Singapore International Water Week

SINGAPORE INTERNATIONAL WATER WEEK 2024

THE GLOBAL PLATFORM TO SHARE AND CO-CREATE INNOVATIVE WATER, COASTAL AND FLOOD SOLUTIONS

18 - 22 June 2024

Sands Expo & Convention Centre
Marina Bay Sands, Singapore

SIWW2024 WATER CONVENTION ADVANCE PROGRAMME

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Water Convention is jointly organised by:

IWA the international water association

PUB SINGAPORE'S NATIONAL WATER AGENCY

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MESSAGE FROM THE PROGRAMME COMMITTEE CO-CHAIRS

Bernard Koh
Assistant Chief Executive
(Future Systems and Technology)
PUB, Singapore's National Water Agency

Darryl Day
Director and Principal Consultant
Wongulla Waters

On behalf of the Programme Committee, we extend a warm invitation to you to join us at the Water Convention, a key flagship programme of the Singapore International Water Week (SIWW) 2024 which takes place from 18 to 22 June 2024.

As one of the leading global water events focused on innovation and solutions, SIWW2024 will once again play host to global leaders, experts and practitioners from governments, cities, water utilities, agencies, industry and academia to share and co-create innovative solutions to solve the world's urban water and sanitation challenges as climate change impacts accelerate.

Co-organised by PUB, Singapore's National Water Agency, and the International Water Association, the 2024 Water Convention will present papers on the newest and latest innovation, technologies, best practices and case studies in six themes covering the urban water cycle. These themes reflect the urgent issues and challenges facing urban water practitioners, such as ensuring the sustainable production and supply of safe and clean drinking water, the effective and efficient collection and treatment of used water, resiliency and adaptability of urban cities to climate change, floods and sea-level rise, water quality and one health, and resource efficiency and circular economy for the water sector.

Delegates can look forward to a high-quality technical programme at the Water Convention including an Opening Plenary session, 5 keynote presentations, 44 oral sessions featuring over 170 expert speakers, a poster session with more than 250 posters, 6 hot issues workshops covering topics such as climate adaptation and water resilience in cities, carbon management in used water treatment, PFAS, GHG emission monitoring in wastewater treatment plants, coastal revitalization and digital transformation of utilities.

It is our wish that the sessions presented at this Water Convention will inspire and foster closer collaborations amongst various stakeholders within the global water community and contribute towards meaningful action to build a sustainable global water future for all.

We look forward to meeting you in Singapore at the SIWW2024 Water Convention.

SINGAPORE INTERNATIONAL WATER WEEK 2024
PROGRAMME OVERVIEW

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PROGRAMME COMMITTEE

CO-CHAIRS

Bernard Koh
Assistant Chief Executive (Future Systems and Technology)
PUB, Singapore's National Water Agency

Darryl Day
Director and Principal Consultant
Wongulla Waters

THEME 1: DELIVERING WATER FROM SOURCE TO TAP (NETWORK)

THEME LEADER

Ridzuan Ismail
Director & Chief Sustainability Officer, Policy & Planning
PUB, Singapore's National Water Agency

MEMBERS

Albert Cho
Senior Vice President and Chief Strategy and External Affairs Officer
Xylem

Amir Cahn
Executive Director
SWAN

Hamanth Kasan
Director, Utilities Partnership Division
ROCKBlue

Martine Watson
General Manager Operations, Maintenance & Planning
Urban Utilities

Zdravka Do Quang
Group Innovation Programs Officer
SUEZ

THEME 2: DELIVERING WATER FROM SOURCE TO TAP (TREATMENT)

THEME LEADER

Jonathan Clement
Director, Global Advanced Water Treatment
Ramboll

MEMBERS

Aik Num Puah
Independent Consultant

Holly Shorney-Darby
Head, Technology Application and Piloting
PWNT

Seungkwan Hong
Professor
Korea University

Nikolay Voutchkov
Executive Director, Water Innovation Center
NEOM

Min Yang
Deputy Director, Research Center for Eco-Environmental Sciences
Chinese Academy of Science

THEME 3. EFFECTIVE AND EFFICIENT WASTEWATER MANAGEMENT (TREATMENT & CONVEYANCE)

THEME LEADER

Kartik Chandran
Professor
Columbia University

MEMBERS

Andrew Shaw
Associate Vice President, Global Practice and Technology Leader in Sustainability & Wastewater
Black & Veatch

Mads Leth
Chief Executive Officer
VCS Denmark

Mark van Loosdrecht
Chair Professor, Environmental Biotechnology
Delft University of Technology

Norhayati Abdullah
Associate Professor, Environmental Engineering
Universiti Teknologi Malaysia, Kuala Lumpur

Susan Moisio
Global Vice President and Global Water Director
Jacobs

Valerie Naidoo
Executive Manager, Business Development and Innovations
Water Research Commission

THEME 4: CITIES OF THE FUTURE AND COASTAL & FLOOD RESILIENCE

THEME LEADER

Tony Wong
Director
Tony Wong Consulting

MEMBERS

Hazel Khoo
Director, Coastal Protection Department
PUB, Singapore's National Water Agency

Mark Fletcher
Global Water Business Leader
Arup

Pritha Hariram
Head, Water Infrastructure and Climate Adaptation
Ramboll

Piet Dircke
Global Director Climate Adaptation
Arcadis

THEME 5: WATER QUALITY AND ONE HEALTH

THEME LEADER

Robert Bos
Independent Consultant

MEMBERS

David Cunliffe
Principal Water Quality Advisor
SA Health

Fiona Waller
Head of Water Quality
Affinity Water

Hiroyuki Katayama
Professor
University of Tokyo

Regina Sommer
Associate Professor
Medical University of Vienna

Ruchika Shiva
Country Coordinator
IRC WASH

THEME 6: NEXUS AND CIRCULARITY

THEME LEADER

Dragan Savic
Chief Executive Officer
KWR Water Research Institute

MEMBERS

Adam Lovell
Executive Director
Water Services Association of Australia

Chee Meng Pang
Chief Engineering and Technology Officer
PUB, Singapore's National Water Agency

Despo Fatta-Kassinos
Professor
University of Cyprus

Gary Gu
Global Technology Director
DuPont Water Solutions

Miriam Otoo
Deputy Chief of Party, URBAN WASH
Tetra Tech

Michael Storey
Managing Director
Isle Utilities

WATER CONVENTION THEMES

THEME 1 DELIVERING WATER FROM SOURCE TO TAP (NETWORK)

Digital transformation has empowered water utilities to leverage advanced technologies and data gathered from multiple sensors to improve their network planning and design. This enables water utilities to achieve an efficient and resilient network. The wealth of network information supports operators in proactive maintenance of their assets, leak detection, condition assessment, valve operations and mains flushing. This informed approach ensures smooth and uninterrupted water supply. The proliferation of digital twins and smart water meters also betters our understanding of the network's behaviour and enables more effective water conservation strategies. However, it is important to note that digital transformation should prioritise people, and digital solutions should be relevant to and embraced by both operators and customers.

THEME 2 DELIVERING WATER FROM SOURCE TO TAP (TREATMENT)

Cities worldwide face the challenge of limited freshwater supply, prompting them to diversify their water sources to become more resilient. As treatment technologies continue to advance, there is an increasing focus on making the process more sustainable by reducing energy requirements, exploring beneficial reuse of brine, and harvesting energy from waste streams. Additionally, these technologies have to be adaptable to the future impacts of climate change, for instance by designing treatment processes that can cope with changing water quality. While ensuring a sufficient and sustainable water supply is critical, it is equally important to ensure that the water supplied is of the highest possible quality. To this end, water utilities are applying advanced technologies that can effectively treat and remove contaminants of emerging concern and specific groups of contaminants that are resistant to conventional processes. Water utilities are also exploring the use of innovative sensors and digital solutions to support them in plant operations, maintenance, and optimisation.

THEME 3 EFFECTIVE AND EFFICIENT WASTEWATER MANAGEMENT

(A) TREATMENT

In our pursuit of a sustainable future, the perception of wastewater has changed from being something unwanted to a beneficial resource. This shift drives the desire to extract as much water, energy, and valuable materials from wastewater as possible. A growing number of technologies have been developed to enhance energy generation during wastewater treatment. Meanwhile, to mitigate climate change, attempts are made to reduce the overall carbon footprint of wastewater management including nitrous oxide and methane emissions. There is an upward trend in recovering and reusing material resources from waste streams. For the remaining wastewater effluent, a high quality is targeted for reuse applications, potentially in part through the use of membrane technologies and processes. Besides looking into new innovations, efforts are also placed in improving the efficiencies of existing processes to enhance sustainability.

(B) CONVEYANCE

Sewers are vital for the sanitary conveyance of wastewater to treatment facilities. To ensure that sewers can carry out their function well, proper operation and maintenance are necessary. Utilities are taking a more proactive approach in these areas with the help of digitalisation and intelligent technologies. In sewer operation, analytics and management tools are employed with real-time sensors and meters for detecting and predicting blockages, inflows, and infiltrations. It is equally important to examine the quality of the wastewater discharged into sewers as it affects downstream treatment processes. In maintenance, advanced inspection equipment is deployed for sewer inspection, cleaning, and rehabilitation. The necessity for cutting-edge technologies becomes more apparent as large sewers are laid more deeply in the increasingly urbanised cities. Such deep tunnel sewage systems require innovative solutions for monitoring the tunnel's structural integrity and conveyance condition.

THEME 4

CITIES OF THE FUTURE AND COASTAL & FLOOD RESILIENCE

Cities and towns are the economic powerhouses. They account for more than 70% of global gross domestic product (GDP). And by 2050, they are expected to accommodate 70% of the world's population. Cities are complex adaptive systems, with multiple interconnected elements converging, concentrating, and exacerbating many of climate change impacts. Over the last decade, SIWW has provided a platform for fostering integrated urban water management across the social-technical domain.

The Cities of the Future Theme of SIWW2024 will focus on coastal cities and small island states. While all cities globally are faced with climate change water-related challenges of water scarcity, floods, environmental pollution, and loss of natural capital, to varying degrees, coastal cities are particularly vulnerable to climate change impact on flooding from multiple fronts, i.e. sea-level rise and storm surges, fluvial floods with many coastal cities located within large river basins, and pluvial floods owing to many coastal cities being located on relatively low-lying and flat terrain. Many small island states are also reliant on vulnerable groundwater resources as their primary source of potable water. Coastal pollution (e.g., plastics and more generally waste management – solid or liquid) is also becoming a critical challenge for coastal cities to ensure local water quality as an asset for liveability and citizens engagement on water-related issues, but also to contribute to a wider range of SDGs. Our focus on coastal cities and small island states is therefore within the context of climate change resilience and adaptive capacity and managing coastal pollution.

THEME 5

WATER QUALITY AND ONE HEALTH

Global climate change has led to an increased focus on water quality and its impact on human, animal, and ecosystem health. Recent progress in the application of genomics has opened up new possibilities for water quality surveillance and management. Wastewater-based epidemiological surveillance (WES) has attracted attention worldwide during the pandemic as a real-time monitoring method for SARS-CoV-2; it has great potential to be applied to monitoring the emergence of new virus variants, antimicrobial resistance (AMR) and pathogens at large, as well as medicine and drug use in communities. Innovative sensors for detecting pollutants and contaminants in drinking water are becoming more sensitive and specific which raises concerns if hazardous concentration standards are driven by the ever-increasing resolution of detection techniques (shifting from parts per trillion to parts per quadrillion) rather than based on proven health risks. The current debate on PFAS highlights the growing divergence between standards across the world. Water quality is also increasingly crucial in the context of medical care; the quality of recreational waters is another issue of concern. Effective communication between sectors and to communities is crucial for the successful promotion of One-Water/One-Health but remains a challenge.

THEME 6

NEXUS AND CIRCULARITY

The water sector has made significant progress in adopting circular economy principles, particularly in the area of closing the water loop through the application of advanced treatment processes. There is now a growing emphasis on closing the resource and carbon loops within and beyond water systems. To achieve this goal, it is essential to adopt a system thinking approach that takes into account not only technological aspects, but also policy and planning, stakeholder engagement, application, marketability, and potential financing solutions. It is also important to adopt a nexus approach that enables systems integration and collaboration with other sectors to fully leverage the benefits of circular solutions.

WATER CONVENTION PROGRAMME OVERVIEW

Date/ Theme	Theme 1: Delivering Water from Source to Tap (Network)	Theme 2: Delivering Water from Source to Tap (Treatment)	Theme 3: Effective and Efficient Wastewater Management (Treatment & Conveyance)	Theme 4: Cities of the Future and Coastal & Flood Resilience	Theme 5: Water Quality and One Health	Theme 6: Nexus and Circularity
18 June (Tues)	Hot Issue Workshops					
19 June (Wed)	Joint Opening					
	Opening Plenary					
	Lee Kuan Yew Water Prize Lecture					
	Poster Session					
20 June (Thu)	1.1 Planning Your Water Supply Network	2.1 Advanced water treatment process	3.1 Advanced Nitrogen Removal 3.8 Pipes Underground		5.1 Global Climate Change, Water Quality and Health	6.1 Policy and Planning
	1.2 Asset Management of Water Distribution Systems	2.2 Innovation in Water Reuse	3.2 MABR 3.9 Water Quality Monitoring (Conveyance)		5.2 Water Quality related to Agriculture and Food Safety	6.2 Cross-Sectoral Collaboration in the Circular Water Economy
	Special Keynote					
	1.3 Next Generation of Water Network Operations	2.3 Innovation in Low Energy Desalination	3.3 Tertiary Treatment for Reuse 3.10 Industrial wastewater treatment- Singapore Stories	4.1 Planning climate-resilient cities	5.3 Wastewater-based Epidemiological Surveillance (WES) Part 1	6.3 System of Systems for a Circular Economy
	1.4 Developing a Business Case for Water Loss Reduction	2.4 Brine Concentration and Mining	3.4 Anaerobic Digestion Enhancement	4.2 Reforming Governance for climate resilience 4.6 Building Resilience for Small Island development states	5.4 Wastewater-based Epidemiological Surveillance (WES) Part 2	6.4 Resource Circularity and Valorisation
21 June (Fri)	1.5 The Water Utility Smart Metering Journey	2.5 AI for water treatment	3.5 Digital Twin for Used Water Systems	4.3A Automation and AI for urban water management 4.3B High resolution modelling and forecasting in Singapore	5.5 Emerging Approaches for Water Quality Monitoring and Management	6.5 Carbon Accounting
	1.6 The Good, Bad and Ugly of Smart Water	2.6 Advances in Membrane Technology	3.6 Emerging Contaminants	4.4 Coastal Resilience through Hybrid Infrastructure: Global Experience	5.6 Communication between Sectors and to Affected Communities	6.6 Monitoring and management of process emissions Part 1
		2.7 Emerging Water Technologies	3.7 Monitoring and management of process emissions Part 2	4.5 Coastal Resilience through Hybrid Infrastructure: Singapore Experience	5.7 Antimicrobial Resistance (AMR)	6.7 Water and Hydrogen Economy

HOT ISSUES WORKSHOPS

18 June 2024 (Tuesday) | 9:30am – 5:30pm

AM: 9:30am – 1:00pm	PM: 2:00pm – 5:30pm
Workshop 1: SIWW SWAN APAC Workshop: New Ripples in Digital Water Transformation	
Workshop 2: GHG Production and Emissions in Wastewater Systems	
Workshop 3: Towards Carbon Circularity in Domestic and Industrial Wastewater Treatment	**Workshop 5:** Building Water Resilience and Security through Alternative Sources^
Workshop 4: Climate Adaptation and Water Resilience in Cities	**Workshop 6:** PFAS - When Toxicologists Disagree^

^Session ends at 5:00pm

WORKSHOP 1 : SIWW SWAN APAC WORKSHOP: NEW RIPPLES IN DIGITAL WATER TRANSFORMATION

18 June 2024 (Tuesday) | 9:30am - 5:30pm

(Co-organised with SWAN Asia-Pacific Alliance)

Synopsis

Digital transformation is the integration of technology into all areas of a business, fundamentally changing how organisations operate and deliver value to customers. It's also a cultural change, which requires organisations to continually challenge the status quo, experiment, and get comfortable with failure. The 3rd SWAN APAC Workshop will bring together water utilities, industry leaders, innovators, and experts from across Asia-Pacific to delve into the value of digital transformation for water utilities. We will cover cutting-edge topics such as generative AI, cybersecurity, digital decarbonisation, and more. Attendees will also be able to participate in interactive roundtable sessions, learn from a shark tank session, and gain important insights and networking opportunities with a global network of water professionals. This workshop is co-organised with SWAN Asia-Pacific Alliance.

Programme

9:30am – 9:40am	**Welcome and Introduction**
	Dr. Amir Cahn, CEO, SWAN Forum
9:40am – 10:00am	**Utility 2.0 – Human-Centric, Digital and Innovation Driven**
	Harry Seah Deputy Chief Executive, PUB, Singapore's National Water Agency
10:00am – 11:00am	**Waterside Chat: "Capturing the Value of Digital Transformation"**
	Moderator: Jenny Francis, Executive Manager Digital, Hunter Water & SWAN APAC Chair • Mirla M. De Leon, General Manager, Maynilad Water Services • George Theo, CEO, TasWater • Chris Toop, Director of Digital & CIO, Scottish Water
11:00am – 11:30am	**Tea Break & Networking Session**
11:30am – 11:40am	**SWAN Update**
	Gayathri Bharadwaj, Asia-Pacific Manager, SWAN Forum
11:40am – 12:40pm	**Panel: "Understanding the Utility Implications of Generative AI"**
	Moderator: Victoria Edwards, Co-Founder & CEO, FIDO Tech • Elizer Nacpil, Head/VP of Digital Transformation, Balibago • Dr. Peter Prevos, Manager Data Science, Coliban Water
12:40pm – 1:00pm	**Keynote**
1:00pm – 2:00pm	**Lunch Break & Networking Session**
2:00pm – 3:15pm	**Interactive Roundtable Session**
	• Dr. Yasuhiro Matsui, Deputy General Manager – Water Business Development Department, Energy Business Development Center, Yokogawa • Geoff Childs, General Manager - Asia, Gentrack • Emma Milburn, Marketing and Partner Director, IoTa • Thomas Debruyne, APAC Future of Water – Technology Integration Lead, GHD
3:15pm – 3:30pm	**Roundtable Rapid Fire Recap**
3:30pm – 4:00pm	**Tea Break & Networking Session**
4:00pm – 5:00pm	**SWAN Shark Tank** (to be held at the TechXchange)

WORKSHOP 2 : GHG PRODUCTION AND EMISSIONS IN WASTEWATER SYSTEMS

18 June 2024 (Tuesday) | 9:30am - 1:00pm

Synopsis

Monitoring and mitigation of direct process emissions of nitrous oxide (N_2O) and methane (CH_4) from wastewater treatment plants (WWTPs) are critical as they play a significant role in achieving net zero emissions target for the water sector. Within the water sector, there has been progressive decarbonisation of grid electricity and ongoing work on biogas carbon capture, storage, and utilisation. That leaves process emissions from the actual wastewater process itself the toughest challenge, with no convenient solutions in sight. Between CH_4 and N_2O, the dynamics surrounding N_2O formation, monitoring, and mitigation are the least well understood and yet its global warming potential is 300 times higher than that of CO_2. Unlike CO_2, there are no obvious sinks for N_2O.

This Hot Issues Workshop is set up to allow utilities, government regulators, consultants, academia, and technology solution providers to discuss, converge, and attempts to reach a consensus on the best practice to monitor and mitigate N_2O emissions. Given that wastewater treatment processes and technologies vary vastly from plant to plant, streamlining sampling strategies, data collection methodologies and data analysis are various challenges that the workshop aims to discuss about. The opening presentation will give an overview of GHG emissions in wastewater systems and to recap on the parts of the wastewater treatment processes where GHG emissions typically arise from. The first part of the workshop will discuss GHG emissions in sewer systems. The second part of the workshop will discuss GHG emissions in wastewater treatment plants. The third part of the workshop will discuss about the path to net zero and consensus building on the way forward in GHG emissions management.

Programme

9:30am – 9:35am	**Joint Welcome and Introduction by the Moderators**
	• Despo Fatta-Kassinos, Professor University of Cyprus • Andrew Shaw, Global Practice & Technology Leader, Black & Veatch • Tom Freyberg, Atlantean Media & Aquatech, England
9:35am – 9:55am	**An Overall Review of GHG emissions in Wastewater Systems**
9:55am – 11:00am	**GHG emissions in Wastewater Plants**
	1. Mechanism of Process Emissions Prof. Kartik Chandran, Columbia University 2. Measuring techniques that worked well for gas and liquid phase N2O emissions Prof. Liu Ye, University of Queensland 3. Dealing with data variance and modelling techniques Wim Audenaert, Co-founder and CEO, AM-TEAM
11:00am – 11:30am	**Tea Break & Networking Session**
11:30am – 11:50pm	**Panel Discussion**
	• Prof. Kartik Chandran, Columbia University • Prof. Liu Ye, University of Queensland • Wim Audenaert, Co-founder and CEO, AM-TEAM • Per Henrik Nielsen, Project Director of Special Projects, VCS Denmark
11:50pm – 12:50pm	**Path to Net Zero**
	Moderator: Tom Freyberg, Atlantean Media & Aquatech, England 1. Presentation Emma Shen, Global Principal for Wastewater Energy Optimization & Sector Decarbonization, Jacobs 2. Panel Discussion • Emma Shen, Global Principal for Wastewater Energy Optimization & Sector Decarbonization, Jacobs • Peter Grevatt, CEO of Water Research Foundation and Chair of the GWRC • Narendran Maniam, CEO, Indah Water
12.50pm – 1.00pm	**Summary and Closing Remarks**

WORKSHOP 3 : TOWARDS CARBON CIRCULARITY IN DOMESTIC AND INDUSTRIAL WASTEWATER TREATMENT

18 June 2024 (Tuesday) | 9:30am – 1:00pm

Synopsis

Management of carbon cycle is essential for sustainable used water treatment, from breakdown of organic matters by microorganisms to the capture and utilisation of carbon for energy production and resource recovery. Conventionally, carbon is recovered in the form of biogas from sewage sludge, and advance biosolid treatment technologies are available to improve the biogas yield and the value of energy extracted. Carbon can also be fixed through pyrolytic conversion of sludge to biochar for further reuse. As more emphasis is placed on circularity, other high value products such as PHA and cellulose are now being considered as alternative biomaterials for recovery. The first half of the workshop discusses the latest technologies for anaerobic digestion like thermal hydrolysis pre-treatment and biogas upgrading technologies, as well as the comparisons at various aspects of anaerobic digestion of sewage sludge with incineration. The second half of the workshop discusses carbon recovery from sewage sludge, including examples such as biochar, cellulose and PHA. The last part will feature a panel discussion to discuss the best way forward for carbon management in wastewater treatment plants.

Programme

9:30am – 9:40am	**Welcome and Introduction**
9:40am – 10:00am	**An Overview of Carbon Management in Wastewater Treatment**
10:00am – 11:00am	**Presentations: Biogas and Biosolids**
11:00am – 11:30am	**Tea Break & Networking Session**
11:30am – 12:15pm	**Presentations: Recovery of Alternate Biomaterials**
	1. Carbon Compounds Recovery from Used Water
	Prof Mark van Loosdrecht, Delft University of Technology
12:15pm – 12:30pm	**Q&A**
12:30pm – 1:00pm	**Panel: Carbon Circularity for Wastewater Treatment**

WORKSHOP 4 : CLIMATE ADAPTION AND WATER RESILIENCE IN CITIES

18 June 2024 (Tuesday) | 9:30am – 1:00pm

Synopsis

In the first part of this workshop, presentations on climate adaptive planning provide a broad overview of climate adaptation and water resilience strategies for cities and provides context to forums and water convention sessions over the next three days. In the second part of this workshop, audience members are invited to discuss co-benefits that can be designed into coastal resilience and provide inputs to the Cities Roundtable on Coastal Resilience and Flood Management through a communique.

Programme

9:30am – 9:40am	**Welcome and Introduction**
	Pritha Hariram, Head of Department, Ramboll
9:40am – 10:00am	**Broader Climate Adaptive Planning for Cities**
	Prof. Tony Wong, Founder, Tony Wong Consulting, Australia
10:00am – 10:20am	**Adaptive Planning Approach in Singapore**
	Sarah Hiong, Deputy Director, PUB, Singapore's National Water Agency
10:20am – 11:00am	**Plenary Discussion**
	• Pritha Hariram, Head of Department, Ramboll • Prof. Tony Wong, Founder, Tony Wong Consulting, Australia • Sarah Hiong, Deputy Director, PUB, Singapore's National Water Agency
11:00am – 11:30am	**Tea Break & Networking Session**
11:30am – 12:20pm	**Breakout Discussion on Climate Adaptation & Water Resilience in Cities**
	• Prof. Tony Wong, Founder, Tony Wong Consulting, Australia • Piet Dircke, Global Director Climate Adaptation, Arcadis • Hazel Khoo, Director, PUB, Singapore's National Water Agency • Pritha Hariram, Head of Department, Ramboll
12:20pm – 12:30pm	**Mentimeter Interaction**
12:30pm – 12:50pm	**Communique Development**
12:50pm – 1:00pm	**Summary and Closing Remarks**
	Piet Dircke, Global Director Climate Adaptation, Arcadis

WORKSHOP 5 : BUILDING WATER RESILIENCE AND SECURITY THROUGH ALTERNATIVE SOURCES

18 June 2024 (Tuesday) | 2:00pm - 5:00pm

Synopsis

Water scarcity is not unique in large parts of the world, and utilities for many decades have adapted successfully with having minimal water resources. in recent years there has been a paradigm shift with climate change and increasing population. Wetter areas where there has never been a water scarcity problem for nearly a century are faced with changing to alternative sources. for many of the utilities they have no experience in how to treat these sources and how to integrate these sources into their existing system. There are globally many successful examples of how utilities and experts have found creative solutions to deal with water scarcity and this workshop will focus on these valuable lessons.

Programme

2:00pm – 2:10pm	**Welcome and Introduction**
	Jonathan Clement, CTO Advanced Water Treatment (Ramboll)
2:10pm – 3:10pm	**Presentations**
	1. The Quest for Alternative Sources – Vitens Living Lab Phase 1
	Rene Hoeimakers, Global Division Director, Ramboll, The Netherlands
	2. Improving the Water Supply Resilience of Metro Manila
	Adrian Marsden, Arup, Philippines
	3. Integrated term Plan for addressing Water Scarcity
	Chris Rockey, Head of Water Quality, South West Water
	4. Using Reused Water to Address the Water Scarcity in Southern California
	Adel Hagekalil, General Manager, Metropolitan Water District of Southern California
	5. Four National Taps
	Bernard Koh, Assistant Chief Executive, PUB, Singapore's National Water Agency
3:10pm – 3:30pm	**Interaction with Panel Speakers**
3:30pm – 4:00pm	**Tea Break & Networking Session**
	Gayathri Bharadwaj, Asia-Pacific Manager, SWAN Forum
4:00pm – 5:00pm	**Panel Discussion**
	Moderator: Jonathan Clement, CTO Advanced Water Treatment, Ramboll

WORKSHOP 6 : PFAS - WHEN TOXICOLOGISTS DISAGREE

18 June 2024 (Tuesday) | 2:00pm – 5:00pm

Synopsis

Per- and polyfluoroalkyl substances (PFAS) are a group of synthetic chemicals used in various industrial and consumer products because of their water and oil repellent properties, heat resistance, and durability. The health and environmental issues related to PFAS include:

- Their persistence and their bioaccumulation: PFAS are highly persistent in the environment and in the human body. They do not break down easily and can accumulate over time, leading to long-term exposure risks. PFAS can bioaccumulate in the food chain, concentrating in organisms at higher trophic levels. This can lead to elevated levels of PFAS in humans and wildlife that consume contaminated food or water.

- The health hazard and risk they represent: PFAS exposure has been shown to be linked or is suspected to be linked to numerous adverse health effects in humans, including cancer (particularly kidney and testicular cancer), immune system dysfunction include a reduced response to vaccines, liver damage, thyroid disorders, and developmental effects on foetuses and infants. PFAS contamination of drinking water sources, such as groundwater and surface water, poses a significant public health concern. Contaminated drinking water sources can lead to widespread exposure among populations.

- Their environmental impact: PFAS contamination can harm aquatic ecosystems, affecting fish, wildlife, and vegetation. This contamination disrupts ecological balance and can lead to population declines and biodiversity loss.

PFAS pose important regulatory challenges: regulating PFAS contamination is challenging due to the widespread use of these chemicals, their persistence in the environment, and the lack of comprehensive data on their health and environmental effects. Efforts to regulate PFAS contamination are on-going but face obstacles related to scientific uncertainty and stakeholder interests. Addressing PFAS contamination requires a multi-faceted approach involving regulation, remediation of contaminated sites, monitoring of drinking water sources, and research into safer alternatives to PFAS in industrial and consumer products.

This Hot Issues Workshop will provide an opportunity to understand some of the views around PFAS. As the toxicological evidence is still developing, consensus on standards in drinking water and food; environmental and social concerns are high and drinking water supply utilities, food safety specialists, regulators and health professionals are working in an uncertain landscape. Our invited speakers will present an update of our current state of knowledge and evidence, and their views on the challenges around determining and agreeing what constitutes a “safe” concentration of PFAS. A Panel session will debate if or how the cycling of PFAS around our environment can be reduced or halted, considering the exposure routes for humans and animals through food, water and other sources. Identifying historic and current PFAS usage, possible pathways and receptors requires dedicated resources. The subsequent decisions on monitoring, treatment options and optimisation are also complex and costly. Some treatment processes have been identified as being effective in removing PFAS from water but there are many more aspects to consider which will be discussed in this topical workshop of international experts.

Programme

2:00pm – 2:15pm	**Welcome and Introduction**
	Peter Grevatt, CEO of Water Research Foundation and Chair of the GWRC
2:15pm – 2:45pm	**Moderated Debate on PFAS Toxicologists: Research and Public Health Views**
	Prof. Tony Wong, Founder, Tony Wong Consulting, Australia
2:45pm – 3:30pm	**Presentations on PFAS**
	Sarah Hiong, Deputy Director, PUB, Singapore’s National Water Agency
3:30pm – 4:00pm	**Tea Break & Networking Session**
4:00pm – 4:45pm	**Panel: PFAS can we reach a consensus?**
	Piet Dircke, Global Director Climate Adaptation, Arcadis

OPENING PLENARY AND KEYNOTE SPEAKERS

Join us at the Water Convention Opening Plenary on 19 June 2024, where global water leaders will gather to discuss urgent issues and challenges facing urban water practitioners, such as ensuring the sustainable production and supply of safe and clean drinking water, the effective and efficient collection and treatment of used water, resiliency and adaptability of urban cities to climate change, floods and sea-level rise, water quality and one health, and resource efficiency and circular economy for the water sector.

OPENING PLENARY

19 June 2024 (Wednesday) | 11:30am – 1:00pm

Prof. (Dr) Anusha Shah

President

Institute of Civil Engineers (United Kingdom)

Prof. Juliet Willets

Professor

Institute for Sustainable Futures, University of Technology Sydney (Australia)

Dr Sunita Narain

Director General

Centre for Science and Environment (India)

Yang Villa

Co-founder

IWA YWP chapter in the Philippines, International Water Association (Philippines)

SPECIAL KEYNOTE

20 June 2024 (Thursday) | 2:00pm – 2:20pm

Prof. Qu Jiuhui

Research Professor

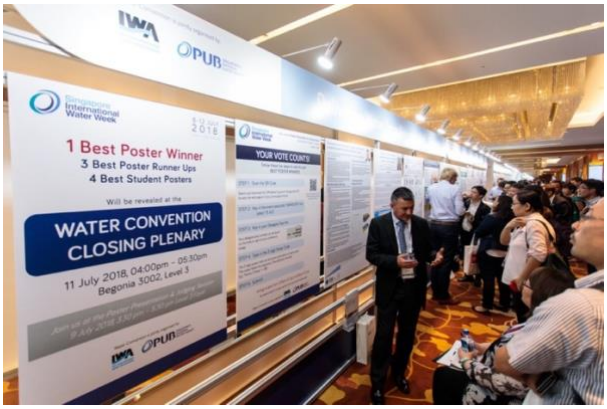
Center for Eco-environmental Sciences, Chinese Academy of Sciences (China)

POSTER SESSION AND CLOSING PLENARY

POSTER SESSION

19 June 2024 (Wednesday) | 4:00pm - 6:00pm

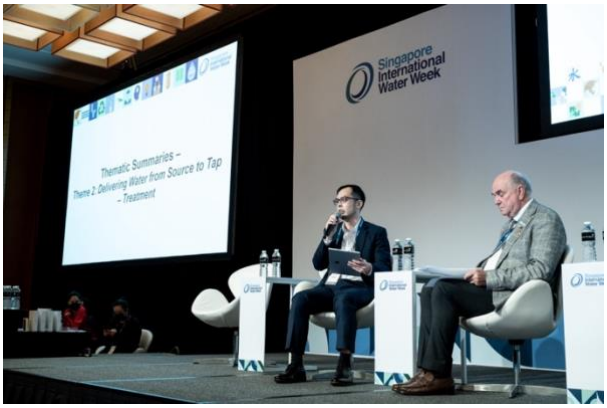
Click here to view the list of poster presentations.



CLOSING PLENARY

21 June 2024 (Friday) | 3:30pm - 4:00pm

During the closing plenary, the Programme Committee will summarise the outcomes of the Water Convention and present the Best Poster awards to poster authors.



THEME 1: DELIVERING WATER FROM SOURCE TO TAP (NETWORK)

SESSION 1.1 - PLANNING YOUR WATER SUPPLY NETWORK
20 June 2024 (Thursday) | 9:00am – 10:30am

Session Chairs:
Hamanth Kasan, IWA (South Africa), *Session Co-Chair 2: TBC*

> **Adaptive Optimized Planning for Water Supply Systems**

***Tom Woolley,* SUEZ (United Kingdom)**

Water supply projects are confronted with numerous uncertainties, such as climate change, population growth, and evolving water demands. Traditional planning methods often struggle to address these uncertainties adequately, leading to inefficiencies and vulnerabilities. Adaptive planning offers a dynamic and flexible alternative by promoting continuous learning, proactive adjustments, and iterative decision-making. Incorporating technology, specifically optimization techniques, within the adaptive planning framework offers significant benefits for water supply projects. These benefits include improved efficiency in long-term planning, enhanced decision-making, optimized infrastructure decisions, and overall cost reduction compared to traditional planning. Furthermore, the integration of technology in adaptive planning empowers decision-makers with valuable insights. Advanced analytics and data-driven approaches enable the analysis of complex scenarios, such as changing water demands, climate variability, and infrastructure constraints. This presentation will discuss how applying Artificial Intelligence and Cloud computing power to these challenges can result in more resilient and efficient water supply systems and will include case studies covering applied use of the techniques.

> **Last Mile Connectivity for Urban Water Supply Services in India**

***Dhruv Bhavsar,* Center for Water and Sanitation, CRDF, CEPT University (India)**

With increasing urbanization, provision of universal access to drinking water to all urban residents has become a major challenge. Our study on 'Last Mile Connectivity for Water Supply' in ten Indian cities suggests that there are bottlenecks that impede provision of water connections to the urban poor. We suggest actions in three key areas: a) improving spatial coverage of infrastructure and access to household water connections, b) simplifying administrative procedures for taking new water connections, and c) making water connection costs and water charges affordable for low-income households. These actions are based on city examples where such actions have been taken in India.

> **Enhancing Water Safety in Porto: Integrating Risk Assessment and Major Strategic Projects**

***Flávio Oliveira,* Aguas e Energia do Porto (Portugal)**

Ensuring the safety, reliability and adaptability of Water Supply Systems (WSS) is crucial for sustaining the public health and well-being of the communities. in the Municipality of Porto, the Water Safety Plan (WSP) emerges as an essential catalyst in achieving these objectives, providing a comprehensive framework that harmonizes risk assessment with strategic initiatives. Implemented for the first time in 2014/15 and fully upgraded in 2020/21, the WSP of Porto became one of the most important management tools of the utility for day-to-day operation and strategic assets management. This paper explores the synergistic relationship between the WSP and three strategic ongoing projects, elucidating how this integration fortifies water safety and responsiveness of the WSS.

> **GeoBIM surges decision making in infrastructure projects: A Case Study**

***Rajesh Kumar V,* L&T Construction (India)**

Building Information Modelling (BIM) can be used to create, manage and share the lifecycle data of vertical facilities such as buildings, mechanical structures, etc., while Geographic Information System (GIS) can be used to store, manage and analyze data describing the environment, which is horizontally distributed such as pipelines. GIS-BIM integration creates a solid model where geographic and infrastructure design data are combined to make it easier to comprehend how assets interact and relate to one another geographically. on review of various methods of GIS-BIM integration, this research work for a mega lift irrigation project reports the most efficient integration method with reference to a real-world case-study. Further the study deep dives into the application of the integrated model in visualization and decision making by taking into consideration various location specific data. This model aids the decision makers in finalizing the location and layout of integral structures to reduce cost and improve efficiency.

SESSION 1.2 - ASSET MANAGEMENT OF WATER DISTRIBUTION SYSTEMS
20 June 2024 (Thursday) | 11:00am – 12:30pm

Session Chairs:
Albert Cho, Xylem (United States)*, Angela Koh,* PUB, Singapore's National Water Agency (Singapore)

> Embedding Asset Condition Assessment into Daily Operation

Pak Lum Lee, **SMEC (Australia)**

Every asset rich utility is responsible for the sustainable management of their assets, to deliver efficient service at an acceptable cost and in accordance with many regulatory requirements. With aging infrastructure assets - condition assessment outcomes will inform utilities of their asset's health; renewal needs and time to failure. Historical low expenditure on planned asset renewal means more assets are reaching end of life, thus the number of assets to be renewed is significantly higher. in the post-COVID era, the cost of asset renewal has also skyrocketed. Condition assessment strategies enable utilities to better understand the condition and performance of their asset portfolio. SMEC has assisted many water and wastewater utilities with Australia, primarily in Queensland with their multi-year planned prioritized condition assessment programs as well as ad-hoc responsive opportunistic investigation. Case studies presented show the value of condition assessment, and the need to embed them within asset rich utilities.

> Using Water Quality Data to Assess Current Pipe Condition

Aoulaya Abdaim, **SUEZ (France)**

We present a web-based tool exploiting historical water quality data to define critical zones within drinking water networks through spatial-temporal analysis and representation. This innovative tool employs novel indicators based on water-material interactions within networks. By deploying this approach on a local network, we were able to assess the water's influence on a pipe section. We produced theoretical levels of pipe degradation for every meter of cast iron pipe of the network, relying on water quality data from the past 10 years. to enhance our methodology, physical models were incorporated to assess residual mechanical resistance. This analysis enabled us to determine the residual lifetime of the entire network. in summary, our web-based tool utilizes water quality data and advanced spatial-temporal analysis to define critical areas in drinking water networks. It also provides valuable insights into the impact of water on pipe sections and predicts network longevity through physical models.

> Data Analytics in Asset Management – Insights on Data Analysis Review of Useful Life of Assets

M Ramasamy Meiyappan, **PUB, Singapore's National Water Agency (Singapore)**

Data analytics of Asset Management Data gave insights on Asset ULS. ULS can be increased where supported by data, condition assessment, OEM inputs, etc. Analysis of Data of Assets Beyond UL showed several used for considerable durations after UL. Maintenance cost data analysis showed similar corrective and preventive satisfactory use more than 20 years beyond UL. There were no significant disruptions due to age-related asset failure. for prudence, proposed UL increase for few assets with additional guidelines: more than 90% reached proposed UL and OEM's verification where possible. Eventually, only UL of PW UF/MF membranes was increased from 5 to 6 years. Data analysis techniques used here are simple over large data sets, validated from independent sources, exploring for exceptions and reasons to reconcile. Going forwards, can hence reviews with longer period data, more data fields, and intricate techniques.

> Reliable Restraint Joint for PE Pipes as an Alternative Technology for SUEZ

Jennifer Ravereau, **SUEZ (France)**

Pipe installation and renewal are critical for network management and extension both in terms of cost and of logistics for installation. Plastic materials for pipes, as polyethylene, are constantly evolving to offer additional benefits (chemical resistance improvement, mechanical resistance). However, they may bring about drawbacks for operators related to installation requirements such as the use of welding techniques. This work aims to study the benefits of an alternative to traditional pipe technologies by improving drinking water network efficiency through an overall technical, economic, and environmental assessment. This work gathers a field test comparison and results of chemical and mechanical accelerated ageing tests to compare a new polyethylene pipe combining the benefits of a PE resin highly resistant to chemical and physical stresses and the ease of installation with the use of restraint locked joint.

SESSION 1.3 - NEXT GENERATION OF WATER NETWORK OPERATIONS
20 June 2024 (Thursday) | 2:30pm – 4:00pm

Session Chairs:
Zdravka Do Quang, SUEZ (France)*, Session Co-Chair 2: TBC*

> Combining Artificial Intelligence and Connected Sensors for the Best Water Network Management Practices and Outcome

***Stephane Gervais, LACROIX* (France)**

Through a strong collaboration with Nevers city (France) and Innovation team from LACROIX, a “Water Augmented Advisor” has been designed to, at first, minimize the time of the water network management team to analyze all the data from increasing IoT devices. Hence, through co-innovation, a solution based on the user needs and dreams has been built. Indeed, new technologies, such as artificial intelligence, and machine learning continuously improved with the knowledge of the experts has been used. Hence, we were able to reduce the time of analysis by 96% with some unexpected outcome such as a faster than expected adoption of the users, short ROI, decisions and actions based on data, allowing to save more resources (water and energy), improved water network efficiency beyond 90%, change in habits and management of the team and knowledge, strengthen resilience of the water network and even detecting leakages that experts were not able to detect.

> Open Network Applying DMA Strategy on Leakage Control - Taipei Experience

***Meng Hsu Yu*, Stantec Consulting Services Inc. (Taiwan)**

Taipei Water Department (TWD) has established 836 DMAs at the end of 2022. to ensure a stable water supply, the boundaries of the DMAs are only closed when metering is required and remain open during regular times. Since each measurement requires labour-intensive work, it is impractical to measure all DMAs at the same time, which poses challenges to active leakage control and long-term management. to this end, TWD adopts a DMA-based approach focusing on pipe network condition improvement, the DMAs rolling health inspections for intelligent management, and expands the application of novel leak detection and monitoring equipment to improve the leakage management results of DMAs in open networks. From 2006 to the end of 2022, it successfully assisted the TWD in reducing the water leakage rate by 15.79%. in the future, TWD will look at more digital tools to continue strengthening the long-term maintenance and management of the open network.

> Online Operational Modelling for Leak Detection and Localization in Water Networks

***Aurelie Chazerain*, SUEZ (France)**

To address the pressing need for significant reduction of non-revenue water (NRW), particularly in the context of the current climatic crisis, SUEZ has devised a comprehensive strategy centred around online operational modelling and AI-based predictive risk/anticipation techniques. The core methodology of its operational modelling solution, Twinet, leverages pressure loggers to dynamically reconstruct the hydraulic behaviour of water networks, enabling the creation of a virtual sectorization. By effectively monitoring the network in real-time, this approach is designed to detect hydraulic anomalies, including clogged pipes and closed valves, and it leads to precise localization of suspected leak areas for early intervention and mitigation. Twinet has undergone testing and real-world deployment in a French metropole, where conventional sectorization is not feasible. The initial outcomes of this implementation have shown promise in reducing NRW (with an objective of less than 10% NRW). Notably, the hydraulic model's performance in detecting closed valves and identifying leak signatures has been encouraging, underscoring its potential as an effective tool for water loss management. However, certain challenges have surfaced, including the need to optimize sensor placement, integrate accurate data, and ensure continuous model updates. These complexities necessitate careful attention to further refine and enhance the approach's capabilities in detecting and localizing leaks, as well as its broader applicability across diverse water distribution systems.

> Applying Data-Driven Analysis and Hydraulic Model Calibration for Cost-Effective Leak Localization

***Ashley Zhang*, Bentley Systems Pte Ltd (Singapore)**

Despite the recent academic advancement in numerical methods of leak localization with the ideal assumptions, it remains challenging to localize leaks in a practical context. PUB’s Smart Water Grid (SWG) provides new prospects for leak localization approaches, by taking advantage of SWG’s well-populated sensor grid and centralized SCADA system. This paper introduces a unique way of leak localization by applying both data-driven and hydraulic model calibration methods to facilitate cost-effective operation. Once a leak event is detected by our software Anomaly Leak Finder (ALF) in the near real-time (Wu et al., 2022), the data-driven method will be triggered in the ALF software to find the clustered leakage areas. The hydraulic model calibration using Darwin genetic algorithm optimization (Wu et al., 2002) will then be activated to search for a few leakage hotspots. The methodology can handle multiple leak events in realistic situations, which is showcased in this paper. Most importantly, with a robust algorithm and well-designed user interface, the localization implementation in our ALF software will largely shorten the leak search time and efforts in the daily operation.

SESSION 1.4 – DEVELOPING A BUSINESS CASE FOR WATER LOSS REDUCTION

20 June 2024 (Thursday) | 4:30pm – 6:00pm

Session Chairs:
Ridzuan Ismail, PUB, Singapore's National Water Agency (Singapore), *Danqian Shen,* PUB, Singapore's National Water Agency (Singapore)

> **Valuing the Invaluable – A Framework for Valuing the Economic, Social and Environmental Benefits of Water Conservation**

Alexus van der Weyden, **Frontier Economics (Australia)**

Amidst changing global climate, population growth and constraints on new infrastructure, water conservation is critical in securing water security and supply resilience across the world. However, the economic benefits of water conservation have not historically been well established or quantified, and therefore not integrated into decision making. in many regions, focus has been on more traditional 'supply' side investments. Frontier Economics developed and applied an economic evaluation framework for the NSW Government to quantify the costs and benefits of water conservation, ensuring the full spectrum of water conservation outcomes are captured in decision making. While this value is highly dynamic and requires a framework and model to vary the value of water in response to changing hydrological and economic factors, it demonstrated that, in certain circumstances (for example, areas with supply shortages, wastewater system constraints and constraints on new infrastructure), water conservation can deliver significant benefits to the community.

> **From 54% to 13% of NRW – Strategies and Tools of an Excellence Program of Porto to Increase Efficiency and Sustainability**

Flávio Oliveira, **Aguas e Energia do Porto (Portugal)**

Porto is the second largest city in Portugal and has one of the country's largest and oldest water supply systems. in 2006, the Non-Revenue Water (NRW) level for the system was 54%. Thanks to a number of water loss reduction initiatives and strategies, the NRW stood at 13.4% in 2022. With the overall objective of continuously improving service quality and environmental and financial sustainability, the NRW Reduction Management Program aims to bring this level down to 13% by 2023. The multiple-faceted integrated methodology underpinning the Program focuses on active leakage control, sectorizing the network, reducing pressure levels, planning the renovation of problematic pipelines, replacing water meters, controlling and reducing illegal consumptions and hydraulic modelling of the system. It also relies on specific data integration, artificial intelligence and decision support platforms. The reduction in NRW since 2006 has resulted in total water purchase savings of over 84 million euros.

> **Collaborative Development of an 'Economic Level of Losses' Tool for Optimal Water Loss Reduction in a Large Water Utility**

Gregory Koffi Kpegli, **International Finance Corporation (United States)**

This collaborative project was to assist a large water utility with the elaboration of a corporate action plan addressing reduction water losses. A good approach to develop an efficient water loss reduction strategy is to consider the Economic Level of Losses (ELL) as a tool to take informed decisions. Indeed, it factors in both the costs and benefits of reducing losses, but also sensible objectives. Our team put together a unique solution including 1) an innovative financing solution, 2) a client-oriented holistic approach and 3) a top-end ELL calculation model. This solution brings a fully operational and adaptive ELL model. This unique tool allows to define the strategic water loss reduction plan, to generate arguments to discuss with the regulator, and to better define the water loss objectives, which ultimately impacts the tariff. The project showed that it is possible to adapt a standard model and to tailor it to the reality of the context in which the utility operates. The main discussion points going forward are 1) how to use ELL models at scale and 2) how to make key stakeholders accept ELL as a key tool for target setting, program planning and regulation. The case study is therefore about a first of its kind project, in which three parties joined forces to provide an innovative ELL calculation model to one of the biggest water utilities in the world.

SESSION 1.5 – THE WATER UTILITY SMART METERING JOURNEY
21 June 2024 (Friday) | 9:00am – 10:30am

Session Chairs:
Amir Cahn, SWAN Forum (Israel*), Waicheng Wong,* PUB, Singapore's National Water Agency (Singapore)

> Coliban Water's Smart Metering Journey

Peter Prevos, Coliban Water (Australia)

Presenter is an invited speaker. No executive summary is available.

> How Is the Global Water Metering Market Changing? Key Trends and Business Model Shifts to Watch

***Christine Ow,* Bluefield Research (United States)**

Meters are a key component of water network management. They are often the first step in a water utilities' digitalization journey. The Global Water Metering Market is set to grow at a 7.8% compound annual growth rate (CAGR) in the coming years. Business models are changing - new incumbents are challenging traditional market leaders such as Honeywell and Kamstrup. At the same time, metering players are expanding their services beyond meters to diversify revenue streams and remain competitive. Priorities differ across regions – for example to meet basic network needs mechanical meters are being rolled out in emerging markets such as Asia and Latin America, whereas more advanced AMI and ultrasonic metering systems are seeing greater traction in mature water markets like North America and Europe. This presentation will provide an overview of the market shifts impacting the global water metering market, including growth projections and key companies to watch.

> Leveraging the Value of Smart Metering - the Case of Canal De Isabel II

***F. Javier Fernandez,* Canal de Isabel II SA MP (Spain)**

Canal de Isabel II is the public company that provides services throughout the whole water cycle to some 6.7 million people in the region of Madrid in Spain. Part of the company's values encompasses the provision of excellent service, with special care for the environment. With this in mind, framed within the global digitalisation strategy and leveraging the widespread availability of low-consumption communication systems such as NBIoT, Canal de Isabel II is deploying a network of smart meters that covers all of its customers, nearly 1.6 million, which will culminate in 2026. The immediate purpose of the hourly readings provided by these meters is, first and foremost, to allow customers to understand their consumption profile and how it can help them become more efficient; secondly, the generation of alerts for internal leaks and other related services; and, thirdly, but not least, the ability to conduct hourly flow balances in distribution district metering areas, significantly improving leak detection capabilities.

> South East Water Achieved Non-Revenue Water Savings with Vibration Sensors Embedded in Smart Digital Meters

***David Lo Jacono,* Jacobs (Australia)**

South East Water (SEW), developed the Sotto® network leak detection sensor (Sotto), an innovative technology designed to be integrated into static Digital Meters. SEW tested Sotto in a trial deployment and found that the trial successfully showed early detection and reduced water loss. Jacobs was engaged in 2022 to review SEW's findings and extrapolate the results across the wider network. Jacobs' analysis determined that installing Sotto sensors will improve the early detection of leaks in either a density of one Sotto per property or one every two properties, with the former providing a better return on SEW's investment. This paper details how Sotto can be useful in network leak identification and location, potential operational changes and the benefit analysis undertaken by Jacobs presented as a case study. The case study results do not infer or imply that equivalent results may or could be experienced by any other water utility.

SESSION 1.6 – THE GOOD, BAD AND UGLY OF SMART WATER
21 June 2024 (Friday) | 11:00am – 12:30pm

Session Chairs:
Martine Watson, SWAN Forum (Israel), *Elizabeth Lee,* PUB, Singapore's National Water Agency (Singapore)

> Understanding Data-As-A-Service Adoption within Water Utilities

***Amir Cahn,* SWAN Forum (Israel)**

The water sector has seen several technological advancements in recent decades, however additional innovation in business models is now needed to support the adoption of these technologies. Today, smart devices such as sensors, meters, and other monitoring equipment can collect and transmit vast amounts of "big data" in real-time. However, water utilities often struggle to manage this magnitude of information due to a lack of skills and resources. One promising solution is "Data-as-a-Service" (DaaS), which involves outsourcing data collection, delivery, and analysis to a third-party technology provider, thus transferring associated risks away from the utility. This study is the first to investigate the drivers, obstacles, and implementation process for water utilities to adopt DaaS. Based on diverse industry feedback, we developed a prototype model to assist water utilities in understanding whether DaaS is the right fit for them or not.

> Achieving Success with IoT Deployment at Scale: Insights for Water Utilities and Companies

***Gerhard Loots,* Kallipr (Australia)**

This abstract explores how to manage a successful deployment of IoT solutions at scale in the water sector, offering valuable insights for water utilities and companies from a leading IoT solutions provider in Australia. By embracing IoT technologies, organizations can drive operational excellence, optimize resource management, and foster innovation. Real-world case studies from Kallipr, including the largest IoT deployment in Australia with Sydney Water, highlight the transformative potential of IoT, showcasing improved efficiency, cost reduction, and enhanced customer satisfaction. However key considerations like solution selection, infrastructure scalability, and overcoming deployment challenges need to be carefully considered. By leveraging IoT-generated data, organizations can optimize processes, drive sustainability, and unlock new business opportunities. This presentation encapsulates the significance of IoT deployment in achieving success and growth in the water sector by sharing learnings taken from large-scale IoT projects within the Australian water industry.

> The Use of Advanced Multi-Parameter Sensors, in Conjunction with Smart Data Management and Analytics Platforms, to Monitor Multiple Potable Water Quality Parameters in a Vast Distribution Network at Rand Water Board

***Ranish Singh,* Rand Water Board (South Africa)**

The pilot study will identify, test and validate the performance of advanced multi-parameter sensors, in conjunction with smart data management and analytics platforms, to monitor multiple potable water quality parameters, in real-time, over a distribution network at Rand Water, South Africa. The systems identified would be installed at 4 identified field sites, which geographically represents the 4 quadrants of an 18000 km2 area with more 3500 km large diameter high pressure piping. The sites are remotely located with various challenges, such as poor to no power sources, poor telemetry and communication coverage, vandalism and low operational skill levels, hence ensuring the validation of the piloted systems for robustness and using advanced technology to overcome the challenges. The systems would be field pilot tested for a period of 6 consecutive months and the results reported on against the predefined success criteria. in parallel, a laboratory validation of the analytical sensors would be undertaken.

> Evergreen Digital Twin as Paradigm Shift for Maximizing Smart Water Grid Return on Investment

***Zheng Yi Wu,* Bentley Systems (USA)**

To address the challenges of climate change and ever-greater water stress, water utilities have increasingly adopted Smart Water Grid (SWG) to ensure that water is delivered with good quality and the minimum disruptions. PUB Singapore's National Water Agency has implemented SWG for many years. However, to fully realize the benefits of SWG, the challenges remain to be addressed along with the innovation solutions. In this paper, Digital Twin (DT) approach is presented for maximizing the SWG return on investment. A generic DT framework is developed to address the challenges of data in silos, model inadequacy, and digital thread weakness. The developed DT approach and solution enable users to achieve adequately accuracy for digital representation of SWG in near real time, namely so-called evergreen DT. The application outcomes have been elaborated and demonstrated that evergreen DT is the paradigm shift for cost-effectively managing SWG and hence maximizing SWG Return on Investment.

THEME 2: DELIVERING WATER FROM SOURCE TO TAP (TREATMENT)

SESSION 2.1 – ADVANCED WATER TREATMENT PROCESS
20 June 2024 (Thursday) | 9:00am – 10:30am

Session Chairs:
Holly Shorney-Darby, PWNT (Netherlands), Session *Co-Chair 2: TBC*

> **Multicriteria Comparison of Three Technologies for The Treatment of 42 Pfas in Drinking Water Using a Comprehensive Experimental Approach**

***Raphaelle Du Besset*, CIRSEE-SUEZ (France)**

Per-fluorinated substances (PFAS) contamination is broad and worldwide: it includes thousands of compounds and is found in all environmental compartments. Regulation is enforced in many countries, with a large variety of compounds and concentrations of targeted PFAS. The aim of this project is to compare different processes for the treatment of drinking water on a multi-criteria basis. The criteria considered cover technical aspects (process performance and ease of implementation), economic aspects (capital and operational costs) and environmental aspects (carbon impact of the process, waste disposal). Laboratory and pilot tests are carried out to consolidate the treatment of a substantial list of 42 PFAS by membrane technologies (low pressure reverse osmosis and nanofiltration) and adsorption processes (activated carbon and resins). The project will enable the selection of the best combination of treatment solutions to implement, depending on the type of water resource, the PFAS contamination and the treatment objectives.

> **Supercritical Water Oxidation for Complete Mineralization of Environmental Toxins (Pfas, Pesticides, Pharmaceuticals Etc.)**

***Zhuoyan Cai*, Aquarden Technologies (Denmark)**

Aquarden SuperOx is a technology used for complete mineralization of organics and difficult-to-treat contaminants in industrial wastewaters, utilizing the working principle of supercritical water oxidation (SCWO). Supercritical water is an effective solvent for both organics and gases and the addition of oxidants to a process flow at supercritical conditions creates rapid oxidation reactions, breaking down organic compounds within seconds. SCWO-treated water contains benign salts and minerals released during the process, while the off gas consists mainly of CO_2, excess O_2, and N_2.

> **Doc Removal from A Turbid and Brackish Water Source with Suspended Ion Exchange (Six®) to Improve the Resilience of Drinking Water Production in a Water Stressed Area**

***Elisabeth Vaudevire*, PWNT (Netherlands)**

Due to the poor quality of its influent water, Llobregat drinking water treatment plant (DWTP) requires extensive treatment with no less than oxidation, coagulation, sedimentation, sand filtration, granulated activated carbon (GAC) and electrodialysis reversal (EDR), to achieve sufficient dissolved organic carbon (DOC) removal to meet the European standards on disinfection by products (DBP). in the near future, the plant will be required to increase its water production from 3.2 m3/s to 4 m3/s. As an alternative to expanding the entire plant's capacity, the implementation of a suspended ion exchange (SIX®) targeting the DOC as a first step treatment was investigated to increase the resilience of the downstream processes. This paper describes one year of operating the SIX® pilot (7m3/h) at Llobregat DWTP which demonstrated stable resin adsorption despite frequent high turbidity events, 40% to 60% DOC removal depending on the influent quality and significant improvement of the DBP formation potential

SESSION 2.2 – INNOVATION IN WATER REUSE
20 June 2024 (Thursday) | 11:00am – 12:30pm

Session Chairs:
Aik Num Puah, PUB, Singapore's National Water Agency (Singapore), Session Co-Chair 2: TBC

> Pure Water Southern California: Developing A New Sustainable Regional Water Supply

***Adel Hagekhalil,* Metropolitan Water District of Southern California (United States)**

The Metropolitan Water District of Southern California is collaborating with the Los Angeles County Sanitation Districts to develop the Pure Water Southern California program. Once fully implemented, PWSC will become one of the world's largest potable reuse programs, providing a new sustainable water supply for Southern California. Various studies have been conducted to date to establish the advanced water treatment plant location, system capacity, process train, phasing strategy, direct potable reuse implementation, conveyance systems, and end user requirements to assess the environmental impacts and advance the program. Alternative delivery method may be considered to expedite program implementation.

> Optimization of an Advanced Industrial Wastewater Treatment Facility for Water Reuse Using Flow Reversal Reverse Osmosis (Fr-Ro) Technology

***Dor Tal,* ROTEC by WFI Group (Israel)**

Flow Reversal Reverse Osmosis (FR-RO) technology was tested for the purpose of treating wastewater at a semiconductor plant, to increase RO recovery beyond 75% and enhance water reuse. The study determined the ability to stabilize operation with recovery rate ranges between 88% and 90%, aiming for low maintenance and scaling cleaning in place (CIP) events. Performance was evaluated in terms of detectable factors which predict mineral scaling over membrane systems such as ΔP, feed pressure and system permeate flux during step-up changes in recovery rate. Set points for recovery rates were adjusted in steps between 70% and 90%. After each step, the system stability was evaluated before moving to the next set point. The system demonstrated the ability to work at high recovery rates with stable operation thanks to the FR-RO technology implementation.

> Real-Time Detection of Volatile Organic Compounds in Potable Reuse

***Eric Dickenson,* Southern Nevada (United States)**

Potable water reuse requires effective treatment technologies and stringent real-time monitoring for chemical and biological constituents of concern. Conventional total organic carbon (TOC) analyzers are not effective at measuring purgeable compounds, such as volatile organic compounds (VOCs), some which are of toxicological concern and can permeate reverse osmosis (RO) and advanced oxidation processes (AOP). We developed a real-time VOC analysis method using a commercially available, thermal desorption cavity ring-down spectroscopy analyzer to detect and speciate VOCs with regulatory limits and health advisories guidance thresholds set at low concentrations (i.e., ug/L - ng/L) prior to and after treatment for RO-based potable reuse applications. This approach uses an online, reagent-less headspace technique providing measurements of 19 VOCs every 50 minutes with replicate analyses showing relative standard deviation of 2 - 12%. This method can confidently distinguish between isomeric compounds and was used to measure VOCs in samples provided by U.S. water utilities.

SESSION 2.3 – INNOVATIONS IN LOW ENERGY DESALINATION
20 June 2024 (Thursday) | 2:30pm – 4:00pm

Session Chairs:
*Key Wee Ong, P*UB, Singapore's National Water Agency (Singapore), *Adil Minoo Dhalla,* Nanyang Technological University (Singapore)

> Understanding Key Considerations for Low Energy Desalination

***Nikolay Voutchkov*, NEOM (Saudi Arabia)**

Presenter is an invited speaker. No executive summary is available.

> Energy Reducing Technology for SWRO Desalination Systems - Closed Circuit Reverse Osmosis Technology

***Santhosh Ramalingam*, DuPont Water Solutions (Singapore)**

Operational efficiency of reverse osmosis (RO) systems is restricted in steady-state designs due to strict hydraulic conditions. Closed Circuit Reverse Osmosis (CCRO) technology for the high-pressure seawater reverse osmosis (SWRO) system in desalination plants eliminates the hydraulic restrictions and allows for optimized performance with lower energy consumption. The CCRO process has been proven successful in brackish water applications for its operational efficiency and flexibility. The technology is currently being evaluated and optimized in a pilot scale testbed at PUB's R&D Facility for the lowest energy consumption in seawater desalination. Simulations show that the CCRO process can reduce energy consumption by 5-18% over conventional RO process using an energy recovery device and identical RO elements. in this paper, we will be discussing the operation of CCRO technology for seawater desalination and demonstrate specific energy consumption <2 kWh/m3. The CCRO pilot is partly funded by PUB under the Competitive Research Programme (Water).

> Ceramics Adsorption Filter (CAF) Combining with Multimedia Filter for Pre-Treatment of SWRO System

***Keiko Nakano*, Proterial, Ltd (Japan)**

Pre-treatment processes serve as the first barrier to remove contaminants in the seawater and to protect the reverse osmosis membrane from severe fouling. Proterial has developed the ceramics adsorption filter (CAF) which is designed to adsorb organic matters and colloid particles, which pass through ultrafiltration membrane. We had conducted the pilot test in the PUB R&D facility in Singapore and applied CAF combining with multimedia filter (MMF) to investigate if this combination could replace UF pre-treatment. The pilot SWRO system consisted of two RO systems, one RO system followed CAF adsorption process after MMF, while UF filtrate was fed into the other RO system. One of the key findings was that the water quality of the RO feed water after MMF-CAF was almost same as that after UF. This indicated that MMF-CAF could replace UF as an effective pre-treatment for SWRO desalination systems. We concluded that MMF-CAF pre-treatment is one of the best solutions for reducing cost of SWRO systems.

> Re-evaluate Practical Performance and Inefficiencies in Close-Circuit Reverse Osmosis (CCRO) Design Using Time-Dependent RO Modelling

***Zijing Mo*, Nanyang Technological University (Singapore)**

Close-circuit reverse osmosis (CCRO) is a newly emerging reverse osmosis approach to desalination, boasting enhanced energy efficiency when compared to traditional single-stage designs. The CCRO system, characterized by a closed stream configuration, offers the dual advantages of customizable hydraulic pressure adjustments to conserve energy and the utilization of standard RO components, similar to single-stage designs, to economize costs. However, the closed configuration necessitates the discharge of concentrate upon achieving the desired recovery, resulting in the coexistence of solutions with substantial concentration differences within the same membrane pressure vessel. This phenomenon triggers reverse water flux across the membrane at the rear elements, potentially undermining the practical performance of CCRO. in order to assess the extent of energy loss due to reverse flux and other inefficiencies during the concentrate purging process in CCRO, this study has developed a multi-cycle, time-dependent finite differential model. This model serves to quantify the flux, applied pressure, and energy consumption associated with CCRO. The result reveals that reverse flux accounts for approximately 5% of energy consumption in practical CCRO applications for seawater desalination at a 50% recovery rate. Although reverse flux can be mitigated by increasing the flow rate during concentrate purging, doing so leads to more substantial pressure losses and necessitates the installation of higher-capacity pumps. Separate storage of the concentrate and the feed through a semi-closed design with multiple tanks, can potentially provide a solution to overcome the challenges of CCRO as it allows for the minimization of the impact of purging on overall energy consumption.

SESSION 2.4 – BRINE CONCENTRATION AND MINING
20 June 2024 (Thursday) | 4:30pm –6:00pm

Session Chairs:
Nikolay Voutchkov, NEOM (Saudi Arabia), *Constanze Simmermacher Schettler*, Jacobs (Singapore)

> Membrane Based Selective Mineral Harvesting System for Innovative Seawater Desalination and Brine Processing

***Hyuk Soo Son,* NEOM (Saudi Arabia)**

Various minerals in seawater are valuable industrial resources, which are products of seawater desalination and brine processing in addition to portable water. to retrieve target minerals from complex seawater compositions in low concentrations, advancement of separation processes is necessary at the level of individual elements or ions. An innovative system for selective separation of monovalent salts is developed for the beneficial use of seawater and its brine. A novel ion-selective membrane is adopted to a seawater reverse osmosis (SWRO) process, enabling the production of a targeted mineral in high concentration. Different potassium-selective compounds are selected for lab testing, and results are evaluated at the zero liquid discharge (ZLD) pilot facility in NEOM, Saudi Arabia.

> Brine Recovery: Achieving High Magnesium Concentration Using Selective Nanofiltration Membranes

***Javier Suarez,* DuPont (Spain)**

Seawater brine recovery is being positioned as a promising technology to recover valuable compounds out of seawater reverse osmosis brine, as well as producing drinking water from seawater. Brine recovery enables the recuperation of natural resources from seawater, through a sustainable process which is aligned with United Nations sustainability development goals as well as with the transition into a circular economy. In order to get these compounds, different steps need to be performed. The first one involves separating divalent compounds from monovalent ones. This is achieved using selective nanofiltration membranes. The subsequent phase of the process requires the production of potable water, followed by the concentration and dewatering of the residual monovalent brine. FilmTec™ SWBR-100 and FilmTec™ SWBR-150 are two types of nanofiltration selective membranes designed specifically to segregate divalent and monovalent compounds. This allows the isolated divalent compounds to be recovered as valuable magnesium salts, following further concentration. At a later stage in the process, the monovalent permeate stream produced by FilmTec™ SWBR-100 or FilmTec™ SWBR-150 undergoes additional concentration enhancement with the aid of FilmTec™ SWBR-200. This membrane enables the recovery of Na and Cl monovalents, even when dealing with high Total Dissolved Solids. This research study aims to evaluate the functionality of these three membranes and highlights the benefits that nanofiltration and seawater reverse osmosis elements bring to the separation process. The membranes were tested under typical operating conditions of a brine recovery process. The experimentation was conducted at the Global Water Technology Center in Tarragona. The trials conducted showed that FilmTec™ SWBR-

> Innovative OARO Process for Low-Carbon Brine Mining and Advanced Hollow Fiber Membrane

***Takahito Nakao,* Toyobo MC Corp (Japan)**

In this study, an innovative brine concentration process named osmotically assisted reverse osmosis (OARO) and advanced hollow fiber membrane applicable to OARO process have been developed. Also, our newly developed membrane for OARO process has been evaluated for the salt production process from seawater at a pilot scale and then will be supplied to commercial salt production plant in Indonesia as a key process for high salinity brine concentration with far less energy consumption than the other existing brine concentration technologies. Also, the overall carbon dioxide emissions of our Indonesian plant have been calculated and a comparison study with the traditional salt production process consisted of electrodialysis (ED) and thermal evaporation. As a result, 50% reduction of carbon dioxide emissions is achievable when introducing our OARO process to the salt production process. Therefore, the OARO process and newly developed hollow fiber membrane will help reduce the electrical energy consumption and also will help achieve the net zero salt production process in the near future.

> Low Pressure RO Permeate Remineralization Through Minerals Recovery from Brines: From Bench-to Pilot-Scale Study

***Emmanuelle Filloux,* SUEZ (France)**

Low-pressure reverse osmosis membranes (LPRO) are gaining interest to treat ground or surface water thanks to the combined effect of softening and micropollutant removal. However, the production of low mineral content permeate requires a post-remineralization with chemicals (lime or limestone), which is expensive and impacts the environment. The alternative proposed in this project is the application of Assisted-Reverse Electrodialysis (A-RED) technology following reverse osmosis (RO) for recovering natural minerals from its brine to directly remineralize the unit's permeate. This approach was tested at both bench- and pilot-scales (patented solution - WO 2021/110865 A1). The process was proven to present viable results: permeate mineral content after A-RED process being increased in terms of both conductivity and hardness. Specific microcontaminant breakthrough tests using spiked micropollutants and natural organic matter (NOM) monitoring were carried out to ensure that these organics did not leach contaminants to the drinking water, causing potential health effects or regulatory problems. Results of this study highlighted the significant barrier provided by the ionic membranes with respect to the issue of organics passage, while allowing for proper remineralization of the permeate water to target potable levels. Process performance stability tests, run over the course of 2000 hours, also showed that the process' performance was maintained stable despite changes in influent water quality and temperature.

SESSION 2.5 – AI FOR WATER TREATMENT
21 June 2024 (Friday) | 9:00am – 10:30am

Session Chairs:
Min Yang, Chinese Academy of Science (China), *Session Co-Chair 2: TBC*

> Machine Learning for Optimizing RO Cleaning Schedules at a PUB NEWater Factory in Singapore

***Mike Dixon*, Synauta (Canada)**

Artificial Intelligence (AI) is becoming a necessity at desalination and water reuse plants in order to optimize and improve operations. Over the last several years, pressure to bid lower and lower values on large reverse osmosis (RO) plants has increased, with some large RO systems at less than USD$0.30/m3. This pressure has increased the need for new optimization methods, primarily the application of Machine Learning (ML), a subset of AI. While energy optimization in seawater RO can reduce costs by up to $2M annually in some large plants, energy optimization yields lower dollar figures in water reuse plants. Focusing optimization efforts on the optimal time to clean-in-place can be far more beneficial to water reuse plant OPEX costs.

> Realization of a Digital Twin of An Operating 2.200 M³/H O_3/H_2O_2 and UV/ H_2O_2 Advanced Surface Water Treatment Plant

***Steffen Rüting*, Xylem (Germany)**

A digital twin of a 2.200 m³/h advanced surface water treatment installation including O_3/H_2O_2 and UV/ H_2O_2 AOP has been developed. This mechanistic virtual model mirrors the actual plant and allows running scenarios for the most economical way of micro pollutant reduction while minimizing bromate formation. The model was set up based on years of on-site research and piloting from the water supplier Dunea and water treatment solution provider Xylem for that specific water source. The advanced modelling company AM-Team then created and calibrated a Sumo-based mechanistic model on the pilot results with further validation based on the installed 2.200 m³/h full-scale plant. The digital twin allows Dunea to quickly and safely simulate the operation of the physical plant with changes in water quality and plant control.

> Seamless Coagulation Control – Using Machine Learning to Optimise Water Treatment Plant Operations

***Silvia Vlad*, Jacobs (New Zealand)**

This paper focuses on the application of machine learning to optimise water treatment operations, including minimizing chemical use, and maximizing organics removal. It outlines the development and applications of a machine learning model to predict post-coagulation water quality at a 190 MLD Waterworks (WW). The initial lab-scale model targets the prediction of jar testing outcomes, incorporating raw water quality, bench scale analysis, and full-scale treatment conditions. This proof-of-concept approach can be used for multi-objective optimization to identify the optimal dose of aluminium sulphate to maximize turbidity removal and reduce treatment cost. The process of data collection, cleaning, and screening will be discussed, along with trade-offs to prioritising data continuity and data quality vs. quantity. By reducing the effort of manual dosing studies (i.e., jar tests), the prototype coagulation model can support water treatment operators in reducing coagulation chemical costs while maintaining treated water quality under fluctuating raw water conditions.

> Real-Time Remote RO Membrane Fouling and Performance Monitoring for Operational Decision Support

***Yoram Cohen*, Noria Water Technologies Inc. (United States)**

Membrane fouling is a major operational hindrance in RO desalination plants. Decisive, unambiguous and direct detection of the onset and monitoring of the progression of membrane fouling, which is lacking in the industry, is much needed to establish informed fouling mitigation strategies. to meet the above challenge a novel direct fouling monitoring technology with remote monitoring capability was evaluated in a yearlong study in a brackish water desalination plant located in Singapore. The fouling monitor utilized a membrane cartridge providing an extension to the spiral-wound RO element channel in the monitored plant zone. Direct surface imaging and image analysis via machine learning analytics, along with various process sensors are used to track membrane performance. The study demonstrated early detection of the onset of fouling significantly in advance of conventional performance fouling metrics. The study shows that direct membrane fouling monitoring, along with automated decision support, can be deployed for membrane performance monitoring, and guide the development of optimal fouling mitigation strategies.

SESSION 2.6 – ADVANCES IN MEMBRANE TECHNOLOGY
21 June 2024 (Friday) | 11:00am – 12:30pm

Session Chairs:
Jonathan Clement, Ramboll (Singapore), Session *Co-Chair 2: TBC*

> Overview of Flat Sheet Ceramic Membranes

***Gilbert Galjaard,* Ramboll (Netherlands),**

Presenter is an invited speaker. No executive summary is available.

> Developing Negatively Charged Nanofiltration Membranes Using Sulfuryl Chloride for Selective Rejection of Organic Micro-Pollutants from Feed Water

***Jinsong Zhang,* CITIC Envirotech Pte Ltd (Singapore)**

Surface modification via secondary interfacial polymerization (SIP) is a promising technology for the enhancement of NF membrane performance such as rejection selectivity. in this study, sulfuryl chloride (SC) was employed to introduce sulfonic groups into the active layer of membranes to improve the membrane performance, also with a purpose of investigating the SIP mechanisms. Results showed that SC in a hexane environment was capable of enhancing membrane surface negative charge density and contracting membrane pores. Membrane surface characterization showed that the sulfur element had a low concentration, indicating that the residual amine groups in the nascent active layer for SIP were quite limited, and the improvement of membrane performance was remarkably affected by the introduced sulfonyl groups. SC in the hexane environment could further enhance the crosslinking degree of the active layer, increase the membrane surface hydrophilicity and narrow the pore size distribution. An optimized membrane with SC modification had a molecular weight cutoff of ~350 Da and a surface zeta potential of ~−55.8 mV, and could effectively reject five negatively charged per- and polyfluoroalkyl substances (with molecular weight ranging from 214 to 414 Da) by over 80% while with a low rejection of $MgCl_2$ below 30%.

> Innovative Drinking Water Treatment: Unleashing the Potential of Hollow Fiber Nanofiltration with Sand Filtration Pre-Treatment

***Jink Gude,* NX Filtration (Netherlands)**

Unleashing the full potential of Hollow Fiber Nanofiltration (HFNF) coupled with sand filtration pre-treatment for drinking water purification, our study compares two concepts: one incorporating HFNF and activated carbon filtration (ACF), and the other integrating sand filtration (without chemical dosing), HFNF, and ACF. Preliminary findings reveal compliance with EU drinking water standards, with low Total Organic Carbon (TOC) and Assimilable Organic Carbon (AOC) levels, and organic removal. Notably, the sand filter enhances HFNF performance, resulting in a 15% permeability increase after just four weeks. This approach, applied to river water, showcases promising results, offering a sustainable solution for improved water quality and environmental challenges. Compared with conventional concepts such as coagulation + UF + RO the energy saving is 70% and the chemical savings >90%, resulting in a lower CO_2 footprint and Opex.

> Ozone and Ceramic Microfiltration to Treat Ferric Coagulant Clarified Water at Choa Chu Kang Waterworks

***Holley Shorney-Darby,* PWNT (Netherlands)**

PUB, PWNT, and Metawater have embarked on a joint research study to investigate the influence of ferric coagulated and clarified water on the performance of ceramic microfiltration with ozone upstream of the membrane. Early results showed that membrane operation was stable at flux 360 lmh. The preliminary results also suggested DOC removal rather than turbidity control was more important in the clarification process for downstream membrane performance with Metawater's ceramic membrane.

SESSION 2.7 – EMERGING WATER TECHNOLOGIES
21 June 2024 (Friday) | 2:00pm – 3:30pm

Session Chairs:
Rong Wang, Nanyang Technological University (Singapore*), Session Co-Chair 2: TBC*

> Development of A Fluorescence EEM-Parafac Model for Online Monitoring of Membrane Integrity Using Natural Organic Components and Antiscalants.

***Tele Anette Mensah,* NTU-NEWRI (Singapore)**

This study used PARAFAC model to characterize excitation and emission of fluorescence naturally occurring organic components and antiscalants in reuse wastewater and seawater systems in Singapore. four and five PARAFAC components were identified respectively in reuse wastewater and seawater including the antiscalants. The results have important implications for online monitoring of membrane integrity as the components identified offer higher levels of removal credit (≥ 3) in comparison to the currently employed methods, while naturally occurring as well as seeded to reverse osmosis RO feed water for scaling purposes. The method is relatively simple, and results can be observed immediately without a thorough data analysis as quantification parameters (i.e. PARAFAC scores) of the components could be obtained from fluorescence EEMs data by simple regression. Based on the identified components, the defective membrane tests are under process to enhance the choice of the components susceptible as the best surrogates to assess the membrane integrity.

> Nanofiltration Innovation: Performance of New Filmtec™ NF270-440 Element in Municipal Wastewater Operation

***Gerard Massons,* DuPont (Spain)**

With more stringent water quality standards, advanced treatment solutions to ensure delivery of reliable, safe water at premium quality are essential. The FilmTec™ NF270-440 nanofiltration element presents an ideal solution for utility managers and operators seeking a technology that removes a high percentage of dissolved organic pollutants from source water while maintaining a suitable level of minerals. Energy efficiency is also of utmost importance for any water treatment facility. Our latest NF innovation enables end-users to reduce CAPEX of nanofiltration systems and simplify the overall systems design by offering a 10% more active membrane area, thus reducing their energy consumption. FilmTec™ NF270-440 is also able to deal with challenging feed water. These benefits were highlighted while in operation in a pilot plant installed in the Vilaseca municipal wastewater treatment plant (Tarragona, Spain). Significant reductions in feed-side pressure drop, fouling resistant properties and reduced energy consumption were observed throughout the trial.

> New Chlorine Stable Reverse Osmosis Membranes Targeted for Potable Reuse

***Sue Mecham,* NALA Membranes (United States)**

Advanced treatment of wastewater effluent using reverse osmosis (RO) for direct potable reuse (DPR) is expanding worldwide. The dominant RO membrane in the market for all applications is the polyamide thin film composite (TFC) and there are essentially no alternative materials available. Polyamide TFC membranes are well-known to be prone to fouling and are damaged by strong disinfectants commonly used in wastewater treatment, such as free chlorine. RO membranes were originally developed for desalination of brackish and seawater feed streams. Due to their tendency to foul from organic contaminants, biofoul, and the difficulty in cleaning them without damaging them, a significant part of the original deployment of RO systems included the development of extensive pretreatment and cleaning operations designed to protect the polyamide RO membranes. These pretreatment, redundancy, and cleaning operations for protecting polyamide membranes have been optimized over 40 years of development and are a significant contributor to the capital and operating costs of today's RO systems. NALA has invented a new TFC membrane based on a patented sulfonated polysulfone that is highly stable to free chlorine, demonstrates low fouling characteristics, and is robust to aggressive cleaning. The opportunity to apply this new membrane technology to direct potable reuse applications is of high interest due to the potential to reduce the cost, complexity, and climate impact of RO systems performing potable reuse operations. The new membrane materials and properties will be presented. Membrane performance will be presented in the context of comparative challenge experiments relevant to potable reuse applications.

THEME 3: EFFECTIVE AND EFFICIENT WASTEWATER MANAGEMENT (TREATMENT AND CONVEYANCE)

SESSION 3.1 – ADVANCED NITROGEN REMOVAL
20 June 2024 (Thursday) | 9:00am – 10:30am

Session Chairs:
Mark van Loosdrecht, Delft University of Technology (Netherlands), *Session Co-Chair 2: TBC*

> **PDN/A - Different Nitrogen Removal Pathways**

Stephanie Klaus, **Hampton Roads Sanitation District (United States)**

Presenter is an invited speaker, no abstract summary available.

> **A New Strategy to Control Nitrite Oxidizing Bacteria (NOB) in the Mainstream Anammox Process Using Supernatant from Anaerobic Digester**

Victory Fiifi Dsane, **BKT Co. Ltd., South Korea (Republic of Korea)**

Practical application of partial nitritation (PN) in the mainstream process faces several challenges, leading to a quest for innovative, economical and environmentally friendly techniques to curb these challenges. in this study, the feasibility of achieving stable PN in the mainstream process with anaerobic digester supernatant was investigated. The research started from a lab-scale sequencing biofilm batch reactor (SBBR) to a pilot scale at the Hyperion plant in Los Angeles, CA. Results showed a new reliable and repeatable strategy to control nitrite-oxidizing bacteria (NOB) in the mainstream process. The adopted strategy offers the advantages of; warm temperature, instant NOB inhibiting environment, as well as alkalinity to buffer pH changes for effective control of the target organisms. in order to maximize residual ammonia concentration and maintain a DO/NH4 ratio below 0.2, the SBBR reactors were operated with 100% fill and decant cycles, and the DO kept below 4.0 mg/L. This unique operational strategy favored ammonia-oxidizing bacteria (AOB) and hindered NOB. A record high stable nitrogen loading rate of 2.2 kgN/m3/d was achieved when the media with the right surface area was employed, thereby indicating a possibility of migrating to a full-scale test in the next phase of this research.

> **Low DO for Low Energy and Carbon Efficient Nitrogen Removal – A New Benchmark**

Aprilia Vellacott, **Jacobs (Australia)**

A new 140ML/d advanced step-feed treatment plant has been constructed to augment Melbourne Water's WTP to meet nutrient load and capacity requirements. The plant includes innovative design concepts to reduce CAPEX and construction GHG emissions, and advanced controls to optimise carbon and energy utilisation efficiency. The plant operation over four years has met stringent requirements including effluent quality and energy usage and has set a new benchmark in energy efficiency utilizing an average of 3.6 kWhr/kgN removed (240 kWhr/ML). A key feature of the facility is low DO operation using advanced controls providing stable, energy efficient operation.

> **Superior Mainstream Partial Nitritation in Membrane Aerated Biofilm Reactor**

Chenkai Niu**, The University of Queensland (Australia)**

Autotrophic nitrogen removal through two-stage partial nitritation/anammox (PN/A) is economically attractive for mainstream treatment. However, the nitrite-oxidizing bacteria (NOB) inactivation and limited ammonia-oxidizing bacteria (AOB) activity is still challenging. This study addressed two barriers simultaneously by a membrane aerated biofilm reactor (MABR) with the novel acid-tolerant AOB (Ca. Nitrosoglobus) for the first time. A robust partial nitritation with NAR close to 100% was achieved and a substantially high ammonium oxidation rate of around 2.8 kg N/(m3·d) was reached. in addition, the unique kinetic features of Ca. Nitrosoglobus in MABR compared with floc sludge were revealed via batch assays, showing that the microbes in MABR were more sensitive towards environmental factors, such as FNA and pH. Overall, this study demonstrates a promising technology for shortcut nitrogen removal via the combination of MABR and acid-tolerant AOB.

SESSION 3.2 – MEMBRANE AERATED BIOFILM REACTOR (MABR)

20 June 2024 (Thursday) | 11:00am – 12:30pm

Session Chairs:
Andrew Shaw, Black & Veatch (United States), *Tim Constantine*, Jacobs (Canada)

> Membrane Aerated Biofilm Reactor (MABR) for Process Intensification at Water Reclamation Plants

***Han Zhuang,* Veolia Water Technologies and Solutions (Singapore)**

Increasing the biological and hydraulic capacity of existing treatment plants (WWTPs) is a function of available SRTs, solids loading capacity of the clarifiers and available footprint. Zeelung MABR and continuous flow densification (CFD) have demonstrated advantages of process intensification and hydraulic intensification individually, but the synergies of the two (called zeeDENSE) to maximize existing wastewater secondary processes will be studied throughout the demo at Integrated Validation and Demonstration Plant (IVP) located at Ulu Pandan Water Reclamation Plant (UPWRP) in Singapore. This study will include, but not be limited to, achieving increased biological treatment capacity, increased overall energy efficiency, and decreased GHG emissions. The existing train of the plant consisting of 5-step feed reactors will be converted to MABR process with installation of 10 Zeelung cassettes distributed in anoxic zones 1-4 (3-3-2-2 configuration). Process intensification will be evaluated at varying bulk SRTs simulating different loading conditions. The results will be used to extrapolate intensification in existing WRPs & set guidelines for future.

> Where and How to Apply Membrane Aeration Biofilm Reactors (MABR) - Lessons from 4 Full-Scale Systems

***Barry Heffernan,* OxyMem (Ireland)**

The performance of four OxyMem™ membrane-aerated biofilm reactors (MABR) located in different geographies and configurations (pure biofilm and IFAS) were evaluated. Oxygen transfer rates between 12 to 19 gO2/m2d and nitrification rates between 1.0 and 2.9 gN/m2.d were achieved. on all sites there was competition for oxygen between autotrophic nitrifiers and heterotrophic bacteria. It is possible to achieve complete COD and ammonia removal in a pure biofilm MABR – when the DOD loading rate is maintained below 15 gCOD/m2.d. High nitrification rates can be achieved when the MABR modules are operated in IFAS mode and installed in anoxic tanks 1.7 and 2.0 gN/m2.d on average and up to 3.0 gN/m2.d when the bulk ammonia concentration is high. The average nitrification rate achieved when the MABR module was installed in an anaerobic zone was just 1 gN/m2.d. The anaerobic tank was deeply anaerobic, and it is like sulfur and iron compounds were reduced. Hydrogen sulfide will inhibit nitrification and the reduced iron and sulfur compounds will be re-oxidized preferentially over ammonia oxidations. It is not advisable to install the MABR modules in a CSTR type aerobic tank or at the end of a plug flow reactor; there will be insufficient substrate to support biofilm formation.

SESSION 3.3 – TERTIARY TREATMENT FOR REUSE
20 June 2024 (Thursday) | 2:30pm – 4:00pm

Session Chairs:
Norhayati Abdullah, University Technology Malaysia (Malaysia*), Session Co-Chair 2: TBC*

> Barriers to Potable Water Reuse Partnerships

***Robert Thompson,* Orange County Sanitation District (United States)**

The partnership between two public agencies, the Orange County Sanitation District (OC San) and the Orange County Water District (OCWD) led to the creation of the Groundwater Replenishment System (GWRS), the world's largest indirect potable reuse facility. Both sought solutions to issues they faced. OCWD needed to expand their recycling efforts, and address continued challenges with seawater intrusion, and OC San faced the challenge of having to build a second ocean outfall. Through collaboration, problem solving ideology, policy changes, and operations modification the GWRS emerged as one of the most celebrated civil engineering and water reuse projects in the world for its innovative approach and use of technology to reuse a once wasted resource. Our agencies continue to be at the forefront of innovation, and we remain committed to sharing our expertise, lessons learned and best practices with others.

> Tertiary MBR: Concept Development and Pilot-Scale Validation of Novel Process for Potable Reuse in Southern California

***Tim Constantine,* Jacobs (Canada)**

The Metropolitan Water District of Southern California (Metropolitan) and Los Angeles County Sanitation Districts (Sanitation Districts) are jointly exploring the potential of implementing the Pure Water Southern California (PWSC) program, which would include building an Advanced Water Treatment Facility (AWTF) capable of producing 568 ML/d (150 mgd) of purified water at the Sanitation Districts' Joint Water Pollution Control Plant (JWPCP). A series of studies conducted by both agencies identified the application of a tertiary membrane bioreactor (tMBR) as a promising approach to provide nitrogen removal at the AWTF, which would receive effluent from the JWPCP as the source water. This pilot study focused on evaluating tMBR design concepts with an emphasis on demonstrating successful operation of nitrification-denitrification (NdN) tMBR concepts. This study showed that NdN operated in a pre-anoxic configuration with the addition of either supplemental carbon or primary effluent provides a promising approach for PWSC and potential future ocean discharge requirements for JWPCP.

> Advanced Treatment of WWTP Effluent for Water Reclamation Schemes Using Ozonation and Ceramic Microfiltration

***Martin Spruijt,* PWNT (Netherlands)**

In the Netherlands, a collaborative initiative involving Water authority HHNK, drinking water supply company PWN, and PWNT was started to explore advanced wastewater treatment through ozonation, a response to evolving EU and Dutch policies concerning pharmaceutical control in WWTP effluent discharge. in addition, the project aims to repurpose WWTP effluent. This study delves into a multi-barrier treatment strategy for reusing WWTP effluent, involving ozonation, coagulation, and ceramic membrane filtration (CMF). Bubble column and venturi dispersion ozonation techniques were both able to achieve >70% degradation for seven out of 11 target compounds, meeting Dutch government requirements. Higher ozone dosages achieved >99% degradation but led to significant bromate formation. Ozone based advanced oxidation (O3/H2O2) can effectively limit bromate formation at high ozone dosages, thereby enabling maximum pharmaceutical degradation. Finally, explorative experiments also demonstrated that ceramic microfiltration (CMF) membranes, coupled with ozonation and coagulation pretreatment, had similar fouling indices to conventionally treated water, showing promise for reuse.

> Concept to Commissioning of a Major Advanced Water Reclamation Plant in Singapore

***Colin Newbery,* Jacobs (Singapore)**

The focus on water security and resilience for Singapore has transformed the appreciation of Singaporeans regarding the value of water. PUB's Total Water Management strategy is appreciated by the populace and is globally recognized. Through positive and constructive terminology such as used water, the focus of used water management has been transformed from the treatment of an effluent, for discharge to the environment, to the production of a sustainable additional water source – NEWater the '4th National tap'. This paper focuses on one facet of this transformation which has been the journey from concept to commissioning of Changi WRP Phase 2 Expansion. While Singapore has pioneered water recycling, plants for the treatment of used water and the production of NEWater have so far been separate, not just physically but in the development of the design right through to the commissioning and operations. Changi WRP Phase 2 Expansion is the latest step in this transformation and this paper focuses on the design of a 'One Water' facility for producing NEWater from used water: the challenges in the design of a large membrane bioreactor (MBR) based facility and the integration with reverse osmosis. in addition to this integration have been demanding targets for high energy efficiency, low land take and a facility that minimizes operator input.

SESSION 3.4 – ANAEROBIC DIGESTION ENHANCEMENT
20 June 2024 (Thursday) | 4:30pm - 6:00pm

Session Chairs:
Bill Barber, Cambi (United States), Colin Newbery, Jacobs (Singapore)

> Overview to Anaerobic Digestion Enhancement

***Per Henrik Nielsen*, VCS Denmark (Denmark)**

Presenter is an invited speaker. No executive summary is available.

> Optimizing Anaerobic Digestion with the Microbial Hydrolysis Process

***Dave Parry*, Jacobs (United States)**

Anaerobic digestion performance was optimized with the microbial hydrolysis process (MHP) using Caldicellulosiruptor bescii (C. bescii), a hyper-thermophilic bacterium. The volatile solids reduction (VSR) was tested at lab-scale and pilot-scale from anaerobic digestion (AD) of solids from several water resource recovery facilities (WRRF). A test AD system with MHP was compared to a control AD system without MHP as well as the full-scale AD performance. The addition of MHP enhanced the performance of all AD systems from a VSR of less than 60 percent to over 75 percent: a 25 percent and greater increase in biogas production and reduction in biosolids production. Design configurations for adding MHP to full-scale AD systems were shown to be compatible with any AD process including mesophilic AD (MAD), thermophilic AD (TAD), temperature phased AD (TPAD), and the thermal hydrolysis process (THP) followed by AD. The MHP operates at 75 C with a hydraulic retention time of 2 days and can be configured for pasteurization to produce Class A Biosolids. MHP can also be configured with recuperative thickening to increase both AD performance and capacity.

> Comparing Conventional Ad Digestion with an Innovative Plug-Flow Digestion Technology in North America

***Eddie Koornneef*, Royal HaskoningDHV (Netherlands)**

For over a year, the Ephyra® technology was tested at pilot scale at the Waterloo WWTP in CANADA. This pilot was operated on the primary sludge (PS) and thickened waste activated sludge (TWAS) from the WWTP. The first objective was to assess whether Ephyra would show a higher VS-destruction rate than the conventional AD while operating under the same conditions. The operating conditions reflected the average situation. The second objective was to demonstrate that the Ephyra can stably operate while the load on the reactor was doubled compared to the control digester. This would ultimately result in either doubling the capability for amount of sludge treated or building a reactor half the size compared to conventional systems. With the obtained results over the course of the pilot, we conclude that Ephyra can operate stably and safely in Ontario environmental circumstances while improving the sludge digestion process and reducing CO_2-footprint.

> Characterization of Refractory Organic Matter from Sludge Treated by Hydrothermal Carbonization: Sludge Type and Temperature Influence.

***Sofiane Mazeghrane*, SUEZ (France)**

Hydrothermal carbonization (HTC) increases the sludge dewatering efficiency, but also the refractory organic compounds (rDOM) return load to a wastewater treatment plant (WWTP). This load increase can jeopardize WWTP effluent quality. Therefore, rDOM should be reduced and hence better characterized. The present study aims at developing a non-destructive method for rDOM characterization and use it to determine the influence of sludge nature and of heating temperature of the HTC process on the quantity and quality of rDOM. Temperature is a crucial parameter which determines both rDOM amount and quality, in particular its nitrogen content. Moreover, the amount of rDOM is influenced by the nature of sludge. The quality of rDOM depends on the sludge origin but only to a lesser extent on the sludge composition. These results show that the developed characterization method can help choose optimal operating conditions of the HTC to reduce rDOM and its nitrogen content.

SESSION 3.5 – DIGITAL TWIN FOR USED WATER SYSTEMS
21 June 2024 (Friday) | 9:00am – 10:30am

Session Chairs:
Jon Grant, Sentry (United States), Thomas Allen, RSK Group (Singapore)

> Overview to Digital Twin

***Amir Cahn,* SWAN Forum (Israel)**

Presenter is an invited speaker. No executive summary is available.

> Energy Intelligent Wastewater Treatment Plant in Germany

***Sleman Saliba,* ABB AG (Germany)**

The energy intelligent wastewater treatment plant of the Municipality of Schwarzenbruck in Germany integrates and exploits all the different existing energy generation, consumption and storage options into a sophisticated energy management and optimization system to re-utilize the gases on site and enable a net-zero waste water treatment on site.

> Implementation of Autonomous Operation of Ultrafiltration Processes Through Hybrid Digital Twin and Data Driven Automation for Industrial Water Production

***Jimmy Yu,* PepsiCo (United States)**

Retrofit digital transformation was explored to assist the operation and maintenance of high efficiency water purification assets at PepsiCo for sustainability purpose. This presentation describes the retrofit digitalization of a pilot scale and a full-scale operational ultrafiltration (UF) system at two beverage production facilities. Customized digital twins with associated historical data structures of the UF systems were created embedding their design, control philosophy, and operational data. Autonomous model predictive control was deployed to trigger backwashes utilizing the digital twin as the kernel. Finally, a learning algorithm utilizing a factorial experimental design matrix was used, whereby backwashes of variable intensity in tune with the rate and extent of membrane fouling were triggered. During a year of operation cleaning water consumption at these facilities reduced by 32-50%, energy consumption of the processes were lowered by up to 18%, and the projected membrane life was extended by 36%.

SESSION 3.6 – EMERGING CONTAMINANTS
21 June 2024 (Friday) | 11:00am – 12:30pm

Session Chairs: *TBC*

> Photocatalytic Ozonation of Wastewater in Membrane Reactors for Degradation of Micropollutants

***Stefan Herrmann*, RWTH Aachen University - Chair of Chemical Process Engineering (Germany)**

Three drawbacks of classical ozonation processes are the low degradation rate of certain micro-pollutants, waste of undissolved ozone, and the formation of carcinogenic bromate. This work uses bubble-free ozonation with ceramic membranes to prevent bromate formation during ozonation. Furthermore, the tubular reactor is equipped with static mixers to avoid hotspots of dissolved ozone. Additionally, a photocatalyst (TiO2) on the membrane's surface increases the concentration of OH-radicals in water, resulting in increased micropollutant degradation by photocatalytic ozonation. A tubular UV reactor is used for the irradiation of the photocatalyst. Experiments with photocatalytic ozonation and static mixers show a 30% faster complete degradation of sulfamethoxazole and an increase of diclofenac degradation from 27% to 78% after two hours compared to sole ozonation. Furthermore, simulations of this process reveal a decrease in bromate formation of up to 31% at the same ozone exposure using static mixers.

> The Role of Reactive Chlorine and Nitrogen Species in Micropollutant Degradation in UV/Monochloramine

***Zi Quan Seah*, Nanyang Environment and Water Research Institute (NEWRI) (Singapore)**

Monochloramine (NH2Cl) is applied upstream of reverse osmosis (RO) membranes for biofouling control and residual NH2Cl can undergo UV photolysis downstream, generating reactive species for an AOP to occur. The performance of UV/monochloramine is affected by pH, chloride, bicarbonate/carbonates and other common water quality parameters by shifting the speciation of radical generated. Thus, the objective of the study is to investigate the role of reactive chlorine and nitrogen species in micropollutant degradation and compared with other oxidants, hydrogen peroxide and chlorine. By addition of preformed monochloramine, the degradation of micropollutants 1,4-dioxane, acetaminophen, caffeine and sucralose were evaluated in presence of methanol as a •OH radical scavenger. The contribution of reactive chlorine and nitrogen species to micropollutant degradation was found to be significant. The performance of UV/monochloramine varies between ammonium chloride and ammonium sulfate, with a higher degradation of 1,4-dioxane and caffeine due to the difference in chloride concentration.

> Targeted and Non-Targeted Monitoring of PFAS in Full-Scale Drinking Water, Wastewater and Leachate Treatment

***Naike Noyon*, CIRSEE-SUEZ (France)**

The worldwide presence of PFAS, their proven toxicity and probable effects on human health have raised scientific, institutional and public concern about these so-called “forever chemicals”. As part of a research program aiming to optimize PFAS removal from resources for drinking water production, both target and not-target analytical methods have been developed and implemented. in parallel, occurrence and fate of PFAS was evaluated on 6 full-scale drinking water, 5 wastewater and 5 leachate treatment facilities under real operational conditions. Non-targeted (suspect) screening has been applied to water resources and drinking water to obtain a wider view of PFAS profiles and follow modifications due to treatment. This presentation focuses on the analytical challenges faced during development and the generated data on occurrence and fate of a large range of PFAS on full-scale water treatment plants.

SESSION 3.7 – MONITORING AND MANAGEMENT OF PROCESS EMISSIONS (PART 2)
21 June 2024 (Friday) | 2:00pm – 3:30pm

Session Chairs:
Kartik Chandran, Columbia University (United States), *Liu Ye*, University of Queensland (Australia)

> Quantifying Nitrogenous Greenhouse Gas from Emerging Biological Nutrient Removal (BNR) Processes

***Gnanaraj Augustine*, Columbia University (United States)**

Nitrous oxide (N2O) is a potent greenhouse gas that contributes considerably to wastewater treatment plants' greenhouse gas footprint. Our previous studies have shown that poorly designed and operated biological nutrient removal (BNR) can lead to increased nitrous oxide levels in the atmosphere. Our current studies focus on quantifying and mitigating N2O emissions from some emerging BNR processes operated to treat both mainstream and sidestream wastewater at different full-scale wastewater treatment plants (WWTPs) using a benchmark U.S Environmental Protection Agency (U.S EPA)-endorsed protocol. The results reported herein focus on step-feed BNR, partial denitratation- anammox (PdNA), ammonia-based aeration control (ABAC) and the single-reactor high-activity removal over nitrite (SHARON) processes. Based on our recent studies, we show that it is possible to achieve much lower N2O emissions relative to the emission fraction (EF), most recently proposed by the Intergovernmental Panel for Climate Change (IPCC) for the wastewater sector.

> Predicting Nitrous Oxide Emissions from the Activated Sludge Process Using BioWin and Sumo Mechanistic Models

***Paul Zuber*, Mott MacDonald (Singapore)**

Nitrous oxide (N2O) is a greenhouse gas emitted during wastewater treatment. The water sector is currently developing tools and strategies to quantify and mitigate these emissions using a combination of field measurement, mechanistic modelling, advanced process control and artificial intelligence. The objective of this research was to develop the mechanistic modelling component of these strategies. BioWin and SUMO were used to predict N2O emissions from the activated sludge process. Initially the models did not align for basic parameters such as MLSS and airflow, and had to be synchronized by optimizing biomass populations, influent fractions, process switches, and kinetic and stoichiometric parameters. The two models were calibrated using field data for liquid phase, gas phase, and emission rates for N2O. Both models predicted N2O emissions effectively and are useful tools in quantifying process emissions. The N2O prediction capability is still being developed, but currently, SUMO's predictions are closer to the measured data.

> N_2O: To Measure or Model, that is the Question

***Tony Koodie*, Binnies Singapore (United Kingdom)**

One of the risks associated with nitrogen removal in municipal wastewater treatment is the unintended generation of nitrous oxide (N2O). This powerful greenhouse gas (GHG) is the main GHG emitted during wastewater treatment and the third most abundant GHG in the atmosphere with a global warming potential of 265 times that of carbon dioxide (CO2) in 100-year life span. Mitigation of N2O is of primary importance to meet bold plans of reducing operational emissions and reducing offsets within the water sector. There is now growing interest in understanding, managing, and ultimately reducing wastewater treatment N2O emissions. The strategy to achieve this involves both measurement and modelling of emissions, however, there is significant debate about the accuracy and effectiveness of these pathways. The aim of this presentation will be to address and discuss the uncertainties of both approaches and eliminate myths and perceptions surrounding measurement campaigns and process modelling simulations in determining N2O emissions and to facilitate N2O mitigation strategies.

> Reduction of N_2O Emissions in Wastewater Treatment Works with Advanced Process Control

***Otto Icke*, Royal HaskoningDHV (Netherlands)**

Water utilities around the globe have set ambitious goals to be carbon neutral by 2030. Nitrous oxide (N_2O) emitted in the nitrogen removal process is ≈265 times more powerful than carbon dioxide (CO_2) and, becoming an increasing part of the CO_2 footprint of wastewater treatment works (WwTWs). A good control strategy can contribute to reducing N_2O emissions. This can be accomplished by Advanced Process Control (APC) using a holistic approach incorporating both artificial intelligence (AI) and domain knowledge. An APC N_2O research pilot was started in close collaboration with the Vallei and Veluwe Water Authority in November 2020. The pilot was carried out at their WwTW Soest, by measuring the two identical treatment lines to determine the differences due to APC control. The results show that, during a period with high nitrogen load in the influent, N_2O could be reduced by ≈⅓ in the line controlled with APC.

SESSION 3.8 – PIPES UNDERGROUND
20 June 2024 (Thursday) | 9:00am – 10:30am

Session Chairs:
Susan Moisio, Jacobs (United States*), Session Co-Chair 2: TBC*

> Using Lagrangian Wastewater Quality Sensors for Sewer Defects Detection: Focus on Saline Intrusion Identification and Location

***Thibaud Maruejouls*, SUEZ (France)**

Sewer asset assessment requires improved inspection capabilities meanwhile sewers are well-known to be hazardous environments. If none of the existing technologies can cover the whole heterogeneity of sewers, it is important to develop new approaches to fill the gap of complicated pipe conditions that are not inspected today. The new SewerBall based approach aims at filling this gap. A new equipment is presented where its capacity to help tackling the saline water problem by detecting and geolocating the defects.

> Bondi Ocean Outfall Sewer Rehabilitation - Resilience for the Future

***Ryan Beheshti*, WSP (Australia)**

The Bondi Ocean Outfall Sewer (BOOS) is iconic wastewater infrastructure designed and constructed between 1880 and 1889, The BOOS conveys sewage from the central business district of Sydney Australia and is now a critical asset operated by Sydney Water as part of the first ocean outfall system built in Australia. to provide resilience for the future and reliable operation for the next 100 years, it is proposed to rehabilitate the sewer. The structure is a 2.4m high x 2.0m wide brick and concrete oviform located below densely populated residential suburbs and access is a major issue. Relining the BOOS with a Glass Reinforced Plastic (GRP) liner by slip-lining is proposed through a complex optioneering and structural assessment. Overall, the GRP liner provides a technical and reliable long-term solution that meets the project objectives and is installed using a safe and economic slip lining methodology.

> Overcoming Construction Challenges of an Undersea Conveyance Tunnel in Singapore

***Karthikeyan Kandawamy*, Jacobs (Singapore)**

Expansion of the water supply conveyance capacity to Jurong Island to cater for future demands is critical. The most effective way to achieve this is via a 6m diameter subsea tunnel enclosing four water pipelines which will convey reclaimed water from Tuas Water Reclamation Plant (TWRP) to Jurong Island under the busy West Jurong channel. Subsea tunnels have slightly different challenges than underground tunnels. Major challenges encountered on this project include high water ingress, limitations in interpreted soil investigation data and active instrumentation monitoring of existing utilities (Gas Transmission Pipe).

SESSION 3.9 – WATER QUALITY MONITORING (CONVEYANCE)
20 June 2024 (Thursday) | 11:00am – 12:30pm

Session Chairs: *TBC*

> Real Time Control/ Sewer Modelling and Network Control

***Jeroen Langeveld*, Delft University of Technology (Netherlands)**

Presenter is an invited speaker. No executive summary is available.

> Data Driven Environment Impact Risk Model

***Ben Dunn*, Aurecon (Australia)**

Across Sydney there is a huge variety of different waterways values. Protecting these values is important, so understanding these values relative to the potential for impact across the wastewater system creates an interesting challenge. An innovative data centric geospatial risk analysis model was developed to inform investment, by defining the value and risk of impact at social and/or environmental waterway sites. The risk of impact was defined through the use of water quality models that included simulation of key wastewater pollutants. With the inherent quantum of data available, it was critical that the tool was easy to use and understand. This was achieved through heat mapping risk with a mesh that was visually appealing and intuitive to comprehend.

> DC Water's Clean Rivers Program

***Moussa Wone*, DC Water (United States)**

Approximately one-third of the District of Columbia is supported by combined sewers that service both sanitary and storm water. for over 125 years, the combined sewer overflows (CSOs) have polluted the Potomac and Anacostia Rivers and tributaries that surround our nation's capital. in response, DC Water is implementing a bold, far-reaching program called the Clean Rivers Project to reduce CSO outflows into the District's waterways – the Anacostia and Potomac Rivers and Rock Creek. Approximately 29 kilometers of deep underground storage are being developed to reduce CSO outflow. Green Infrastructure is also being created to manage runoff in the Rock Creek and Potomac River sewer sheds in delivering triple-bottom-line benefits (environmental, social, and economic) for District citizens. This paper will focus on efforts achieved and underway to deliver a resilient and reliable solution for a cleaner environment. Conference attendees will gain insight and new knowledge from DC Water's experience in providing effective and efficient wastewater management.

> Life Rubies - Real-Time Pollution-Based Control of Urban Drainage and Sanitation Systems for Protection of Receiving Waters

***Thibaud Maruejouls*, SUEZ (France)**

LIFE RUBIES is a European co-funded project aimed at demonstrating the benefits of deploying Real Time Control (RTC) strategies to mitigate urban drainage impacts on the receiving aquatic ecosystems. LIFE RUBIES seeks to combine both hydraulic-and quality-based RTC concepts to enhance environmental benefits. The quality monitoring strategy is now fully operational (sewer and river) and first results are presented and analysed. The impact of the sewer on the environment is explored and further discussed.

SESSION 3.10 – INDUSTRIAL WASTEWATER TREATMENT IN SINGAPORE

20 June 2024 (Thursday) | 2:30pm - 4:00pm

Session Chairs:
Somnath Basu, Independent Consultant (United States), Session Co-Chair 2: TBC

> Reducing Cooling Tower Water Consumption through Advanced Electrooxidation Technology

Mohammad Sherafatmand, **Hydroleap Pte Ltd (Singapore)**

A substantial part of the freshwater used in the industry is consumed in cooling towers. Cooling towers discharge saline cooling tower blowdown (CTBD), and the reuse of CTBD in the cooling tower can lower the industrial freshwater footprint. Due to evaporation in the cooling tower, the concentration of salts in the cooling tower water increases. After a salt concentration threshold is reached, cooling tower water is discharged as so-called cooling tower blowdown (CTBD) and replaced with fresh water. The reuse of this CTBD in the cooling tower itself could allow the industries to reduce their freshwater consumption. Among existing chemical treatments, electrochemical oxidation (EO) is of interest because of its versatility, controllability, and enhanced removal efficiency for recalcitrant and toxic contaminants. Hydroleap offers its proprietary advanced electrooxidation process (EO) that works for large as well as small buildings, where there might not be a full-time mechanic or on-site cooling-tower O&M contractor. Hydroleap's EO technology oxidizes minerals and contaminants in the water, killing bacteria (including legionella) and breaking down calcium buildup to mitigate scaling. Once installed, the AOP system needed no regular maintenance or monitoring. The approximate blowdown saving would be up to 40%.

> Advanced Ozonation Catalyst: Development, Commercialization & Application

Yanling Shi, **Sembcorp China Holding Corporation (Singapore)**

The granular activated carbon (GAC) based ozonation catalyst developed by Sembcorp is used for advanced treatment of chemical industrial park wastewater through catalytic ozonation. The average total organic carbon (TOC) removal rate of the wastewater in the on-site pilot testing is over 50%, which is 20%-40% higher than commercial catalysts in the market. Based on pilot testing for a period of over 4 months, the catalyst can achieve ~30% reduction in ozone dosage in the catalytic ozonation process of Sembcorp's newly built chemical industrial park wastewater treatment plant in Nanjing. Compared with a commercial ozonation catalyst with a high market share, Sembcorp's catalyst exhibits 20% lower total life cycle cost of 10 years, demonstrating a good commercialization prospect.

> New Treatment Technology of IPA in Wastewater

Hwee Kiang Lee, **Micron (Singapore)**

Wastewater streams generated from fab processes can be grouped having organic contaminants or inorganic contaminants. One of the individual organic contaminants is Isopropyl Alcohol (IPA) which is a low molecular weight organic and is difficult to be removed by some physical processes. When IPA is present in wastewater, it can impact the quality of wastewater in the form of Bio Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) when wastewater with IPA is sent to public sewer, it can cause treatment difficulties in downstream government or public owned treatment plants. The purpose of this study is to determine an effective method to remove IPA to enable discharge compliance, higher water recycle rate and recovery of IPA for external reuse. Macro Porous Polymer Extraction (MPPE) was the process selected for review as it is IPA selective, low in CAPEX/OPEX and footprint.

THEME 4: CITIES OF THE FUTURE AND COASTAL & FLOOD RESILIENCE

SESSION 4.1 – PLANNING CLIMATE RESILIENT CITIES
20 June 2024 (Thursday) | 2:30pm – 4:00pm

Session Chairs:
Mark Fletcher, Arup (United Kingdom), *Adam Hosking*, Jacobs (United Kingdom)

> **Linking Land Use and Urban Planning to Water Metabolisms Through Semantic Web Technologies for Resilient Future Water Systems.**

***Andrea Bartolini*, Singapore ETH Centre (Singapore)**

Modern cities are complex environments, with interconnected and interdependent systems impacting each other through feedback loops. It is then important to have adequate tools for scenario making and planning: allowing to infer potential futures through simulation and modeling, eventually providing planners with critical information for decision making. This work introduces a framework to help urban and system planners tackle the task of designing for robust and resilient future water infrastructure, by linking knowledge about urban planning to water metabolisms towards estimating realistic future scenarios. The framework uses semantic knowledge representation to model the links between urban planning and urban water metabolisms: from the necessity to supply drinking water to buildings, to collecting rain and waste-water for appropriate disposal and re-use. The framework is applied to selected parts of Singapore, quantifying present metabolisms and estimating scenarios for future ones.

> **Valuation of Ecosystem Benefits of Coastal Parks and Nature Areas for Prioritisation of Climate Adaptation Projects**

***Joost Buurman*, Royal HaskoningDHV (Singapore)**

Substantial investments in adaptation measures, such as beach nourishment, flood levees, and storm surge barriers, will be necessary to safeguard coastal cities like Singapore from rising sea levels. These measures will have consequences for the coastal zone and impact its environmental, cultural, and amenity values. This study provides an overview of these ecosystem values of urban coastal parks and nature areas that are affected positively or negatively by coastal adaptation to sea level rise in Singapore. Additionally, the paper presents a comprehensive database with monetary unit values. The database contains 163 values from 60 studies. The database could be used in cost benefit analysis to prioritize coastal adaptation measures. A case study of hypothetical adaptation measures at Changi Beach in Singapore was conducted to demonstrate the use of the values in the database.

> **The River Thames Scheme – A Landscape Based Approach to Climate Resilience and Flood Risk Management**

***Andrew Mowl*, WSP (United Kingdom)**

This abstract sets out the funding model for delivery of the River Thames Scheme, a blue green infrastructure project that enables communities along the River Thames in an area of West London, in the UK, to live more sustainably. The objective of the paper is to highlight how the multiple benefit approach has enabled funding of the flood risk solution. Demonstrating how a landscape-based approach to the design has provided a solution to other climate resilience challenges in the local area. The paper details the approach taken to securing the partnership funding commitment, through the development of a collaborative working agreement and demonstrate how this collaborative agreement has international application, by outlining the areas the agreement covers in terms of decision making, funding and benefits, resourcing the scheme and ownership and operation of assets. The findings of the paper are that sustainable solutions to managing flood risk are intrinsically linked to other climate challenges and that individually may not attract sufficient funding to create a viable business case for delivery, but can be integrated to create affordable, fundable solutions. Highlighting that collaborative partnership working is the key to unlocking these problems, taking shared ownership of both delivery risks. Providing working examples of how this has been achieved and how this can be applied elsewhere.

> **Enhancing Sustainability and Resilience in Coastal Cities Through the Incorporation of Seawater into Urban Metabolism**

***Zi Zhang*, Hong Kong University of Science and Technology (Hong Kong, China)**

Urban metabolism relies heavily on water and energy, but climate change-induced water scarcity and high temperatures present a significant threat to sanitation and space cooling services in coastal cities, where over 40% of the population lives. Hong Kong has demonstrated the effectiveness of seawater use for toilet flushing and district cooling, which could be a potential solution for other coastal cities worldwide. However, there is a lack of comprehensive insights on how seawater use can be adopted to promote sustainable development. to address this, we developed a four-principal framework that provides technical and policy guidance for sustainable seawater use. The framework includes location analysis, urban spatial analysis, integrated sustainability assessment, and nexus analysis. Breaking barriers between sectors and encouraging inter-municipal cooperation are critical to the successful use of seawater. By adopting this framework, coastal cities can enhance their sustainability and resilience, improving the quality of life for their citizens.

SESSION 4.2 – REFORMING GOVERNANCE FOR CLIMATE RESILIENCE
20 June 2024 (Thursday) | 4:30pm - 6:00pm

Session Chairs:
Pritha Hariram, Ramboll (Singapore), *Sarah Hiong,* PUB, Singapore's National Water Agency (Singapore)

> Overview of Reforming Governance for Climate Resilience

***Bart Schoonbaert,* Arup (United Kingdom)**

Presenter is an invited speaker. No executive summary is available.

> International Handbook on Emergency Response for Flood Defences

***Bart Vonk,* Ministry of Infrastructure and Water Rijkswaterstaat (Netherlands)**

Floods pose eminent threats for people, economy and environment. The risks will increase as a result of climate change, increasing population and increasing economic value. Mitigating risks asks for a total system approach from source (water system) to pathway (flood defences) and receptor (consequences). The International Handbook on Emergency Response for Flood Defences (IHERFD) wants to share the possible measures at the “pathway” in the flood risk management system, by looking at the flood risk management cycle, from preparation, via response to recovery and mitigation. This Handbook will not be a simple cooking recipe but will provide the needed guidance to come to an effective flood risk management approach. Early 2024, the final draft of the Handbook will be ready, and the publishing process will start. The SIWW conference 2024 will be a unique opportunity to present and discuss the developments and potentials of the Handbook with the flood defence managers attending.

> Governance is Key to Developing an Integrated Flood Response Approach in Washington DC

***Salil Kharkar,* DC Water (United States)**

In recent years, DC has experienced short duration high intensity storms. The accompanying damage, and its impact on residents and businesses was significant. While every agency in the City responded admirably, each had their own area of responsibility leaving gaps between their roles. After several of these events, the Mayor commissioned a Task Force comprising 28 Agencies to develop a wholistic response to Flooding. Operationally, the Task Force was co-led by the Director of the Department of Energy and Environment and the CEO of DC Water. These are the two entities that are directly connected with water in the District of Columbia. The Task Force membership consisted of 28 agencies -District, Federal, NGO, and Private Utilities. A challenge with Task Forces created around multi-jurisdictional issues is obtaining tangible and actionable outcomes that are focused on the greater good versus mission of the dominant agency. to overcome this challenge, the duration of the Task Force was limited to 12 months and provided with an established goal of developing tangible and implementable Action Plans in 9 identified areas of concern to benefit the residents. The Task Force maintained a website that listed all meetings and video recordings. The Public input ensured transparency and that the solutions being developed met the needs of the constituents who were most impacted by these weather events.

> Prioritising National Investment Plans a Framework for Strategic Investment Planning, With Case Studies

***Blair Spendelow,* JBA Consulting (Singapore)**

Often, governments and International Financial Institutions are challenged with determining optimality of a portfolio of diverse resilience projects. We present a Strategic Investment Framework (‘the Framework’) developed to guide risk-informed prioritization of flood risk reduction investments. It is intended that this applied Framework be used by those promoting a flood risk reduction project to a) help conceptualise the performance of the project in the context of a broader strategic response, b) assess the economic benefits of the proposed project against a baseline and the economic benefits of other investment options, and c) provide a consistent context in which the preparedness of project can be understood and enhanced in order for like-to-like project appraisal. The Framework offers a robust tool to assess optimal present-day response to existing adaptation gaps to avoid maladaptation and promote low-regret risk reduction measures.

SESSION 4.3A– AUTOMATION AND AI FOR URBAN WATER MANAGEMENT
21 June 2024 (Friday) | 9:00am – 10:30am

Session Chairs:
Tony Wong, Tony Wong Consulting (Australia)*, Perrine Hamel,* Nanyang Technological University (Singapore)

> Overview of Automation and AI for Urban Water Management

***Vladan Babovic,* National University of Singapore (Singapore)**

Presenter is an invited speaker. No executive summary is available.

> Implementation of The Smart Drainage Grid System for Data Driven Drainage Management

***Shailesh Singh,* National Institute of Water and Atmospheric Research (New Zealand)**

PUB (Singapore's National Water Agency)'s Smart Drainage Grid (SDG) System, which is part of PUB's Smart Networks, enables data-driven decision support for the strategic planning and maintenance of drainage infrastructure. Developed for PUB by the New Zealand National Institute for Water and Atmospheric Research (NIWA), this innovative system seamlessly integrates custom data analytics applications with industry-standard GIS and time-series software, specifically ESRI's ArcGIS and Aquatic Informatics' AQUARIUS. By amalgamating data from PUB's extensive hydrometric monitoring network, alongside rainfall datasets sourced from the National Environment Agency (NEA) and pertinent GIS layers, such as construction work and catchment data, the SDG System delivers dual functionality. Firstly, it promptly identifies anomalies in drainage behavior and issues alerts, facilitating pre-emptive maintenance of drainage infrastructure. Secondly, it furnishes valuable insights into drainage performance for strategic drainage planning purposes.

> Flood Risk Indication: Empowering Drainage Operations with AI for Early Flood Detection

***Karim Claudio,* SUEZ (Singapore)**

In this paper we present a methodology for the design of a flood risk indicator based on data from water level sensors and close-circuit television (CCTV) cameras. The indicator is generated based on the results of two artificial intelligence (AI) models: a forecast model for the water level in the drainage system and a detection model from the CCTV system. Each model answers a specific question: what the current situation is, and how this situation is supposed to evolve in the forthcoming 30 minutes. The combination of the two model outputs enables assessment of the criticality of a rainfall event for specific locations.

> Application of Digital Tools and Automation for Study on Improvement of Drainage and Sewerage Infrastructures Against Climate Change Effect and Adverse Weather Conditions

***Yuvi Luo,* Arup (Hong Kong, China)**

Hong Kong Special Administrative Region of People's Republic of China ("Hong Kong") is a dense urban coastal city vulnerable to flooding due to heavy rainstorm and high sea level. The situation will be worsened as a result of climate change impact of sea level rise and more frequent and intense adverse weather events including typhoons and rainstorms. The Drainage Services Department ("DSD") attaches great importance to the capability of DSD's drainage and sewerage infrastructures in combating climate change effects and adverse weather conditions to safeguard the well-being of the population and ensure the sustainable development of the city. Ove Arup & Partners Hong Kong Limited ("Arup") was appointed by DSD to conduct an investigation study for the improvement of DSD Infrastructures against climate change effects and adverse weather conditions in Mainland North and Outlying Islands of Hong Kong ("the Study"). Arup applied digital tools and automation to comprehensively assess the flood risk, formulated adaptation and resilience measures and prepared design drawings for 308 nos. drainage and sewerage infrastructures situated at scattered locations of Hong Kong. The successful application of digital tools and automation not only saved manpower resources and enhanced work efficiency, but also optimized design workflow, ensured accuracy and consistency, and enabled knowledge sharing and innovations.

SESSION 4.3B – HIGH RESOLUTION MODELLING AND FORECASTING IN SINGAPORE
21 June 2024 (Friday) | 9:00am – 10:30am

Session Chairs:
Hazel Khoo, PUB, Singapore's National Water Agency (Singapore)*, Paul Nettleton,* Ramboll (Singapore)

> A High Resolution (1.5 Km) Fully Coupled Atmosphere-Ocean-Wave Model for Singapore

Rajesh Nair, **National Environment Agency (Singapore)**

Oceanic conditions in Singapore and nearby waters are strongly influenced by intense air-sea coupling and ocean dynamics. Hence, it remains a challenge to realistically predict atmospheric and oceanic hazards over the region. Moreover, the region's complex coastlines and bathymetry significantly affects local weather and climate, high-spatial resolution models are needed to provide accurate predictions. to address this issue, the Centre for Climate Research Singapore (CCRS) has developed a kilometre-scale resolution, atmosphere-ocean-wave coupled model for the Western Maritime Continent (WMC), to improve the weather and ocean forecasting and support climate services.

> Ultra-High Resolution Urban Weather Modelling for Extreme Rainfall in Singapore

Song Chen, **Centre for Climate Research Singapore (Singapore)**

As a densely populated coastal city situated near the equator, Singapore has a typical tropical climate with abundant rainfall throughout the year. Augmented by future global warming and rapid urbanization, Singapore is highly prone to extreme rainfall events and hence at risk of urban flooding. High-resolution urban weather and climate modelling provides a promising way towards more accurate forecast of extreme rainfall events. The Centre for Climate Research Singapore has been developing an ultra-high resolution urban modelling system, 100 m uSINGV, to explore its potential for weather/climate applications in Singapore and its adjacent region. With increased grid resolution and representation of small-scale urban surface features like buildings, urban canyons, and roads, it is found that uSINGV can better represent convection and the complex structure of the atmospheric boundary layer. in this work, a detailed evaluation of 100 m uSINGV for extreme rainfall events in Singapore will be presented. The added values of uSINGV for understanding the tropical weather process will be reported.

> Evaluating High Resolution Data Gathering Methods for Inter-Tidal Areas

Seng Keat Ooi, **National University of Singapore (Singapore)**

In intertidal areas, design and modelling tools are now able to efficiently use high resolution, relatively uniform spacing and highly accurate geo-spatial datasets to produce reliable, accurate and timely forecasts. This in turn requires an efficient means to gather and produce a robust, unified set of such data. Different single operation methods exist for use in clearer waters, as well as in steep-sided coastlines. However, these methods have not been used to cover the entire inter-tidal area especially in very shallow, gently sloping coastlines with highly turbid waters as in Singapore. This presentation outlines the challenges, previous work carried out, and the methods tested in the confines of an urban, multi-use coastal environment to evaluate (i) The feasibility of a single high resolution data gathering method proving to be effective across different types of coastline features, water clarity and topography, and (ii) The potential to create a robust, fit for purpose, accurate geo-spatial dataset for high resolution modelling of coastal zones from multiple sources

> Fast Urban Flood Mapping with Sub-Grid Approaches

Abhishek Saha, **Hydroinformatics Institute (Singapore)**

Urban flood models that solve shallow water equations in 1D and 2D are utilized for flood risk assessment and mitigation. However, incorporating high-resolution terrain and drainage infrastructure data into these models is complex and computationally expensive, yet necessary for obtaining accurate flow paths. to address this issue, we employ the subgrid method, which allows for the inclusion of high-resolution terrain data in 2D free surface flow and incorporate conveyances from small 1D drains through "embedded" approaches. We have implemented this solver and conducted tests on real-world terrain to assess pluvial flooding. Experiments demonstrate that the subgrid method, combined with "burnt" and "embedded" drains, produces realistic flood maps and flow paths without significantly increasing computational complexity. in comparison to fully coupled 1D-2D models, where small drains are configured in 1D and explicitly linked to 2D flows using bi-directional flow connections, the subgrid approach with burnt and embedded drains proves to be more efficient. This approach has the potential to significantly improve the efficiency of large-scale urban flood models. This project is supported by PUB, Singapore's National Water Agency.

SESSION 4.4 – COASTAL RESILIENCE THROUGH HYBRID INFRASTRUCTURE: GLOBAL EXPERIENCE
21 June 2024 (Friday) | 11:00am – 12:30pm

Session Chairs:
Piert Dircke, Arcadis (Netherlands*), Perrine Hamel,* National Technological University (Singapore)

> Overview of Coastal Resilience Through Hybrid Infrastructure

***Todd Bridges,* University of Georgia (United States)**

Presenter is an invited speaker. No executive summary is available.

> Redesigning Urban Shorelines for Resilience

***Dmitrijs Obolevics,* Arup (United States)**

Coastal zones are an essential element of the blue economy. Globally they represent the most urbanized and economically productive areas, provide habitat and nursery areas for marine biodiversity, and support important fisheries and aquaculture. However, sea level rise and increased risk of storm surge are threatening the people and economic value of urban coastal areas. Hardening has been the major tool for protecting urban shorelines, but many existing structures are failing and need replacement. They have depauperate ecological communities, reduced nursery areas for fish, are ineffective during storm surges, and limit human interaction with the waterfront. Therefore, there is an urgent need for innovative replacements to protect the urban edge, support biodiversity, and elevate human experience. The main goal of the Urban Shorelines project is to design a new type of infrastructure to better protect urban shorelines while simultaneously enhancing local biological communities and human engagement with the coastline. The team connects natural and social sciences, engineering, and architectural design with local users, stakeholders, regulatory agencies, and industry through a convergence framework. The designs will deliver a novel coastal model capable of increasing well-being for people, ocean edges, and shoreline species, boost disaster risk reduction, and increase ecosystem and urban services. This new model of interconnected benefits will represent a benchmark approach for future research on the development and application of shoreline infrastructure.

> One Resilient Tacloban: Implementing Nature-Based Solutions for Disaster Risk Reduction in the Philippines

***Travis Bunt,* One Architecture (Philippines)**

After Typhoon Haiyan in 2013, the city of Tacloban in the Philippines was left decimated. Recovery funding streamed in from across the globe, but governmental agencies and intermediaries with overlapping responsibilities experienced difficulty implementing longer-term recovery and climate-adaptation strategies. in 2016, a team led by One Architecture was awarded a seed grant by the Global Resilience Partnership to implement a series of pilot projects for mangrove and beach-forest restoration throughout the coastal area surrounding Tacloban. The team (including ONE, Wetlands International, and the Philippines Reclamation Authority/PRA) encountered larger bureaucratic and data-based hurdles to implementing similar projects across the region and thus expanded the project's scope to more thoroughly document regulatory hurdles. It also proposed a more streamlined, science-based methodology and explored opportunities for hyper-local partnerships to better ensure the success of similar, future projects. Although several external factors further complicated the process along the way, 35,000 seedlings were ultimately planted under the initial, aptly named, seed grant. The project was a remarkable success—achieving survival rates of over 90 percent—largely due to focused efforts to train, employ, and partner with local residents as key agents and future stewards of restoration projects, creating a framework to measure and better ensure value capture within the target beneficiaries.

> The Importance of Integrating Lessons Learned on Management, Maintenance and Operations of Storm Surge Barriers

***Marc Walraven*, Rijkswaterstaat Ministry of Infrastructure and Water Management (Netherlands)**

Storm surge barriers are increasingly becoming a major component part of flood risk management solutions worldwide. This paper and presentation seeks to form conceptual guidelines for those looking to design new barriers to ensure they take account of the learning from those existing barriers which have been in operation for decades. The maintenance and management challenge of existing barriers will only increase with climate change as it looks to increase operations resulting in reduced time for maintenance. We need to start thinking differently now for existing barriers and make sure this thinking is incorporated now into any future designs.

SESSION 4.5 - COASTAL RESILIENCE THROUGH HYBRID INFRASTRUCTURE: SINGAPORE EXPERIENCE
21 June 2024 (Friday) | 2:00pm - 3:30pm

Session Chairs:
Hazel Khoo, PUB, Singapore's National Water Agency (Singapore), *Eva Castro,* SUTD (Singapore)

> Adaptation of Urban Coastal Cities to Climate Change

***Zi Qian Yang,* Delta Marine Consultants (Singapore)**

Towards the urbanization of coastal cities, the challenges of coastal adaptation are amplified. Climate change and sea level rise, coupled with land-use intensification and development expansion, are exacerbating the cities' vulnerabilities to coastal hazards. Delta Marine Consultants (DMC) has developed a modularized coastal protection system, XblocPlus, to provide better utilization of waterfront land, flexible incremental enhancement, and reduced disruption to existing measures. Under the PUB Global Innovation Challenge (GIC) on Innovative Solutions for Coastal Protection Measures, DMC has been commissioned to conduct a Proof-of-Concept study to optimize XblocPlus for effective and suitable application for Singapore's coast. Design concepts for application at various shorelines are illustrated, including hybrid infrastructure integrating green, blue, and grey features. Under the GIC, physical model tests are conducted to validate the effectiveness of such engineered structures. Specifically, the structure stability is assessed with damaged armor to determine its failure behavior. XblocPlus remains stable up to the highest tested overload at 160% of the design wave height, guaranteeing the functioning of the structure during exceedance of design storm events. Even with artificial large-scale damage, XblocPlus shows long and gradual damage progression. The feasibility and applicability of XblocPlus armor are demonstrated in achieving resilient coastal protection with additional benefits.

> An Assessment of Coastal Protection Effectiveness with Soft Structures

***Zhengyu Hu,* National University of Singapore (Singapore)**

Soft coastal structures aim to balance protection needs with ecological considerations, which can offer adaptability to changing environmental conditions and provide long-term resilience to coastal communities. However, their effectiveness relies on wave reduction performance and proper design. in this study, we aim to evaluate the protection effectiveness and provide optimization designs for an elastic steep-fronted coastal structure in periodic waves. A fully-coupled computational fluid dynamics (CFD) and computational solid mechanics (CSM) model is used to investigate the hydrodynamic characteristics and structural responses. We find that the wave reflection, run-up, and loading decrease as the structure becomes more flexible. The stress increases with the decreased ratio of the wave frequency to the structural natural frequency. Based on these findings, a preliminary design optimization is conducted by considering both the coastal protection and the structural integrity. This study will offer a better insight into the coastal protection effectiveness with soft structures.

> Restoring Mangroves for Greater Coastal Resilience and Biodiversity Gains in Pulau Ubin

***Ash Welch,* AECOM (Singapore)**

In conjunction with the National Parks Board, Singapore, AECOM undertook research to design and re-engineer the seabed of 2 abandoned prawn ponds at the mouth of Sungei Durian, Pulau Ubin to enable the natural establishment and restoration of a native mangrove forest that is estimated to support over 9,000 trees that will help sequester up to 30 million kg of CO2 whilst providing more habitat for native coastal wildlife and protecting the coastline against erosion and anticipated negative consequences of climate change drawing on scientific research undertaken by National University of Singapore (NUS) and the Restore Ubin Mangroves (RUM) initiative, AECOM's engineers, hydrologists, landscape architects and ecologists devised a design which would utilise dredged material from other coastal protection projects to create a nature-based solution that would provide a multitude of benefits to Ubin's coastline.

> A Hybrid Eco-Engineering Solution at Kranji Coastal Nature Park for Coastal Protection and Mangrove Restoration

***Jonathan Tan Yong How,* National Parks Board (Singapore)**

Kranji Coastal Nature Park (KCNP) is a buffer park for Sungei Buloh Wetland Reserve, Singapore's only mangrove nature reserve. From 2016-2018, NParks undertook a project to arrest erosion along a 400m stretch of shoreline in KCNP. The mangroves on site were retained, while the eroded high shore behind was backfilled with soil and armoured with a gently sloping, ungrouted rock revetment to attenuate waves and promote sediment accretion. Coastal tree species were planted on the high shore above the revetment to restore the natural zonation from terrestrial rainforest to coastal forest to mangrove, creating additional natural habitat and buffering inland areas against wave run-up during storm surges and as sea levels rise. Erosion has ceased and surveys show rapid regeneration of naturally recruited mangrove saplings growing amongst the rocks of the revetment. This suggests that such hybrid eco-engineering nature-based solutions can be effective in both coastal protection and habitat restoration.

THEME 5: WATER QUALITY & ONE HEALTH

SESSION 5.1 – GLOBAL CLIMATE CHANGE, WATER QUALITY AND HEALTH
20 June 2024 (Thursday) | 9:00am – 10:30am

Session Chairs:
Robert Bos, Independent Consultant (Switzerland), *Shin Giek Goh,* National University of Singapore, (Singapore)

> **Climate Change, Drinking Water and Health – An Australian Perspective**

***Paul Byleveld,* New South Wales Ministry of Health (Australia)**

Between 2016 and 2022, the Australian state of New South Wales experienced drought, widespread bushfires (wildfires), and heavy rain and flooding. Climate change contributed to the intensity of these events and increased their impact on public drinking water supplies. The recent experience in Australia highlights the range of climate-related challenges that water utilities and communities can expect in the future. A comprehensive drinking water management system, based on the Australian Drinking Water Guidelines, can help water utilities prepare and respond. A coordinated approach by water utilities, governments and communities will be required to address the coming challenges.

> **Aquatic System Understanding for Designing Floating Solar**

***Marloes van der Kamp,* Witteveen+BOS (Netherlands)**

Floating solar attends to the need for renewable energy whilst minimizing carbon emissions, mitigating land-use conflicts and preserving terrestrial ecosystems. Yet, the introduction of artificial structures on water provides opportunities and challenges for the ecological water quality. Therefore, this study advocates for a sound aquatic system understanding to determine and act on foreseen interactions with the environment to benefit water quality. to achieve this, we propose the combined use of numerical modelling (D-Water Quality, PCLake), field visits and ecosystem understanding. A fictive case correlates floating solar to reduced local primary production, moderation of water temperature, increased sediment deposition and, sometimes, anoxia. Hence, floating solar appears more advantageous for water with a strong economic function (e.g. dredging, sand-mining), which exhibits fewer drawbacks from floating solar than water with strong ecological, societal and recreational functions. Understanding of cumulative effects of floating solar on water quality is essential to determine project-specific design.

SESSION 5.2 – WATER QUALITY RELATED TO AGRICULTURE AND FOOD SAFETY
20 June 2024 (Thursay) | 11:00am – 12:30pm

Session Chairs:
Fiona Waller, Affinity Water (United Kingdom), Gin *Yew-Hoong,* National University of Singapore (Singapore)

> FDA's Research on Agricultural Water Quality, Leafy Greens, Food Safety and Health

***Steven M. Musser,* US Food and Drug Administration (United States)**

Presenter is an invited speaker. No executive summary is available.

> At the Intersection of Water and Food Safety: Environmental Sampling Projects Using WGS in the Context of a One Health Approach to Improve Food Safety

***Eric Stevens,* US Food and Drug Administration (United States)**

Whole Genome Sequencing (WGS) has been broadly accepted as the new standard in Food Safety to characterize foodborne pathogens. This technology has been primary employed in outbreak response and linking food and environmental isolates together with clinical illnesses to better respond and prevent foodborne diseases. The idea of a One Health approach has broadened the scope for pathogen surveillance and characterization, and it is becoming clear that water is a large source of foodborne contamination events. This symposium brings together three separate talks outlining water sampling projects conducted by FDA/JIFSAN, FDA/MMAF, and FAO in Latin America, the United States, Africa, and Indonesia to better understand the relationship between foodborne pathogens in water and how they contaminate food. With this better understanding, better preventive control strategies can be undertaken to reduce contamination caused by water, and thus reduce foodborne illness and improve overall food safety.

> Salmonella Enterica Surveillance in Surface Water

***Eric Stevens,* US Food and Drug Administration (United States)**

Whole-genome sequencing (WGS) approaches have been broadly used in Food Safety to characterize foodborne pathogens. FDA established the GenomeTrakr network in 2013 to build a global, One Health WGS database where foodborne pathogens are rapidly characterized and linked to closely-related food and environmental isolates to investigate and respond to outbreaks. in that time it has become clear that water is a large source of contamination events. Thus, FDA and JIFSAN engaged international academic partners in Brazil, Chile, and Mexico to isolate and sequence Salmonella enterica from surface waters. Over 5,000 samples were collected and more than 4,000 sequenced. These projects, which are continually generating more data, allow us to better understand how foodborne pathogens move throughout the One Health spectrum, particularly water. With this better understanding, better preventive control strategies can be undertaken to reduce contamination caused by water, and thus reduce foodborne illness and improve overall food safety.

> Economics of WGS and Environmental Sampling: A Pilot Study

***Julie Haendiges,* US Food and Drug Administration (United States)**

Whole Genome Sequencing (WGS) has been broadly accepted as the new standard in Food Safety to characterize foodborne pathogens. This technology has been primarily employed in outbreak response and linking food and environmental isolates with clinical illnesses. The idea of a One Health approach has broadened the scope for pathogen surveillance and characterization. to ensure global food safety, the number of isolates sequenced must increase but the economic burden of this technology must also be addressed. A partnership between FDA and MMAF provided the basis to conduct a pilot study in determining the economic feasibility of WGS and the use of alternative sequencing equipment to provide quality data for enhanced surveillance of pathogens in Indonesia water. The results from this study can be applied to implementing WGS technology in other countries with resource or infrastructure limitations.

SESSION 5.3 – WASTEWATER-BASED EPIDEMIOLOGICAL SURVEILLANCE (WES) PART 1
20 June 2024 (Thursday) | 2:30pm – 4:00pm

Session Chairs:
David Cunliffe, SA Health (Australia), *Amy Kirby,* CDC (United States)

> The Future of Wastewater-Based Epidemiological Surveillance: Roadmap for the New IWA Cluster

***Gertjan Medema,* KWR Water Research Institute (Netherlands)**

Wastewater-based epidemiological surveillance has gone viral in the COVID-19 pandemic, as a relatively unbiased, efficient early warning tool for COVID-19 circulation in the community, as well as the introduction of new variants. in the current transition from epidemic to endemic state, the question is what the place of wastewater surveillance will be in the future. A global cluster of experts is reviewing the lessons learned from wastewater surveillance in the pandemic, the state-of-science and public health use cases, as well as the governance of surveillance programs to suggest future directions for wastewater surveillance. Key recommendations are to consolidate and harmonise current wastewater surveillance for COVID-19 and polio, add other respiratory and enteric pathogens, antimicrobial resistance, as well as (illicit) drugs, expand wastewater surveillance to countries and communities with limited health surveillance, and create a global observatory in major cities and transport hubs.

> Wastewater-Based Epidemiology in Wales - From Covid-19 to One Health

***Bhavik Barochia,* Arup (United Kingdom)**

Wastewater-Based Epidemiology (WBE) has become a pivotal tool in public health surveillance, offering timely insights into pathogens, chemicals, and pharmaceuticals within communities. By monitoring these contaminants from human, animal, and environmental sources, WBE aligns with the "One Health" approach that interconnects human, animal, and environmental health. Established during the COVID-19 pandemic, the Welsh National Wastewater Monitoring Program used WBE to detect the virus in wastewater, giving early outbreak warnings even before patients displayed symptoms. The program, backed by multiple stakeholders including universities and governmental bodies, expanded its scope beyond the pandemic to monitor One Health markers, other infectious diseases, antimicrobial resistance genes, and the environment. Sampling from 47 wastewater-treatment works over two years, the data collected validated the reliability of WBE insights. The findings also traced COVID-19 variant changes, highlighting the Omicron variant's rise. Moreover, by observing antimicrobial resistance genes, the program provided valuable data for health boards and vets on antibiotic-resistant bacteria, guiding better medicinal practices. This Welsh initiative underscores the potential of wastewater as a data-rich resource in proactively enabling environmental monitoring and tackling One Health threats in our interconnected ecosystem.

> Towards a Regional Framework for Wastewater-Based Epidemiology

***Tomoko Takeda,* The University of Tokyo (Japan)**

Applicability of wastewater-based epidemiology to the Asian Region was explored from the onset of the COVID-19 pandemic. Wastewater and environmental water samples were analysed for SARS-CoV-2 RNA as an indicator of the prevalence of COVID-19. in this presentation, we will introduce recent findings from around the region, discuss key successes and challenges, and propose next steps to support the decision-making process in preparation for future pandemics.

> Low-Cost Virus Concentration Method for Wastewater-Based Epidemiology

***Vu Duc Canh,* Tokyo University (Japan)**

Low-cost and efficient virus concentration methods play a crucial role in wastewater-based epidemiology. However, the current methods are often expensive, complicated, and time-consuming. This study aimed to develope a cost-effective, straightforward technique using Moringa oleifera (MO) seed extract (MO method) to recover both enveloped and non-enveloped viruses like pepper mild mottle virus (PMMoV), murine norovirus (MNV), Aichivirus (AiV), murine hepatitis virus (MHV), and influenza A virus subtype H1N1 (H1N1) in wastewater. Optimal MO method conditions were identified: MO extract concentration at UV280 value of 0.308 cm-1 and elution buffer (0.05M KH2PO4, 1M NaCl, 0.1% Tween80 [v/v]). Compared to InnovaPrep, HA, PEG, and Centricon, the MO method proved more efficient and cost-effective for virus recovery. Additionally, the MO method successfully detected various viruses (PMMoV, AiV, NoV II, EV, influenza A virus, and SARS-CoV-2) in raw wastewater. Thus, the MO method offers a simple, low-cost, and efficient tool for virus concentration in wastewater.

SESSION 5.4 – WASTEWATER-BASED EPIDEMIOLOGICAL SURVEILLANCE (WES) PART 2
20 June 2024 (Thursday) | 4:30pm – 6:00pm

Session Chairs:
Regina Sommer, Medical University of Vienna (Austria), *Gertjan Medema*, KWR Water Research Institute (Netherlands)

> Overview of Wastewater-Based Epidemiological Surveillance

***Amy Kirby*, CDC (United States)**

Presenter is an invited speaker. No executive summary is available.

> Tracking The Impact of the Covid-19 Pandemic on Other Viral Diseases Through Wastewater-Based Retrospective Epidemiological Surveillance

***Massaki Kitajima*, Hokkaido University (Japan)**

A wastewater-based epidemiology (WBE) study in Sapporo, Japan, aimed to assess the influence of the COVID-19 pandemic on respiratory and gastroenteritis viruses. Before April 2020, concentrations of respiratory viruses like influenza A (IAV) and respiratory syncytial virus (RSV) in wastewater correlated with clinical cases, but they significantly decreased after the pandemic's onset. Regarding gastroenteritis viruses, including norovirus (NoV), sapovirus (SaV), and group A rotavirus (ARoV), WBE showed a substantial decline in SaV and ARoV detection ratios post-May 2020, along with a significant drop in NoV GII concentrations. These findings highlight that COVID-19 preventive measures may exert virus-type-specific impacts on respiratory and gastroenteritis viruses, demonstrating the potential broader benefits of pandemic control measures for infectious diseases. The present study underscores the practical utility of WBE and wastewater banking as effective tools for enhancing the management of respiratory viral diseases. Furthermore, the WBE findings shed light on the significant influence of COVID-19 countermeasures on the circulation of gastroenteritis viruses, revealing varying degrees of impact across different virus types. These epidemiological insights emphasize that the hygiene measures implemented to combat COVID-19 infections can also prove effective in curbing the prevalence of gastroenteritis viruses. Such revelations offer invaluable guidance for public health authorities and the development of robust disease management guidelines.

> Monitoring the Spread of Norovirus GI and GII through Wastewater-Based Epidemiology in the Absence of Clinical Data during COVID-19 pandemic

***Jatuwat Sangsanont*, Chulalongkorn University (Thailand)**

This research explored the prevalence and seasonal variation of norovirus GI and GII in Thailand through wastewater-based epidemiology, especially during the COVID-19 pandemic when clinical data were scarce. The influent samples were collected from wastewater treatment plants in Bangkok and underwent virus concentration, RNA extraction, and RT-qPCR for norovirus GI and GII analysis. The correlation between norovirus clinical cases and the prevalence of norovirus in wastewater was examined. Our findings revealed a distinct seasonal trend in norovirus prevalence, even in a tropical climate, peaking during the winter, and highlighted a prevalence of norovirus GI over GII. The scarcity of clinical data during the study period emphasized the essential role of WBE in tracing disease prevalence and informing public health strategies. Our research underscores the invaluable insights WBE can provide in understanding infectious diseases' dynamics, particularly when conventional clinical data are scarce, demonstrating its applicability in diverse climatic scenarios.

> Co-Incidence of BA.1 and BA.2 At The Start of Singapore's Omicron Wave Revealed by Community and University Campus Wastewater Surveillance

***Desmond Chua*, SCELSE NTU (Singapore)**

Wastewater surveillance (WWS) has been globally recognised to be a useful tool in quantifying SARS-CoV-2 RNA at the community and residential levels without biases associated with case-reporting. in this study, we developed an allele-specific (AS) RT-qPCR assay which simultaneously targets the stretch of mutations from SL24 - SA27S for quantitative detection of Omicron BA.2. Together with previous assays that detect mutations associated with Omicron BA.1 (69-70) and all Omicron (493-498), we report the validation and time series of these assays from September 2021 to May 2022 against influent samples from two wastewater treatment plants and across four University campus sites in Singapore. Viral RNA concentrations which agree with locally reported clinical cases, suggest co-incidence of Omicron BA.1 and BA.2 at the treatment plants on 12 January 2022, almost two months after initial BA.1 detection in South Africa and Botswana.

> Understanding SARS-Cov-2 VOC Transition Dynamics Using Wastewater Monitoring

***Nishita D'Souza*, Michigan State University (United States)**

The decline of clinical testing and reporting of COVID-19 cases has posed challenges to public health agencies in monitoring communitywide disease spread. Wastewater surveillance is shown to be a widely accepted monitoring strategy to complement clinical investigations and can be used to provide information on new and emerging viral variants of concern (VOCs) by monitoring the bio health of communities. This study describes the utility of ddPCR targeted mutational analysis for monitoring VOCs through wastewater and understanding their temporal transition dynamics. The monitoring tracked the rise and fall of VOCs Alpha, Beta, Gamma, Delta, Delta Plus, Epsilon and Omicron subvariants, BA.1, BA.2, BA.4, BA.5, BQ.1 and XBB on a university campus and in the surrounding community between 2021 and 2023. Real time monitoring of VOCs through targeting mutation analysis has proved to be a rapid, sensitive and cost-efficient tool to study the transition dynamics of VOCs and inform public health.

SESSION 5.5 - EMERGING APPROACHES FOR WATER QUALITY MONITORING AND MANAGEMENT
21 June 2024 (Friday) | 9:00am – 10:30am

Session Chairs:
Fiona Waller, Affinity Water (United Kingdom), *Jerome Kok,* NUS College (Singapore)

> Using Natural Virus Markers to Safeguard the Integrity of Membrane Treatment Plants

***Emile Cornelissen,* KWR Water Research Institute (Netherlands)**

Water reuse is a crucial development to mitigate increasing global water stress. Membrane filtration systems are increasingly used for the production of high-quality water, also particularly for the reuse of highly contaminated water sources (e.g. wastewater or effluent). A lack of an essential membrane integrity method for virus removal resulted into the development of a new natural virus (NV) method, which is based on indigenously present virus markers in water sources. This novel NV method is used to regularly monitor four full scale drinking water treatment plants, including micro- and ultrafiltration (MF/UF) and reverse osmosis (RO) membranes. Furthermore, on pilot scale deliberately induced membrane damage to membranes was investigated to determine the effect on virus rejection. The successful NV method will leverage the implementation of water treatment processes, like membrane based treatments, for global requirements like drinking and irrigation water production, water reuse, and contribute directly to SDG6.

> Integrated Closed Loop Health & Environment Surveillance

***Rutwik Shah,* Hydrolabs Pvt Ltd (India)**

Hydrolabs ran an integrated early warning system for disease & environmental surveillance in a closed loop system with one of the largest townships in India. Monitoring Air, Water, Sewage, testing for SARS COV-2 in sewage and monitoring vector borne viruses - Dengue, Cholera, Malaria. Addressing the problem through proactive health Inspection, testing & identifying location of high density mosquito larvae growth & setting up mosquito traps. Creating a first of its kind complete one health model across the entire. We further created a real time digital dashboard for all stakeholders to view at a click of a button and take immediate action across the township

> LCA of full-scale ozonation plant for wastewater treatment: case study in the Netherlands

***Nadine Boelee,* Nijhuis Saur Industries (Netherlands)**

Many micropollutants are poorly degraded in conventional wastewater treatment plants. This results in negative effects to the receiving water bodies due to chronic exposure at low concentrations. The European Water Framework Directive prioritizes the reduction of these high-risk substances in communitarian waters. This opens an opportunity for investment in deployment and implementation of advanced technologies for the treatment of micropollutants in wastewater. In this paper we share results on removing micropollutants and bromate management for the first ozone solution on a municipal wastewater treatment plant in the Netherlands.

SESSION 5.6 – COMMUNICATION BETWEEN SECTORS AND TO AFFECTED COMMUNITIES
21 June 2024 (Friday) | 11:00am – 12:30pm

Session Chairs:
Ruchika Shiva, IRCWASH (India), *Xuneng Tong,* National University of Singapore (Singapore)

> Undertaking Outreach Campaign as a Tool to Achieve 100% Household Sewerage Connection: Case of Dharampuri, India

***Priyank Khare,* All India Institute of Local Self Government (India)**

Poor sanitation in households of many towns in India is not a result of not having access to toilets and proper infrastructure, but is a result of many social stigmas, myths, and misconceptions. This article explains how institutionalising a communications strategy along with the implementation of state government's objective to improve water-quality of River Narmada helped Dharampuri achieve its status of 100% household sewerage connections.

> Now You See It: Visual Risk Management

***Annalisa Contos,* Atom Consulting (Australia)**

In this complex and rapidly changing environment, effective risk management is essential for water utilities to continue to deliver safe services that meet customer and stakeholder expectations. Risks need not only to be assessed but managed. This paper examines the efficacy of visual tools in enhancing risk communication and understanding. Risk management is integral to water sector activities and enables prioritization of improvements, even in resource-constrained environments. While traditional spreadsheets are commonly used for risk assessment, the paper introduces two visual methods for effective risk communication: Bow-tie diagrams and Sankey diagrams. The paper supports these techniques with three case studies, illustrating the practical applications of both bow-tie and sankey diagrams in the water sector, including water safety planning, project delivery framework improvement, and visualizing interlinks between risks in enterprise risk management systems.

> Spatial distribution and determinants of limited drinking water and sanitation services among households in India: evidence from the National Family Health Survey of India (NFHS-5), 2019-2021

***Chandan Roy,* Mizoram University (India)**

Good health and well-being require improved drinking water and sanitation facilities. Lack of access to drinking water and sanitation facilities poses serious health risks. There are very few studies based on NFHS-5 data in the literature. Therefore, the present study used the fifth round of National Family Health Survey (NFHS-5) data. After excluding missing values or ineligible households, the total sample of 6, 09,130 households. The Stata version 14.1 software was used for statistical analysis, and the Arc Map 10.4 was used for spatial analysis. Further, a hotspots analysis was carried out to identify regions, which are limited access to drinking water and sanitation services in India. A binary logistic regression model was applied to investigate the association between dependent and independent variables. The prevalence of limited drinking water and sanitation facility service levels were higher in Madhya Pradesh (12.28%) and Manipur (22.65%), respectively. Besides, spatial distribution of limited drinking water and sanitation facility were spatially clustered among a few central and western Indian states. In the binary logistic regression model, education, wealth index, and place of residence were significantly associated with limited drinking water and sanitation services. There is regional heterogeneity in drinking water and sanitation services. With this in mind, the study suggest spatially-optimized target-oriented policy measures in unprivileged areas. It is also recommended to improve the water distribution networks and construct sanitation facilities.

> Operation and Maintenance of Public Handpumps In Rural Bangladesh: A Mixed Model

***Digbijoy Dey*, IRC International Water and Sanitation Centre (Bangladesh)**

The Department of Public Health Engineering (DPHE) is the responsible line department to provide water services in small towns and rural areas of Bangladesh. This study looked at the process DPHE follows to select, install, and handover water services in rural areas. It was found that DPHE's effort is mainly limited to the installation of handpumps. Operation and maintenance (O&M), as well as minor and major repairs of the handpumps becomes the responsibility of the users. Rough estimates indicate that DPHE has installed more than 1 million handpumps over the past 30 years. Despite that safe water service delivery remains a challenge in rural areas of Bangladesh. One of the reasons is that there is no post-handover operation and maintenance plan for the handpumps DPHE installs which makes it an "install and forget" model. This paper outlines the lack of clarity in roles and responsibilities in the handover process which results in poor O&M of the DPHE installed handpumps.

SESSION 5.7 – ANTIMICROBIAL RESISTANCE (AMR)

21 June 2024 (Friday) | 2:00pm – 3:30pm

Session Chairs:
Hiroyuki Katayama, University of Tokyo (Japan)*, Session Co-Chair 2: TBC*

> Overview of Antimicrobial Resistance (AMR)

***Erica Donner*, CRC SAAFE (Australia)**

Presenter is an invited speaker. No executive summary is available.

> Assessing Antimicrobial Resistance Risks in Effluent of Water Reclamation Treatment Plant

***Shin Giek Goh*, NUS Environmental Research Institute, NUS (Singapore)**

This study addresses the global issue of AMR with key emphasis on the critical environmental perspective, particularly within Singapore's wastewater management. Despite innovative strategies, wastewater treatment lacks explicit AMR removal measures. Assessments include relative ARG risk and integration of QMRA and DALY, offering policymakers insights into AMR-related health burdens. The data from this study revealed the high concentration of ARG in sludge, highlighting risks in sludge for potential agriculture reuse. Health burden assessments identify ESBL-resistant E. coli as a major concern in wet well discharge. Nevertheless, the ocean's dilution and decay processes could substantially mitigate the risk. The modern membrane bioreactor (MBR) system improved the treatment, resulting in significantly low risks of AMR in the discharged water. Future efforts in developing a hydrodynamic model to simulate the fate, transport and assess the risk of AMR would enhance our understanding and management of AMR in the environment.

> Metagenomic Insights on Microbial Contaminants and Horizontal Gene Transfer of Arg in Aerobic and Anaerobic Membrane Bioreactor

***Julie Sanchez*, King Abdullah University of Science and Technology (Saudi Arabia)**

Two configurations of membrane bioreactor (aerobic and anaerobic) treating the same influent were evaluated in terms of their potential horizontal gene transfer (HGT) events of antibiotic resistance genes (ARG) using metagenomic analysis. A lower prevalence of ARG in the suspended sludge of the aerobic membrane bioreactor was found. in contrast, there was a higher ratio of potential HGT of ARG and HGT involving potential opportunistic pathogens in the aerobic membrane bioreactor (0.27 vs 0.09 in the aerobic and anaerobic treatment respectively). in addition, there is a higher diversity in ARG types for the aerobic MBR (resistance to quinolones, multidrug, macrolides and tetracycline). A significant proportion of these ARG were transferred to Burkhorlderia sp., with mobile genetic elements linked to recombination and phages co-localized with the corresponding recipient contigs. Our findings suggest that the risk of potential horizontal gene transfer to potential pathogens is higher in the AeMBR sludge which is significant given the higher sludge disposal requirement of the aerobic treatment.

THEME 6: NEXUS & CIRCULARITY

SESSION 6.1 – POLICY AND PLANNING
20 June 2024 (Thursday) | 9:00am – 10:30am

Session Chairs:
Despo Fatta-Kassinos, University of Cyprus (Cyprus*), Session Co-Chair 2: TBC*

> **Conditions and Strategies for a Circular Water Economy**

***Jos Frijns,* KWR (Netherlands)**

Moving from a linear to a circular water economy, solutions to close water systems, reuse water and recover nutrients and energy from wastewater are taking shape. This study describes the physical, societal and system-level characteristics of a circular water economy, and identifies the technological, economic, socio-cultural and regulatory drivers, barriers and support instruments needed for the wider uptake of circular solutions in the water sector. A comprehensive package of enabling strategies is presented, including providing proof of concept of sustainable water technologies; a shift from a financial cost-benefit model to circular value approach; increasing social acceptance by ensuring active stakeholder engagement; and an adapted regulatory framework that incentivizes circular water solutions. Efforts are needed to rethink the system, so that not only the impact of the water cycle on the ecological ceiling is reduced, but also the values for the social foundation are strengthened.

> **Effluent Reusability Potential of Urban Sewage Treatment Facilities in India: Towards Achieving SDG 6 Targets**

***Dina Zaman,* Indian institute of Technology Kharagpur (India)**

Wastewater reuse is a potential avenue to economize freshwater usage and advance the SDG 6 targets by promoting water circularity. in this study, a comprehensive assessment of the reusability status of urban sewage generated across India is conducted. Secondary information on sewage treatment and reuse in wastewater utilities is accumulated from government databases. for assessing the sewage reusability potential of states and union territories on a common platform, three novel indicators - reuse status (R1), reuse driver (R2), and reuse barrier (R3) were formulated. Combining the three indicators, a composite indicator, Effluent Reusability Potential (ERP) was developed to comparatively assess the Indian states and union territories based on sewage reuse. in this study, 1085 operational STPs with an installed capacity of 26858 MLD were selected for the analysis. Treated wastewater was predominantly reused for irrigating non-food crops, city gardening and landscaping and occasionally used for pisciculture, industrial uses, and groundwater recharge. Treated effluent from merely 285 STPs amounting to 4585 MLD was reused across India. Only 172 STPs amounting to 3039 MLD of the reused sewage met with the full compliance standards, while the rest of the treated effluent either partially complied or non-complied with the standards. The indicators, R1, R2, and R3 for India were computed as 6.42%, 1.00%, and 0.68%, respectively. R1 and R2 were highest for Karnataka, whereas Puducherry accounted for the highest R3. ERP was highest for Karnataka, followed by Uttar Pradesh and Daman & Diu. The proposed indicators are universally applicable, and the generalized framework developed provides a simple and easy-to-comprehend method for reusability analysis and comparative assessment.

> **Water Circularity and Stewardship in Industry - Water Savings and Risk Management**

***Heleen de Fooij,* Witteveen+Bos Consulting Engineers (Netherlands)**

To gain a comprehensive overview of potential improvements of water circularity and stewardship for 4 oil and gas production sites, a 6-step approach was used. The findings of material flow analysis and hotspot identification formed the basis for recommendations for water savings, treatment, and re-use. The impacts of these recommendations on water footprint (50-86% reduction is possible), but also on energy use, CO2 emissions, and costs were then quantified and ranked, resulting in a practical roadmap presented as stacked measures. Finally, the studies provided insight in water stewardship for the sites by showing which of the water stewardship criteria are already met and which require more action. Thereby, these studies provide a comprehensive overview of the current status and potential improvement of water stewardship for oil and gas production sites.

> **Melbourne: Leading Progress in Integrated Water Management**

***Celeste Morgan,* Arup (Australia)**

In the face of climate change, population growth and rapid urbanisation, integrated water management offers a key to unlock resilient, liveable and even regenerative cities. The evolution of policy, new governance structures and the mainstreaming of IWM practice over the last 7 years in Melbourne, has delivered on-ground delivery of change but still leaves significant action needed to deliver the city's 2030 targets. So how far has Melbourne come, and what can other cities learn to leap-frog ahead?

SESSION 6.2 – CROSS-SECTORAL COLLABORATION IN THE CIRCULAR WATER ECONOMY

20 June 2024 (Thursday) | 11:00am – 12:30pm

Session Chairs:
Miriam Otoo, Tetra Tech (United States*), Session Co-Chair 2: TBC*

> Net Zero Ready Goulburn Valley Renewable Hydrogen Ecosystem

Sam Skinner, **Aurecon (Australia)**

In strong alignment with Singapore's Green Plan 2030 (SGP30), this project explored the role of renewable hydrogen in shaping a green and resilient future for the Goulburn Valley region (GVR). Goulburn Valley Water took the first (and most difficult) steps to unlocking the massive potential for renewable hydrogen by engaging with 15 prominent local firms and organisations with a shared goal of rapid decarbonisation accelerating the transition away from fossil energy. The study identified a potential 11,000 tonnes/year demand for renewable hydrogen and abatement of up to 870,000 tCO2-e/year. There are multiple technology transition pathways that were highlighted through the story of Artie the Apple – one of the world's first net zero apples. GVR has huge potential for development of a renewable hydrogen ecosystem that is focused on building stronger regional resilience, more robust supply chains, future prosperity and accelerating decarbonisation of difficult to abate industries and applications. This economically-vital agro-industrial-manufacturing-transportation region, like Singapore, aspires to move to the forefront of green industry and a net zero emissions future.

> Sustainable Irrigation Alliance Tapped - Wamuran Irrigation Scheme

Michael Bissett, **Pensar (Australia)**

The Wamuran Irrigation Scheme Joint Venture (WIS JV) was conceived in 2019 when Pensar led the concept in collaboration with the region's two largest growers Pinata Farms and Twin View Turf in response to the local water authority's requirements from the EOI phase through to the completion of construction in late 2023. Pensar designed and constructed a 22 km pipeline network and pumping infrastructure to deliver approximately 2.6 gigalitres of Class A water per year to the region's growers. Driven by a customer centric solution, Pensar, Pinata Farms and Twin View Turf worked towards the common goal of creating agricultural water security for the Wamuran region along with supporting the environmental goals and initiatives of the water authority in reaching zero nutrients in the Moreton Bay Region waterways by 2040. The Scheme will provide a year-round water supply enriching the social, economic, and environmental benefits for the Wamuran region.

> Circular Water Economy: Lessons Learned From North America

Aimee Killeen, **Water Environment Federation (United States)**

A circular water economy recycles and recovers resources within the water use and treatment cycle to maximize value for people, nature, and businesses. As the global water sector transitions to support the circular economy, sharing lessons learned, both positive and negative is imperative. This panel of Singapore Scholars, utility leaders funded by WEF, NACWA, and The Water Research Foundation will feature both aspirational plans and case studies of successes from across North America.

SESSION 6.3 – SYSTEM OF SYSTEMS FOR A CIRCULAR ECONOMY
20 June 2024 (Thursday) | 2:30pm – 4:00pm

Session Chairs:
Chee Meng Pang, PUB, Singapore's National Water Agency (Singapore), *Mark Smith*, RSK Group (United Kingdom)

> Overview of System of Systems for a Circular Economy

***Francesco Fatone*, Polytechnic University of Marche (Italy)**

Presenter is an invited speaker. No executive summary is available.

> First of Its Kind in Hong Kong - Innovative Reuse of Treated Effluent and Enhanced Energy Efficiency for Air Conditioning Systems

***Carry Cheung Pik Sin*, Drainage Services Department of the HKSARG (Hong Kong, China)**

In Hong Kong, air-conditioning (A/C) systems are major consumers of electricity. Although water-cooled air-conditioning systems (WACSs) are more energy efficient, the need for water towers, water treatment and other operation and maintenance (O&M) demands restrain their application in most buildings. This paper reviews a pilot application of secondarily-treated effluent from sewage treatment works (STWs) as a cooling medium for the A/C system within the treatment Plant. The Drainage Services Department (DSD) installed a WACS with a self-assembled effluent-cooled condenser to study the energy efficiency, cooling performance and actual O&M requirements of the new system over a one-year pilot. It revealed that an energy saving of up to 27.6% per year could be achieved when compared with a conventional air-cooled air-conditioning system. This innovative effluent cooling A/C system achieves extended reuse of treated effluent as well as reduction in carbon footprint as a result of higher energy efficiency.

> Assessing Bacterial Community Dynamics and Contaminants of Emerging Concern During Reclaimed Water Reuse in Real-Field Environment

***Despo Fatta-Kassinos*, University of Cyprus (Cyprus)**

The growing demand for freshwater has led to the adoption of reclaimed water (RW) as a dependable source for irrigation. However, this practice is not without its challenges, including the presence of emerging contaminants (CECs) and microbial pollutants in the environment. The reuse of RW can lead to the uptake of CECs by crops and may also result in alterations to the indigenous microbial community of the surrounding ecosystem. in this study, we conducted lettuce cultivation experiments in lysimeters irrigated with RW under real-field conditions to investigate the occurrence, accumulation, and uptake of specific chemical CECs. Additionally, we explored how the storage of RW before irrigation impacted the RW microbial community through 16S rRNA amplicon sequencing analyses. Moreover, we found that increasing soil depth had a mitigating effect on the influence of RW irrigation on the soil microbial community.

> Unconventional Hydropower the Hidden Opportunity – The South African Experiences

***Jayant Bhagwan*, WYC (South Africa)**

Energy serves as the fundamental driver for global economic and social advancement. With the ongoing issue of energy scarcity worldwide, there is a growing emphasis on reducing CO2 emissions and developing alternative energy sources in all sectors of the South African economy. to generate energy more efficiently, optimize existing systems, and explore new methods of converting energy from one form to another, citizens, universities, and various utilities are all actively searching for innovative solutions to generate electricity. Conduit hydropower represents an unexplored unconventional opportunity, whereby excess energy from pressurised pipelines can be harnessed. This eco-friendly innovation has immense potential and promises long-term energy security if water continues to flow. The strides in developing, scaling and adopting conduit hydropower and its potential in South Africa is demonstrated.

SESSION 6.4 - RESOURCE CIRCULARITY AND VALORIZATION

20 June 2024 (Thursday) | 4:30pm – 6:00pm

Session Chairs:
Adam Lovell, Water Services Association of Australia (Australia), Aprilia Vellacott, Jacobs (Australia)

> Biochar for Battery

***Lara Olsen*, South East Water (Australia)**

Presenter is an invited speaker. No executive summary is available.

> A Technical Evaluation and Demonstration of Converting Sewage Sludge to Slag and Its Utilization as an Alternative Construction Aggregate in Structural Applications

***Grzegorz Lisak*, Nanyang Technological University (Singapore)**

In this project, evaluation and demonstration research works are performed aiming to achieve 100% sludge gasification through a long-term gasification trial to generate sludge-derived slag (SDS) with consistent physical and chemical properties meeting the requirements for its re-utilization. This project will also study the use of SDS as a sand replacement in concrete production for structural applications. in addition, further resource recovery from the by-products generated from the high temperature slagging gasification process such as phosphorus and valuable metals will be attempted. Techno-economic analysis and life cycle assessment (LCA) of the sludge gasification process and slag re-utilization will be performed based on the technical evaluation proposed. With the robust assessments planned, this project aims to reduce at least 80% (by mass) of the sludge and ash residues, as compared to the conventional incineration process, by converting these waste materials into recyclable metals and reusable slag as the NEWSand for Singapore.

> Moving Toward Multi-Dimensional Resource Recovery from Wastewater

***Leonie Hartog*, Waterschap Brabantse Delta (Netherlands)**

Society is increasingly pushing for a transition to a circular economy, including wastewater treatment. in the Netherlands, water authorities are experimenting with resource recovery methods, often focusing on one resource. to maximize investments, long-term planning is essential, considering how new approaches fit into a broader development path. Achieving a true circular wastewater treatment means recovering multiple resources, requiring an understanding of resource synergy and conflicts. Our presentation explores dilemmas, opportunities, and development suggestions in this context.

SESSION 6.5 - CARBON ACCOUNTING
21 June 2024 (Friday) | 9:00am – 10:30am

Session Chairs:
Michael Storey, Isle Utilities (Singapore), *Stephanie Wray*, RSK Group (United Kingdom)

> Overview of Carbon Accounting

Will Fargher, **Ricardo (United Kingdom)**

Presenter is an invited speaker. No executive summary is available.

> Water & Resources Factory 2.0: Carbon Neutral Water and Resources Recovery - An Innovative Solution for Sustainable Used Water Treatment

Arjen van Nieuwenhuijzen, **Witteveen+Bos (Netherlands)**

The Water & Resources Factory 2.0 is an innovative water reuse and resource recovery plant ready to create high quality water and produce several circular material streams to boost the circular economy. This highly innovative treatment plant focuses on the separation of used water into high quality water, and reusable raw materials by applying advanced particle separation technologies. Contrary to conventional UWTP's, where biological processes destroy or convert the organic components and nutrients and produce greenhouse gases like N2O, here only physico-chemical processes are applied. Organic matter and nutrients remain intact and can be upcycled to raw materials for several (biobased) value chains at a lowest carbon emission. This paper elaborates on the sustainability impact of the WRF2.0 by means of carbon-emission and environmental cost indicators.

> Atmospheric Carbon Dioxide Removal and Green Hydrogen Co-Production by Seawater Electrolysis

Gaurav Sant, **University of California, Los Angeles (United States)**

The trapping of carbon dioxide (CO_2) as an aqueous (bi)carbonate ion (e.g., HCO_3–, CO_{32}–) or as a mineral solid is attractive because of favourable thermodynamics, and the durability and permanence of storage. Herein, we describe an approach to rapidly precipitate Ca- and Mg- carbonates and hydroxides from seawater to achieve large-scale, cost-effective CO2 removal. We describe a quantitative basis for assessing CO_2 removal via this technological approach including the development of a robust measurement, reporting, and verification (MRV) strategy. in addition, we describe the commissioning and operations of a pilot-project in Tuas, Singapore which demonstrates a net energy intensity (NEI) of ~1-to-1.5 MWh per t of atmospheric (420 ppm) CO_2 removal. in addition, we describe the necessary data requirements for robust carbon accounting and inform the design of full-scale commercial plants.

> The Carbon Footprint from Removing PFAS and Similar Contaminants from Biosolids

Bill Barber, **Cambi, Inc. (United States)**

There is growing concern over per- and polyfluoroalkyl substances (PFAS), a group of synthetic chemicals, also known as "forever chemicals" due to their persistence in the environment. Whilst there is a concern regarding the concentration of these chemicals in drinking water, this anxiety has expanded to the use of biosolids. Ironically, their intrinsically desirable properties of thermotolerance and hydrophobicity make them recalcitrant and difficult to destroy. Regarding biosolids, this has led to growing interest in the thermal destruction and movement away from land application due to concerns over uptake into crops. However, thermal destruction has a high carbon footprint due to intensive energy demands. Furthermore, land is typically considered the best practice environmental option. Whilst many studies have looked at potential thermal destruction of PFAS, none have looked at the carbon footprint of doing so which is the aim of this paper.

SESSION 6.6 – MONITORING AND MANAGEMENT OF PROCESS EMISSIONS (PART 1)

21 June 2024 (Friday) | 11:00am – 12:30pm

Session Chairs:
Tony Koodie, RSK Group *(United Kingdom), Session Co—Chair 2 TBC*

> Towards Net-Zero Carbon Utilities: Challenges and Opportunities

Ye Liu, The University of Queensland, Australia (Australia)

The water industry is setting targets to achieve net-zero emissions by at least 2050 and some as early as 2025. Adoption of emission reduction strategies is hindered by a lack of reliable monitoring protocols as well as methods to predict the effect of different reduction strategies. This talk will focus on sharing state-of-the-art knowledge, practical experience from the greenhouse gas team at the University of Queensland (UQ), together with the Australian water utilities, in managing fugitive greenhouse gas emissions from urban water industry in the past decade, as well as the new collaborative emissions monitoring campaign in Australia and New Zealand. It will also discuss challenges and opportunities lie in our future in achieving net-zero emissions in the water sector in the coming years.

> Monitoring Process N_2O Emissions Helps Mitigate Climate Footprint of Water Resource Recovery Facilities – Global Case Studies

***Emma Shen,* Jacobs (Canada)**

Process N_2O emission can be a significant contributor to the GHG footprint from Water Resource Recovery Facilities (WRRFs). Using the default EF specified by the 2019 IPCC Refinement, there is little scope to reduce reportable N_2O emission for WRRFs. Technologies are available to monitor actual N_2O emissions and develop site-specific EFs, which would allow the WRRFs to better understand their baseline N_2O emissions, and to develop mitigation strategies that can make a positive impact and align with the net zero targets established by the cities and municipalities. This paper provides 3 full-scale, long-term monitoring studies in Denmark and Canada, covering a range of facility sizes (< 10 ML/d to > 600 ML/d), process configurations (conventional activated sludge to membrane aerated biofilm reactor (MABR)), and monitoring methodologies (unit process to whole plant measurements).

> Effective Assessment, Mitigation, and Reporting of N_2O Emissions At Two Full-Scale WWTPS

***Wim Audenaert,* AM-Team (Belgium)**

Nitrous oxide (N_2O) emissions in wastewater treatment have become a key topic and (inter)national regulation is expected to develop at a rapid pace. Computational Fluid Dynamic (CFD) simulations with mechanistic biokinetic models can be used to help with understanding the root causes and designing effective N_2O mitigation strategies. Two full-scale case examples will be discussed.

> Abatement of N_2O in Exhaust Gas From Full-Scale WWTPS

***Nerea Uri Carreño,* VCS Denmark (Denmark)**

The project NACAT, carried out by a consortium of public and private enterprises in Denmark, addresses the challenge of reducing direct nitrous oxide (N_2O) emissions from WWTPs, by testing a new type of catalyst for abatement of N_2O in the exhaust gas from covered processes. N_2O is a powerful greenhouse gas and is often the single most important contributor to the CO_2 footprint from the operational phase of WWTPs and water utilities in general. Technologies to help reduce this emission are therefore essential for the water sector's move toward climate neutrality.

SESSION 6.7 – WATER AND HYDROGEN ECONOMY
21 June 2024 (Friday) | 2:00pm – 3:30pm

Session Chairs:
Dragan Savic, KWR Water Research Institute (Netherlands), *Session Co-Chair 2: TBC*

> Overview of Water and Hydrogen Economy

***Sander Mager*, Union of Water Authorities (Netherlands)**

Presenter is an invited speaker. No executive summary is available.

> Water for Hydrogen – Will There Be Enough to Support the Energy Transition?

***Priyani Madan*, Arup (Australia)**

In the coming years the demand for green hydrogen is set to increase, which will require a substantial amount of water for feedstocks and cooling processes. Arup's "Water Usage in Hydrogen" study was completed to better understand the considerations and potential design requirements regarding the supply and treatment of water for the production of hydrogen and conversion carriers. This study provided a groundbreaking and robust technical basis upon which the hydrogen industry can use to engage with the challenges of water resources. Locations where green hydrogen is attractive from an energy demand and supply perspective may not align with areas rich in sustainable water resources, posing a challenge. Leveraging our experience with "Water Usage in Hydrogen", Arup has had the opportunity to undertake a water demand analysis at hydrogen production locations across Victoria (and now nationally), combining our findings with a comprehensive water resource assessment to better understand the nuances of the water-energy nexus.

> From Biogas to Green Hydrogen – What's The Impact of The Energy Transition on Water and Wastewater Utilities?

***Ethan Edwards*, Bluefield Research (United States)**

Approximately 2% of global greenhouse gas emissions have been attributed to the water sector. Spurred by environmental policies, many utilities are striving to reduce emissions. Green hydrogen and biogas capture from wastewater are poised to help utilities achieve these goals, with utilities benefitting from existing access to water, land, treatment, and distribution capabilities. Projects at municipal and industrial facilities are accelerating thanks to industrial policy tailwinds (e.g., Inflation Reduction Act). This presentation will provide an overview of incentivizing policies, case studies, and market-based strategies of global water and wastewater utilities on biogas capture and green hydrogen.

> Navigating Water's Role in the Australian Green Hydrogen Economy: An Industry Led Approach to Finding the Way

***Lindsey Brown*, GHD (Australia)**

The expansion of the Australian hydrogen industry has been gaining momentum for several years. to date, exploratory efforts to realise a green hydrogen economy has focused on renewable power, price, production, transport, end users and government funding. Australian water utilities have been asking how they should engage with this emerging industry, and how the water industry plays its part given the importance of water availability to making hydrogen production viable. to explore this, we sought to generate stronger industry focus and understanding through a series of webinars creating a platform for an industry-wide conversation and the opportunity to collect data on perceived risks and opportunities directly from participants and expert guests. The findings from this investigation were the basis for a series of steps for water utilities to navigate their role in this new green hydrogen economy and determine how they can engage and benefit the communities that surround them.

LIST OF POSTER PRESENTATIONS

THEME 1: DELIVERING WATER FROM SOURCE TO TAP (NETWORK)

- **Achieving Consistent Reuse Source Water Quality via Online Monitoring and Deterministic Control Strategies**
  Steve Myers, Hach Company (United States); *Maureen Wager,* City of Oceanside (United States)
- **Adoption of Advanced Process Control in Wastewater treatment**
  Francesco Ghiotto Marco Achilea, Riccardo Martini, ABB (Italy)
- **Advanced Wastewater Monitoring in Support of Industrial Growth in Vietnam: Bioelectrochemical Systems (SENTRY™)**
  Jon Grant, Mack Pardy, Sentry: Water Monitoring and Control Inc. (Canada); *Rodney Chapin, Ardurra International Pte Ltd* (United States); *Nguyen Quang Khai, Phu Khanh Environmental Service Co., Ltd* (Laos)
- **An Integrated Water Loss Monitoring System for Leak Detection and Correlation on Large Diameter Pipelines and Non-Metallic Pipelines**
  Xiaolei Du, Xylem (China); *Ye Li,* Xylem (Singapore)
- **Applying Analytical Techniques to Improve Asset Management in Cathodic Protection of Water Assets**
  Will Maize, Matt Barrett, Mobiltex Data Ltd. (Canada)
- **Assessment of the Operational Challenges & ways out of individual iron removal treatment unit: A study on Dhaka was a 3-Vessel IRU Piloting Project**
  Sumaiya Binte Islam, Asif Kabir, Rajib Ahmed, S M Toufiqur Rahman, Md Mizanur Rahman, Dhaka Water Supply & Sewerage Authority (Bangladesh)
- **Case Study: Dhaka Domestic Water Flow**
  Digbijoy Dey, Ingeborg Krukkert, IRC International Water and Sanitation Centre (Bangladesh); *Lukas Bouman,* EAWAG (Switzerland)
- **Cloud-based Software Solution for Operationalizing Anomaly Leak Finder (ALF) Detection and Localization Processes**
  Juen Ming Wong, Rony Kalfarisi, Alvin Chew, Fred Cao, Bentley Systems Pte Ltd.(Singapore); *Jia Jie Wong, Kah Cheong Lai,* PUB, Singapore's National Water Agency (Singapore)
- **Condition Assessment and Rehabilitation of Cast Iron Water Mains in the City, Singapore**
  Aldred Er, Jacobs (Singapore); *Nikki Ye, Selvakumar Thanyasalam,* PUB, Singapore's National Water Agency (Singapore)
- **Digital Transformation and Human-Centric AI: Revolutionizing Water Leak Detection with The Public Utilities Board of Singapore**
  Waseem Khan, Kanishk Noel, PUB, Singapore's National Water Agency (Singapore)
- **Delivering Water from Source to Tap (Treatment)**
  Maidah Khan, Salman Yusuf, Asian Development Bank (Pakistan)
- **District Metered Area: DWASA's Innovative Approach towards Sustainable Water Supply and Reducing Non-Revenue Water**
  Rajib Ahmed, Sazia Afreen, Md Mizanur Rahman, Dhaka Water Supply and Sewerage Authority (Bangladesh)
- **Digital Maturity Assessment of A Leading Water Utility in South Africa**
  Mogan Padayachee, Rand Water (South Africa); *Ani Nair, Chantal Kotze*, Isle Utilities (Australia)
- **Guwahati Water Supply Project funded by Japan International Cooperation Agency, JICA**
  Zadid Ahmed, Uday Kelkar, NJS Engineers India Pvt Ltd (India)
- **Hawle.Live KEY**
  Daniel Wagner, Hawle Service GmbH (Austria)
- **Heartbeat Technology build-up index for electromagnetic flowmeters**
  Sean Yew, Emmy Lim, Endress + Hauser (SEA) Pte Ltd (Singapore)
- **High-Resolution Assessment of Aging Water Main in California, USA**
  Vincent Shen, Kristopher Embry, Pipeline Inspection and Condition Analysis Corporation (PICA) (Canada)
- **How Modern Pressure Regulating Valves Combat Water Loss by Bringing Balance to Water Networks**
  Rebecca Indlekofer, Georg Fischer Wavin Ltd. (Switzerland)
- **Increased Plant Efficiency by Digital Field Level Connectivity**
  Benedikt Spielmann, Georg Fischer (Switzerland)
- **Integrated Software Solution and Benchmark Study for Near Real-Time Anomaly Event Detection in Singapore**
  Alvin Chew, Xue Meng, Jocelyn Pok, Fred Cao, Zheng Yi Wu, Bentley Systems (Singapore); *Jia Jie Wong,* PUB, Singapore's National Water Agency (Singapore)
- **Internalizing Pressure Transient at Air Selangor's Intelligent Command Centre (ICC): An Exploration towards Enhanced Operational Excellence**
  Ezarif Hasnol Basri, Air Selangor (Malaysia)

- **Joint Excellence in Water Network Management - Transformative Leak Detection in Large Diameter Pipes - A Collaborative Case Study by ST Engineering, AQS and PUB**
  Danny Rosenbluth, Anca Axente, Aquarius Spectrum (Israel);
  Liang Ming Chong, ST Engineering(Singapore); *Waseem Khan,* PUB, Singapore's National Water Agency (Singapore)
- **Lab-Scale Evaluation of Total Residual Chlorine Decay and Microorganism Growth in a Drinking Water Distribution System in Using a Lab Pipeline Reactor**
  Yuanpeng Sun, Cunqiang Wei, Zhong Sheng Tai, Yuyao Fu, Say Leong Ong, Jiangyong Hu, National University of Singapore (Singapore)
- **Leveraging AI and ML for Operational Optimization in the Water and Wastewater Industry**
  Laith Liyanage, WSP Canada Inc (Canada)
- **Methodology for establishing representative hydraulic sectors in a Water Distribution System using Machine Learning Tools**
  Edwar Forero-Ortiz, Jaume Cardús, Aigues de Barcelona (Spain); *Eduardo Sánchez-Juny, Martí Sánchez-Juny*, Universitat Politècnica de Catalunya (Spain)
- **Operational efficiency for water conservation: Improving Leakage Detection in Water Networks using Artificial Intelligence**
  Karim Claudio, Cyril Lecler, Charlotte Sakarovitch, Jason Vallet, Aurélie Chazerain, Pierre Bonardet, SUEZ (Singapore)
- **Oita Prefecture Satellite Leak Detection Case Study – Comparison to Benchmark Data and Worldwide Performance Results**
  Jonathan Jacobi, Yonatan Rabinovitch, Asterra (Israel); *Paul Gagliardo,* Gagliaqua (United States); *Toshikazu Kishimoto,* J21 Corporation (Japan)
- **Promoting Sustainable Inclusion: Systematic Tap Water and Complementary Services in Urban Slums of the Philippines and Bangladesh.**
  Philippe de Roux, Eau et Vie (France)
- **Rapid monitoring of bacteriological quality in water distribution networks through flow cytometry**
  Jessica Ong, Jacqueline Yeo, Mu En Chan, Regina Ang, PUB, Singapore's National Water Agency (Singapore) (Singapore)
- **Reaching Out New Initiatives to Maintain a Sustainable and Resilient Water Supply System for Northern Metropolis in Hong Kong**
  *Tso Yuk Ke*i. Water Supplies Department (Hong Kong, China)
- **Reliable Forecasting of Chlorine Degradation in Potable Water Networks Through Combined Use of Water Quality Monitoring and Digital Twin Technology**
  Rongmo Luo, Emily Ng, Yixiong Chua, Xylem (Singapore), *Jafari Iman, Szu Hui Ng, Jiangyong Hu,* National University of Singapore (Singapore),
- **Safe Water At A Giant Scout Camp: An Automated Flow Cytometry story**
  Vivian Hauss, Celine Jaeger, bNovate (Switzerland), *Nana Diarra dit Konté, Christine Egli, Inter Kantonales Labor* (Switzerland); *Vera Ganz, Corina Meyer,* EAWAG (Switzerland); *Rahel Oechslin,* Wasserversorgung Zürich (Switzerland)
- **Saving Energy with Ammonium Control at Wastewater Treatment Plants**
  Tao Su, Xylem (Japan); *Mark Tepper,* Xylem (China)
- **Settlement and Seismic Design at Pipeline-Structure Interface**
  Christian Sundberg, Luke Prinsloo, Victaulic (United States)
- **Sustainable Irrigation Pipe Distribution Network Routing by Leveraging Geospatial Technology**
  Rajesh Kumar V, Sathiyanarayanan S, Hussain Babu D, Kumaresan P, Guganesh S, Nitessh Kumar L R, L&T Construction (India)
- **Sustainable Water for Drinking**
  Habibur Rahman Talukder, Social Economic Development Society [SEDS] (Bangladesh)
- **Sustainable Water Network through Advanced Polyethylene Piping Solutions**
  Peck Tze Kang, Borouge Pte Ltd (Singapore)
- **UV Liner Trenchless Techniques for Rehabilitation of Existing Sewers in Singapore**
  Philip Wong, Renius Coonghe, Cam Linh Lai, WSP Singapore (Singapore); *Chee Leong Lim, Lay Beng Cheng, Kum Peng Seetoh, Hui Yan Chi,* PUB, Singapore's National Water Agency (Singapore)
- **Viral indicators for combined sewer overflow pollution based on capsid integrity quantitative PCR**
  Miaomia Liu, Vu Duc Canh, Shunsuke Kadoya, Hiroyuki Katayama, University of Tokyo (Japan)
- **Water-Industry-Community Nexus Approach for Long Term Sustainability and Resilience**
  Wini Wong, Lars Henrik Skjolding, Aprisium (Singapore)
- **What is the carbon impact of increasing leak rates in a changing climate?**
  Emily Tyhurst, Paul Murray, Mueller Water Products (Canada)
- **Why AI-Driven Analytics is Essential for Next Generation Pipeline Condition Assessment**
  Eric Toffin, Marshall Kennedy, Boyu Liu, Xylem (United States)

- **Accelerating safe WASH for Subtropical Villages With a Community-Centered Approach**
  Yudha Prasetyatarna, Marc Van Loo, Safe Water Gardens (Singapore); *Daly Wettermark,* Stanford University (USA); *Lilik Sutiarso,* National University of Singapore (Singapore); *Henky Irawan,* UMRAH University (Indonesia); *Sungwoo Bae,* National University of Singapore (Singapore)
- **Advancing Wastewater Treatment: A Focus on Advanced Oxidation Processes**
  Reashika Das, Xiangyi Qiao, Evoqua Water Technologies, Xylem (Singapore)
- **Automated Coagulation Control in Drinking Water: Benefits at 4 Plants**
  Delphine Steinmann, Christophe Caudron, Jean-François Robin, Anne Brehant ,SUEZ (France)
- **Automated Mitigation of Nitrous Oxide Through Real Time Control and Soft Sensor Strategies**
  Vishnu Rajasekharan, Matthew Gray, Hach Company(United States)
- **Assessing the Fouling and Microbial Regrowth Potential of Reclaimed Wastewater from Activated Sludge and Aerobic Granular Sludge Membrane Hybrid Systems For Sustainable Water Reuse**
  Zhao Li, RWTH Aachen University (Germany), RWTH Aachen (Germany), *Peter Desmond, Hamad Bin,* Khalifa University (Qatar)
- **Cake Layer Three Dimensional Structures and Water Channel Characteristics during Ultrafiltration Process**
  Baiwen Ma, Chinese Academy of Sciences (China)
- **Case Studies of RO Membrane Fouling and Mineral Scaling via Direct Surface Imaging for Plant Performance Assessment and Operational Support**
  Bilal Khan, Yoram Cohen, Danish Syed, Sambuu Uuganseren, Leobardo Clark, Noria Water Technologies, Inc. (United States)
- **Challenges, Components & Continuity to Adopting Higher Maturity and Sophistication With Digital Twins**
  Eland Afuang, Patrick Bonk, Javier Cantu, Autodesk (Australia)
- **Chemical and in vitro Cell Assessments of Tire Wear Compound 6PPD and Its Disinfection By-products**
  Caixia Li, Anette Mensah, Shi Tang, Mauricius Marques Dos Santos, Shane Snyder, Nanyang Technological University (Singapore)
- **Concentrating Hypersaline Brines with Dimethyl Ether: Water Extraction with Ultra-Low-Grade Heat**
  Zi Hao Foo, Akshay Deshmukh, John Lienhard, Massachusetts Institute of Technology (United States)
- **Control of Disinfection By-products in Hong Kong Drinking Water when Using Sodium Hypochlorite for Chlorination From Onsite Chlorine Gas Generation System**
  Kin Man Ng, Lai Wah So, Tak Yip Choy, Water Supplies Department. (Hong Kong, China)
- **Decreasing Water Scarcity with Reverse Osmosis in a Sustainable, Economical, Operational, And Safe Way**
  Tianyan Chen, Tota Agustin, Air Liquide (Japan); Eiichi Mizutani, ROC marketing, SEA,NEAPac+ALFE, Tomas Alexandersson, Air Liquide Gas AB, *Roel Boussemaere, Rudy Lamond,* Air Liquide (Belgium)
- **Determining Impact of Artisanal & Small-scale Mining on Drinking Water Quality by Investigating Heavy Metal Concentration Variations from Source Water to Tap Water**
  Jacob Amenqor, Kerry Black, University of Calgary (Ghana); *Albert Duncan*, University of Cape Coast (Ghana)
- **Developing Water Reuse Facilities Experience in India - Gujarat Cities and Bengaluru, Karnataka**
  Pankajkumar Sampat, Institute for Social and Economic Change (India)
- **Effect of Micro-Milling and Coagulation On Soluble MN Removal By Powdered Activated Carbon and Free Chlorine**
  Shun Saito, Yasuhiko Yamamoto, Metawater Co. Ltd. (Japan); *Shuhei Matsushita,* Hokkaido University (Japan); *Yoshihiko Matsui,* Waseda University (Japan)
- **Emerging Micropollutants Removal And Disinfection By-Products Formation in UV-LED/Dichloramine AOP For Non-Potable And Indirect Potable Reuse Of Wastewater**
  Yu Zhong, Jiangyong Hu, National University of Singapore (Singapore)
- **Hybrid solution to remediate groundwater contaminated by petroleum-hydrocarbons**
  Claudia Sanchez-Huerta, Shuo Zhang, Peiying Hong, King Abdullah University of Science and Technology (KAUST) (Saudi Arabia); *Manal Alahmari, Abdulmohsen Humam,* Aramco (Saudi Arabia)
- **Improving The Water Supply Resilience of Metro Manila**
  Adrian Marsden, Mervick Salamat, Arup (Philippines); *Robinson Salenga,* Maynilad Water Services (Philippines)
- **Improvements in Coagulation Control using integrated Deterministic Modelling and Machine Learning approaches**
  Sam Towndrow, Chaim Kolominskas, Ryan Sfand, Envirosuite (Australia); *Ruicheng Zhang, Linzi Zhang,* PUB, Singapore's National Water Agency (Singapore)
- **Industrial Scale Fabrication and Applications of Low Energy Reinforced Membranes for Desalting**
  Jiun Hui Low, Li May Goh, Zhiwei Tong, A.M. Dhalla, Nanyang Technological University (Singapore); *Jian Zuo, Mark Perry,* SideStroem Water Technologies Pte. Ltd (Singapore)
- **In-situ Water Remediation Practice Based on Algal Inhibiting Microbials and Submerged Plant Ecosystem**
  Zhu Bing, SUEZ (China); *Xu Zhang, Chongqing Derun,* Simbond Environment Remediation Co., Ltd (China)

- **Innovative Ultrafiltration based remineralization system capable of providing consistently low turbidity effluent**
  Olga Ferrer, Nil Llopart, Daniel García-Huertas, Enrique Palacios, Jorge J. Malfeito, ACCIONA (Spain); *Ramon Garrote, David Shin, Rich Franks,* Hydranautics (Spain)
- **Kerb-Space Infiltration System: Future-proofing Urban Landscapes**
  Harsha Sapdhare, Space Down Under (Australia)
- **Investigation of Disinfection Process of 1,3-Diphenylduandine (DPG) in Water Treatment**
  Lebing Ying, Jia Shenglan, Lee Theodora, Li Caixia, Marques Mauricius, Mensah Tele Anette, Shane Snyder ,Nanyang Technological University (Singapore)
- **Moving towards water secure and climate resilient cities**
  Priyadarshini Choudhary, Aasim Mansuri, Dinesh Mehta, Dipti Tanna, Meera Mehta, Center for Water and Sanitation – CRDF – CEPT University (India)
- **Nutrient Recovery from Brackish Groundwater with Selective Electrodialysis and Nanofiltration**
  Samuel Health, Zihao Foo, Jakob Wegmueller, John Lienhard, Massachusetts Institute of Technology (United States)
- **Optimization of Operating Conditions for Coagulation/Ceramic Membrane Filtration Process Dosing FeCl3 coagulant in Water Treatment Plant**
  *Su Chin Lee, Hiroshi Noguchi, Seetharaman Krishnan,*Terutake Niwa, Meiden Singapore Pte Ltd. (Singapore); *Linzi Zhang, Miao He, Aik Num Puah,* PUB, Singapore's National Water Agency (Singapore)
- **Phosphate Removal from River Water by a Novel Lanthanum-based Polymeric Nanocomposite Material – A Pilot Study in Hong Kong**
  Frances Leung Chui-fan, Tak Yip Choy, Irene M. C. Lo, Water Supplies Department, Hong Kong (Hong Kong, China)
- **Pilot-scale evaluation and optimization of pretreatment strategies for a seawater reverse osmosis desalination system**
  Jiajian Liu, Andy Kwok, Kon Shing Anthony Mok, Binnies Hong Kong Limited (Hong Kong, China); *Arnaud Heuzard, Ran Yin, Chii Shang,* Hong Kong University of Science and Technology (Hong Kong, China); *Wing Lok Sam Hui, Yik Fai Sunny Chu,* HKSAR Government China (Hong Kong, China)
- **Pollutants removal by coupling nature-based biofiltration system with biochar**
  Xiong Yanghui, Pawel Marczewski, Hongbo Zhang, Adair Junior, Himanshu Mishra, Peiying Hong, King Abdullah University of Science and Technology (Saudi Arabia); Ana Deletic, Veljko Prodanovic, Queensland University of Technology (Australia)
- **Predicting Benefits of Sludge Densification in a Wastewater Treatment Plant with Membrane Aerated Biofilm Reactor and Biomass Densification**
  Hui Guo, Sylvain Donnaz, Niclas Astrand, Gabriel Kicsi, Neil Hu, Veolia WTS (Canada)
- **Process Intensification & Innovation - Membrane Aerated Biofilm Reactor (MABR)**
  Salvatore Plano, Louise Elliott, Darren Ritchie, WSP (United Kingdom)
- **Pricing as a tool for groundwater management in the Indo-Gangetic basin – Case of Kanpur City**
  Kriti Trivedi, Maulana Azad National Institute of Technology (India)
- **Quantification of Carbon Emissions in Potable Reuse Treatment Configurations**
  Brett Wagner, Vijay Sundaram, Greg Bowden, AECOM (United States)
- **Real-time Condition-Based and Predictive Sand Filter Backwash Optimizer for Water Treatment Plants**
  Zixian Jiang, Xylem (China)
- **RO Membranes: Modern Analytical Technologies for Dechlorination Optimization, Monitoring and Control**
  Vadim Malkov, Hach (United States)
- **Scale-Up the Fabrication of High Performance Aquaporin (AQP)-Based Biomimetic Flat-Sheet Membranes fFor Seawater Desalination**
  Li May Goh, Rong Wang, A.M. Dhalla, K.C.Tan, Zhiwei Thong, Weikun Paul Li, Gwo Sung Lai, Nanyang Technological University - NTUitive Pte. Ltd. (START Centre) (Singapore)
- **Semi-Closed Reverse Osmosis (SCRO) for Low-Energy And High-Resilience Desalination**
  She Qianhong, Zijing Mo, Dan Li, Nanyang Technological University (Singapore)
- **Status Implementation of EU Reuse Regulation 2020/741 in Germany - Wastewater Reuse for Agriculture and Urban Irrigation**
  Achim Ried, Xylem (Germany)
- **The Quest for Alternative Sources - Vitens Living Lab Phase 1**
  Rene Hoeimakers, Gilbert Galjaard, Ramboll (Netherlands)
- **Testing of DuPont™ B-Free™ technology in Arabic Gulf water at Sharjah Electricity & Water Authority (SEWA) Hamriyah Desalination Plant**
  Guillem Gilabert-Oriol, Javier Suarez, Gerard Massons, Marc Slagt, Rajesh Balakrishnan, Hardik Pandya, Alaa Elsayed, DuPont (Spain)
- **Treatment of Brackish Groundwater Permeate with Bipolar Membrane Electrodialysis (BMED)**
  Jakob Wegmueller, John Lienhard, Samuel Heath, Eddy Calel, Massachusetts Institute of Technology (United States)
- **WaterOSTM: Optimize OPEX of Water Plants with Offsite Monitoring and Unmanned Operation**
  Sin Zhi Goh, Hongbo Bobby Ding, Charles Koh, Hui Guo, Sembcorp Watertech Pte Ltd (Singapore); *Wei Hu, Yanling Shi, Tao Wang, William Chang,* Sembcorp China Holding Corporation (China)

- **Zwitterionic Poly(Sulfobetaine Methacrylate-co-Acrylic Acid) Assisted Simultaneous Anti-wetting and Anti-fouling Membranes for Membrane Distillation**
  Yueh-Han Huang, Tai-Shung Chung, Meng-Jiy Wang, National Taiwan University of Science and Technology (Taiwan)

THEME 3: EFFECTIVE AND EFFICIENT WASTEWATER MANAGEMENT (TREATMENT & CONVEYANCE)

- **"Active Control" of UV Advanced Oxidation Systems Using Free Chlorine can Reduce Cost of Ownership in Advanced Wastewater Treatment for Potable Reuse**
  Scott Bindner, Trojan Technologies (Canada)
- **A Bromate Mitigation Strategy for Ozonation of Wastewater: Bubble-free Membrane Reactors with Static Mixers**
  Stefan Hermann, RWTH Aachen University (Germany)
- **A collaborative model to accelerate and scale transformative solutions to critical water challenges**
  Victoria Edwards, FIDO Tech (United Kingdom)
- **A Comparative Study on Treatment of Spent Coolant by Electrocoagulation and Chemical Coagulation**
  Shu Pei Ng, Singapore Institute of Manufacturing Technology (SIMTech) (Singapore)
- **A Full-Scale Study of Real Time Decision Support System for External Carbon Source Addition in Biological Nitrogen Removal Process**
  Zixian Jiang, Xylem (China)
- **A Green Low-Carbon Process for Ammonium Recovery from Municipal Wastewater: Algae-Bacteria consortia**
  Xiaoyuan Zhang, Nankai University (China)
- **A high-throughput analysis workflow to characterize Pharmaceuticals and personal care products (PPCPs) in aquatic environment**
  Shenglan Jia, NEWRI (Singapore)
- **A new generation of reverse osmosis membranes that are durable and immune to chlorine cleaners**
  Zhiwei Thong, Nanyang Technological University - NTUitive Pte Ltd (Singapore)
- **A Novel Method for Prevention/ Removal of Struvite and Reduction of Polymer Flocculant in Wastewater Treatment**
  Denzil Rodrigues, Hydropath Technology Ltd (United Kingdom)
- **A Practical Approach to Reducing Fugitive GHG Emissions in Wastewater Management**
  Per Henrik Nielsen, VCS Denmark (Denmark)
- **A Sustainable One Stone Three Birds Approach to Reinvent the High Strength Industrial Wastewater into Clean Energy**
  Hong Wei Bai, Nanosun Pte Ltd (Singapore)
- **Adapting CFIHOS for Water Industry - Standardise Asset Information**
  Min Zhong, Enowa Neom (Saudi Arabia)
- **Advanced New Ro Membrane Having High Rejection for Small Neutral Substance**
  Hiroki Minehara, Toray Industries, Inc. (Japan)
- **Advanced Self-Reliant Deep Tunnel Sewerage System Inspection Rover**
  Vimal Govind MK, Genrobotic Innovations Pvt Ltd (India)
- **Algae-Based Treatment of Anaerobic Digestor Effluent for Nutrient Recovery and Reduction of Carbon Emissions**
  Rongmo Luo, Xylem (Singapore)
- **Anaerobic Digestion intensification: Rethinking the sizing of municipal sludge digesters**
  Mathieu Haddad, SUEZ (France)
- **Analysis of 25 Commonly Prescribed Antibiotics and Antivirals Using Direct Injection LC-MS/MS**
  Zhi Siang Toh, PUB, Singapore's National Water Agency (Singapore)
- **Application Experience of Energy-Saving Integrated Aeration Membrane Bioreactors (IA-MBR) in A Fine Chemical Wastewater Treatment Plant**
  Jie Tie, Memstar Membrane Centre, CITIC Envirotech Ltd. (China)
- **Application of advanced chlorine stabilizer chemistry in wastewater improves RO performance and enables wastewater recycling.**
  Miky (Hong) Jiang, Solenis Chemical Co Ltd. (China)
- **Approaches to Remove Nitrates from Water**
  Marion Savill, Affordable Water (New Zealand)
- **Approach to Trade Effluent Management in PUB, Singapore's National Water Agency**
  Kevinpreet Singh, PUB, Singapore's National Water Agency (Singapore)
- **Automation and Integration of Industrial Water & Wastewater Treatment Plants to Improve Asset Management Efficiency**
  Hui Guo, Sembcorp Watertech Pte Ltd (Singapore); *William Chang*, Sembcorp China Holding Corporation (China)

- **Automated anomaly detection to ensure data quality and integrity**
  Vishnu Rajeskharan, Hach (United States)
- **Biomass-derived Carbon Cathode toward Sustainable Electro-Fenton Treatment of Emerging Contaminants**
  Zhang Bei, Tokyo Institute of Technology (Japan)
- **Carbon Quantum Dots Derived from the Polysaccharides of Floc Sludge for Fluorescent Sensing of Fe (Ⅲ)**
  Jie Liu, The Hong Kong University of Science & Technology (Hong Kong, China)
- **Case Study of Mercury Removal Technology for Gas Processing Wastewater Treatment Plant**
  Nadzirah Ramly, Petronas (Malaysia)
- **Characterization of Unknown Leachate from Plastic in contact with drinking Water through Non-Targeted Analysis Using UPLC-QTOF MS**
  Yan Huang, PUB, Singapore's National Water Agency (Singapore)
- **Circular economy for used water management – Cases from Maharashtra, India**
  Jigisha Jaiswal, Centre for Water and Sanitation - CRDF - CEPT University (India)
- **Clean-in-place (CIP) of a Ceramic Microfiltration Membrane**
  Jemeng Zheng, PWNT (Netherlands)
- **Climate efficient Water & Resource Recovery Facility through advanced sludge line implementation**
  Eric Judenne, Private Company (France)
- **Decentralized Wastewater Treatment for Domestic Water Reuse to augment Japan's Aging Infrastructure.**
  Sayani Halder, Junko Tashiro, WOTA Co. Ltd. (Japan)
- **Demonstration of Side-stream PN/A Intensification with ZeeNAMMOX Process**
  Han Zhuang, Veolia Water Technologies and Solutions (Singapore)
- **Designing a Full-Scale Ozonation Plant gor Maximum Micropollutant Removal and Minimal Bromate Formation, Using CFD Simulation With Integrated Chemical Kinetics as Optimization and Validation Tool**
  Wim Audenaert, AM-Team (Belgium)
- **Determination of The Performance Based on Protocol-Based Indicators of The Sewage Treatment Services: A Case Study on Dasherkandi & Pagla Sewage Treatment Plants**
  Sumaiya Binte Islam, Dhaka Water Supply & Sewage Authority (Bangladesh)
- **Efficient Recovery of Organics from Wastewater by MPPE/S**
  Jeroen Boom, Veolia Water Technologies (Netherlands)
- **Energy efficient phototropic wastewater treatment for reuse**
  Mahshid Sedghi, Algaesys S.A. (Portugal)
- **Energy saving in biological stage of sewage treatment plants**
  Andreas Toews, Wilo SE (Germany)
- **Enhancement of Key Operational Parameters Using Novel Antiscalant Deactivation Chemical in Sludge Return Process (SRP) for Wastewater Reuse**
  Eileen Tan Chen Huey, Kurita R&D Asia Pte Ltd (Singapore)
- **Enhancing Energy Efficiency and Reducing Greenhouse Gas Emissions through Intelligent Load-Responsive Aeration Control in Wastewater Treatment**
  Heiko Hermann, Binder GmbH (Germany)
- **Experimental investigation and numerical optimization of periodic in situ ozonation to control fouling in ceramic ultrafiltration membranes**
  Matteo Tagliavini, Nanyang Technological University (Singapore)
- **Feasibility of direct PFAS removal from contaminated wastewaters with ion exchange in suspension**
  Elisabeth Vaudevire, PWNT (Netherlands)
- **From improved settling to improved filterability? Lessons learned from mixed liquor property changes of densified MBR at full-scale**
  Sylvain Donnaz, Veolia WTS (Canada)
- **Green Non-Phosphorus Inhibitors for Better Corrosion, Scaling, and Microorganism Control**
  Kangjia Lu, Ecolab Pte Ltd, (Singapore)
- **Impact of Climate Change on chlorine decay and DBPs formation in drinking water distribution**
  Yelong Chen, National University of Singapore (Singapore)
- **Implementing Zero / Near Zero Liquid Discharge: The Challenges and Approach**
  Mohamad Anil Carle Pun, Petronas (Malaysia)
- **Innovating Wastewater Management: The Implementation and Impact of Maynilad's Hybrid Sewerage System in Challenging Urban Environments in the Philippines**
  Ronnie Isorena, Maynilad Water Services Inc. (Philippines)
- **Innovative MXene Modified Self-cleaning Membrane for Microplastic Degradation**
  Zhuoyao Wang, Nanyang Technological University (Singapore)
- **Integrity Testing and Filtrate Quality Evaluation of MemPulse® B50N MBR Module: Analysis of Membrane Self-Healing**
  Geoffrey Johnston-Hall, DuPont (Australia)

- **Inter- and Intra- Pandemic Variation of Antibiotic, Disinfectant & other Pharmaceutical usage, during the COVID 19 Pandemic**
  Kavindra Senaratna, National University of Singapore (Singapore)
- **Is meeting stringent TN limits the "killer" MABR app? Results from Yan'er Bay WWTP - largest operational IFAS-MABR**
  Yi Li, Beijing ENFI Environmental Protection Co. Ltd (China)
- **Kinetics Development for Ammonium Removal in Anaerobic MBR (AnMBR) Permeate by MABR (Membrane Aerated Biofilm Reactor) as Tertiary Treatment**
  Yountae Seo, St Engineering Marine (Singapore)
- **Lowering the Cost of MBR Wastewater Treatment with DuPont MemPulse® MBR B50N Product**
  Geoffrey Johnston-Hall, DuPont (Australia)
- **Manhole Rehabilitation Methods in Examination and Certification Safe Technical Evaluation of Deterioration Resistance**
  Kosuke Takamizawa, The Japan Institute of Wastewater Engineering Technology (South Africa)
- **Maximizing Nutrient Removal Efficiency and Energy Savings for Water Reclamation**
  Yifan Zhang , National University of Singapore (Singapore)
- **Membrane Contactor for Ammonia Recovery from Ammonia-rich Semiconductor Wastewater Using Concentrated Acid as a Strip Solution**
  Hansol Jang, Samsung Electronics (Korea, Republic of Korea)
- **Micro-Aerobic Anaerobic Digestion for Advanced Process Stability and Biogas Desulphurisation**
  Bart Kraakman, Jacobs (United Kingdom)
- **Monitoring of Nitrous Oxide Emissions from Water Reclamation Plants**
  Guihe Tao, PUB, Singapore's National Water Agency (Singapore)
- **Microbial Sludge Hydrolysis Processes: Recent Advancements in Sustainable Water Resource Recovery Applications**
  Per Henrik Nielsen, VCS Denmark (Denmark)
- **NEOM's Biosolids Demonstration Center**
  Lamees Alkhamis, Enowa Neom (Saudi Arabia)
- **Operations of Submerged Ceramic Membranes at Singapore Waterworks**
  Nasharudin Bin Supa'at, PUB, Singapore's National Water Agency (Singapore)
- **Operator Trust and Uncertainty in Critical Data Sources are Holding Smart Water Systems Back**
  Jacquelyn Schmidt, University of Michigan (United States)
- **Operator's Perspective on Artificial Intelligence and Machine Learning Tools for Streamlining Plant Operations at World's Largest Potable Reuse Facility**
  Derrick Mansell, Orange County Water District (United States)
- **Optimizing Air Scouring Energy for Sustainable Membrane Bioreactor Operation by Characterizing the Combination of Factors Leading to Critical Flux**
  Glen Daigger, The University of Michigan - Ann Arbor (United States)
- **Performance Evaluation of Enhanced Sewer Self-Purification**
  Ryousuke Takkase, Japan Institute of Wastewater Engineering and Technology (Japan)
- **Performance of Multizone Attached Growth Batch Bioreactor for Efficient Wastewater Reuse – A Novel Technology**
  Kowsalya Vellingiri, Larsen & Toubro - Construction (India)
- **Pilot-scale performance and benchmarking study of Aquaporin Inside® CLEAR series low energy BWRO membranes**
  Khung Hanh Le, Aquaporin A/S (Denmark)
- **Piloting Wastewater-based Epidemiology Monitoring Program for SARS-CoV-2 in Metro Manila, Philippines**
  Jitendra Singh, Asian Development Bank (Philippines)
- **Real-time Monitoring of Wastewater Quality Using a Bio-Electrode Sensor**
  Jon Grant, Sentry: Water Monitoring and Control Inc. (Canada)
- **Reduction of laughing gas emissions by complementary injection of pure oxygen**
  Chen Tianyan, Air Liquide (Japan)
- **Research on Performance Requirements of Manhole Rehabilitation Methods**
  Takeshi Hirokane, Japan Institute of Wastewater Engineering and Technology (Japan)
- **Restoring human dignity by mechanized sanitation activities**
  Anil Kumar Singh, Delhi Jal Board (India)
- **Rethinking the Management of Dairy Wastewater: Synergistic Treatment of Agriculture-Derived Waste Streams**
  Zhongzhe Liu, California State University-Bakersfield (United States)
- **SaNiTi - new innovative sanitation game changing strategy to meet water security and SDG goals**
  Jayant Bhagwan, WRC (South Africa)

- **Security by Design: A Must-Have for Water Utilities**
  Sindhu Govardhan, Xylem (India)
- **Simultaneous Nitrification and Denitrification (SND) Biofilm Reactor for Wastewater Treatment**
  Chuansheng Wang, National University of Singapore (Singapore)
- **Sludge management for various wastewater treatment plants in Delhi, India**
  Parul Goel, NJS Engineering India Pvt Ltd. (India)
- **Sludge Thickening with Rotary Drum Thickener at Kranji WRP: Energy Efficiency versus O&M Considerations**
  Sock Hoon Koh , Binnies Singapore (Singapore)
- **Smart stormwater management in urban infrastructures: virtuous case studies in the Veneto Region (Italy)**
  Stefano Biondi, SIW Group Sri (Italy)
- **Sullage Water Treatment Plant with CDS Technology-A case study of Tiong Nam Urban Area, Kuala Lumpur , Malaysia.**
  Yale Wong, EcoClean Technology Sdn Bhd. (Malaysia)
- **Suspended ion exchange for N-removal after a high-loaded municipal wastewater treatment plant**
  Elisabeth Vaudevire, PWNT (Netherlands)
- **Sustainable Water Management in the Food and Beverage Industry by Membrane Technology**
  Jimmy Yu, PepsiCo (United States)
- **The difference in carbon footprint among conventional activated sludge, membrane bioreactor and moving-bed bioreactor technologies in wastewater treatment plants**
  Hung Bui, Ramboll Finland Oy (Finland)
- **The Innovation Program Removal of Micropollutants At Wastewater Treatment Plants in The Netherlands**
  Cora Uijterlinde, STOWA (Netherlands)
- **Ultra-Short Double Membrane System for Integrated Resource Recovery from Municipal Wastewater**
  Conghui He , Tsinghua University (China)

THEME 4: CITIES OF THE FUTURE AND COASTAL & FLOOD RESILIENCE

- **A Roadmap for Circular Economy Integration in Wastewater and Desalination Plan**
  Meena Yadav, K. Clode, V. Moscovia, Isle Utilities (Australia)
- **Adaptive Planning Decision Making Tool for Coastal Protection**
  Peter Stones, Arup (Singapore)
- **An efficient cross-scale regional storm surge model - SCHISM: A practical perspective**
  Jie Hu, Surbana Jurong (Singapore)
- **Applying Computer Vision Approaches to Stream Gauging**
  Daniel Wagenaar, Xylem (Australia)
- **Archipelagic Futures**
  Kai Jie Phua, SUTD (Singapore)
- **Assessing Urban Flood Susceptibility in Response to Climate Change and Urbanization Based on Shared Socio-Economic Pathways**
  Mo Wang, Guangzhou University (China)
- **Assessing Settling Velocity of Biofilm-Encrusted Microplastics**
  Denis Meng, National University of Singapore (Singapore)
- **Coastal Climate Resilience through Mangrove restoration**
  Michiel van der Ruijt, Van Oord Dredging and Marine Contractors (Netherlands)
- **Coastal Reservoir: A Sustainable Engineering Solution for ASEAN Cities of the Future**
  Fang Yenn Teo, University of Nottingham Malaysia (Malaysia)
- **Cryptospheric Energy Network**
  Valent Tan, Singapore University of Technology and Design (Singapore)
- **Development of Singapore's High-resolution Rainfall by Integrating Simulated Spatial Covariances with in-situ Observations**
  Xiao Peng, National University of Singapore (Singapore)
- **Digital tools for interactive community engagement in urban water management**
  Adrian Butler, Imperial College London (United Kingdom)
- **Ecological Engineering Solution for Resilient Coastal Cities: Evaluating Construction Materials for Eco-Engineered Seawall**
  Dinda Mazeda, National University of Singapore (Singapore)
- **Economic Evaluation of Adaptive Pathways for Flood Resilience Strategies**
  Matthijs Bos, Royal HaskoningDHV (Singapore)

- **Empowered by Blockchain, Electric Coral DAOs in the Philippines**
  Jeff Neo, Singapore University of Technology and Design (Singapore)
- **Envisioning a Sustainable, Liveable, and Resilient Future for Singapore's Greater Southern Waterfront**
  Ashleen Tan, Surbana Jurong Pte Ltd (Singapore)
- **From Ecosystems to Impact: Embracing Nature-Based Solutions for A Sustainable Future**
  Steven Weisscher, Witteveen+BOS (Netherlands)
- **Future Climate Resilient Sponge Cities Integrating Green-Blue and Gray Systems**
  Stefan Rau, Asian Development Bank (China)
- **Greenslade Reserve – A Blue-Green Flood Resilience Success Story**
  Josh Irvine, WSP (New Zealand)
- **Hyperresolution Rainfall Simulations in Singapore Based on the Weather Research and Forecasting (WRF) mode**
  Zhixiao Niu, National University of Singapore (Singapore)
- **HYSPLIT-Based Analysis of the 2014 Drought in Singapore**
  Shuping Ma, National University of Singapore (Singapore)
- **Improving Rainfall Observation in Urban Areas: A Large-Scale Study on Repurposing CCTV Cameras for Precipitation Measurement**
  Gineesh Vattamkandathil Sukumaran, HydroInformatics Institute Pte Ltd (Singapore)
- **Multiple lines of defense for adaptive coastal resilience at Tyndall Air Force Base**
  Adam Hosking, Jacobs (United Kingdom)
- **Nature-Based Mangrove Restoration and Hydrodynamics Attenuation Effects: Research and Practice**
  Yiming Wu, Hohai University (China)
- **Recovering resources: from linear water infrastructure to circular closed loop system for water-on-demand to reduce impact of drought, reduce drinking water usage and reduce micropollutants.**
  Peter Scheer, Nijhuis Saur Industries (Netherlands)
- **Reinvestigating the Environmental Kuznets Curve Hypothesis for the relationship between Water Pollution and Economic growth in less industrialized economies**
  Francis Ayensu, Jiangsu University (Ghana)
- **Resilient Indonesian Slums Envisioned: Data atlas towards inclusive governance**
  Rizka Akmalia, Deltares (Indonesia)
- **Sensitivity of input parameters of infiltration-on-grid in a 2D integrated hydrologic-hydrodynamic flood modelling**
  Oshini Peramuna, RMIT University (Australia)
- **Smart Monitoring and Detection of Water Quality Events: Leveraging AI and Sensor Technologies for Effective Surface Water Quality Management**
  Karim Claudio, SUEZ (Singapore)
- **Survey and Research on the Promotion of Sewage Works through the Utilization of Green Infrastructure**
  Hideyuki Aikou, Japan Institute of Wastewater Engineering and Technology (Japan)
- **Sustainable Maintenance of Coastal Protection Structures**
  Zi Qian Yang, Delta Marine Consultants (Singapore)
- **Synergistic Storm Surge and Rainfall modelling: A compound simulation approach for enhanced flood risk assessment**
  Jie Hu, Surbana Jurong (Singapore)
- **Terminology and application surrounding Blue-Green Cities – an updated classification**
  Nanco Dolman, Deltares (Netherlands)
- **The New Wave of Risk Reduction: Fostering Integrated Urban Resilience in the Rapidly Urbanizing Asia-Pacific**
  Travis Bunt, One Architecture (Philippines)
- **Valuing Alternative Governance Models to Unlock Planning at Scale for Blue-Green Stormwater Infrastructure**
  Rosemary Jones, Frontier Economics (Australia)
- **Valuing the economic, social & environmental costs and benefits of flood resilience**
  Alexandra Humphrey, Frontier Economics (Australia)
- **Water supply and reticulation systems in coastal towns of Bangladesh**
  SA Abdullah Al Mamun, Asian Development Bank (Bangladesh)
- **Wave Decay by Rigid Vegetation Under Orthogonal Wave-Current Conditions**
  Zi Chen Xu, National University of Singapore (Singapore)

THEME 5: WATER QUALITY AND ONE HEALTH

- **A Mangrove Rehabilitation Initiative in Bintan for Climate Mitigation and Adaptation - Year 2 Progress Update**
  Jair Smits, Witteveen+BOS (Singapore)
- **A Novel Lab Automation System for Testing E. coli and Total Coliforms in Water by Standard Method**
  Hai Bao Zhang, PUB, Singapore's National Water Agency (Singapore)
- **Addressing WASH Failures Through a Networked Customer Service Approach**
  Benjamin Agbemor, Netcentric Campaigns (Ghana)
- **Application of Imaging Flow Cytobot (IFCB) for Monitoring Marine Phytoplankton in Singapore Seawaters**
  Yukino Koh, PUB, Singapore's National Water Agency (Singapore)
- **Assessment of Microbial Water Quality, Waterborne Diseases Propagation Vis-A-Vis Water Supply In Goma, Democratic Republic of Congo**
  Akash Kahasha, IHFC TIH of IIT Delhi (India)
- **Automated enumeration tool for monitoring chironomid larvae in reservoirs**
  Wan Teng Lim, PUB, Singapore's National Water Agency (Singapore)
- **Campus Wastewater Surveillance: From Pandemic to Endemic**
  Wei Jie Ng, National Technological University (Singapore)
- **Data Imputation of Water Quality Measurements Using Machine Learning In Singapore Waters**
  Simen Hexeberg, National University of Singapore (Singapore)
- **Delivering Safe Water Amidst Pandemic (The importance of Business Continuity Plan (BCP) in continuous operation for the welfare of the people)**
  Robinson Salenga, Maynilad Water Services Inc (Philippines)
- **Development of a Novel Sensor to Predictively Measure the Deposition Stress of Water Systems**
  Ivan Tang, Ecolab Pte Ltd (Singapore)
- **Development of Real-time IoT Sensor Capable of measuring turbidity and bacteria**
  Youngdug Kim, The. Wave. Talk. Inc. (South Korea)
- **Development of Testing Methodology for Tritium in Water**
  Daisy Setyono, PUB, Singapore's National Water Agency (Singapore) (Singapore)
- **Dynamic of Sediment Nutrients and Potential Release to Water Column at a Freshwater Reservoir in Singapore Using an In-Situ Measurement Method**
  Trang Huynh, NSW Health (Australia)
- **Effect of Monochloramine on the Microbial Community of Bulk Water in Intermittent Water Supply System in a Pilot-Scale Study**
  Dan Cheng, Singapore Centre for Environmental Life Sciences Engineering (Singapore)
- **Elevating Public Health Assurance Standards: Air Selangor's Sustainability Strategies on Laboratory Analysis**
  Fariq Fitri, Pengurusan Air Selangor Sdn Bhd (Malaysia)
- **Enhancing Enterovirus Detection in Water Samples: Optimization of Elution and Culturing Protocols Across Diverse Matrices**
  Wan Shoo Cheong, PUB, Singapore's National Water Agency (Singapore)
- **Formulating a behavioural change communications strategy to optimize the health outcomes of urban WASH services in Pakistan.**
  Umar Shah, Adb-prm (Pakistan)
- **One Health in Water Management: Chester Wetland Centre (UK)**
  Kimberly Hague, Binnies Ltd (United Kingdom)
- **One Health Surveillance of Zoonotic Viruses in Water**
  Omar Khalilur Rahman, Singapore Centre for Environmental Life Science Engineering (Singapore)
- **Reduction of Ecological Risk with UV-based AOP for Treating Sweetener**
  Surapong Rattanakul, King Mongkut's University of Technology Thonburi (Thailand)
- **Supporting the implementation of drinking water management systems in New South Wales, Australia**
  Paul Byleveld, NSW Health (Australia)
- **Surveillance of CrAssphage in Singapore Water**
  Zuhairah Hanafi, PUB, Singapore's National Water Agency (Singapore)
- **The Development of Risk-based Chemical Spill Management Criteria Related to the Beneficial Use Impairment in the St. Clair River**
  James Li, Toronto Metropolitan University (Canada)
- **The Utility of Escherichia coli as an Indicator of Safe Water for Healthcare Use: Evidence from Bangladesh**
  Li Ann Ong, University of Oxford (United Kingdom)

THEME 6: NEXUS AND CIRCULARITY

- **A circular solution to resolve water supply shortfalls in England Southeast - Grand Union Canal (GUC) strategic transfer.**
  Ritchie Carruthers, Arup (United Kingdom)
- **Assessing the Risks for Transitioning to Net Zero for the UK Water Sector**
  Liam McCabe, Arup and Brunel University London (United Kingdom)
- **Comparative life cycle assessment and life cycle cost analysis of centralized and decentralized urban drainage systems: a case study in Zhujiang New Town, Guangzhou, China**
  Wang Mo, Guangzhou University (China)
- **Corporate Innovation Labs: Accelerating technology adoption for water utilities and environmental managers through third-party partnerships and collaboration**
  Max Storto, Xylem (United States)
- **Decarbonising Wastewater Treatment – Planning Our Route Through Uncharted (Waste)Waters**
  Rigo Manahan, Arup (Australia)
- **Developing a Successful, Saleable Biosolids Brand**
  Maile Lono-Batura, Water Environment Federation (United States)
- **Disposition of Oil: Algae Biofuel as New Sustainable Energy**
  Nicholas Lim, Singapore University of Technology and Design (Singapore)
- **Floating Photovoltaic Systems at Flood Storage Ponds with Human-Centric Design – Integrating Sustainability and Ecology into Communities**
  Alex So, Binnies Hong Kong Limited (Hong Kong, China)
- **Food Waste as a Sustainable Substrate for Microalgae Cultivation and Bioproduction**
  Li Zhuo, National University of Singapore (Singapore)
- **Highly Efficient N-Recovery from Municipal Wastewater using Nitrogen Stripping Technology**
  Tuur van den Eijnde, Nijhuis Saur Industries (Netherlands)
- **Integrated Framework and Appraisal Tool to Assess Greenwashing in Climate Adaptation Programs and Projects**
  Amancio Melad, UNICEF Philippines (Philippines)
- **Biosolids Biochar for Carbon Capture and Storage - The Need for a Consistent Approach to Comparing Carbon Credits**
  Marlene Hsu, Isle Utilities (Australia)
- **NEOM – A Case Study in Generating Investment Opportunities within a Fully Circular Water Supply**
  Greg Welch, NEOM (Saudi Arabia)
- **Opportunities for Funding Circularity – Examples from Australia**
  Ben Mason, Frontier Economics (Australia)
- **Rainwater Management Supporting Urban Biodiversity**
  Hanne Kjaer Joergensen, KLAR Utility (Denmark)
- **Rural Clean Water Supply without Electricity: Sustainable Applications for Developing Countries**
  Chun Ming Chew, Techkem Group (Malaysia)
- **Towards professionalisation of water services industry through licensing and regulation – the South African experience**
  Sean Phillips, Department of Water and Sanitation (South Africa)
- **Urban Water Communities: A New Paradigm for The Urban Water Sector?**
  Carla Pimentel-Rodrigues, ANQIP (Portugal)
- **Water Requirements for Renewable Hydrogen Production: Quantification and Key Factors Driving Demand**
  Matthew Brannock, GHD (Australia)
- Water Resource Assessment of Potential Source of Potable Water Supply in Response to Higher Water Demand and Customer Usage
  Robinson Salenga, Maynilad Water Services Inc (Philippines)
- **Water Treatment Sludge Management and Reuse in Australia: Benefits and Challenges towards the Circular Economy**
  Minh Duc Nguyen, Isle Utilities (Australia)
- **Water Treatment Technologies and Its Implications for Residuals and Carbon Footprint**
  Jouke Boorsma, AquaMinerals (Netherlands)
- **Watering Down the Cost Of Green Hydrogen**
  Ryan Grljusich, GHD (Australia)
- **What are the Important Influencing Factors Generating N_2O Emissions?**
  Tony Koodie, Binnies Singapore (United Kingdom)

REGISTRATION AND ENQUIRY

Pass types and fee structure can be viewed online here before registration.

SIWW2024 offers various fee structure, including lower registration fees for delegates from lower-middle-income countries and low-income countries (based on the World Bank Classification) and students.

Student discount is applicable to students currently studying in an Institute of Higher Learning. Students are required to email the organiser at registration@siww.com.sg with a copy of their student matriculation card or ID to obtain a student promo code before they proceed to register.

Promo codes will emailed to eligible reviewers, oral and poster presenters.

CONTACT INFORMATION

For any enquiries, please contact the SIWW2024 Water Convention Secretariat at: waterconvention@siww.com.sg.

Detailed information of the Water Convention is also available here at https://www.siww.com.sg/home/programme/water-convention .

ABOUT THE CO-ORGANISERS

International Water Association (IWA)

The International Water Association is the organisation that brings together science and practice of water management in order to reach a world in which water is wisely managed to satisfy the needs of human activities and ecosystems in an equitable and sustainable way.

The IWA is a global knowledge hub and international network for water professionals and anyone concerned about the future of water. We bring together know-how and expertise to instigate ground-breaking solutions.

PUB, Singapore's National Water Agency

PUB is a statutory board under the Ministry of Sustainability and the Environment (MSE). It is the national water agency, which manages Singapore's water supply, water catchment, and used water in an integrated way. From April 2020, PUB also took on the responsibility of protecting Singapore's coastline from sea-level rise as the national coastal protection agency.

PUB has ensured a diversified and sustainable supply of water for Singapore with the Four National Taps (local catchment water, imported water, NEWater, desalinated water). PUB leads and coordinates whole-of-government efforts to protect Singapore from the threat of rising seas and the holistic management of inland and coastal flood risks.

PUB calls on everyone to play a part in conserving water, in keeping our waterways clean, and in caring for Singapore's precious water resources. If we all do our little bit, there will be enough water for all our needs – for commerce and industry, for living, for life.

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About Singapore International Water Week

As one of the premier global platforms, the biennial Singapore International Water Week (SIWW) gathers thought leaders, experts and practitioners from governments, cities, utilities, and industry to share knowledge and best practices on innovative water, coastal and flood solutions, and foster partnerships to tackle urban water and associated climate challenges.

Organised by PUB, Singapore's National Water Agency and Singapore's Ministry of Sustainability and the Environment, SIWW flagship programmes include the Lee Kuan Yew Water Prize, Leaders Roundtable and Summit, Water Convention, Water Expo, Thematic and Business Forums and Technical Site Visits.

The 10th edition of SIWW will be held from 18 to 22 June 2024 at the Sands Expo and Convention Centre in Singapore, alongside CleanEnviro Summit Singapore organised by Singapore's National Environment Agency.

SIWW is part of the strategic programme of the Singapore Government to grow the water industry and develop water technologies.

For enquiries on Water Convention, please contact:

Water Convention Secretariat
Email: waterconvention@siww.com.sg

For enquiries on Singapore International Water Week, please contact:

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