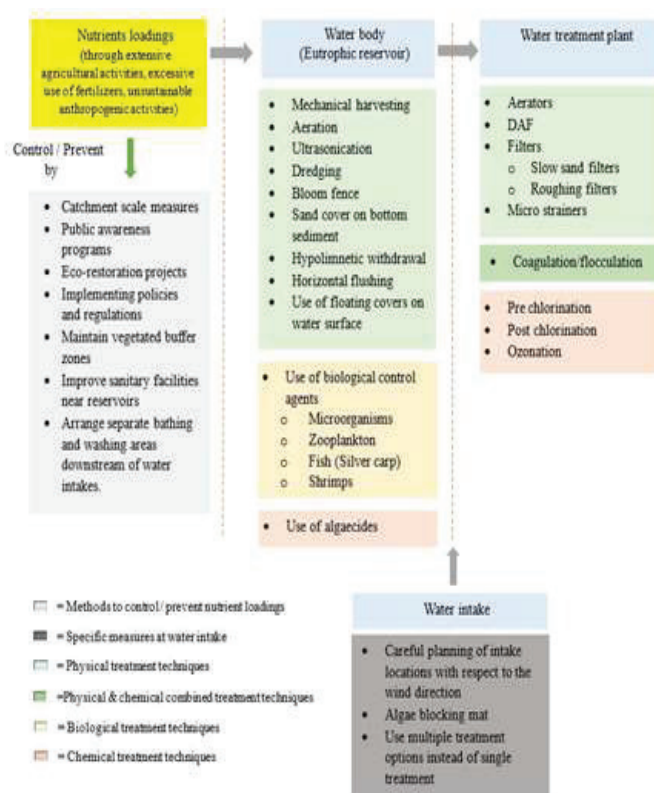


Figure 1: Conceptual diagram of potential integrated methods/techniques for effective algal treatment (DAF = Dissolved Air Flotation)

Conclusions/Key Messages:

Nutrients (N and P), warm temperature, stagnant water, and dry season were recognized as the critical driving factors for eutrophication, leading to algal blooms. Climate change is intensifying this algal bloom forming and we propose a multi-barrier management framework instead of a single water treatment focusing on three separate stages (i) catchment management, (ii) prevention and control of algal blooms in reservoirs, and (iii) optimization of water treatment technologies at drinking water treatment facilities for a continuous safe drinking water supply.

References:

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IWA Water Safety Conference & Exhibition
23-25 March 2026, Sri Lanka

Comparative Study of TiO_2 and MnO_2 Nanoparticles for the Degradation of Methylene Blue in Water.

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Keywords: TiO_2 nanoparticles; MnO_2 nanoparticles; methylene blue; photocatalytic degradation; water treatment

Abstract: Water pollution from persistent dyes is a serious environmental issue. This study compared sol–gel synthesized TiO_2 and precipitated MnO_2 nanoparticles for degrading 10 mg/L methylene blue under sunlight, monitored at 664 nm for 4–5 hours. TiO_2 showed an initial absorbance increase before decreasing, while MnO_2 exhibited a steadier reduction, reaching 1.436 AU at 4 hours. Both show potential for wastewater treatment, though further characterization and kinetic studies are needed.

Introduction:

Water pollution from persistent dyes remains a significant environmental issue. This study evaluated TiO_2 and MnO_2 nanoparticles for degrading 10 mg/L methylene blue under laboratory conditions. TiO_2 (sol–gel) and MnO_2 (precipitation) were tested under sunlight, with degradation monitored at 664 nm for 4–5 h. MnO_2 showed a steady absorbance decrease (1.436 AU at 4 h), while TiO_2 displayed an initial increase followed by decline. Both materials demonstrate potential for wastewater treatment, though further characterization and kinetic studies are required.

Methodology:

Synthesis of TiO_2 Nanoparticles

TiO_2 nanoparticles were prepared via sol–gel using titanium(IV) isopropoxide and ethanol. Nitric acid was added to induce hydrolysis and condensation, then the sol was aged, dried, and powdered.

Synthesis of MnO_2 Nanoparticles

MnO_2 nanoparticles were prepared by reacting KMnO_4 with NaOH , forming a brown precipitate that was filtered, washed, and dried.

Degradation Experiment

A 10 mg/L methylene blue solution was stirred under sunlight (TiO_2 : 320→530 rpm, 30–45 °C, 5 h; MnO_2 : 300→500 rpm, 40 °C, 4 h). Absorbance at 664 nm was measured hourly. Structural characterization and dark controls were not done.

Results:

TiO₂ and MnO₂ nanoparticles degraded methylene blue under laboratory conditions. TiO₂ showed an initial rise followed by a gradual decrease in absorbance, while MnO₂ steadily reduced it to 1.436 AU within 4 h. Further studies, including catalyst characterization and kinetic analysis, are needed to confirm the degradation mechanisms.

Conclusions/Key Messages:

TiO₂ and MnO₂ nanoparticles degraded methylene blue under laboratory conditions. TiO₂ showed an initial absorbance increase followed by a gradual decrease, while MnO₂ displayed a steady reduction, reaching 1.436 AU after 4 h. Further studies, including characterization and kinetic analysis, are required.

Figures and Tables

Table 1: Absorbance Values for TiO₂ Degradation Study

Time / h	Absorbance / AU
0	1.921
1	2.050
2	3.200
3	3.100
4	3.000
5	2.800

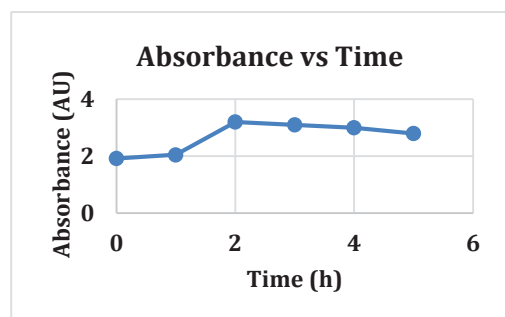


Figure 1: Absorbance vs Time graph for the degradation of water pollutants using TiO₂ nanoparticles.

Table 2: Absorbance vs Time for the degradation of water pollutants using MnO₂ nanoparticles

Time / h	Absorbance / AU
0	2.210
1	2.450
2	1.450
3	2.450
4	1.436

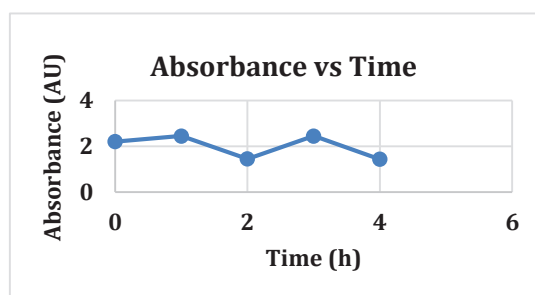


Figure 2: Absorbance vs Time graph for the degradation of water pollutants using MnO₂ nanoparticles.

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Mining for Insights: An Evaluation of Association Rules for Household Water Perception Data

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Keywords: Apriori Algorithm; Data Mining; Drinking Water; Public Health; Rule Mining

Abstract: Understanding household perceptions of water quality and safety is essential for effective water management and public health planning. This study analyses household water perception data from Sri Lanka's Northern Province using Association Rule Mining (ARM). Data from 101 households covering twelve categorical perception variables were examined using the Apriori algorithm. Frequent itemsets and association rules were evaluated using support, confidence, and lift measures. The analysis identified consistent perception patterns, particularly linking perceived water quality and supply reliability with household precautionary practices. Several strong, high-confidence rules indicated non-random relationships among perception variables. Overall, the findings demonstrate that ARM is a transparent and effective method for uncovering latent perception structures in household survey data and provides useful insights to inform water management and public health interventions.

Introduction:

Public health organizations commonly use Knowledge, Attitudes, and Practices surveys to assess household perceptions of drinking water safety. However, such high-dimensional categorical data are difficult to analyse using conventional descriptive methods alone. Recent advances in data mining have shown that Association Rule Mining (ARM) is effective in uncovering hidden patterns in perception-based survey data (Sarker, 2021). Applying ARM to household water perception data enables the identification of dominant perception structures that may not be evident through traditional analytical approaches.

Methodology:

The present study analyzed 101 valid household responses, comprising 12 categorical perception variables related to water quality, availability, safety, and household management practices. Given the categorical nature of the data, Association Rule Mining was selected as an appropriate analytical framework. All perception variables were transformed into a transactional format using one-hot encoding prior to analysis. The Apriori algorithm was then employed to extract frequent itemsets and association rules. This approaches have been widely validated for survey and perception data analysis due to their interpretability and robustness (Al-Maolegi & Arkok, 2020; Wu &

Zhang, 2021). Rule strength was evaluated using support, confidence, and lift measures, which are standard metrics in association rule analysis.

Findings/Results:

The Apriori algorithm revealed consistent household perception patterns, with individual variables showing ~14% support and multi-variable combinations ~13%. Several rules achieved 1.0 confidence with high lift, indicating strong, non-random associations. An average of 77.23 rules (SD = 74.32) reflected expected variability in household water perceptions. As shown in Table 1, the itemsets capture interpretable links between water quality concerns, supply reliability, service dissatisfaction, and household treatment behaviors, suggesting adaptive responses to perceived risks.

Table 1: Frequent Itemsets Derived from Household Water Perception Survey Data

No.	Itemsets (Interpreted)	Support
1	Irregular water supply	0.141176
2	Concern about drinking water quality	0.141176
3	Irregular water supply AND quality concern	0.141176
4	Use of household water treatment methods (boiling/filtering)	0.129412
.....		
8	Household treatment practice AND quality concern	0.129412
9	Irregular supply AND dissatisfaction with water service	0.129412
10	Quality concern AND use of alternative water sources	0.129412

Nodes represent perception variables and edges denote strong Apriori-identified associations (**Figure 1**), with the network visualization intuitively revealing interconnected perception structures, dominant variables shaping household attitudes, and complementing quantitative association rule metrics as demonstrated in prior survey-based perception studies.

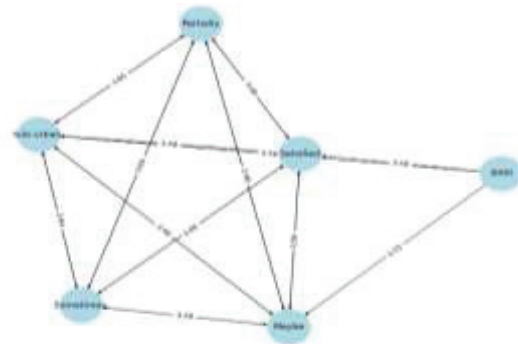


Figure 1: Network Graph of Association Rules for Household Water Perceptions

Conclusions:

This study confirms that Apriori-based ARM is effective for identifying latent perception structures in household water survey data. Household water safety perceptions are influenced by interconnected factors, particularly perceived quality, supply reliability, and precautionary behaviours, with observed variability reflecting genuine differences in household experiences.

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Poster Presentations

Day 02



Integrating Water Safety Planning For Enhanced Risk Characterization of Community-Based Water Supply Systems in Sri Lanka

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Keywords: WSP; Risk Factors; Contextual Issues; Hazards; Potential Risks;

Abstract: Ensuring the safety of drinking water is critical, particularly within community-based water supply schemes (CBWSS) in Sri Lanka because many risk factors for water safety has been experienced (Ramos-Parra *et al.*, 2025). Water Safety Planning (WSP) provides a robust framework risk identification and assessment. (Bellanthudawa *et al.*, 2019). The primary objective of this study was to evaluate the type and severity of risks identified through water safety planning. The study reveals that effective water safety management in CBWSS requires a departure from standardized approaches. The observed district-specific variability in risks underscores the need for highly localized and context-specific implementation of WSP, ensuring that resources and mitigation strategies are precisely targeted toward the actual threats present in each area.

Introduction:

Ensuring the safety and security of drinking water is paramount in Community-Based Water Supply Schemes (CBWSS) which serve a significant portion of the rural and semi-urban population in Sri Lanka. Recent experience indicates that CBWSS face a multitude of risk factors threatening water safety, and need a systematic approach to water safety management.

In Water Safety Planning (WSP) the essential first step is the identification and assessment of risks. This study directly addresses this basic requirement.

Methodology:

The study employed a site-specific risk identification and assessment methodology at the Water Safety Planning process. The study spanned ten districts across Sri Lanka. Trained development officers assessed Water Safety risks from 145 CBOs (10% of CBWSS implementing WSPs).

Findings/Results:

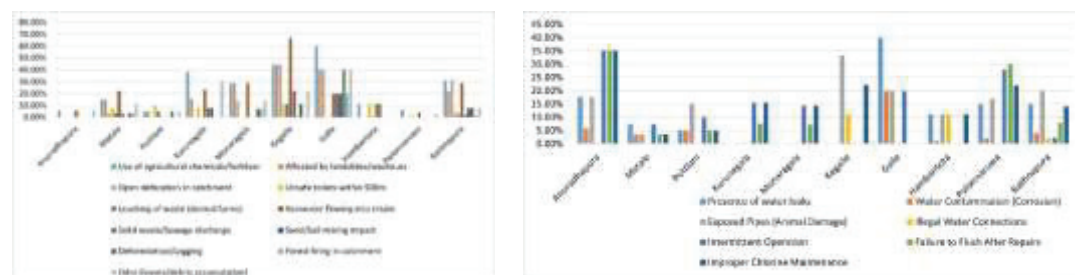
The study successfully identified a broad and complex range of potential risks across the ten districts. These risks were categorized as the stage of the water supply system and their levels were examined.

Conclusions/Key Messages:

The study demonstrates that Community-Based Water Supply Schemes (CBWSS) in Sri Lanka are exposed to a complex matrix of hazards across all functional stages, from catchment to distribution. While risks are ubiquitous, their severity and frequency exhibit significant district-specific variability.

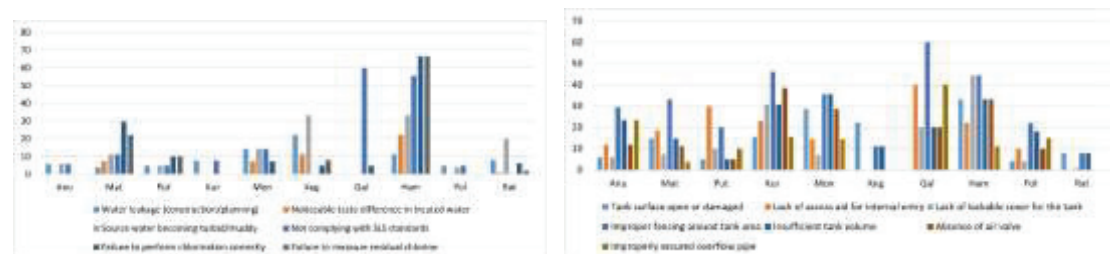
This evidence suggests that standardized, non-contextual water safety approaches are insufficient. Effective risk characterization and public health protection require a transition toward localized Water Safety Plans (WSPs) that account for unique regional environmental and contextual factors.

Figures and Tables



Graph 1 - % Risks in Water Source and Catchments of CBWSSs

Graph 2 - % Risks in Distribution systems CBWSSs



Graph 3 - % Risks in Water Treatment CBWSSs systems of CBWSSs

Graph 4 - % Risks Storage tanks of CBWSSs

Few other detailed findings were done related to catchment and water source.

References:

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IWA Water Safety Conference & Exhibition
23-25 March 2026, Sri Lanka

Statistical Assessment of Water Safety Awareness and Hygiene Practices in Rural Communities: A Case Study of Bulathsinhala, Sri Lanka

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Keywords: water safety awareness; hygiene practices; community engagement; rural sanitation

Abstract: This study assesses water safety awareness and hygiene practices among 150 rural households in Bulathsinhala, Sri Lanka, to evaluate readiness for community-based Water Safety Planning (WSP). Using a quantitative cross-sectional survey, descriptive and multivariate regression analyses were applied. Results indicate moderate awareness ($\$M = 3.6/5\$$) but inconsistent hygiene practices, with only 60% reporting regular household water treatment. Awareness, education level, and participation in WSP significantly predicted safe practices (adj. $\$R^2 = 0.48$, $p < 0.001\$$). Findings highlight the necessity of participatory, awareness-driven interventions alongside infrastructure improvements to support localized, climate-resilient water safety strategies in rural Sri Lanka.

Introduction:

Safe drinking water remains a critical public health concern in rural Sri Lanka, where households rely on shallow wells and springs vulnerable to seasonal contamination (Gunasekara & Silva, 2017). National policy promotes Water Safety Plans (WSPs) as a preventive approach; however, effective implementation depends heavily on household awareness and community participation (NWSDB 2018). Empirical evidence suggests that infrastructure alone is insufficient without behavioural engagement (WHO 2017). This study addresses the gap by statistically assessing water safety awareness in Bulathsinhala to inform participatory WSP implementation.

This study assumes that water safety awareness, participation in Water Safety Plan (WSP) activities, and education level influence household hygiene practices and water treatment behaviour. Awareness and community engagement are expected to directly improve safe practices, while education supports understanding and adoption of preventive measures. Household income is included as a control variable. This framework guided the regression analysis.

Methodology:

A cross-sectional survey of 150 households across six hamlet clusters in Bulathsinhala was conducted using a structured questionnaire assessing socio-demographics, water safety awareness, hygiene practices, and WSP participation. Awareness and practice indices were measured on five-point Likert scales (Cronbach's $\alpha > 0.78$). Data were analysed using SPSS v.26 with descriptive statistics, Pearson correlation, and multivariate regression. Ethical clearance was obtained and informed consent secured from all participants.

Findings/Results:

Descriptive analysis showed that 53.3% of respondents were female, mean age was 41.2 years (SD = 12.6), and secondary education was most common (52%). Most households (60%) earned below LKR 50,000 per month. Primary water sources were protected springs (42%) and shallow wells (34%), and only 60% reported regular household water treatment.

Regression analysis indicated that awareness ($\beta = 0.45$, $p < 0.001$), participation in WSP activities ($\beta = 0.22$, $p = 0.005$), and education level ($\beta = 0.20$, $p = 0.010$) significantly predicted hygiene practices (adjusted $R^2 = 0.48$, $p < 0.001$), while income was not significant. Logistic regression confirmed that higher awareness (OR = 1.80, 95% CI: 1.34–2.41) and WSP participation (OR = 2.50, 95% CI: 1.40–4.47) increased the likelihood of adequate water treatment.

Conclusions/Key Messages:

The findings demonstrate that water safety awareness and community participation are critical determinants of safe household water practices. Integrating community engagement and practical training into local Water Safety Plans can strengthen rural water governance and enhance climate resilience.

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Domestic Water Consumption Patterns in Vavuniya Region

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Keywords: Region Specific Analysis; Water Saving; Average Consumption

Abstract: In Sri Lanka, domestic water supply is primarily managed by the National Water Supply and Drainage Board. However, there is a notable lack of detailed, region-specific analyses of water consumption patterns in the country's northern regions. This study addresses that gap by providing a data-driven analysis of water consumption in Vavuniya. Based on a survey of 200 households from both urban and rural areas, the study adopts a mixed-methods approach. An adjusted $R^2=0.557$ from regression analysis indicates that 55.7% of the variation in consumption is explained by the studied variables. The study offers a framework for understanding the key drivers of domestic water consumption in the Vavuniya area.

Introduction:

This study examines household water use in Vavuniya, Sri Lanka, focusing on factors like connection types, consumption volumes, seasonal variations, and socio-economic influences. It tackles issues such as unreliable supply and low awareness to guide better water management, pricing strategies, and service upgrades, especially amid post-conflict shifts in population and infrastructure. Global studies highlight household water use drivers like income, size, pricing, awareness, climate, and alternatives, with pricing and campaigns curbing demand—especially seasonally (e.g., Domene & Saurí 2006; Willis et al. 2013). In South Asia, including Sri Lanka, patterns reflect socio-economic gaps, infrastructure, and subsidies, varying by urban/rural and metering status, though local research remains sparse (Kumar 2014; Edirisinghe & Pathirana 2021).

This study fills a data gap on domestic water use in Sri Lanka's northern Vavuniya District, analyzing post-conflict demographic impacts on demand to guide policy, infrastructure, and engagement for sustainable management

Methodology:

This study employs a mixed-methods approach, combining quantitative and qualitative data to analyze domestic water consumption. Primary data was collected from a sample of 200 households in the Vavuniya region. A stratified random sampling technique was used, with strata based on administrative divisions (urban

and rural) to ensure representation of different household types. Data was gathered through a structured questionnaire covering household income, residence type, water usage patterns, conservation practices, and perceptions. Additionally, semi-structured interviews were conducted with a subset of 25 households to gain deeper insights into water use behaviors and challenges. Secondary data was obtained from the National Water Supply and Drainage Board (NWSDB) on billing and connection details. Quantitative data was analyzed using SPSS, employing descriptive statistics and multiple linear regression to identify key determinants of water consumption. Qualitative data from interviews was analyzed thematically to contextualize and enrich the quantitative findings.

Findings/Results:

Table 1: Model Summary of Regression Analysis

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.755 ^a	.570	.557	.99708

The regression model is statistically significant and provides a good fit, explaining 55.7% of the variance in household water consumption. An analysis of the individual predictors reveals that Monthly Income and Water Usage Pattern emerged as the strongest and most statistically significant positive correlates with water consumption. Residence also showed a positive correlation, suggesting that the type of dwelling influences overall consumption levels. Water Conservation Practices and Perception/Awareness both exhibited a negative correlation with water usage, suggesting that greater awareness and conservation efforts lead to lower consumption, although these relationships were not statistically significant in this model.

These findings reveal inelastic water demand among high-income, high-use households, advocating multi-pronged policies like targeted awareness campaigns and subsidies for water-saving devices. For Vavuniya, they highlight the need for customized demand management addressing affordability and behavioural factors.

Conclusions/Key Messages:

- Monthly income and water usage patterns are the strongest positive correlates of water consumption in Vavuniya.
- Water conservation practices and awareness show a negative correlation with consumption, but their effect is weaker than income or usage patterns.
- The findings suggest that effective water demand management in the region requires multi-pronged strategies, including targeted awareness campaigns and subsidies for water-saving devices, rather than relying on price signals alone.

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Towards Early Prediction of Saltwater Intrusion in the Nilwala River: A Machine Learning based Rainfall-Runoff Modelling Framework for Sustainable Water Management

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Keywords: Machine learning; Nilwala river; Runoff prediction; Saltwater intrusion; XGBoost

Abstract: Saltwater intrusion in the lower Nilwala River adversely effects freshwater abstraction for drinking and irrigation near Matara district pumping stations. Therefore, timely electrical conductivity (EC) prediction is critical for proactive water management and mitigation of saline impacts. Accordingly, as an initial step, this study developed and validated a machine learning (ML) rainfall-runoff model, identifying river discharge as the key factor of saline intrusion. Monthly rainfall and runoff data from the Irrigation Department of Sri Lanka were used to train an Extreme Gradient Boosting (XGBoost) model incorporating antecedent and seasonal features. The model demonstrated moderate yet consistent performance ($R^2 = 0.41-0.51$; RMSE = 16.73-25.65 million m^3), effectively reproducing low and medium flow conditions pertinent to saltwater intrusion. This supports future EC prediction and sustainable water resource management in coastal basins.

Introduction:

Saltwater intrusion in coastal rivers threatens freshwater resources for both drinking and irrigation. During low-flow periods, saline intrusion in the lower Nilwala River raises EC at Matara intake points, disrupting pumping and reducing water supply reliability. Early EC prediction facilitates timely interventions, such as intake shutdowns or gate operations, to safeguard water quality and manage supply. Accurate runoff forecasting is particularly important in data-scarce regions such as Sri Lanka. This study develops a machine learning framework employing XGBoost to predict EC, thereby providing actionable insights for water authorities and stakeholders (Sun et al., 2021; Mosavi et al., 2018).

Methodology:

Monthly rainfall and runoff data (2010-2022) for the Nilwala River at the Pitabaddara station were obtained from the Irrigation Department of Sri Lanka. EC is the target variable for saltwater intrusion prediction; however, this study validated the rainfall-runoff component required to support EC modelling. After data quality control and seasonal encoding, antecedent rainfall, antecedent runoff, and a three-month rolling average of rainfall were used as predictors. An Extreme Gradient Boosting (XGBoost) model was trained using chronological data splitting (80:20, 70:30, and 90:10), with hyperparameters optimised via cross-validation (300 estimators, learning rate = 0.003,

maximum depth = 5, subsample = 0.7, column sample = 1.0). The model was validated to assess its predictive accuracy and reliability.

Findings/Results:

The optimised XGBoost rainfall-runoff model showed moderate but consistent performance ($R^2 = 0.41\text{--}0.51$; RMSE = 16.73–25.65 million m^3), accurately capturing low and medium flow conditions that drive saltwater intrusion. Antecedent rainfall, prior runoff, and seasonal patterns were the most influential predictors, supporting hydrological consistency and model interpretability. These runoff estimates form a foundation for subsequent EC modelling, enabling early identification of periods prone to salinity intrusion.

Conclusions/Key Messages:

This study presents a preliminary machine learning based rainfall-runoff model for the Nilwala River, demonstrating that reliable discharge estimates can be achieved even under data-scarce conditions. These preliminary results provide a solid foundation for future work on predicting EC and assessing saltwater intrusion, highlighting the feasibility of using such model for effective planning and management of water quantity and quality for both irrigation and drinking purposes.

Figures and Tables

Table 1: Model performance evaluation under varying test data proportions

Test Size	RMSE (MCM)	R^2	Interpretation
0.3	25.65	0.411	Moderate fit on longer unseen period
0.1	16.73	0.507	Improved fit on shorter forecast horizon

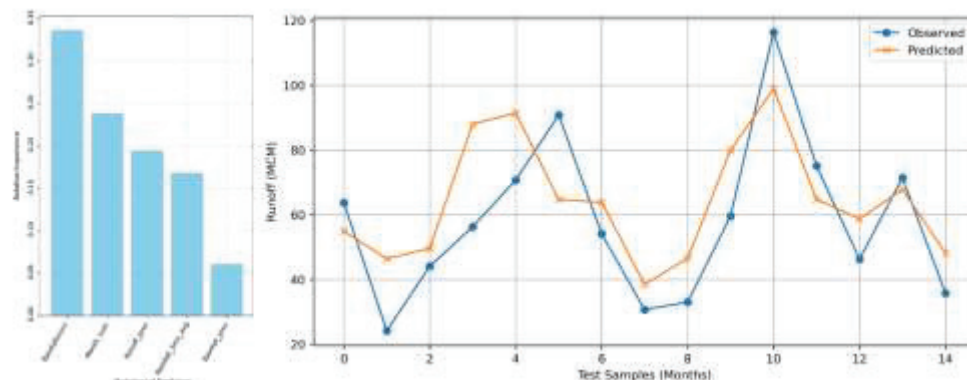


Figure 1.1 Feature importance distribution of hydrological predictors employed in the XGBoost rainfall-runoff model (left) and comparison of observed and model-predicted runoff for the Nilwala river using a 0.1 test split (right).

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Assessing Asset Management Knowledge and Practices of a Community-Based Water Supply Organization

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Keywords: Infrastructure Asset management; Community-Based Organizations; Water supply systems; Consumer awareness

Abstract: Effective asset management is essential for sustaining rural water supply systems managed by Community-Based Organizations (CBOs). This study evaluated asset management knowledge and practices within the Palitha Lanka CBO, Kalugamuwa, through a questionnaire survey of 183 consumers using the KOBO Toolbox platform. While 64.3% of respondents were aware of the CBO's administrative structure, understanding of asset management principles was limited. Most recognized only visible components such as pipes, meters, pumps, and storage tanks. The findings reveal a gap between administrative awareness and technical knowledge, highlighting the need for targeted capacity-building programs to improve management and system sustainability.

Introduction:

An effective asset management system enables to deliver reliable water services at the lowest sustainable lifecycle cost while minimizing risk, reducing NRW, and maximizing public value (Alegre et al., 2016; Lambert & Hirner, 2000). This is particularly important for small utilities run by community-based organizations (CBOs), which manage a significant share of rural and peri-urban water supply schemes in many developing countries (Whittington et al., 2009). Limited understanding of asset management concepts among CBO members often leads to challenges in system operation, maintenance, and long-term sustainability. We conducted a social survey of the members of Palitha Lanka CBO, Kalugamuwa, Sri Lanka to ascertain the knowledge and understanding of Asset management concepts.

Methodology:

The study targeted all 223 registered water consumers of the Palitha Lanka CBO. A structured questionnaire was developed using the KOBO Toolbox platform and administered by university interns attached to the National Water Supply and Drainage Board (NWSDB). Of the total consumer base, 183 respondents (A confidence level of >99% for a margin of error of 5%) were successfully interviewed. The collected

data were analyzed to determine the level of understanding, awareness, and application of asset management principles within the CBO.

Findings/Results:

Survey findings show that 64% of respondents are aware or fully aware of the administrative structure of the CBO, indicating a reasonable understanding of its governance. However, awareness of asset management concepts is comparatively low. Pipes and meters were recognized as key assets by 27% of respondents, while pumps and storage tanks were each identified by 21%, demonstrating that consumer awareness is focused mainly on visible components. Regarding the broader water supply system, 35% identified storage as the main component, followed by the distribution network (24%), with fewer recognizing critical elements such as intake, raw water, and treatment processes. The in depth interviews conducted show that the administrative work of the Prajamullaya continues to be done by the same team. Also, it was revealed that without allowing an alternative group or an individual to be elected to the office, they themselves were appointed to the positions after prior discussion. These results indicate that while basic system awareness exists, deeper technical understanding related to asset management is limited among consumers.

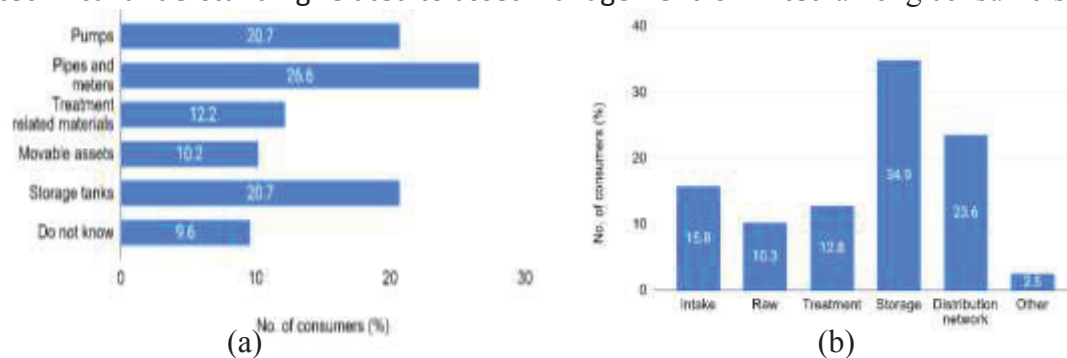


Figure 1: Consumer awareness on (a) Asset components, (b) Main components of the system

Conclusions

The findings show that although most consumers have been connected to the Palitha Lanka CBO's water supply system for over five years, their understanding of asset management remains limited. Persistent issues such as billing inaccuracies, inadequate maintenance, and low transparency indicate management gaps. Strengthening staff competencies through capacity-building in asset management, leadership, and communication is essential for sustainability. The community's recurring request for NWSDB involvement highlights trust in professional oversight and the need for continued technical support.

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GIS-Based Soil Erosion Modelling for Smart Water Quality Monitoring in Maskeliya Oya – Kehelgamu Oya Watershed

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Keywords: Geographical Information System; InVEST-SDR model; Soil Erosion; Sustainable Monitoring

Abstract: Water quality is significantly threatened by the increased soil erosion of watersheds. Quantitative spatial assessments of soil erosion are important to prioritise soil conservation areas. The Integrated Valuation of Ecosystem Services and Trade-offs (InVEST) Sediment Delivery Ratio (SDR) model was utilised to analyse the spatial distribution of sediment dynamics in the Maskeliya Oya – Kehelgamu Oya Watershed. The results of this study revealed that the mean annual soil loss of $7.1 \pm 6.5 \text{ t ha}^{-1} \text{ yr}^{-1}$, exceeding the national tolerance threshold of $5 \text{ t ha}^{-1} \text{ yr}^{-1}$. Higher soil erosion is concentrated in agricultural and urban areas that need immediate conservation. This demonstrates the utility of the InVEST-SDR model as an advanced tool for sustainable watershed management and smart water quality monitoring.

Introduction:

Soil erosion rates have increased in many regions of the world, profoundly impacting water quality and reservoir management. Eroded sediments contain heavy metals, nutrients, and agricultural runoff that influence downstream water quality (Piyathilake et al., 2021). Limitations of the field measurements of soil erosion are overcome through the integration of GIS-based modelling and environmental analytics. The InVEST-SDR model is frequently used for soil erosion assessment. The upper catchment of the Kelani River, containing Kehelgamu Oya and Maskeliya Oya, faces severe watershed degradation due to agrochemical run-off, dense population, and poor land management (Mahagamage and Manage, 2018). This study employs the InVEST-SDR model as a sustainable watershed management tool to simulate the unexamined spatial sediment dynamics in the watershed.

Methodology:

ArcGIS Pro 3.4.0 software was utilised to preprocess the data of Digital Elevation Model (DEM), rainfall data, soil type, and Land Use Land Cover (LULC). Rainfall data were interpolated using the IDW technique. The Rainfall erosivity factor (R) was calculated from: $R = ((972.75 + 9.95 \times \text{MAR})/100)$ where R = rainfall erosivity factor ($\text{MJ. mm}/(\text{ha. h. yr})$), and MAR = mean annual rainfall (mm). The Soil Erodibility (K) was developed by assigning K values for each soil type. Biophysical table with crop

management (C) and support practice (P) factors corresponding to the LULC classes developed from the literature. Soil erosion was modelled by InVEST 3.16.1 using the processed data and default parameter values (Hamel et al., 2015).

Findings/Results:

The InVEST-SDR model provides different sediment dynamics outputs between 2019 and 2023 of the Maskeliya Oya – Kehelgamu Oya Watershed. Mean potential soil erosion (excluding the cover-management and support practice factors) is $38.1 \pm 25.6 \text{ t ha}^{-1} \text{ yr}^{-1}$ consequent to the steeply sloping, hilly terrain (ranging between 99 m and 2320 m) and higher mean annual rainfall (MAR is $3850.1 \pm 950.7 \text{ mm}$), illustrated in **Figure 1**. The mean annual avoided sediment is $31.0 \pm 22.1 \text{ t ha}^{-1} \text{ yr}^{-1}$, illustrating the higher sediment capture by the vegetation (**Figure 2**). **Figure 3** showcases that the watershed has a mean annual soil loss of $7.1 \pm 6.5 \text{ t ha}^{-1} \text{ yr}^{-1}$. It surpasses the $5 \text{ t ha}^{-1} \text{ yr}^{-1}$, the soil erosion tolerance level in Sri Lanka. The higher soil erosion is concentrated in the agricultural and urban areas compared to the vegetated areas.



Figure 1: Potential soil loss (RKLS) map

Figure 2: Avoided erosion map

Figure 3: Actual soil loss maps (USLE) map

Conclusions/Key Messages:

The health of the watershed water quality can be directly correlated with the sediment dynamics of the watershed. The headwater regions of the Kelani River are vulnerable to soil erosion and, consequently, to the water quality. This highlights the need for targeted soil and water conservation measures for the area. The findings of the study revealed that the forest vegetation acts as a natural buffer, sediment filter, and soil and water conservation mechanism. The usage of GIS-based modelling, like InVEST, provides a scalable and cost-effective method for water quality monitoring in data-scarce areas and supports sustainable water resource management.

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A Novel Fluorescence Screening Method for Microplastics in Drinking Water Using CdTe Quantum Dots

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Keywords: Microplastics; CdTe quantum dots; Staining; Fluorescence detection

Abstract: Microplastics are emerging contaminants in the drinking water system, requiring rapid and practical monitoring tools within water safety plans. In this study, Cadmium Telluride (CdTe) quantum dots (QD) were used to study fluorescence-based detection of microplastics (MP) as an alternative method to the standard Nile Red (NR) stain. Polystyrene (PS), polyethylene (PE), polypropylene (PP) and polyvinyl chloride (PVC) fragments (100-200 μm) were pre-treated using H_2O_2 /Fenton's reagent and acid treatment at pH 3. They were incubated with QDs (50 ppm) for 1h, 24h, and observed under a fluorescence microscope. MPs showed the strongest fluorescence after 1h, while longer incubation did not significantly improve fluorescence. CdTe QDs exhibited higher fluorescence intensity and photostability than Nile Red under comparable conditions, demonstrating their potential as a sensitive and efficient qualitative tool for microplastic detection in drinking water.

Introduction:

The visually identified method of MPs rely mainly on microscopic observation, which is unreliable for small, transparent or fibrous particles (Shim *et al.*, 2016). FT-IR and Raman spectroscopy provide chemical identification but are costly and time-consuming. Fluorescence-based staining has gained attention as a rapid and simple alternative for MP identification, with NR being the standard staining method (Desforges *et al.*, 2014b). We investigated the applicability of QDs for the identification of MPs among other interference particles as an alternative to NR staining, as it poses some limitations regarding photostability and sensitivity.

Methodology:

CdTe quantum dots (QDs) were synthesized using a modified aqueous method and initially evaluated using pure polymer microplastics (PS, PE, PP, and PVC; 100–200 μm) to assess staining efficiency and photostability. The plastics were mechanically fragmented and pre-treated using H_2O_2 /Fenton's reagent followed by mild acid treatment (pH 3) to enhance surface binding. Nile Red staining was performed in parallel for comparison. Optimized staining conditions (CdTe QDs, 50 ppm; 1 h

incubation) were then applied to microplastics observed in drinking-water samples and examined under fluorescence microscopy using blue (excitation: 460–495 nm; emission: 510 LP nm) and green (excitation: 510–550 nm; emission: 575 LP nm) filters.

Findings/Results:

Stained PS, PP and PE showed strong fluorescence intensity in QD under blue filter, compared to NR. Also, QD exhibited better photostability than NR even after 24 h. PVC does not show promising results compared to the other MPs. The aging patterns of the MP surfaces can be also visualized as the QD only adsorb onto specific sites on the polymer surface. The optimized staining conditions further allowed clear fluorescence-based identification of microplastics observed in drinking-water samples.

Conclusions/Key Messages:

In conclusion an alternative, novel, simple and photostable method to identify MPs using QDs is developed. The combination of the treatment strategies and 1 h incubation provides the optimum fluorescence response in the MPs.

Figures and Tables

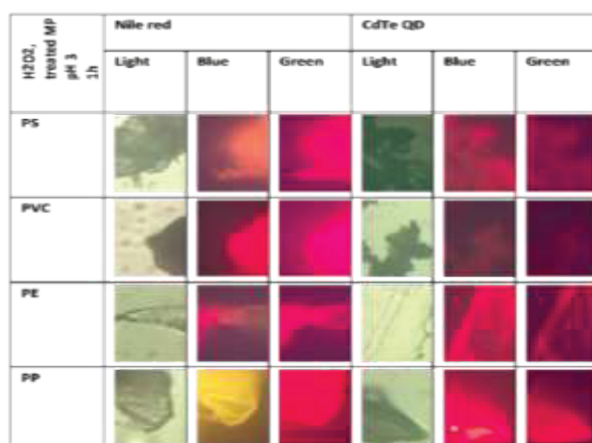


Figure 1.1 Fluorescence images of different MPs stained with NR and QDs.

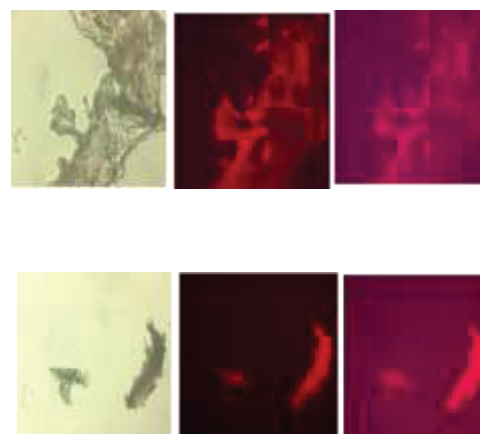


Figure 1.2 Fluorescence microscopy images of microplastics observed in drinking-water samples stained with CdTe quantum dots

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Impacts of Urban Land Use on River Water Quality, Antibiotic Resistance Genes, and Farmer Health Risks in Galle, Sri Lanka

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Keywords: Urban river; land use; *E. coli*; quantitative microbial risk assessment (QMRA); antibiotic resistance genes (ARGs).

Abstract:

The Moragoda Ela (M River), with the highest residential land use (up to 89%), was severely contaminated among 3 rivers (G and K), exhibiting significantly elevated levels of culturable *E. coli*, chemical oxygen demand (COD), and the macrolide resistance gene *mphA* compared to the less urbanized rivers. Quantitative Microbial Risk Assessment (QMRA) revealed that the annual disease burden for farmers using the heavily polluted M River for irrigation (2.16×10^{-4}) exceeded the WHO tolerable threshold of 10^{-4} per person per year. In contrast, the risks from using cleaner rivers and reclaimed water were well below this benchmark. The findings underscore that untreated wastewater discharged from dense urban areas critically degrades water quality, disseminates antibiotic resistance, and poses significant health risks, thereby highlighting the urgent need for wastewater treatment and the potential of water reclamation as a safer alternative.

Introduction:

Urban rivers in developing regions face severe degradation from untreated wastewater discharge, threatening ecosystem health and human safety (zhou et al., 2022). This study assessed the interplay between residential land use, water quality, bacterial communities, and antibiotic resistance genes (ARGs) in urban rivers of Galle, Sri Lanka, and evaluated the health risks to farmers using these waters for irrigation.

Methodology:

Water samples were collected from three rivers Gin Ganga (G), Kepu Ela (K), and Moragoda Ela (M) representing a gradient of urban land use. Analyses included land use mapping, standard water quality parameters (pH, EC, COD), *E. coli* enumeration, 16S rRNA gene sequencing for bacterial community structure, and qPCR for ARGs (*mphA*, *bla_{IMP}*) (Shayan et al., 2025). A Quantitative Microbial Risk Assessment (QMRA) was conducted to estimate the annual enteric disease burden for farmers who are consuming these river water for the irrigational activities targeting on annual probability of infection for a farmer per year ($P_{D\text{ Annual}}$) (Amarasiri et al., 2020). *E. coli* concentration of G, K, M and a reclaimed water system in Japan was used to calculate corresponding QMRA of reclaimed water.

Findings/Results:

The M River, with the highest residential land use, showed significantly higher *E. coli* (up to 86 CFU/mL), COD, and *mphA* gene concentrations. Bacterial community structure was distinctly different in the M River, influenced by anthropogenic inputs. QMRA results indicated that the annual disease burden from using the M River for irrigation (2.16×10^{-4}) exceeded the WHO tolerable risk threshold, 10^{-4} per person per year, while risks from the other rivers and reclaimed water were significantly lower (Table 1).

Table 1. The calculated values of M, G, K and reclaimed water values of $P_{D\text{ Annual}}$

Parameter	M	G	K	Reclaimed water
$P_{D\text{ Annual}} (\times 10^{-4})$	2.16	0.00842	0.136	0.00156

Conclusions

Untreated wastewater discharge from urban areas is a primary driver of river contamination, antibiotic resistance propagation, and unacceptable health risks for agricultural users. Implementing wastewater treatment infrastructure is critical. Reclaimed water presents a demonstrably safer and sustainable alternative for irrigation, essential for protecting public health in rapidly urbanizing regions.

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Efficacy of Centralized Wastewater Treatment in Mitigating Urban River Pollution: Empirical Evidence from the Dasherakandi STP, Bangladesh.

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Keywords: Ammoniacal nitrogen (NH₃-N); Dissolved Oxygen (DO); Chemical Oxygen Demand (COD); Biochemical Oxygen Demand (BOD₅).

Abstract: This study presents a comprehensive one-year longitudinal analysis to evaluate the impact of the Dasherakandi Sewage Treatment Plant (DSTP) on the water quality of the Shitalakshya River. Key physicochemical parameters, including turbidity, NH₃-N, COD, and DO, were monitored monthly upstream of the discharge point. Concurrently, plant operational data on chemical and energy consumption were recorded. Results indicate a statistically significant post-commissioning improvement in river water quality, with average turbidity decreasing by approximately 10% and NH₃-N levels reducing by over 13%. Correspondingly, aluminium sulphate (alum) consumption at the Saidabad WTPs decreased by up to 30%, indicating improved raw water treatability. This study empirically demonstrates the pivotal role of large-scale centralized sewage treatment in mitigating urban river pollution and highlights its effectiveness as a critical model for improving downstream drinking water treatment efficiency in urban catchments of developing countries.

Introduction: Urban river systems of Bangladesh face heavy stress from untreated wastewater discharge, causing severe ecological damage and public health concerns. The Shitalakshya River, an important source for drinking water in Dhaka, Bangladesh, illustrates this problem (Serajuddin et al., 2025). The launch of the Dasherakandi Sewage Treatment Plant (DSTP), a major infrastructure project, is a key effort aimed at reversing this trend. Although the benefits of such plants are well-known in theory, there is a strong need for real-world, data-based studies to measure their actual environmental effect. This research addresses this need by performing a before-and-

after analysis of the plant's operation. The main goals are: (1) to evaluate changes in critical water quality parameters of the Shitalakshya River after the DSTP became operational, and (2) to relate these changes to the WTPs' operational data, including chemical consumption and energy used.

Methodology:

A comparative longitudinal study was designed, analyzing water quality data from the Shitalakshya River for the corresponding peak of the dry season (Months: March) in 2021 (pre- or early-operation) and 2023 (post-operation). The primary data was sourced from the Saidabad Water Treatment Plants' Monthly operation and quality monitoring data.

Findings/Results:

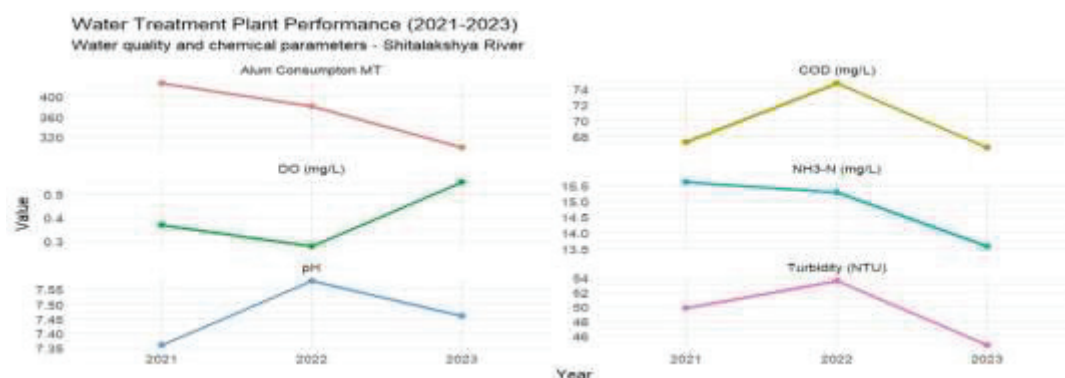


Figure 1: Key Chemical Parameters

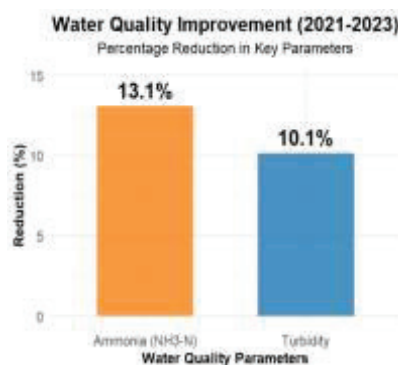


Figure 2: Ammoniacal-N and Turbidity Reduction

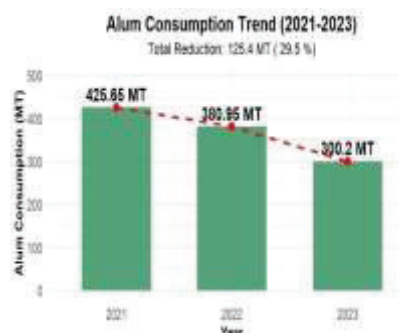


Figure 3: Alum Consumption Reduction

Conclusion/Key messages:

This study provides empirical evidence that investment in centralized sewage treatment can deliver measurable water quality, operational, and resource efficiency co-benefits, supporting its role as a strategic intervention for urban water security in developing countries.

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Basic Assessment of Community Based Water Projects in Sri Lanka

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Keywords: Community-Based Water Projects; Water Safety Plans; Rural Water Supply; Community Governance; GIS Mapping

Abstract: Community-Based Water Projects (CBWPs) play a critical role in delivering safe drinking water to rural communities in Sri Lanka. However, sustainability challenges persist due to governance weaknesses, limited technical capacity, and inconsistent water quality monitoring. This study develops a GIS-based national assessment framework to evaluate CBWPs across all 25 districts. A pilot assessment of 86 schemes in Badulla, Mannar, Matale, and Nuwara Eliya districts examined technical performance, governance structures, financial management, catchment protection, and monitoring practices. Results indicate significant inter-district variation in institutional capacity and source protection measures. Well-performing schemes demonstrate strong governance, routine water quality testing, and effective financial administration, while under-performing schemes exhibit weak oversight and irregular monitoring. The study establishes a GIS-enabled decision-support database to identify spatial performance gaps and prioritize interventions. Findings confirm that governance strength and community ownership are as critical as infrastructure quality in ensuring water safety and long-term sustainability.

Introduction

Community-managed rural water systems are recognized internationally as sustainable when supported by strong institutional capacity and accountability mechanisms (Alam, 2022). In Sri Lanka, CBWPs serve rural and estate communities but face challenges related to source vulnerability, limited treatment capacity, financial instability, and inadequate monitoring. Climate variability further increases contamination and supply risks (Disanayake & Ranasinghe, 2023). Water Safety Plans (WSPs) provide a risk-based framework for safeguarding decentralized systems (Alazaiza et al., 2022). However, structured national-level assessments integrating technical and governance indicators remain limited. This study aims to establish a comprehensive assessment model and develop a GIS-based database to inform policy and investment decisions.

Methodology

A GIS-based mapping and assessment framework was developed for national application. During the pilot phase, 86 CBWPs were randomly selected across four

districts: Badulla, Mannar, Matale, and Nuwara Eliya. Structured questionnaires were administered to community water societies with institutional support from relevant sector agencies. Indicators covered technical reliability, governance arrangements, financial management, source protection, water quality monitoring frequency, and community participation. Pilot findings were used to refine the national survey instrument and database structure.

Findings/Results:

The assessment demonstrates statistically observable variation in governance capacity, monitoring frequency, and source protection practices across districts. Well-performing CBWPs are characterized by clearly defined governance structures, regular water quality monitoring, effective catchment protection, strong financial management practices, and active community engagement. In contrast, under-performing or failed schemes are commonly associated with poor source protection, limited technical expertise, irregular monitoring, and weak institutional oversight. The GIS database enables spatial visualization of performance gaps and risk clusters, supporting evidence-based prioritization of technical assistance and investment. The findings confirm that institutional strength and community ownership are critical determinants of water safety outcomes.

Conclusions/Key Messages:

This study establishes a foundational national assessment framework for Community-Based Water Projects in Sri Lanka. It demonstrates that technical performance alone does not determine sustainability; governance capacity, institutional support, and community participation are equally critical. The developed GIS database functions as a decision-support tool for policymakers and sector stakeholders. By integrating Water Safety Plan principles with community governance strengthening, CBWPs can significantly enhance resilience, safeguard public health, and ensure long-term sustainability of rural water supply systems. The framework provides a scalable platform for future impact evaluations across health, environmental, and socioeconomic dimensions.

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Achieving “Excellent Qualitative Rating” for Water Safety Plans: Factors Limiting Performance of Sri Lankan Water Supply Schemes

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Key Words: Water Safety Plan; WHO Audit criteria; Qualitative Rating; Water Supply Schemes

Abstract: Water Supply Schemes (WSS) operated by the National Water Supply and Drainage Board (NWSDB) fail to achieve the "Excellent" rating for Water Safety Plans (WSP) when using the World Health Organization's (WHO) audit criteria. This study aimed to identify factors that hinder WSP's achievement of an excellent rating. A questionnaire survey combining qualitative and quantitative methods was the primary research tool, covering 42 water supply schemes that had completed all audit evaluations. The data were analyzed using statistical software. Results showed that the attributes of WSP's team leaders and members were significantly associated with WSP's performance. While mode analysis highlighted key module-wise hindering factors based on high mean Likert scores (greater than 3.41). Six influencing factors were identified that prevent the WSP's excellent performance. The findings provide NWSDB's management with insights to implement targeted solutions to achieve an excellent rating for water supply schemes.

Introduction:

Access to safe drinking water is an important public health issue in Sri Lanka. Since 2004, the World Health Organization (WHO) has recommended Water Safety Plans (WSPs) to manage risks to water quality from the source to the consumer (Setty et al., 2017). Water Supply Schemes are evaluated through various audits and rated from “Excellent” to “Priority Attention Needed,” but many do not achieve excellent ratings due to limited resources, lack of knowledge, weak teamwork, poor documentation, limited management support, and limited stakeholder involvement (Kumpel et al., 2018). This study identified the factors that prevent schemes from achieving the “Excellent” rating.

Methodology:

Data for this study were collected using a structured 5-point Likert scale questionnaire (1 = Strongly Disagree, 5 = Strongly Agree). Questionnaire development involved an extensive literature review, expert consultation, and finalization through a pilot study conducted with selected schemes. The sampling strategy adopted a purposive sample of 42 Water Supply Schemes (WSSs), which represented the entire population and was considered adequate for robust statistical analysis (Roscoe, 1975). The study applied both qualitative and quantitative approaches, focusing specifically on WSSs that had completed all four types of Water Safety Plan (WSP) audits by the end of 2024. For data analysis, selected statistical tests, including mode, chi-square, correlation, and regression, were applied using the Statistical Package for the Social Sciences (SPSS) version 20.

Results and Discussion:

Chi-square analysis was used to examine the relationship between background characteristics and the performance categories of Water Supply Schemes. Significant relationships ($P < 0.05$) were found with the authority level of the team leader, education level of the WSP team, their experience with water supply schemes, and their participation in WSP training and audit activities. Mode analysis identified major barriers across modules, with mean scores of 3.41 or higher on the 5-point Likert scale, indicating key obstacles to achieving an excellent rating. The main issues included transfer or promotion of key team members (3.82), limited top management support (3.69), and the lack of a dedicated coordinator (3.54), along with resource, training, and organizational challenges. Regression analysis further showed that team coordination, knowledge and skills, financial constraints, documentation practices, management support, and stakeholder engagement significantly affect WSP performance ($P < 0.05$).

Conclusion:

The findings of this study assist the NWSDB in refining practices, developing strategies, and enhancing water safety management. Ultimately, the results provided a framework to strengthen WSP implementation, address gaps, ensure safer drinking water, and support public health outcomes.

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Decoding Organic Matter Dynamics: UV₂₅₄ Absorbance as a Cost-Effective Surrogate for TOC and COD Monitoring in Surface Water.

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Keywords: UV₂₅₄; Total Organic Carbon (TOC); Chemical Oxygen Demand (COD); Principal Component Analysis (PCA); Regression Analysis.

Abstract: Ultraviolet absorbance at 254 nm (UV₂₅₄) is widely recognized as a robust surrogate indicator of organic matter in surface water. This study evaluated the relationship among UV₂₅₄, total organic carbon (TOC), and chemical oxygen demand (COD) using 12 surface water samples collected from the Shitalakshya River at the intake point of Saidabad Water Treatment Plant, Dhaka, during 2024. Descriptive statistics, Pearson correlation analysis, principal component analysis (PCA), and linear regression were applied to assess interrelationships among key water quality parameters. UV₂₅₄ showed strong positive correlations with TOC ($r = 0.97$) and COD ($r = 0.96$). PCA clustered UV₂₅₄, TOC, and COD within the same principal component, representing an organic pollution gradient. Linear regression revealed significant relationships: $\text{TOC} = 0.02 \cdot \text{UV}_{254} + 0.014$ ($R^2 = 0.97$) and $\text{COD} = 0.0049 \cdot \text{UV}_{254} - 0.022$ ($R^2 = 0.96$). These results confirm UV₂₅₄ as a rapid, cost-effective indicator for monitoring organic pollution in drinking water sources.

Introduction:

Natural organic matter (NOM) is a key concern because it acts as a precursor for disinfection by-products (DBPs) and affects the efficiency of coagulation and oxidation processes (Serajuddin et al., 2025). Traditional measurements like chemical oxygen demand (COD) and total organic carbon (TOC) are accurate but time-consuming and costly. UV absorbance at 254 nm (UV₂₅₄) provides a rapid optical surrogate for aromatic organic compounds. This study quantifies the relationship between UV₂₅₄, TOC, and COD in raw surface water using correlation, PCA, and regression analysis, demonstrating UV₂₅₄'s effectiveness for rapid monitoring of organic pollution in surface water treatment systems.

Methodology:

Water samples collected from the Shitalakshya River (Sarulia point), which serves as the intake for the Saidabad Water Treatment Plant, Phases I and II, were analyzed using standard APHA methods (APHA et al., 2012). However, the novelty of this study lies in the site-specific calibration of UV₂₅₄ against TOC and COD under tropical river conditions, providing locally relevant relationships for rapid organic matter

assessment in a highly impacted urban surface water source. Correlation, PCA, and regression analyses were conducted in R Studio [R version 4.5.0, 2025] (Wickham, 2016).

Findings/Results:

UV₂₅₄ showed strong positive correlations with TOC and COD ($r \geq 0.96$) and clustered with organic pollution indicators in PCA. Regression analysis confirmed linear relationships, supporting UV₂₅₄ as a rapid proxy for organic load.

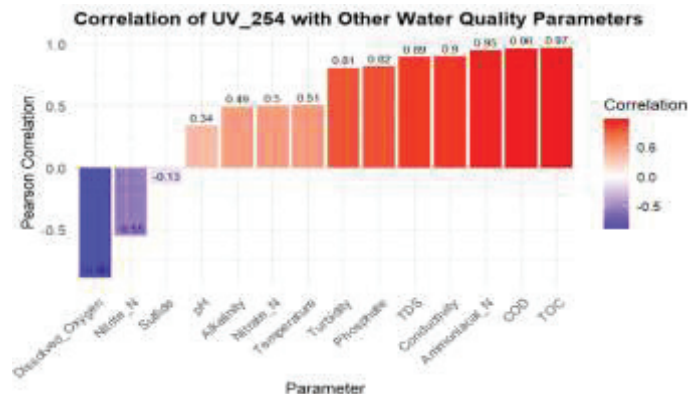


Figure 1: Pearson correlations among Shitalakshya River parameters show UV₂₅₄ strongly linked with TOC, COD, and nitrogen pollution, alongside reduced dissolved oxygen.

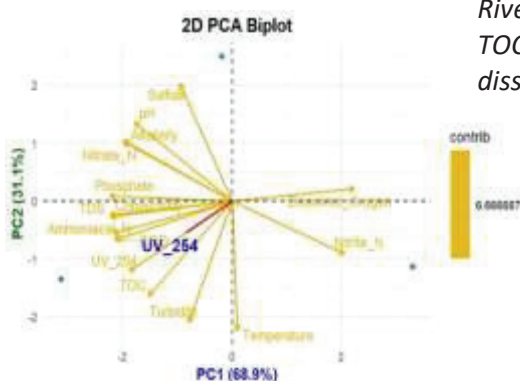


Figure 2: PCA biplot showing clustering of water quality parameters. The first two components capture most variance, highlighting associations among organic matter, nutrients, turbidity, and their inverse relationship with dissolved oxygen and pH.

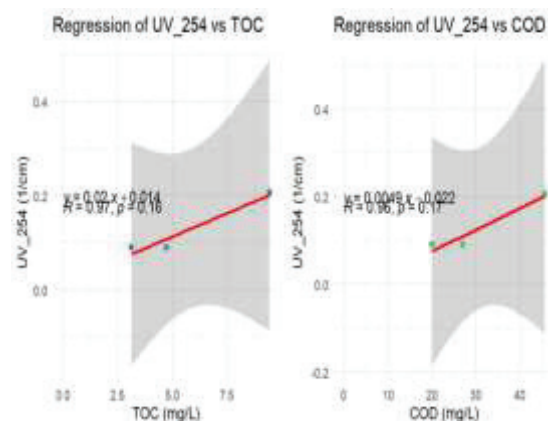


Figure 3: Linear regression analysis between UV₂₅₄ absorbance and organic pollution indicators in the Shitalakshya River, establishing calibration curves for TOC and COD to enable rapid, surrogate-based estimation of organic matter concentration.

Conclusion/Key messages:

This study confirms UV₂₅₄ as a reliable, rapid, site-specific tool for real-time organic load monitoring at water treatment plant intakes, supporting operational decision-making and early warning tools under tropical river conditions.

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Risk Assessment of Water Supply System Safety Based on Water Safety Plan (WSP) Implementation in Dhaka City, Bangladesh

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Keywords: Water Safety Plan; Risk Assessment; Drinking Water Supply; Public Health; Dhaka Metropolitan Area, Bangladesh

Abstract: This study integrates the water safety plan (WSP) approach and risk assessment and management in water treatment plants and drinking water supply systems by using WSP tools. This integration ensures the identification of potential hazards related to drinking water and enables improvements in public health outcomes. The concept of WSP has become a globally recognized and accepted approach to managing and operating drinking water supplies. This study aims to assess and identify vulnerable points in the Dhaka metropolitan area water supply system (DWSS) using the WSP. The desk review of Dhaka WSS and site monitor were the methodology to determine the risk assessment factors. The study's major findings included a lack of staff training, right man at right place and budget limitation for the water safety plan. The important barriers to the water supply system were found in the treatment processes and distribution system steps. This study recommends utilizing the WSP tool for decision-making in WSS by improving administrative, operational, financial i.e. organizational management.

Introduction:

The traditional approach of monitoring the drinking-water quality at the point of compliance is not enough to guarantee its safety, because by the time the results of monitoring are available, the water has been consumed or otherwise used (Bartram et al., 2009). The poor representativeness, low frequency of monitoring (few samples taken compared to amount of water produced), and limitations of some microbiological indicators do not always allow timely control measures to avoid hazardous events before water distribution to consumers (Summerill et al., 2010).

Methodology:

Discussing about process is the first step of WSP implementation.

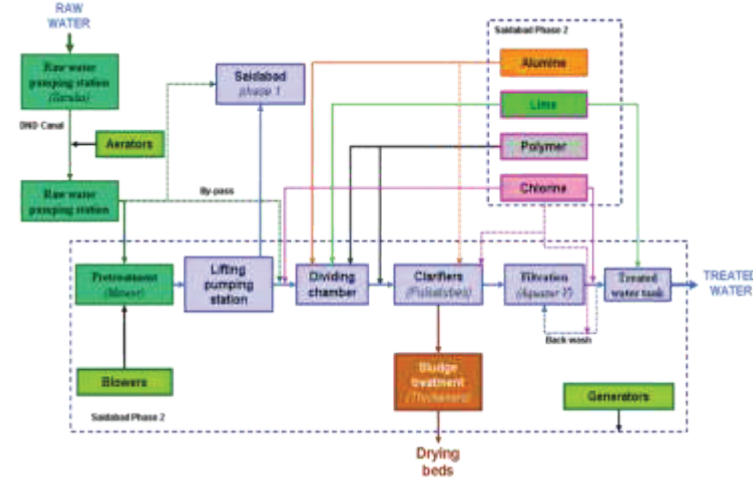


Figure 1: The process of water treatment

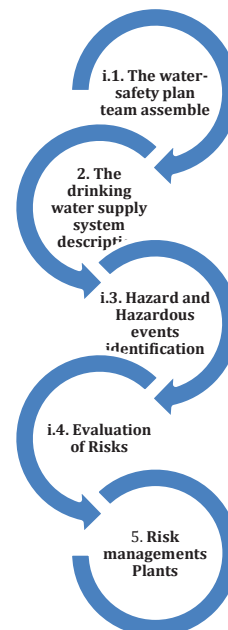


Figure 2: The stages that involve stage for water safety plan in Dhaka city

Result and Discussion

The water system assessment for Dhaka water supply system are descripts in this study. The results showing that some factors are involved for proper water safety plan implementation. The study mainly findings that a lack of staff training, right man at right place and budget limitation affected for the water safety plan.

Conclusions

This study shows that integrating the Water Safety Plan (WSP) framework into Dhaka's water supply system is essential for effective risk assessment and management. The assessment identified critical vulnerabilities in both treatment and distribution, revealing operational and systemic weaknesses that threaten drinking water safety. Key challenges include insufficient staff training, inappropriate human resource allocation, and budget constraints, all of which hinder effective WSP implementation. The findings show that risks are present in both treatment processes and the distribution network, underscoring the need for a comprehensive, preventive management approach. Addressing these issues requires building institutional capacity through targeted training, proper staffing, and adequate financial resources. Overall, the study highlights the WSP as a practical tool for improving drinking water safety in Dhaka. Strengthening administrative, operational, and financial management will be essential for sustainable public health improvements and long-term reliability of urban water services.

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Experimental Optimisation of Sodium Hydroxide Dosing for Chemical Softening of Bohitiya Borehole Water: Effects on pH, Hardness and Overall Water Quality

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Keywords: Water softening; Sodium hydroxide; Hardness

Abstract: This study assesses the effectiveness of sodium hydroxide (NaOH) for softening groundwater from the Bohitiya borehole in Monaragala district. High geogenic hardness (276 mg/L as CaCO₃) demands treatment to meet aesthetic and functional requirements. Laboratory testing with 1 M NaOH (2.1 to 8.7 mL/L) showed a dose-dependent reduction in hardness. The optimal dose of 8.7 mL/L resulted in 82% elimination, lowering hardness to 50 mg/L and raising pH to 10.5. The findings indicate that NaOH is a suitable low-cost reagent for resource-constrained areas, especially when combined with a Fluidized Bed Reactor (FBR) to improve precipitation control.

Introduction:

Groundwater is the primary water supply for more than 40% of Sri Lanka's population (Indika et al., 2022), but high hardness levels in borehole waters in areas like Monaragala lead to scaling and increased maintenance costs for the water-supplying system. Bohitiya borehole water total hardness exceeds the WHO guideline values for aesthetic acceptability. While membrane filtration is efficient, it is cost-prohibitive for many local schemes (Dey et al., 2024). Chemical precipitation using NaOH offers rapid reaction kinetics and easy pH control. This study aims to optimize NaOH dosing for the Bohitiya borehole water and propose fluidized bed reactor (FBR) integration to manage precipitation and recover reusable calcium-coated sand.

Methodology:

Raw water samples were collected from the Bohitiya borehole. Four water treatment process scenarios were conducted in laboratory scale using 1M NaOH at dosages of 2.1, 3.3, 4.4, and 8.7 mL/L. NaOH was added to 1L samples and mixed at 85 rpm for 5 minutes, followed by 10 minutes of settling. Supernatants were filtered through 0.45 µm filters to simulate FBR filtration. Analysis followed APHA standard methods

for pH, electrical conductivity, total hardness (TH), alkalinity, and chloride concentration.

Findings/Results:

Figure 01 illustrates the variation of TH across different dosing conditions. A dose of 2.1 mL/L achieved a 35% reduction of TH, while 8.7 mL/L achieved 82% removal (reducing hardness to 50 mg/L). High dosages significantly impacted water quality, with pH rising to 10.5, EC to 1,077 $\mu\text{S}/\text{cm}$, and alkalinity to 550 mg/L. The resulting high pH requires post-treatment, such as CO_2 sparging or blending with raw water, prior to distribution.

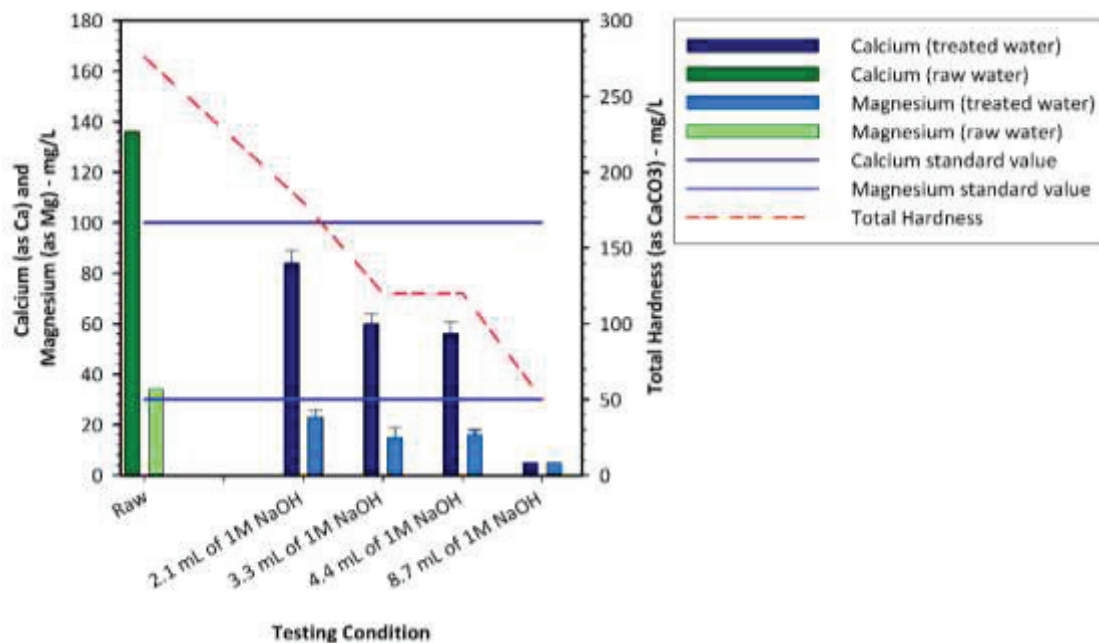


Figure 1: Calcium, Magnesium & Total Hardness variation according to testing conditions

Conclusions:

This study demonstrates that NaOH softening is an effective, rapid, and low-cost method for hardness removal from Bohitiya groundwater. At 8.7 mL/L of 1 M NaOH, total hardness decreased from 276 mg/L to 50 mg/L (82% removal). The process, however, induces a significant pH increase and elevated alkalinity, which requires downstream adjustment. The observed precipitation behavior supports the use of a fluidized bed reactor to enhance crystallization control, reduce filter fouling, and recover useful by-products. Implementation at pilot scale is recommended to assess economic feasibility, sludge management, and operational stability under field conditions.

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Success and Challenges in Water Safety Plan Auditing

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Keywords: WSP; WSP Auditing; CBO; Climate resilient; Sri Lanka

Abstract: This paper evaluates the effectiveness of Water Safety Plan (WSP) auditing within Community-Based Organizations (CBOs) in Sri Lanka. Using a mixed-methods assessment of audit reports from 2023–2025, the study identifies a success rate of 30% against a 70% challenge rate. Successes are characterized by robust stakeholder engagement and systematic risk management, while challenges stem from resource scarcity, technical gaps, and climate variability. The findings suggest that the auditing process serves as a critical diagnostic tool for identifying support needs rather than a mere compliance check (WHO & IWA, 2014, p. 7). This summary highlights the urgent need for national policy shifts toward capacity building and financial support to bridge the gap between WSP intent and operational reality in community water systems.

Introduction:

Ensuring safe drinking water is a critical priority, managed in Sri Lanka through the preventive, risk-based Water Safety Plan (WSP) framework (World Health Organization [WHO] & International Water Association [IWA], 2014). While Community-Based Organizations (CBOs) use WSP audits to validate system reliability, success rates vary significantly. This study assesses the current status of these audits across multiple districts to document successes and identify systemic challenges. By focusing specifically on the auditing process—intended by the WHO/IWA as a diagnostic tool for internal and external review—this research provides evidence-based insights to strengthen national policy and CBO support mechanisms (WHO & IWA, 2014, p. 7).

Methodology:

This study utilized a national-level, mixed-methods assessment by analyzing WSP audit reports and structured performance reviews from CBOs across key districts between 2023 and 2025. The research focused on the three WSP cycle components: System Assessment, Monitoring and Operational Control, and Management and Review. The

primary instrument was a standardized national audit checklist, ensuring consistency and comparability across diverse regional schemes.

The quantitative phase involved content analysis of audit findings. Each report was categorized based on a predetermined WSP framework criteria, leading to a binary (successful/challenging) outcome for key components. Aggregated results established the overall success-to-challenge ratio. The qualitative phase aggregated recurring non-compliance issues and specific incident reports noted by the auditors. Descriptive statistics were employed to detail the frequency and distribution of successes and challenges (e.g., resource availability, technical expertise gaps), clearly distinguishing implementation struggles specific to the formal WSP auditing and validation process.

Findings/Results:

The aggregated analysis revealed that the WSP auditing process resulted in 30% of cases representing successes and 70% representing challenges. Successes (30%) were demonstrated through comprehensive system descriptions, systematic risk assessment, and robust stakeholder engagement. Conversely, challenges (70%) included limited resource availability, insufficient technical expertise, system complexity, and inadequate preparedness for emergency responses, often tied to climate change and variability.



Figure 1 Yearly success vs. challenge trends in WSP Auditing from 2023 to 2025.

Conclusions/Key Messages:

The significant 70% challenge rate demonstrates that sustained, robust WSP implementation is severely compromised by resource constraints and technical deficiencies. This study argues that the high challenge rate necessitates a strategic shift in national policy towards targeted interventions, including structured capacity-building programs and greater financial support. Strengthening WSP auditing is crucial for achieving sustainable, climate-resilient, and safe community water supply systems in Sri Lanka.

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Sustainable Socio-economic Impact of the HCH Water Treatment Technology Wetland+®

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Keywords: Socio-Economic Impact; LCA; Hexachlorocyclohexane; lindane; natural based solution; constructed wetland

Abstract: Sustainable water quality monitoring requires not only monitoring its quality, but also monitoring the measures taken to improve its quality, and covers not only chemical and biological, but also the life cycle assessment (LCA) of the applied technologies. The applied socio-economic survey to monitor scientific and non-scientific perspectives on applied technology was carried out by all project beneficiaries, external stakeholders, and local or regional authorities, environmental authorities, watershed authorities, and local NGOs. The 15 broad categories of indicators, which revolve around three main elements of sustainability (environment, society, and economy), were established. As a result, Wetland+® outranked WWTP use across most of the 15 general categories, and both performed significantly better than the no-intervention scenario.

Introduction:

The purpose of applying sustainability in remediation is to ensure optimal and appropriate choices are made during risk management decision-making. Risk management remains the trigger for remediation and defines its critical objectives. However, better choices about how these objectives are delivered can improve the overall value of the remediation work by widening opportunities for wider benefits and minimising/mitigating undesirable secondary impacts.

Methodology:

An essential factor in selecting the most suitable remediation process is evaluating both its environmental effects and socio-economic impacts. The guidance of Bardos et al. (2016) offers a framework for qualitative sustainability assessment, covering three key dimensions: environment, society, and economy (CL:AIR 2020a; CL:AIR 2020b). In the initial assessment, out of a total of 73 criteria, 45 relevant criteria were selected: 15 from the Environment category, 19 from the Economic category, and 11 from the Social category. Based on stakeholders' responses, alternative technologies (Wetland+®, a WWTP, and a no-intervention) are compared and rated (1 = best, 3 = worst). Answers are subjective, but because 20 responses of stakeholders across different areas were analysed (in Excel), it is statistically objective.

Findings/Results:

The ranked results were visualised using radar graphs (Fig. 1). The wetland-based solution outperformed the WWTP in 10 out of 15 general categories. In the remaining categories, performance was very similar, except in the "uncertainty and evidence" category, where the WWTP ranked higher because it is well-established and thoroughly documented. Another key finding was the differences in perspective between evaluator groups. While the core team of experts generally showed strong agreement in their assessments, the external assessors—including authorities and NGOs—often expressed conflicting views, influenced mainly by their professional backgrounds and interests.

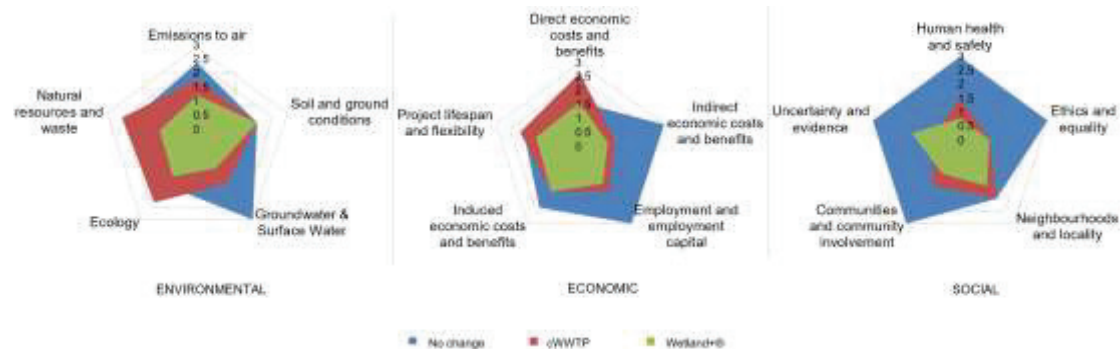


Figure 1: Sustainability assessment outcomes: Comparison of Wetland+® (green), WWTP (red) and no-change (blue) in three categories of benefits. The smaller the area, the better the technology's score.

Conclusions/Key Messages:

Assessing sustainable remediation is site and project-specific and is strongly multifactorial across a wide range of categories. The Wetland+® outperformed WWTP, and both performed significantly better than the no-intervention scenario. This approach shows that monitoring water quality alone is not sufficient to assess the adequacy of individual technologies. The solution that is most effective for solving a given problem may not be the best from an LCA perspective. The WWTP is effective at removing pollutants, but it produces waste, requires chemicals, and is generally less accepted than natural-based solutions such as Wetland+®. To select the best technology, we must also consider other criteria (economic, broader environmental, and social). Supporting decision-making in water management practice is more complex and comprehensive.

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Smart and Sustainable Dissolved Oxygen Monitoring in Meda Ela: A Case Study for Data-Driven Water Quality Management

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Keywords: Dissolved Oxygen; Smart Water Quality Monitoring; Sustainable Water Management; Urban Stream Pollution

Abstract:

By evaluating dissolved oxygen (DO) dynamics in Meda Ela, an urban stream in Kandy city, Sri Lanka, this study primarily focuses on sustainable water-quality monitoring. Over a five-month period, DO levels were monitored at six locations using a portable DO meter, and the data were subsequently analysed using digital methods to identify spatial and temporal differences and contamination issues. The study jointly field monitors with smart data analytics to improve explanation, visualization, and reporting efficiency. The integration of field data and digital analysis determines how inexpensive, data-driven methods can support local water management plans. The study highlights the potential for scalable and sustainable smart monitoring frameworks adaptable to urban catchments in developing regions.

Introduction:

Continuous and responsive monitoring systems capable of identifying pollution sources and ecological stress determine the accessibility to clean water. Urban waterways such as Meda Ela face rising challenges from wastewater inflows, solid waste disposal, and limited flow, which deteriorate water quality (*Weerasinghe et al., 2025*). Conventional monitoring methods often lack temporal resolution and analytical integration. By exploring DO variations as a vital water quality parameter over a five-month period, this study aims to determine how simple, protective ecosystem, cost-effective monitoring combined with data analytics can support smarter, more sustainable water management (*Jinadasa et al., 2012*).

Methodology:

Dissolved oxygen levels were measured at six multiple sampling locations along Meda Ela using a YSI ProSolo Dissolved Oxygen meter and laboratory methods over the five following months. Measurements were taken every day, both in the morning and in the evening, to detect variations. Additionally, basic parameters such as pH, temperature, Electrical Conductivity, and Turbidity were also recorded. The following data were processed and visualized using digital analytical tools (Microsoft Excel) to

measure spatial patterns, temporal variations, and relationships with environmental and contamination parameters.

Findings/Results:

According to the results, clear spatial and temporal variations in DO concentrations were observed along the study locations. DO levels were higher in the morning than in the evening at all locations, due to photosynthetic oxygen production during daylight hours and nighttime respiration and decomposition.

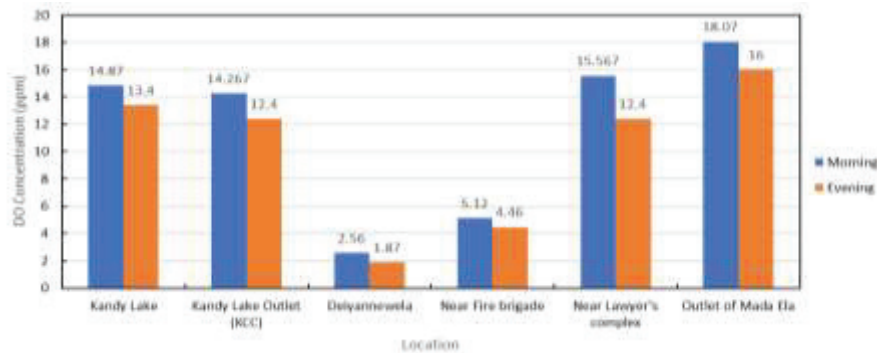


Figure 1: Five-month summary of DO variation along Meda-Ela in Morning & Evening

At Kandy Lake and the KCC outlet, DO concentrations are relatively high (Figure 01), indicating good aeration and photosynthetic action. A sharp decrease was observed at Deiyannawela, where DO levels were critically low (around 2.56 mg/L & 1.87 mg/L), indicating severe organic pollution and reduced water quality. And it should be slightly improved near the Fire Brigade site (5.12 mg/L & 4.46 mg/L), while values remained below the ideal threshold. Important recovery was detected near the Lawyer's Complex (15.56 mg/L & 12.4 mg/L) and at the outlet of Meda Ela, where DO reach its highest levels, possibly as an outcome of improved flow and re-aeration.

These differences suggest the combined effects of photosynthesis, respiration, and pollution load upon oxygen availability. The five-month analysis shows that continuous monitoring captures seasonal and diurnal patterns, reinforcing the value of DO as an indicator of ecosystem health.

Conclusions/Key Messages:

This study emphasizes that integrating long-term field monitoring with smart analytical tools can significantly enhance the accuracy, sustainability, and responsiveness of water quality assessments. Continuous DO monitoring is helpful as a reliable early warning of pollution and ecological imbalance. This approach, combining cost-effective monitoring techniques with digital analysis, is adaptable, scalable, and well-suited to urban waterways in developing regions, advancing smart, data-driven, and sustainable water quality management.

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Regulation of Selective Layer Thickness by Spin Acceleration in Thin Film Nanocomposite Membranes: Experimental Verification and Theoretical Insight

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Keywords: Spin coating; thickness; nanofiltration performance

Abstract: Thin Film Nanocomposite (TFN) membranes are promising candidates for advanced water purification, but their performance is constrained by the permeability–selectivity trade-off, where higher water flux often reduces salt rejection. Controlling selective layer thickness is therefore critical to overcome the trade-off. This study evaluates the effect of spin acceleration during spin-assisted interfacial polymerization on thickness regulation. Membranes were fabricated at 20–100 rpm/s with constant speed (3600 rpm). A strong inverse linear relationship ($R^2 = 0.97$) was observed between thickness and spin acceleration. Theoretical modelling based on classical spin coating theory confirmed that film thickness is inversely proportional to angular acceleration ($h \propto 1/\alpha$). Importantly, optimization at 80 rpm/s enabled enhanced water flux ($31.0 \pm 0.1 \text{ L m}^{-2} \text{ h}^{-1}$) while maintaining 90% rejection of Ca^{2+} and Mg^{2+} , demonstrating effective mitigation of the permeability–selectivity trade-off through controlled thickness tuning. These findings validate spin acceleration as a scalable and reliable parameter for precise selective layer engineering in high-performance nanofiltration membranes.

Introduction:

Spin coating is an efficient technique for depositing nanoparticle and polymer solutions, enabling uniform and controllable membrane thickness to enhance water flux without compromising salt rejection. The process involves four steps deposition, spin-up (acceleration), spin-off (constant speed), and evaporation but the impact of spin acceleration on membrane thickness and performance is not well understood. Given that selective layer thickness critically affects permeability and salt rejection, this study employs spin-assisted interfacial polymerization to investigate how spin acceleration can be optimized to improve desalination performance (Mustafa & Jameel, 2021; Spin Coating: Complete Guide to Theory and Techniques | Ossila, n.d.).

Methodology:

The selective PA layer was formed by interfacial polymerization of piperazine (aqueous phase) and trimesoyl chloride (organic phase) on polyether sulfone

supports. A series of membranes were prepared at spin acceleration rates from 20 to 100 rpm/s, constant spin speed of 3600 rpm. Thickness was measured through cross-section SEM imaging. Classical spin coating theory was applied for theoretical correlation. Nanofiltration performance of the membranes was checked using lab-made cross flow filtration cell.

Findings/Results:

According to classical spin coating theory, the fluid film thickness is given by

$$h \propto \left(\frac{\eta}{\rho \omega^2 t} \right)^{1/2}$$

where h is the film thickness, η is the dynamic viscosity, ρ is the solution density, ω is the angular velocity and t the spin time.

Substituting as $\omega = \alpha t$ (under a constant spin acceleration)

$h \propto \frac{\eta}{\rho \alpha t^{3/2}}$ which shows an inverse proportionality between film thickness h and angular acceleration α . Experimental observations strongly support this inverse relationship, with a correlation coefficient of $R^2 = 0.97$.

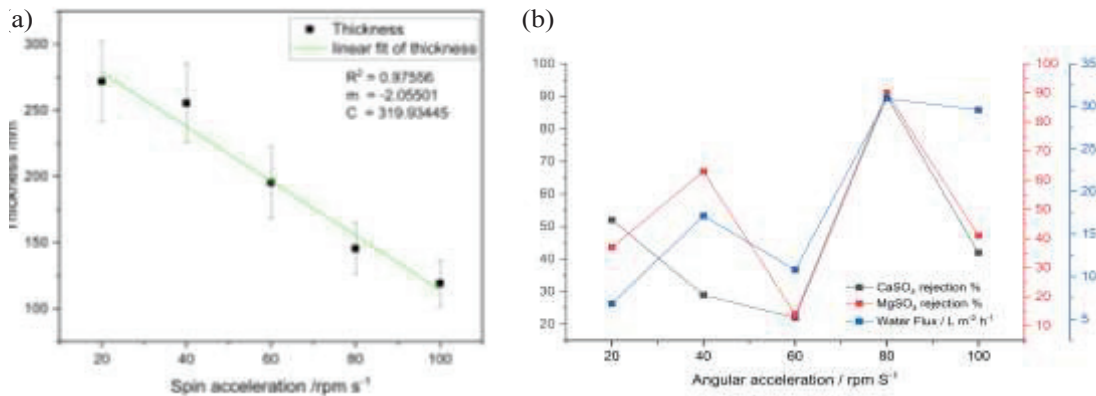


Figure 1: (a) Graph of selective layer thickness vs spin acceleration, (b) nanofiltration performance

Experimental results have confirmed the inverse proportionality between selective layer thickness and spin acceleration in classical spin coating theory. This is due to the interplay between the outward-driving centrifugal force and opposing viscous resistance during early stages of spin acceleration. Consequently, tuning thickness has achieved an optimal balance between permeability and selectivity, with the membrane prepared at **80 rpm/s** exhibiting the best performance.

Conclusions:

Spin acceleration is an effective parameter to control PA layer thickness in TFN membranes. It provides a scalable fabrication strategy and allows precise tuning to enhance filtration performance for desalination.

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Ensuring Climate Resilient Water Supply through Prioritised Areas in Water Safety Plan Auditing

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Keywords: Climate Change; CRWSP; WSP Auditing; WSS

Abstract: Water Safety Plans (WSPs) provide a proactive framework for safeguarding drinking water from catchment to consumer. National Water Supply & Drainage Board (NWSDDB) has implemented WSPs in 356 Water Supply Systems (WSSs); however, climate change impacts continue to threaten WSS resilience, with limited progress in transitioning to Climate Resilient WSPs (CRWSPs). WSP audit reports from 2021–2024 were analysed against nine assessment areas of audit criteria to identify priority areas for CRWSP development. Findings revealed operational monitoring (67.9%), supportive programs (76.1%) and management procedures (74.5%) as key areas requiring improvement. It is recommended to develop these areas to strengthen CRWSP implementation and ensure sustainable water supply.

Introduction:

Climate change threatens water quality and quantity through floods, droughts, and extreme weather, requiring resilient management strategies. While the conversion of WSPs into CRWSPs is critical for sustainable water supply and public health protection (Pham & Dam, 2024), progress toward this transformation remains challenging, despite the NWSDDB implementing 356 WSPs out of 362 WSSs. WSP auditing is a mandatory requirement to evaluate the completeness, adequate implementation and effectiveness of WSPs.

This study aims to identify key areas to be improved in transitioning existing WSPs to CRWSPs by analysing Internal Formal Audit (IFA) findings.

Methodology:

WSP IFA scores for each assessment area were tabulated, averaged, and calculated percentage of average score relative to maximum possible score for all WSSs. Frequency of occurrence of percentages over four years were analysed and assessment areas with the lowest percentages were identified and prioritized the three key areas requiring improvement for CRWSP development. Then the number of occurrences of lowest percentages for each assessment area were determined and ranked 1, 2 and 3 based on the highest number of occurrences.

Findings/Results:

The analysis identified Operational Monitoring, Supportive Programs and Management Procedures as the priority areas for strengthening CRWSPs. Operational Monitoring is critical for detecting and managing climate-related risks such as floods, droughts, and contamination. Supportive Programs, including staff training, preventive maintenance, equipment calibration, and research, enhance system reliability. Management Procedures, particularly Standard Operating Procedures (SOPs) and Emergency Response Plans (ERPs), are essential to ensure consistent operations and preparedness for climate-induced emergencies.

Overall, the findings show that while WSP auditing has strengthened water safety, addressing these three areas is vital for embedding climate resilience and ensuring sustainable, safe water supply under changing climate conditions.

Table 1: Prioritisation of Assessment Areas

Assessment Area	Percentage of Average Marks Received			
	2021	2022	2023	2024
WSP Team	78.3	78.9	79.8	85.1
System Description	74.7	72.9	75.1	80.1
Hazard Identification & Risk Assessment	67.9	77.2	74.1	80.8
Improvement Plan	78.5	81.6	72.8	82.4
Operational Monitoring	63.8	74.0	62.3	68.9
Verification	74.5	86.3	87.0	85.7
Management Procedures	74.1	74.1	73.5	77.7
Supporting Programs	73.0	73.4	77.8	78.9
Review & Revision	74.3	92.8	90.8	91.0

Conclusions/Key Messages:

Verification was carried out by comparing results from the WSP IFA findings with field data from water supply managers. The top two priority assessment areas were consistent (Operational Monitoring and Supportive Programs), while the third differed: WSP IFA findings highlighted Management Procedures, and field data emphasized Improvement Plans.

The study recommends strengthening Operational Monitoring, Supportive Programs, and Management Procedures in CRWSP development, together with implementing Improvement Plans to address climate change impacts on WSSs in NWSDB.

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Pham, L., & Dam, H. T. 2024 Challenges in designing and implementing climate resilient water safety planning (CRWSP): initial observations from a CRWSP pilot in rural Viet Nam.



Canopy Elevation Controls on Rainfall Partitioning and Soil Erosion: Implications for Water Safety Plans

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Keywords: Rainfall interception; Throughfall; Canopy height; Soil erosion; Water Safety Plan

Abstract: Turbidity and sediment pulses are important catchment hazards in Water Safety Plans. We assessed how canopy height alters throughfall and event scale soil erosion under natural rainfall in woodland at Ritsumeikan University, Shiga, Japan. Three trees of one species were grouped by crown height (low 2 m, medium 4 m, high 6 m). Soil boxes filled with decomposed granite and silica sand captured sediment for 19 rainfall events, and throughfall was measured for events 10 to 19. High canopies produced greater throughfall and higher sediment yields than medium and low canopies, and throughfall scaled linearly with gross rainfall (R^2 about 0.94 to 0.96).

Introduction:

Rainfall interception and throughfall modify the amount and kinetic energy of water delivered to soils, influencing erosion hotspots (Muzylo et al. 2009; Levia et al. 2017). This study isolates vertical canopy elevation as a structural factor that can be considered in catchment hazard control for Water Safety Plans.

Methodology:

Field monitoring ran September 2024 to October 2025. Three trees of one species were classified into high 6 m, medium 4 m, and low 2 m crown heights; Leaf Area Index was not measured and canopy density was assessed qualitatively. Under each canopy height, soil boxes (37 cm × 25 cm) containing decomposed granite and silica sand captured event scale sediment yield for 19 rainfall events. Gross rainfall was measured in an open area, and throughfall was measured beneath each canopy height for events 10 to 19 using an under canopy gauge plus three collectors.

Findings/Results:

Sediment yield ranked high canopy greater than medium canopy greater than low canopy for both substrates, and decomposed granite produced higher yields than silica sand. Sediment increased with throughfall, consistent with higher drop energy delivery from taller canopies. Greater fall distance under high canopies promotes drop/drip coalescence and acceleration toward terminal velocity, increasing kinetic energy delivered to the soil surface

Conclusions/Key Messages:

Canopy elevation is a practical structural indicator of rainfall redistribution and erosion potential. Including canopy height in catchment assessments can support Water Safety Plan source water protection by highlighting canopy zones with higher sediment hazard and guiding targeted erosion control and woodland design.

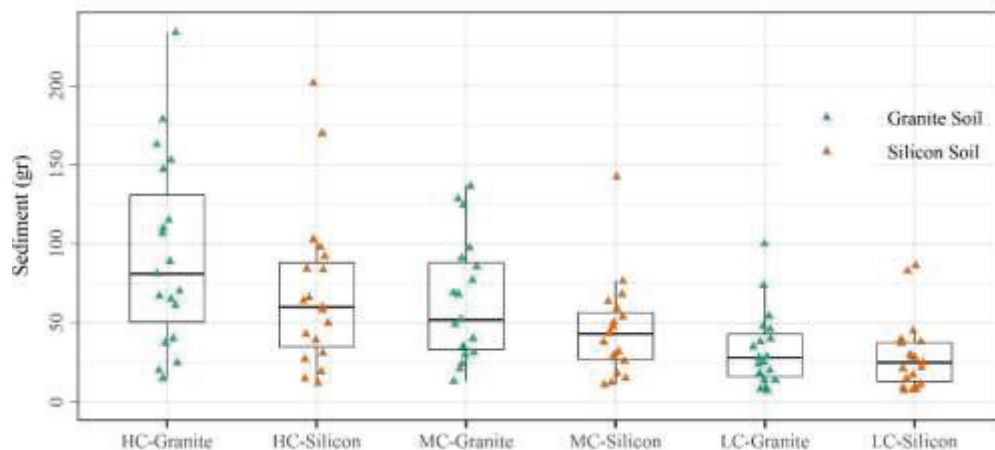


Figure 1: Event-scale sediment yields for DG and SS under three canopy elevations

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