



## SINGAPORE INTERNATIONAL WATER WEEK 2021

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

SIWW2021 SPOTLIGHT

21 June 2021

SIWW2021 ONLINE

21 June – 2 July 2021

### Singapore International Water Week 2021 Spotlight (21 June 2021)

#### SESSION 1 (0930 – 1130 Singapore time)

**Opening Address by Singapore Minister for Sustainability and the Environment, Ms Grace Fu**

#### **Plenary 1 - Fostering Innovation and Collaboration: Overcoming Challenges for Water Sustainability**

Session will showcase approaches by different stakeholders such as governments, utilities, academia and industry towards innovation, and how embracing an innovative mindset and working collaboratively uncovers opportunities to achieve water sustainability.

Panel Members:

1. Peter Ng Joo Hee, Chief Executive, PUB, Singapore's National Water Agency
2. Steve Demetriou, Chairman and Chief Executive Officer, Jacobs
3. Patrick Decker, Chief Executive Officer, Xylem
4. Dr Alan Ryder, Founder and Chief Executive Officer, RSK Group
5. HP Nanda, Global Vice President and General Manager, DuPont Water Solutions
6. Tan Cheng Guan, Executive Vice President and Head of Group Centre Excellence, Sembcorp Industries
7. Bambang Susantono, Vice President (Knowledge Management and Sustainable Development), Asian Development Bank
8. Jennifer Sara, Global Director for Water Global Practice, World Bank Group

#### SESSION 2 (1500 – 1645 Singapore time)

#### **Plenary 2 - Riding the Wave: Ensuring Security Against Climate Uncertainties**

Session will examine how different stakeholders leverage innovation to implement solutions to safeguard urban water systems against shocks caused by climate uncertainties. Case studies will be presented to demonstrate solutions in building resilience to extreme weather events and enhancing resource efficiency.

Panel Members:

1. Ahmed Aboutaleb, Mayor of Rotterdam
2. Chew Men Leong, President, Singapore Water Association
3. Cindy Lim, Chief Executive Officer, Keppel Infrastructure
4. Ana Giros, Senior Executive Vice President, Suez
5. Carlos Cosin, President, International Desalination Association
6. Prof Hamanth Kasan, General Manager (Scientific Services), Rand Water, South Africa and Vice President, International Water Association
7. Richard Threlfall, Global Head of Infrastructure, KPMG (UK)

*Accurate as of 20 May 2021*

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**SESSION 3 (1700 – 1815 Singapore time)****In Conversation with Singapore's Deputy Prime Minister and Coordinating Minister for Economic Policies Mr Heng Swee Keat**

Jointly organised with World Cities Summit, DPM will deliver a keynote address and participate in a moderated dialogue focused on how Singapore can respond to the pandemic, climate crisis and other disruptions to emerge more sustainable and resilient.

## SMART WATER MANAGEMENT USING IOT AND AI/MACHINE LEARNING: CASE STUDIES AND OVERCOMING CHALLENGES

### **Objective:**

To inform and engage the water sector industry on the emerging IOT technologies and how it can be applied to enhance efficiency, safety and resilience of the operations. The course will highlight actual use-cases deployed in water sector in Singapore, so the participants can better appreciate the applications of the Technology. Through the hands-on engagement during the course, the participants will be able to understand the end-to-end IOT system architecture such as sensors, gateways, wireless communications, Cloud, Analytics, and Custom Apps. The course will also inform the participants on the challenges of existing technologies like different wireless protocols, interoperability, technology obsolescence, cyber security etc., and how to overcome these challenges. In the end, it will also give some guidance on how to embark on IOT at their work and how to bring change management so that organisations can reap benefits from IOT.

### **Learning Outcomes:**

1. Understand basics of IOT, Cloud, AI/ Machine Learning and associated terminologies.
2. To be informed on existing and emerging technologies in IOT, challenges and how to overcome those challenges.
3. Hands-on learning on setting up end-to-end IOT system, from setting-up sensors, device/ gateway for communication, access and visualize data on the cloud software.
4. Learn about basics of AI / Machine learning and how it can help generate actionable insights or alerts for smart operations.
5. How to start the digital transformation journey at work through IOT and enabling change Management so that the enterprise can reap benefits of IOT.

### **Course Outline:**

- Introduction to IOT and Terminologies
- LPWAN Technologies for Industrial IOT
- Advantages and limitations of different technologies
- Different Applications / Case Studies of IOT for water applications
- Using IOT software for device management, data visualization setting up rules for generating alerts and notifications
- Introduction to Data Analytics, AI/ Machine Learning
- Practical Use Cases using Data Analytics / AI / Machine Learning using Enterprise IOT Cloud Software
- Challenges with existing IOT Technologies – different wireless protocols, standards, hardware, cyber security, interoperability, standards etc., and how to overcome the challenges
- How to start with Digital Transformation Journey through IOT at work and how to enable change management

### **Programme**

Date	1 <sup>st</sup> -2 <sup>nd</sup> Jul 2021
Duration	2 days (PM session)
Time	1.00pm – 5.30pm
Venue	Virtual Training

### **Course Fee (Excluding GST)**

Course Fee	SWA Member	Non-Member
Full Fee	SGD 250.00	SGD 350.00

Discount code for SWA members: **SIWW21SWATRG**



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## Innovation to Practice Series

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*\*Denotes free-to-air sessions*

## **I2P.1 The Journey of Innovation Implementation: Ceramic membrane microfiltration for surface water treatment**

22 June 2021 (Tuesday), 6.00pm-7.00pm SGT (GMT+8)

Co-organiser: PWNT

Membranes for filtration during water treatment have been operating for a few decades, but only recently have ceramic membranes been installed for surface water treatment. Ceramic membranes offer not only the robust filtration barrier that membranes provide, but also the durability (>15 years) and compatibility with chemicals such as ozone, to allow greater flexibility for operation and cleaning.

PWNT's CeraMac® system has been installed at 400 Mld capacity, in total, for surface water treatment plants in Singapore, the United Kingdom, Switzerland, and the Netherlands. The journey of consideration, testing, and implementation for a new innovative technology is unique to each utility, but all involve a pilot- or demonstration-scale evaluation.

This session will feature speakers from PUB, Singapore's Water Agency and Scottish Water who will share their perspective on the journey of implementing these new technologies into their utilities. Their experiences will help other utilities with options for how to plan and evaluate filtration technologies to gain confidence in full-scale implementation.

<b>Introduction</b> <i>Holly Shorney-Darby, Senior Project Manager, PWNT</i>
<b>From Pilot to Full-Scale Implementation: Singapore's Choa Chu Kang Waterworks, PUB</b> <i>Puah Aik Num, Chief Specialist (Water Treatment) &amp; Chief Engineer, Water Supply (Plants) Department, West Division, PUB, Singapore's National Water Agency</i>
<b>From the Stone Age to the Future of Water Treatment</b> <i>Stewart Sutherland, Transitional Risk and Asset Capability Team Leader, Scottish Water</i>
<b>Moderated discussion and Q&amp;A</b> <i>Puah Aik Num, Chief Specialist (Water Treatment) &amp; Chief Engineer, Water Supply (Plants) Department, West Division, PUB, Singapore's National Water Agency</i> <i>Stewart Sutherland, Transitional Risk and Asset Capability Team Leader, Scottish Water</i> <i>Holly Shorney-Darby, Senior Project Manager, PWNT – Moderator</i>
<b>Summary and Closing</b> <i>Holly Shorney-Darby, Senior Project Manager, PWNT</i>

## **I2P.2 Digital Blueprint for Water Utility Companies – Data Driven Decision Making**

22 June 2021 (Tuesday), 8.00pm-9.00pm SGT (GMT+8)

Co-organiser: Binnies

Binnies, water and environment services provider and Aarhus Vand, Denmark's leading water utility company, are currently implementing a first of its kind digital blueprint across the water utility's business.

A digital blueprint forms a link between digital initiatives and wider business goals to ensure they are aligned across short-, medium- and long-term time horizons. It recognises the need for a line of sight between the decisions a water utility company makes and the data necessary to make them. Creating a digital blueprint requires an understanding of the organisation's current digital maturity. The Digital Readiness Level tool can be used by organisations to evaluate their maturity across six key areas: organisational intent, standards and governance, digital architecture, data quality, the implementation roadmap and digital investment planning.

## **I2P.3 Building Water Resilience with Membrane Technology – Urban and Industrial Applications**

23 June 2021 (Wednesday), 6.00pm-7.00pm SGT (GMT+8)

Co-organiser: Memstar

This session will showcase the following two case studies:

Case Study 1: Taiwan's worst drought in decades has resulted in seriously unbalanced water resources within the island. At the north and south ends, many reservoirs are exhausted and dry. What is the solution for such an existential challenge brought about by global warming? JHB and Memstar completed the mobile emergency desalination equipment deployment within 66 days.

Case Study 2: Effective industrial wastewater treatment is key to ensuring water security. We will present a case study about a WWTP for a large cheese production facility that has been operational since August 2020 in the USA. The major objectives are to have stable operation despite the challenging influent which can have high levels of solids and FOG through the MBR membrane, and to consistently produce an effluent with low TSS & TP. The MBR system utilizes Memstar's Energy Saving Air Scouring (ESAS) technology and operates at a very low energy while meeting all performance metrics.

<b>Opening</b> Shiladitya (Shil) Basu, Sales Director, Memstar (USA)
<b>Presentation by JHB Envirotech INC</b> <i>Neal Chen, Vice President of Business Development, JHB Envirotech INC</i>
<b>Advantages of MBR to Treat Dairy Wastewater for Direct Surface Water Discharge</b> <i>Jeff Vanvoorhis, Vice President of Sales &amp; Marketing, Symbiont</i>
<b>Moderated discussion and Q&amp;A</b> <i>Neal Chen, Vice President of Business Development, JHB Envirotech INC</i> <i>Jeff Vanvoorhis, Vice President of Sales &amp; Marketing, Symbiont</i> <i>Shiladitya (Shil) Basu, Sales Director, Memstar (USA)</i>
<b>Summary and Closing</b> <i>Shiladitya (Shil) Basu, Sales Director, Memstar (USA)</i>

## I2P.4 Planning Blue and Green Cities

24 June 2021 (Thursday), 4.00pm-5.00pm SGT (GMT+8)

Co-organiser: Arup

This session presents innovative case studies from China and Singapore focusing on blue and green infrastructure, water cycle governance, stormwater analytics, and city masterplanning. The Shanghai Drainage Masterplan, comprising a blue, green, grey infrastructure masterplan, was developed for one of the largest cities in the world. This masterplan features innovative digital approaches to stormwater analytics and water governance mapping as well as drawing on global best practice for blue and green infrastructure. In Singapore, blue and green infrastructure masterplans embracing the Active, Beautiful, and Clean Waters approach are being implemented, and selected masterplans will be featured during the session.

<b>Opening by Moderator</b> <i>Vincent Lee, Global Water Skills Leader, Arup</i>
<b>Blue Green Master-planning in China</b> <i>Michael Zhao, China Water Leader, Arup</i>
<b>Blue Green Masterplanning in Singapore</b> <i>Peter Stones, Singapore Water Leader, Arup</i>
<b>Moderated Panel Discussion and Q&amp;A</b> <i>Michael Zhao, China Water Leader, Arup</i> <i>Peter Stones, Singapore Water Leader, Arup</i> <i>Lanzhu Shao, Digital Water Governance Specialist, Arup</i> <i>Thomas Sagris, Digital Water Research Leader, Arup</i> <i>Vincent Lee, Global Water Skills Leader, Arup – Moderator</i>
<b>Summary and Closing by Moderator</b> <i>Vincent Lee, Global Water Skills Leader, Arup</i>



## **I2P.5 Breaking Boundaries in Digital Delivery**

24 June 2021 (Thursday), 5.30pm-6.30pm SGT (GMT+8)

Co-organiser: Mott Macdonald

### **Case Study 1**

Anglian Water Strategic Pipeline Alliance – a case study to explore an innovative approach to delivering a major programme of water transmission pipelines. The Anglian Water region is water scarce and subject to climate uncertainties. This case study will focus on the development of the programme using an innovative project delivery model, the Project 13 approach. This approach integrates the full supply chain into the project delivery process, described as an enterprise model, boosting certainty and productivity in delivery and improving whole life outcomes in operation. The case study will focus on setting up differently to deliver outcomes (using a Construction to Production ethos), give live examples on efficiency and sustainability benefits and discuss some of the digital enablers.

### **Case Study 2**

This case study will demonstrate how an innovative combination of IoT data capture, real-time process modelling, and machine learning provided valuable insight into plant operation. Mott MacDonald have supported Watercare (NZ) in the design and construction of Rosedale Wastewater Treatment works. This case study will explore how the implementation of process modelling tools (e.g. EnviroSim BioWin) combined with machine learning predictions can support plant commissioning and operations.

The Rosedale Digital Twin uses a novel combination of real-time process modelling and predictive machine learning models to provide unique insight into plant operations. By combining data from multiple disparate sources (e.g. weather, telemetry) and integrating with industry leading analytics, engineers and operators gain new insights into current and future plant performance. This leads to improved plant performance, decreased risk and consumables consumption. Treatment Digital Twins have been successfully used for predictive performance and virtually trialling plant operating conditions, resulting in up to 20% savings on power costs and 12% reduction in commissioning time.

## **I2P.6 Imagine H2O Asia Startups in Action: Case Studies from Singapore, Vietnam & Cambodia**

25 June 2021 (Friday), 1.00pm-2.00pm SGT (GMT+8)

Co-organiser: Imagine H2O Asia

Successful water technology startups don't just sell technology – they must deliver a whole solution that solves an urgent and underserved problem for a customer. While financial barriers and perceived risk slow the adoption of innovation across Southeast Asia, early champion customers play a transformational role in the ecosystem – helping innovators verify problem statements, test and localize solutions for specific markets, and crucially, secure the reference cases required to replicate and scale their businesses.

This interactive session will feature three practical case studies featuring Imagine H2O Asia startups jointly presenting with their pilot or commercial customers in Singapore, Vietnam and Cambodia. From apparent loss detection in rural Cambodia, to water reuse and recovery in Vietnam's industrial parks, case studies will showcase a diverse set of innovation projects in progress as well as share insights on the ingredients for successful startup collaborations in the water sector. Featured case studies include:

- 1) SmartTerra: AI-powered analytics that predicts leaky pipes and incorrect meters to reduce real and apparent losses. (Customer: Khmer Water Supply Holdings - Cambodia)
- 2) Environsens & SpaceAge Labs: Water toxicity sensor for real-time contamination detection enabled through low-power, wireless connectivity. (Customer: PUB - Singapore)
- 3) Fluid Technology Solutions: Osmotically-assisted RO solution for high recovery water reuse (Pilot customer: Renewable Technology Solutions (RTS) - Vietnam)

<b>Imagine H2O Asia Scene Setting</b> <i>Nimesh Modak, Director, Imagine H2O Asia</i>
<b>Case Study 1 Discussion (Cambodia) and Q&amp;A</b> <i>Gokul Krishna Govindu, Chief Executive Officer, SmartTerra</i> <i>William Puyo, General Manager, Khmer Water Supply Holdings</i>
<b>Case Study 2 Discussion (Singapore) and Q&amp;A</b> <i>Leela Sriramula, Co-founder, SpaceAge Labs</i> <i>Shailesh Kharkwal, Chief Executive Officer and Co-founder, Environsens</i>
<b>Case Study 3 Discussion (Vietnam)</b> <i>Margarita Luis, Vice President of Applications &amp; Inside Sales, Fluid Technology Solutions</i> <i>Rodney Chapin, Chief Executive Officer, Ardurra International</i> <i>Ngoc Cao Minh, Managing Director, Renewable Technology Solutions</i> <i>John Tracy, Vice President of Sales &amp; Marketing, Fluid Technology Solutions</i>
<b>Closing</b> <i>Nimesh Modak, Director, Imagine H2O Asia</i>

## **I2P.7 Sembcorp Innovation to Market Programme – SWING**

25 June 2021 (Friday), 4.00pm-5.30pm SGT (GMT+8)

Co-organiser: Sembcorp Industries

Sembcorp Water Innovation Nanjing (SWING), a global innovation to market programme developed by Sembcorp, provides funding, technical and commercial expertise to water companies to jointly develop or test-bed new technologies for scale in Sembcorp's key wastewater markets. Launched in 2019, SWING enables innovative technologies to be deployed in markets to address global wastewater treatment challenges in various industries.

In this webinar, two partners will share their experience with SWING on engineering localisation and business development support to realise and deploy their solutions in new markets. The session will be of interest to water start-ups looking for industry partners, technology investors, venture capitalists and incubators.

<b>Opening Remarks</b> <i>Dr Adrian Yeo, Senior Vice President, Sembcorp Industries</i>
<b>Introduction to Sembcorp's SWING Programme</b> <i>Tai Kee, Programme Manager, Sembcorp Industries</i>
<b>Oxford Molecular Biosensor's Innovation to Market Experience</b> <i>Professor Paul Whitehead, Managing Director, Oxford Molecular Biosensors Ltd</i> <i>Dr Cordelia Rampley, Chief Technology Officer, Oxford Molecular Biosensors Ltd</i>
<b>SENTRY's Innovation to Market Experience</b> <i>Dr Patrick Kiely, Chief Executive Officer, SENTRY</i> <i>Jon Grant, Chief Commercial Officer, SENTRY</i>
<b>Moderated discussion and Q&amp;A</b> <i>Professor Paul Whitehead, Managing Director, Oxford Molecular Biosensors Ltd</i> <i>Dr Cordelia Rampley, Chief Technology Officer, Oxford Molecular Biosensors Ltd</i> <i>Dr Patrick Kiely, Chief Executive Officer, SENTRY</i> <i>Jon Grant, Chief Commercial Officer, SENTRY</i> <i>Tai Kee, Programme Manager, Sembcorp Industries – Moderator</i>
<b>Closing</b> <i>Dr Adrian Yeo, Senior Vice President, Sembcorp Industries</i>

## **\*I2P.8 Increased Efficiency using Digital Water Solutions for Water Utilities**

25 June 2021 (Friday), 8.00pm-9.00pm SGT (GMT+8)

Co-organiser: Netherlands Water Partnership and Embassy of the Kingdom of the Netherlands

### **Case 1.1: AquaSuite / Vitens**

Water use varies greatly depending on the time of day, location, weather and many other factors. Each morning millions of us take a shower; on hot days we use hosepipes to water our gardens. The challenge is how to predict and meet the demand?

Vitens is the Netherlands' largest drinking water provider, supplying more than 5.6 million households in Friesland, Overijssel, Gelderland, Flevoland and Utrecht with clean drinking water. Vitens supplies around 360 billion litres of water per year. Managing and optimizing operations for almost 240 pumping stations and 96 production facilities is a challenge. Especially in times of prolonged draught. Vitens decided to centralise automation and ICT and apply smart digital solutions to optimise the drinking water production and meet this challenge.

While all assets are fully automated locally, operations come together centrally in a central control room where a smart water solution provides the top-level holistic control over the water loop. It provides source to tap overall control using AI to predict demand and all levels, flows and pressure in the network. The water supply is now fully automated. With 65% less variations in production it results in a calm network that can be operated with less people. And this has also resulted in improved water quality (42% less particle load in produced water) and energy savings (7%).

### **Case 1.2: AquaSuite / WBL**

There are substantial challenges in wastewater treatment management: climate change, an urgent need for sustainability, and stricter regulations make transport systems and treatment plants increasingly technically complex. At the same time, a growing number of digital technologies can convert data streams into valuable insights. That is why WBL is focusing on the digital transformation of its wastewater treatment infrastructure.

The transformation consists of two parts: the development and implementation of a big data platform and the implementation of a machine learning application on this big data platform. This monitors the performance of all 149 WBL sewage pumping stations and will detect abnormal behaviour at an early stage: blockages, leaks, unaccounted for water (infiltration or illegal spills) and early detection of pump blockage or performance reduction.

By using machine learning for the entire system, its performance will improve continuously. It will also allow for more efficient management and anticipate the need for maintenance — the largest expense for water authorities. The professional implementation and management of these rapidly developing technologies, which have to run 24/7 for operational support for operators and maintenance staff, places high structural demands on the cloud platform to be used. This is one of the reasons why WBL has chosen Microsoft Azure for the implementation of the big data platform and the solutions for advanced machine learning and artificial intelligence.

### **Case 2: Optiqua / PUB**

Monitoring water quality is an important part of the operations of a water utility. Traditionally, grab sampling and laboratory analysis have been the pre-dominant approach to quality monitoring. The use of grab samples, however, is not well suited for continuous monitoring of changeable water quality, as it only provides snap shots of the water composition and no information on variation therein during the time between samples. A further drawback of this approach is the time to result,

which can be hours or even days. To monitor the dynamics in water quality, as they for example occur in drinking water distribution networks, and to facilitate a quick and timely response to quality incidents and pro-active network operations, real time water quality information is vital.

Since all substances that come into the water matrix influence (the Refractive Index (RI) of the water, careful monitoring of this refractive index using Optiqua's EventLab system has proven to be a very powerful tool in drinking water quality event detection. Advantages of this technique include consistent sensitivity for all substances, response linear with concentration and high resistance to matrix interference. Once an unexpected change in RI is detected, the Root Cause of this so call "Event", needs to be established to determine the proper response by the utility company. With AI concepts Events could be classified into events that could adversely impact water quality. This will provide utility companies with even more actionable information.

## **I2P.9 Phnom Penh Water Story**

28 June 2021 (Monday), 4.00pm-5.00pm SGT (GMT+8)

In this session, we bring you the inspirational story of how Phnom Penh Water Supply Authority (PPWSA) transformed itself into an efficient and progressive water utility. Within 15 years, PPWSA introduced 24-hr water supply, widened its distribution network from serving 40% of Phnom Penh to 90% with clean and affordable water and reduced non-revenue water to 6%. Discover the factors behind the transformation, and learn how utilities around the world can emulate the success of PPWSA.

<b>Welcome and Introduction</b> <i>Professor Cecilia Tortajada, Professor in Practice – Environment Innovation, University of Glasgow</i>
<b>Building capacity for urban water management: Experience of JICA</b> <i>Dr Megumi Muto, Deputy Director, Ogata Research Institute, Japan International Cooperation Agency (JICA)</i>
<b>The Phnom Penh Water Story</b> <i>Sim Sitha, Director-General, Phnom Penh Water Supply Authority (PPWSA)</i>
<b>Moderated Panel Discussion and Q&amp;A</b> <i>Dr Megumi Muto, Deputy Director, Ogata Research Institute, JICA</i> <i>Sim Sitha, Director-General, Phnom Penh Water Supply Authority</i> <i>Professor Asit Biswas, Distinguished Visiting Professor, University of Glasgow, UK and Managing Director, Water Management International Pte Ltd, Singapore</i> <i>Pawan Sachdeva, Director, Avendus Capital Pte Ltd and Non-Executive Director, Water Management International Pte Ltd</i> <i>Professor Cecilia Tortajada, Professor in Practice – Environment Innovation, University of Glasgow – Moderator</i>
<b>Closing Remarks</b> <i>Professor Cecilia Tortajada, Professor in Practice – Environment Innovation, University of Glasgow</i>

## **I2P.10 Achieving Carbon Net Zero Utilities**

28 June 2021 (Monday), 5.30pm-6.30pm SGT (GMT+8)

Co-organiser: Isle Utilities Ltd

In this session two internationally leading utilities (Melbourne Water from Australia, and Aqualia from Spain) will share their experiences in embracing the Zero Net Carbon challenge. This will include approaches to monitor and measure the scale of emissions (both Scope 1 and Scope 2) and case study reports of ground-breaking projects which these two utilities have undertaken to address the challenge.

<b>Welcome and Opening</b> <i>Dr Piers Clark, Chairman, Isle Group</i>
<b>Scope 1 emissions – Measure what can be measured, make measurable what cannot be measured</b> <i>Chris Williams, GM Integrated Planning, Melbourne Water</i>
<b>The Water Cycle as a Model of Circular Economy: Examples of Zero Carbon Solutions</b> <i>Frank Rogalla, Head of Innovation, Aqualia</i>
<b>Moderated Panel Discussion and Q&amp;A</b> <i>Chris Williams, GM Integrated Planning, Melbourne Water</i> <i>Frank Rogalla, Head of Innovation, Aqualia</i> <i>Dr Piers Clark, Chairman, Isle Group – Moderator</i>
<b>Summary and Closing</b> <i>Dr Piers Clark, Chairman, Isle Group</i>

## I2P.11 Nanostone Water Innovative Ceramic Membrane Technology in Water Treatment Applications

28 June 2021 (Monday), 9.00pm-10.00pm SGT (GMT+8)

Co-organiser: Nanostone

The Nanostone ceramic membrane represents the latest technological breakthrough from Nanostone Water. This unique and patented “segmented monolith” product is the most innovative ceramic membrane technology in the market, which has helped us gain rapid adoption in both municipal and industrial applications.

For drinking water treatment, the Nanostone ceramic membrane replaces the conventional treatment processes with a reliable, compact single-step process, which provides high reliability and significant cost reduction.

**Case study 1:** Nanostone technology has helped CRWA to achieve extraordinary results. This plant was experiencing the fiber breakage and frequent cleanings when using PUF membrane, which led to significantly reduced recovery rates and increased manpower to maintain the membrane system. Additionally, because the system was operated in crossflow mode, there was a significant amount of pumping energy used to run the system. After Nanostone CM-151 retrofit, CRWA Achieved a 97.7% recovery rate compared to 83.6% prior to the retrofit, and a 50% reduction in power use.

The Nanostone industrial solutions with compact, robust treatment systems are ideal for on-site treatment and optimized for multiple applications and industries, successful installations are running in power, mining, microelectronic and chemical refinery industries.

**Case study 2:** In one North American semiconductor fabricator, the end user needed to upgrade its existing hydrofluoric acid (HF) wastewater treatment process to address compliance concerns caused by particulate breakthrough, and to reuse the wastewater to reducing its environmental impact. After system upgrade with Nanostone ceramic membrane, this fabricator not only enabled the wastewater reuse, it also eliminated the need to treat and discharge 23 m<sup>3</sup>/h of wastewater. As a result, more than \$800,000 in annual savings through a reduction in wastewater treatment costs, discharge fees, and the acquisition and treatment of freshwater, also ensures more stable reverse osmosis (RO) operation and consistent water quality.

<b>Opening</b> <i>Jonathan Clement, Global Technology Officer, Nanostone Water, Inc.</i>
<b>Nanostone Drinking Water Case Study</b> <i>Adam Telfer, Operation Manager of Canyon Regional Water Authority</i>
<b>Nanostone Industrial Applications Case Study</b> <i>Carlo Patteri, Business Leader Industrial Water, Nanostone Water, Inc.</i>
<b>Q&amp;A</b> <i>Adam Telfer, Operation Manager of Canyon Regional Water Authority</i> <i>Carlo Patteri, Business Leader Industrial Water, Nanostone Water, Inc.</i> <i>Jonathan Clement, Global Technology Officer, Nanostone Water, Inc. – Moderator</i>
<b>Summary and Closing</b> <i>Jonathan Clement, Global Technology Officer, Nanostone Water, Inc.</i>



## **I2P.12 Innovative Tools and Resources for Selecting City Sanitation Systems**

29 June 2021 (Tuesday), 2.30pm-3.30pm SGT (GMT+8)

Co-organiser: Asian Development Bank

Many middle income and most lower income cities have not yet been able to make safe, affordable sanitation systems available for all their residents. This poses serious risks to citywide public health and perpetuates environmental and water resource pollution and degradation. Every city has a unique combination of urban development; housing type and tenure; topology, climate and water resources; policy, institutions and regulations; private sector engagement; revenue and budgets. These factors – and others - impact the choice of sustainable sanitation options in urban settings. The complexity and uniqueness of these factors limit the practicality of universal approaches and ‘short-cuts’ to decision making. They suggest the need for situation-tailored tools and the application of professional expertise and experience in applying them.

Several case studies from India and Bangladesh will profile innovative, practical, bespoke tools which have been developed to support sanitation-decision or operating and in these specific cities.

These innovative approaches to decision-making will provide ideas and first step to other cities in the process of similar decision making and operational support.

## **I2P.13 Advancing Water Sustainability with Innovations - Learnings from Municipal**

29 June 2021 (Tuesday), 4.00pm-5.00pm SGT (GMT+8)

Co-organiser: DuPont Water Solutions

Water sources for municipal localities vary from ground water to lakes and rivers — even the sea and wastewater with latest innovations and technologies. Innovation plays a major role in ensuring a clean, safe, and affordable supply of water. DuPont Water Solutions offers expertise and advanced technologies that enable municipal water-treatment solutions such as wastewater treatment, drinking-water production, and trace contaminate removal.

The highlights of this panel discussion include, but not limited to the sharing of:

- DuPont FilmTec at Australia's first large-scale municipal desalination plant in Perth (PSDP);
- How Southern Seawater Desalination Plant (SSDP) reduce heavy reliance on climate in Perth;
- Results from applying the new dry seawater reverse osmosis membranes in a desalination municipal plant.

## I2P.14 Delivering Vibrant and Climate-Resilient Coastal Communities

29 June 2021 (Tuesday), 5.45pm-6.45pm SGT (GMT+8)

Co-organiser: Jacobs

Rising sea levels globally present a growing risk to coastal areas, with flooding during major storm events and the more permanent inundation of low-lying areas. Pro-actively managing this risk is essential to maintaining sustainable coastal areas.

Lessons from diverse international programmes will demonstrate differing approaches to actively addressing this threat, while maintaining the coastal economy, facilitating ongoing development, and protecting the environment and its communities.

From the long-term protection of London, UK, to sustainable development in the Red Sea, and resilience for low lying Miami Beach, USA, attendees will hear transferrable lessons from these programmes, in delivering vibrant coastal areas in the face of sea level rise. We will hear case studies from:

- Thames Estuary Asset Management 2100 (TEAM2100) Programme in the UK, where flood protection of London is being implemented in line with its adaptive long-term strategy to address sea level rise and storm surges. Evolving from the existing flood protection asset system, integrating green and grey solutions, supported by an innovation programme and comprehensive digital strategy to optimise resilience delivery.
- The Red Sea Project in the Kingdom of Saudi Arabia will be the world's most ambitious and exciting tourism and hospitality project, setting new standards in sustainable development. The Red Sea Development Company is uncompromising in its commitment to protect and preserve the natural environment; pioneering new standards in sustainable development is at the heart of the Project. We will discuss the precautionary and environmental sustainability principles adopted to deliver long-term social and environmental benefits, and the goal of integrating engineering and nature-based solutions for coastal resilience, by enhancing natural features such as reefs and mangroves to provide protection which will naturally adapt over time.

Following the case study presentations, the speakers will be joined by a representative from Singapore's PUB coastal resilience team for a panel discussion on the transferrable lessons from these programmes.

Attendees will have opportunity to understand the varied drivers and approaches being adopted across these coastal programmes. From centuries old infrastructure to new development; programmatic approaches to site-specific solutions; and hard protection to nature-based solutions; the discussion will cover the spectrum of coastal resilience and offer insights for attendees to consider as they too seek to deliver vibrant coastal areas in the face of sea level rise.

<b>Opening and Introduction</b>
<i>Adam Hosking, Global Director for Water Resources and Resilience, Jacobs</i>
<b>Sustainable Island Development an A Changing Climate: Red Sea Development</b>
<i>Julian Harvey Bennett, Marine Infrastructure Director, The Red Sea Development Corporation</i> <i>Dr Sean O'Neil, Global Lead for Coastal Infrastructure, Jacobs</i>
<b>Long-term Coastal Resilience for a Major City: Thames Estuary Asset Management 2100</b>
<i>Helena Henao-Fernandez, Deputy Program Director, Thames Estuary Asset Management 2100</i>

<i>Abby Crisostomo, Project Director, Thames Estuary 2100, Environment Agency, UK</i>
<b>Moderated discussion and Q&amp;A</b> <i>Julian Harvey Bennett, Marine Infrastructure Director, The Red Sea Development Corporation</i> <i>Dr Sean O’Neil, Global Lead for Coastal Infrastructure, Jacobs</i> <i>Helena Henao-Fernandez, Deputy Program Director, Thames Estuary Asset Management 2100</i> <i>Abby Crisostomo, Project Director, Thames Estuary 2100, Environment Agency, UK</i> <i>Adam Hosking, Global Director for Water Resources and Resilience, Jacobs</i>
<b>Closing</b> <i>Adam Hosking, Global Director for Water Resources and Resilience, Jacobs</i>

## **I2P.15 Resource Circularity through Digital Solutions**

30 June 2021 (Wednesday), 4.00pm-5.30pm SGT (GMT+8)

Co-organiser: Wittenveen+Bos

**\*I2P.17 Adaptation in South East Asian Cities: Solutions for Heat Stress, Flooding & Planning an Integrated Vision for the Future**

30 June 2021 (Wednesday), 9.00pm-10.00pm SGT (GMT+8)

Co-organisier: Netherlands Water Partnership and Embassy of the Kingdom of the Netherlands

This session will bring together resilience expertise in the Netherlands and southeast Asia in a joint exchange of solutions kicked off by a high-level panel of representatives from Singapore and the Netherlands to reflect on the important role of international knowledge exchange and collaborations to help build resilient cities.

This session will focus more specifically on climate-resilient solutions to two of the most pressing challenges for the future of climate resilience in cities: flooding and heat stress. Additionally, we will take a closer look at the role of master planning and innovative solutions for adaptive integrated management and city planning in coastal cities, sharing strategies on long term adaptation visions.

Adaptation measures being addressed on this session will include resilient infrastructure, nature-based solutions, integrated management of water resources, innovative modeling, and coastal engineering to provide examples of initiatives for future-proof and resilient cities.

<b>Opening Remarks</b> <i>Henk Ovink, Special Envoy for International Water Affairs for the Kingdom of the Netherlands, Ministry of Infrastructure and Water Management</i>
<b>The Power of Building with Nature to Mitigate and Adapt to Flooding</b> <i>Matthijs Bouw, Founding principal, Eco Shape – One Architecture</i> <i>Laura Vonhögen-Peters, Associate Director Singapore Operations, Deltares</i>
<b>Combating Urban Heat Stress</b> <i>Wouter Vos, Director International, KuiperCompagnons</i>
<b>Coastal Cities Adaptation as the Next Frontier</b> <i>Kristina Knauf, Associate and Architect, MVRDV</i> <i>Sander den Blanken, Managing Director, Bam Delta Marine Consultants</i> <i>Rutger de Graaf, Director, Blue21</i>
<b>Reflections on a Resilient Vision for Coastal Cities</b>
<b>Summary and Closing</b> <i>Bianca Nijhof, Managing Director of the Netherlands Water Partnership</i>

## **\*I2P.19 ReCirc - Towards integrated zero waste solutions for a circular economy**

1 July 2021 (Thursday), 4.00pm-5.30pm SGT (GMT+8)

Co-organiser: Ministry of Infrastructure and Water Management and Netherlands and Embassy of the Kingdom of the Netherlands

The 4-year public-private partnership program ReCirc Singapore was established in 2018 to help accelerate Singapore and The Netherlands' ambition in transitioning towards a circular economy. The outline of the webinar is to share the advancements and legacy of the PPP ReCirc on how material and resource recovery creates circular opportunities in diverse sectors like food waste, plastic waste, used water and sludge, and incineration bottom ashes for companies and R&D institutes - and how governments can play a stimulating and supporting role.

We will touch upon examples like the created circularity scans, zero-waste solutions, and innovative circular technologies fitting within the Singapore Green Plan 2030 and the upcoming developments at Mandai.

<b>Opening and Introduction</b> <i>Ms Sann Carrière MA, Liaison of the ReCirc program</i>
<b>Governmental collaboration Netherlands-Singapore on Circular Economy</b> <i>Mr Joan Prummel, (International Circular Economy Advisor), Ministry of Infrastructure and Water Management, Netherlands</i>
<b>Singapore's Material Flow Analysis &amp; City Blueprint</b> <i>Mr Kees Roest, (Senior scientific researcher - Energy &amp; Circular Systems), KWR Water Research Institute</i>
<b>Integrated Zero-waste Solutions in Water, Sludge and Food</b> <i>Mr Wilfred Appelman, (Expertise leader Separation &amp; Purification), Wageningen Food &amp; Biobased Research</i>
<b>Water and Resources Refinery</b> <i>Mr Arjen Van Nieuwenhuijzen, (R&amp;D and Innovation Director Circular and Biobased Solutions), Witteveen+Bos</i>
<b>Moderated Panel Discussion and Q&amp;A</b> <i>Mr Joan Prummel, International Advisor Circular Economy, Ministry of Infrastructure and Water Management, Netherlands</i> <i>Mr Arjen Van Nieuwenhuijzen, R&amp;D and Innovation Director Circular and Biobased Solutions, Witteveen+Bos</i> <i>Mr Kees Roest, Senior Scientific Researcher - Energy &amp; Circular Systems, KWR Water Research Institute</i> <i>Mr Wilfred Appelman, Expertise leader Separation &amp; Purification, Wageningen Food &amp; Biobased Research</i> <i>Ms Sann Carrière MA, Liaison of the ReCirc program – Moderator</i>
<b>Closing</b> <i>Ms Sann Carrière MA, Liaison of the ReCirc program</i>

## I2P.20 Beyond the Buzz: Demystifying Smart Water

1 July 2021 (Friday), 4.00pm-5.30pm SGT (GMT+8)

Co-organiser: SWAN Forum APAC Alliance

Water and wastewater utilities face challenges of aging infrastructure, high energy costs, and declining revenues. While many see the value in “digital water solutions,” there are complexities that slow down advancement, such as selecting the right technology, meeting regulatory compliance, and competing investment decisions.

During this 90-minute Workshop, the SWAN APAC Alliance will demonstrate the value of digital transformation in the water sector, by highlighting global perspectives on data and asset management strategies for water utilities. These strategies improve the ability to monitor asset health, capture data for strategic insights, and communicate with customers. Developing the foundations for smart water networks, can lead to powerful analytics further enable optimisation and smarter operation to meet these challenges.

<b>Opening Remarks</b>
<i>George Theo, Chief Executive Officer, Unitywater and Chairman of the SWAN APAC Alliance</i>
<b>Global Perspective on the Smart Water Journey</b>
<i>Kelven Lam, Sector Specialist, Emerald Technology Ventures</i>
<i>Rebecca Chenery, Chief Digital Officer, Watercare</i>
<i>Patrick Keaney, Worldwide Director of Development, AWS</i>
<i>Andy Smith, Smart Water Manager, Anglian Water - Moderator</i>
<b>The Value of Data for Utility Asset Management</b>
<i>Martine Watson, General Manager for Operations, Maintenance &amp; Planning, Queensland Urban Utilities</i>
<i>Rob Main, Business Program Manager Intelligent Networks, Hunter Water – Moderator</i>



## **I2P.21 Smart Water Safety Technologies for Augmented Capabilities and Performance: Case Studies from Singapore and China**

2 July 2021 (Friday), 2.00pm-3.00pm SGT (GMT+8)

Co-organiser: ZWEEC

Learn how leading water authorities, PUB, Singapore's National Water Agency and Yangtze River Monitoring and Scientific Research Centre (Yangtze River Authority), leverage Smart Technologies to augment their operational capabilities and performance in securing water safety.

At this interactive session, you will learn about PUB's Integrated Smart Biomonitoring Network: Next-generation Water Security Infrastructure for Comprehensive Water Quality Monitoring, as well as Yangtze River Authority's adoption of AI-based Smart Algae Monitoring technology which is revolutionising traditional algae monitoring approaches.

<b>Opening and Introduction</b> <i>Foo Say Tun, Chief Executive Officer, ZWEEC Analytics</i>
<b>Singapore Case Study: PUB, Singapore's National Water Agency</b> <i>Dr Lim Mong Hoo, Chief Specialist (Water Quality), PUB (invited)</i> <i>Sarah Teng, Director of Water Quality Department, PUB (invited)</i>
<b>China Case Study: Yangtze River Monitoring and Scientific Research Centre</b> <i>Wang Ying Cai, Chief Engineer, Yangtze River Authority</i>
<b>Moderated Panel Discussion and Q&amp;A</b> <i>Dr Lim Mong Hoo, Chief Specialist (Water Quality), PUB (invited)</i> <i>Sarah Teng, Director of Water Quality Department, PUB (invited)</i> <i>Wang Ying Cai, Chief Engineer, Yangtze River Authority (invited)</i> <i>Foo Say Tun, Chief Executive Officer, ZWEEC Analytics – Moderator</i>
<b>Closing</b> <i>Foo Say Tun, Chief Executive Officer, ZWEEC Analytics</i>

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



SIWW2021 ONLINE



**21 June – 2 July 2021**

# WATER CONVENTION – ORAL & POSTER PRESENTATIONS

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Date	4pm – 5.30pm SGT (90mins)				6pm – 6.30pm SGT (30mins)		7pm – 8.30pm SGT (90mins)			
22 Jun, Tue	WC3.1 Decentralised Water Treatment	WC2.1 Improving Water Treatment	WC3.2 Resource Efficient Treatment I	Break (30mins)		Break (30mins)	WC1.1 Network Planning for Resilience	WC5.1 Systems Approaches and Enabling Environment	WC3.3 Resource Efficient Treatment II	
23 Jun, Wed	WC4.1 Water Circular Economy in Cities of the Future I	WC2.2 Innovation in Desalination	WC3.4 Intensification of Anaerobic Digestion		WCP.1 Poster Q&A Session		WC1.2 Optimising Network Operations	WC5.2 Source Tracking	WC3.5 Advancement in Solids Treatment	
24 Jun, Thu	WC4.2 Water Circular Economy in Cities of the Future II	WC2.3 Membranes - Fast Forward	WC3.6 Membrane Bioreactor Processes		WCP.2 Poster Q&A Session		WC1.3 Water Conservation and Efficiency Measures		WC3.7 Nutrient Removal	
25 Jun, Fri	WC4.3 Hybrid Blue/Green/Grey Infrastructure	WC2.4 Expanding Ceramic Membrane Applications	WC3.8 Process Intensification: Integrated Approaches		WCP.3 Poster Q&A Session		WC1.4 Non-revenue Water	WC5.3 Wastewater Monitoring and Management	WC3.9 Biofilm Processes	
26 Jun, Sat										
27 Jun, Sun										
28 Jun, Mon	WC1.5 Smart Water Grid	WC4.4 Water for Liveability	WC3.10 Advanced Modelling, Sensing & Control I - Outside the Fence		WCP.4 Poster Q&A Session		WC5.4 Water Resources in Catchments/ Reservoirs	WC2.5 Emerging Contaminants - Practice and Science	WC3.11 Advanced Modelling, Sensing & Control II - Inside the Fence	
29 Jun, Tue	WC1.6 Smart Metering	WC4.5 Basin Connected Cities	WC3.12 Used Water Asset Management		WCP.5 Poster Q&A Session			WC2.6 Integrated Water Reuse	WC3.13 Microbial Ecology	
30 Jun, Wed	WC1.7 Asset Management for the Distribution Networks		WC3.14 Industrial Wastewater Treatment, Recycling and Reuse		WCP.6 Poster Q&A Session		WC5.5 Water Quality in Distribution Systems and Buildings	WC2.7 Intelligent Plant of the Future		
1 Jul, Thu		WC4.6 Social resilience of communities to climate extremes						WC5.6 Bio-sensing	WC2.8 Source Control in Advanced Reuse Applications	WC3.15 Wastewater Treatment for Developing Countries

### Legend:

	Delivering Water from Source to Tap (Network)
	Delivering Water from Source to Tap (Treatment)
	Effective and Efficient Wastewater Treatment
	Cities of Future
	Water Quality and Health

**22 June 2021 (Tuesday)**

**7.00pm-8.30pm (SGT) (GMT +8)**

**Session 1.1 – Network Planning for Resilience**

**Overview Of Network Planning Using Digital Twin, Including Initiatives To Predict, Discover And Repair Leaks And How The Results Are Used For The Network Planning For A Complete Picture.**

P. Plowman. Sydney Water (Australia)

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

**Planning For Drought Resilience City**

K. Sorensen. Kyl Center for Water Policy at Morrison Institute, Arizona State University (United States)

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

**Planning For Sponge City Network**

S. Liu. Tsing Hua University (China)

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

**Streamlining Delivery Of A 24X7 Water Supply Scheme In India**

N. Bockhoff, J. Cantone, A. Askar. SUEZ India (India)

SUEZ is currently working with municipalities in Coimbatore and Davanagere, India, to design, construct and maintain distribution networks that can provide continuous, 24X7 potable water supply. There was limited asset data available for the existing systems in these communities. To combat this, SUEZ developed a systematic approach to fill in data gaps, involving base mapping using satellite imagery, utilization of in-house digital platforms such as Real-time Operation Performance System (ROPeS), and management of extensive field surveying. The condition of existing mains in the networks were analyzed using non-destructive acoustic sensors, and an innovative machine learning based approach was utilized to help select suitable sections of pipe to scan to provide a representative sample of the entire network. The Optimatics' software platform Optimizer™, which employs evolutionary algorithm optimization, was used to analyze a broad range of design options and determine the optimal solution to maximize service level while minimizing CAPEX.

**23 June 2021 (Wednesday)**

**7.00pm-8.30pm (SGT) (GMT +8)**

**Session 1.2 – Optimising Network Operations**

**CALM NETWORK: The Next Generation Of Pressure Management For A Healthier Lifestyle For Water Systems**

A. Chazerain, D. Duccini, A. Rossi, H. Yin, G. Cussonneau, R. Wright. SUEZ Water Technology & Solutions (France)

Thanks to its proven impact on reducing water losses and slowing down the degradation of network infrastructure, water pressure has always been a lever for action for planners and operators. In the evolution of pressure reduction and modulation practices, SUEZ has been working since 2016 on a performance-based management system called the "Calm Network". One of its components, in combination with Inflowmatix, is the elimination of all point or cyclic pressure variations and excesses. Recent work includes: Solutions that can minimize pressure variations while meeting the minimum pressure at all points; solutions where DMA limits can be dynamically modified to minimize pressure drops during peak demand; and pump planning solutions that can automatically adapt to real-time conditions to meet water demand while optimizing performance. In our analysis, it is observed that by calming systems with appropriate methods, tools and accessories, pipe stresses can be avoided, resulting in noticeable tangible benefits.

**Data Driven Decisions - Operational Analytics To Inform Network Performance And Operations**  
**P. Bonk, J. Klaric. Innovyze (Australia)**

The Big Data era provides potential for far greater integration between operations, engineering and management. Smart meters, AMR, SCADA and other data collection processes are generating bigger/better but underutilised data sets. In pursuit of proactive decision making, operational analytics allows for prioritisation of response resources & deployment of accompanying action plans. The methodology of sourcing and configuring real-time data capture, identifying KPIs for application, running an analysis to create operational insights and utilising such insights for proactive system management will allow utilities, councils and supporting consulting companies to discover, address and solve the complex challenges confronting the industry. The intent of this paper is to methodically demonstrate ways in which Operational Analytics are within every utility and council's grasp utilising their existing skillsets, data sets, IT infrastructure and software tools. The paper will discuss a step by step approach for operational analytics grounded in the discussion of successful case studies.

## **Data-Driven And Model-Based Framework For Smart Water Grid Anomaly Detection And Localization**

Z. Wu, Y. He, A. Chew, M. Chen, LK. Cheong, SF. Hew, JJ. Wong. Bentley Systems, Inc. (United States)

With an increasing adoption of Advanced Meter Infrastructure (AMI), smart sensors together with SCADA systems, it is imperative to develop data analytics and couple the results with hydraulic modelling to improve the quality and efficiency of water service. One important task is to timely detect and localize anomaly events, which may include, but not be limited to, pipe bursts and unauthorized water usages. In this paper, a comprehensive solution framework has been developed for anomaly detection and localization by formulating and integrating the data-driven analytics with the hydraulic model calibration. Data analysis for anomaly detection proceeds in multiple steps including (1) a data-preprocess to eliminate and correct erroneous data records, (2) outlier detection by statistical process control methods and the deep machine learning, (3) system anomaly classification by correlation analysis of multiple sensor events. Classified system anomaly events are localized via hydraulic model calibration. The integrated solution framework is developed as a user-friendly and effective software tool, tested and validated on the selected target areas in Singapore.

## **Optimisation Of Pump Operations: NRW And OPEX Reduction**

K. Garcia. Maynilad Water Services, Inc. (Philippines)

With an increasing adoption of Advanced Meter Infrastructure (AMI), smart sensors together with SCADA systems, it is imperative to develop data analytics and couple the results with hydraulic modeling to improve the quality and efficiency of water service. One important task is to timely detect and localize anomaly events, which may include, but not be limited to, pipe bursts and unauthorized water usages. In this paper, a comprehensive solution framework has been developed for anomaly detection and localization by formulating and integrating the data-driven analytics with the hydraulic model calibration. Data analysis for anomaly detection proceeds in multiple steps including (1) a data-preprocess to eliminate and correct erroneous data records, (2) outlier detection by statistical process control methods and the deep machine learning, (3) system anomaly classification by correlation analysis of multiple sensor events. Classified system anomaly events are localized via hydraulic model calibration. The integrated solution framework is developed as a user-friendly and effective software tool, tested and validated on the selected target areas in Singapore.



**24 June 2021 (Thursday)**

**7.00pm-8.30pm (SGT) (GMT +8)**

**Session 1.3 – Water Conservation and Efficiency Measures**

**Efficiency And Commitment: Guaranteeing The Sustainability Of Water Supply In The Future**

FJ. Fernández, N. San Román. Canal de Isabel II, S.A. (Spain)

Climate change and population growth is currently threatening the sustainability of water supply for the 6.5 million people in the region of Madrid. Canal de Isabel II, S.A., the company that manages the water cycle as a whole in the region, has set out an ambitious plan aimed at guaranteeing supply, with a holistic approach ranging from the use of reclaimed water to customer engagement and loss minimisation, in which cutting-edge technologies play a major role. Additionally, the company has a progressive and seasonal tariff that strongly discourages excessive consumption and a unique model based upon centralised planning, design, operation and management of water infrastructures and resources throughout the region for all its 179 municipalities. As a result, the company has managed to reduce global demand per-head by 32% over the last 14 years and has set a further target representing a 25% reduction by 2030.

**Incorporating Behaviour Insights in Smart Water Meters Programme**

S. Seah, I. Toh, S. Koh, H. Ang, HH. Koh. Public Utilities Board (Singapore)

We tested the effect of using behavioural insights to reduce household water consumption via a water-tracking app linked to households' smart water meters. As a follow-up to a smart metering customer engagement pilot in 2017 and 2018, PUB and SUEZ partnered BIT in 2019 to conduct a new trial to use behavioural insights to enhance long-term customer engagement strategies. This trial specifically aims to decrease household water consumption and reduce the amount of time households take to fix leaks. The primary behavioural principles tested are: (i) making relevant social comparisons; (ii) helping households close the intention-action gap; (iii) reducing friction costs, and; (iv) personalisation. These behavioural insights were operationalized in the form of new app features such as a graph comparing the household's water consumption to their neighbours', a goal-setting feature to encourage households to practice water-saving behaviours, and a list of nearby plumbers available within the app.

**Sustainable Water Conservation In Brisbane**

L. Dudley. Queensland Urban Utilities (Australia)

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

## Using Data Science To Optimize Meter Asset Management: A Case Study In A Medium-Sized Utility

C. Boyle, J. Poff. Xylem (United States)

A common dilemma faced by water utilities interested in proactive apparent water loss control is (a) how to manage the overwhelming volume of data and (b) how to glean value-added insight in a timely manner from the data? Xylem partnered with Clayton County Water Authority in Georgia to answer these two questions. The project covered 3 phases and continues to run today, now in the third year of deployment. It leverages 5 years of historical billing, meter, and customer information data, ongoing data updates, and Xylem's Hidden Revenue Locator apparent loss technology, built off data science methodologies, to identify apparent loss issues on a monthly basis. Utility staff from IT, Meter Services, and Customer Services were instrumental in investigating the flags prioritized and presented in the dashboard, and resolving issues. This presentation will show that data science can be used to efficiently locate apparent loss issues, and also share how Clayton County Water Authority have been able to operationalise these outputs and tackle their meter under-registration issues in a proactive manner to meet revenue assurance and operational process efficiency.

**25 June 2021 (Friday)**

**7.00pm-8.30pm (SGT) (GMT +8)**

**Session 1.4 – Non-revenue Water**

**Finding Big Leaks With Big Data: New Approaches To Pipe Failure Monitoring**

R. Madhavanewswaran, V. Burtea. Mueller Water Products (Canada)

Typically, 10-30% of the treated water introduced to a water network is not accounted for and is labelled as non-revenue water. A large share of the non-revenue water percentage is real water loss due to leakage. To further reduce water loss due to leakage utilities in North America and South East Asia have installed Mueller/Echologics' EchoShore-TX leak detection sensors to monitor over 200 kilometres of transmission water mains. These devices record and transmit acoustic data which are analysed to detect leaks. As these critical leak monitoring systems have been deployed at scale, new processes and algorithms have been developed to differentiate leak noise from ambient noise, to manage gigabytes of data daily and to ensure a high accuracy of leak classification. Additionally, by combining both single channel and correlation based leak detection, quiet leaks can be detected in various locations along the pipe segment.

**Large scale VIEW deployment for burst reduction**

K. Siew. Air Selangor (Malaysia)

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

**Locating Hidden Water Leaks With Mobile Acoustic sensors**

O. Fruchtmann. Aquarius-Spectrum (Israel)

Water pipe deterioration leads to constant increase in operational costs for leak repair, pipe replacement, water and energy waste. Catastrophic bursts are much more expensive to fix than scheduled fix of small leaks that are detected by monitoring system. Proactive detection of small leaks and fixing them before they burst have huge operational benefits as enormous amounts of water and energy are saved. Aquarius' mobile solution enables Water Utilities to proactively monitor their network, trace leaks and pinpoint their exact locations on a daily basis. To date, the company's technology is monitoring thousands Km of pipes, helping Water Utilities reduce their Non-Revenue-Water (NRW) and their Maintenance & Operational costs by using highly sensitive sensors, management software and a mobile application.

**Overview Of NRW, What We Are Looking Forward**

KC. Lai. PUB, Singapore's National Water Agency (Singapore)

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

**28 June 2021 (Monday)**

**4.00pm-5.30pm (SGT) (GMT +8)**

**Session 1.5 – Smart Water Grid**

### **Digital Twin For Resilient Water Infrastructure**

Z. Wu, R. Kalfarisi, LK. Cheong, SF. Hew, JJ. Wong, G. Teopilus, I. Song, JM. Yip. Bentley Systems, Inc. (United States)

Resilient water infrastructure is essential for achieving sustainable growth of future cities, where digital Twin (DT) technology plays a key role in enhancing the resilience of water systems. DT has been developed and applied in manufacture industry for more than a decade but relatively new for water infrastructure engineering. It is defined as digital replica of a physical system. This paper briefly elaborate the framework of DT for resilient water system management and the digital threads that connect and update both the virtual/digital and physical twins via essential DT technologies, including Artificial Intelligence (AI), AI-enabled 3D modeling and inspection of water infrastructure, optimization-based simulation modeling integrated with data analytics for prediction and anomaly detection and the system analysis to construct a high-fidelity model or DT, which eventually facilitates water infrastructure resilience management.

### **Planning for an Intelligent Network**

J. MacIntyre. South East Water (United Kingdom)

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

### **Recent Developments/applications Of Sensor Networks In UK, Australia And Singapore, And Its Challenges**

M. Iqbal. Xylem Water Solutions Singapore Pte Ltd (Singapore)

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

### **VIRTUAL NETWORK: Live Operational Modelling For Water Networks Lifespan Safeguard**

F. Figuères, A. Chazerain. SUEZ Water Technology & Solutions (France)

Suez initiated a project founded on the valorisation of pressure measurements and remotely read data through a "live" digital twin of the network, designed to ultimately make informed choices and allow optimization problem solving. The proposed solution allows for the aggregation of the total flows of each virtual sector, which makes it possible to monitor the network in real time and ensure "virtual sectorisation" on more or smaller sectors, as well as on sectors that cannot be isolated for operational reasons, thus avoiding the multiplication of closed flowmeters and/or valves. The first application gave satisfactory results allowing for the reconstitution of the volume delivered to the network and the detection of failures on flow meters, as well as the identification of the proposition of physical losses per sector. These results give a first glimpse of the scope of the application of the solution while a full operational implementation is underway.

**29 June 2021 (Tuesday)**

**4.00pm-5.30pm (SGT) (GMT +8)**

**Session 1.6 – Smart Metering**

### **Acoustic Leak Detection Using Data From Smart Meters**

K. Andersen, J. Sorensen, S. Dupont. Kamstrup A|S (Denmark)

This paper addresses a novel approach to leak detection in the fight against non-revenue water. The presentation covers Kamstrup's work implementing an acoustic noise logger in a standard water meter and presents results from a field test with 1,250 meters installed at seven different utilities. From the data collected, 13 previously unknown leaks have been detected. The algorithm used in the water meters is explained and several examples of leaks and ambient noise sources seen during the field test are shown. Based on these results, it is confirmed that leak noise can successfully be distinguished from ambient noise.

### **Pilot study of South East Water's static meter with vibration/acoustic sensor**

D. Sullivan. Iota Services (Australia)

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

### **Real-time Data Analytics Of Advanced Metering Infrastructure And IoT Based Sensors To Quantify And Reduce Non-Revenue Water**

V. Singh, R. Kadiyala, B. Skeens. Jacobs (Singapore)

This presentation will describe real-time data analytics and machine learning algorithms that help to quantify non-revenue water (NRW) using AMI and SCADA data in two specific case studies. One used AMI data combined with SCADA data from selected time periods for offline analysis. The other is a live distribution system and used AMI along with IoT based sensors that were fed through unique machine learning and data analytics algorithms. The algorithms and corresponding data visualization components were also used to bolster water security and customer service. The presentation will include specifics covering the system architecture, source data and algorithms in play along with implementation challenges, results, lessons learned, and benefits for other utilities.

### **Water Metering Evolves -- Yesterday's Billing System Is Tomorrow's Sensor Network**

D. Nicklin, T. Wise. Xylem (United Kingdom)

Historically the primary function of residential water meters has been for customer billing purposes. They offered the utility the opportunity to bill customers based on their individual water consumption, rather than other methods, such as property size or business type. It was left to the utility to select the accuracy they were prepared to accept, even though this often lead to mechanical meters that degraded over time and appreciable under-reporting of actual water usage. However, with the development of cost-effective solid-state meters, there has been a significant change in emphasis in which the water meter is perceived not simply as a billing device, but rather as an integral sensor in a smarter digital water network. This presentation looks at the factors, technological developments and business cases that are driving the evolutionary transition of solid-state water meters from billing-only devices to network edge sensors, and contains case studies of real-world deployments that help illustrate this trend.

**30 June 2021 (Wednesday)**

**4.00pm-5.30pm (SGT) (GMT +8)**

**Session 1.7 – Asset Management for the Distribution Networks**

**Asset Management Customer Value Benchmarking To Improve Water Sector Asset Management**

F. Ibrahimi, J. Goode. Isle Utilities (Australia)

The Water Services Association of Australia (WSAA) is the peak industry body that supports the Australian Urban Water Industry. In 2020, WSAA conducted a program titled 'Asset Management Customer Value (AMCV) Benchmarking, involving 19 leading water utilities across Australia. The benchmarking was undertaken, using an internationally recognized framework, which comprised use of WSAA's customized assessment toolkit (Upmark and Tableau), aligned to the global forum in maintenance and asset management (GFMAM), principles. With more significant involvement of utility Executive Management, than ever before, the program highlighted a number of themes across the AM lifecycle, important to the sustained performance of businesses, and delivery of higher value to customers. This paper highlights the methods used to carry out this program along with key outcomes that benefit an international AM audience.

**Condition Assessment using Acoustic Sensors**

D. Ryan. SA Water (Australia)

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

**Failure Risk Analysis For Asset Renewal Prioritisation**

A. Bisso, K. Claudio, E. Goh, D. Fu. Mueller Water Products (Singapore)

As water infrastructure ages, utilities face the looming questions of: whether or not to replace pipes, which pipes should be replaced and when to replace the pipes. A combined approach of Condition Driven Asset Management (CDAM) and Asset Management Desktop Models (AMDM) can be utilised to enhance the replacement plan. This approach minimises failure risks whilst optimising the use of limited capital. A project was conducted in Singapore with this approach on 450 kilometers of cast iron water mains. The results of the project included deferred replacement of 161 kilometers of cast iron mains equating to a saving of approximately \$72,900,000 (SGD) in capital investment.

## **NETSCAN: Condition-driven Health Diagnosis Of Water Infrastructure For The Optimization Of The Network's Life-cycle**

P. Bonardet, T. Van Becelaere, K. Claudio, G. Fay. SUEZ Water Technology & Solutions (France)

For water utilities, the use of either condition-based or asset management desktop models to establish renewal strategies comes with challenges related to the choice of a representative sample and the integration of the current condition of the pipes in the analysis. To tackle this issue, SUEZ launched an R&D project for the construction of a tool to shape and target field condition assessments in order to optimize results and integrate them into the asset management value chain. Several studies were conducted with water system operators and data specialists to develop a method to compile in-depth information on infrastructure conditions and extrapolate the results of the field condition assessment based on a cluster analysis. A tool has been developed to support this methodology and applied to a 435 km cast iron network. Selection of 50 km length pipes was made 4 times more efficient compared to a random selection in term of failure prediction and avoided bursts.

**22 June 2021 (Tuesday)**

**4.00pm-5.30pm (SGT) (GMT +8)**

**Session 2.1 – Improving Water Treatment**

**Development And Application Of A Novel Integrated Drinking Water Treatment Plant Model For Better Operational Decision Making**

U. Rehman, J. Plooi, W. Audenaert, I. Nopens, R. van der Neut, B. Martijn. AM-TEAM (Belgium)

An unprecedented integrated modelling study was conducted at PWNs drinking water and process water treatment facilities in Andijk (Netherlands). An integrated model predicting the interaction between water storage basins and treatment facilities was built and applied. The dynamic plant wide model was able to predict the impact of future operational decisions and as such, was used for optimal decision making. Some decisions were already implemented in practice. Further, the model can be used to assess the impact of climate change induced water changes of surface water quality.

**Removal Of Carbonaceous And Nitrogenous Disinfection By-product (DBP) Precursors In Conventional And Advanced Treatment Processes Of Drinking Water: Is Fluorescence PARAFAC Analysis A Sensitive Indicator?**

H. Dong, Y. Wang, Z. Qiang. Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences (China)

Disinfection by-product (DBP) precursors removal was regarded as the most important method for DBPs control in drinking water treatment plants. Removal efficiencies of DBP precursors by conventional and advanced treatment processes were investigated via fluorescence PARAFAC analysis and DBPs formation potential (DBPsFP) test. Conventional treatment processes exhibited overall higher performance than advanced treatment processes. Coagulation-sedimentation process performed best, and preferentially removed humic-like component. Efficiencies of O<sub>3</sub> and BAC processes were much better than ultrafiltration. The highest reduction ratio was observed for tryptophan-like and tyrosine-like components across O<sub>3</sub> process, but for protein-bound component across BAC process. Reductions of carbonaceous DBPs were generally best correlated with humic component removal, while reduction of dichloroacetonitrile exhibited the strongest correlation with protein-bound component. The results reflected that fluorescence PARAFAC analysis was a promising tool to indicate DBP precursors removal.



### **Solving Algae Based Taste And Odor Issues With Ozone AOP In South Carolina**

T. Puehmeier, S. Dominguez, S. Besser, A. Ried, H. Stapel. Xylem Services GmbH (Germany)

In June 2013, Anderson Regional Joint Water System (ARJWS) began experiencing seasonal taste and odor problems due to algal blooms found in Lake Hartwell, naturally produced by the common taste and odor compounds, 2-methylisoborneol (MIB) and geosmin. These compounds create a strong earthy odor and noticeable at low concentrations (<10 ng/L). A CMAR team helped identifying the most efficient Advanced Oxidation Process (AOP) to remove the taste and odor causing compounds, reduce other compounds of emerging concern (CECs) and procure and install the new AOP system within two years. Since commissioning of the new ozone AOP system in early 2018, the plant is measuring non-detect MIB/Geosmin in their finished water. In addition, it enabled ARJWS to improve the operation of their clarification process with less chemicals and transform their dual media filtration system into a biological active filtration system. This paper will present measured performance and cost developments before and after implementation of the ozone based AOP system.

### **UV-LED/Chlorine For Water Treatment: Do Tailored Wavelengths Make Things Better Or Worse From A DBP Perspective?**

I. Carra, J. Fernandez, O. Autin, J. Bolton, P. Jarvis. Cranfield University (United Kingdom)

The UV/Chlorine process has gained attention in recent years due to the high quantum yield and absorbance of chlorine. However, there are still many unknowns around its application, such as the potential for the formation of DBPs. Some research has been published on the formation of DBPs after UV/Chlorine treatment with low and medium pressure lamps. However, there are no studies reporting on DBP formation at tailored wavelengths more specific to the UV/Chlorine process, which is possible thanks to LEDs. The aim of this research was to therefore determine the effectiveness of the UV/Chlorine process for the degradation of pesticides in real source waters whilst also considering the wider water quality impact of the process. The novelty of this work resides in the use of an innovative UV-LED reactor emitting at 285 nm for the removal of three pesticides, and the impact of the process on the formation of three THMs, HAAs and bromate. The impact of having GAC treatment after the UV/Chlorine process on DBP formation was also studied.

**23 June 2021 (Wednesday)**

**4.00pm-5.30pm (SGT) (GMT +8)**

**Session 2.2 – Innovation is Desalination**

**“Innovation is Desalination” session is focused on latest trends in desalination plant design and operations for cost-effective production of desalinated water.**

B. Liberman. IDE Technologies (Israel)

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

### **Evaluation Of Ceramic Adsorption Filter As Pretreatment For Seawater Reverse Osmosis Desalination**

J. Wang, LN. Sim, TH. Chong, K. Nakano, Y. Kinoshita, K. Sekiguchi. Nanyang Technological University (Singapore)

Pre-treatment processes are important for seawater reverse osmosis desalination that serve as the first barrier to remove contaminants and protect the downstream reverse osmosis (RO) systems from severe fouling and scaling. The current study implemented an aluminium oxide (Alumina, Al<sub>2</sub>O<sub>3</sub>) coated ceramic filter, known as ceramic adsorption filter (CAF), as pre-treatment process for SWRO. The performances of two RO systems with two pre-treatment approaches were compared. One pre-treatment approach was UF filtration (denoted as UF-RO) and the other was UF followed by CAF (denoted as UF-CAF-RO). The presence of CAF treatment prior RO showed positive effect on the downstream RO filtration system, showing less fouling as compared to the system without CAF. The flux enhancement was promoted from 10% to 30% with more frequent CAF backwash, i.e., from weekly to daily. The autopsy analysis found that UF-CAF-RO membrane had less inorganic scaling, EPS content and bacteria accumulation compared to UF-RO.

### **Sustainable Water Desalination By Means Of A Solar PV-T Powered MED-MVC Technology**

J. Cen. Desolenator (Netherlands)

This paper presents specific solutions for a novel solar-powered multi-effect distillation with mechanical vapour compression (MED-MVC) hybrid technology which can operate 24/7 with simple hot water storage. The technology uses an optimized Photovoltaic-Thermal (PV-T) system to harvest solar electricity and solar thermal energy to drive the desalination process. The system has several unique solutions: \* By cooling the PV-T panel with distilled water we increase the efficiency of solar electricity generation, while reducing the problem of scaling and fouling in the PV-T and piping system; \* Aside from solar electricity, the system also harvests thermal energy that is stored in hot water; \* The hot distillate is delivered by pipelines to the Multi-Effect Distillation (MED) unit and flashed to generate steam continuously in all effects; \* The cooled distillate is pumped back to cool the PV-T system; \* Solar electricity is used to drive a Mechanical Vapour Compressor (MVC) to increase output and efficiency of the MED unit; \* Excess solar electricity is stored in safe, sustainable and fully recyclable NiFe Batteries to power the MED-MVC system during the night.

## **Why Your RO Membrane Cleaning May Not Be Effective. The Benefits Of Reverse Cleaning**

K. Andes, CR. Bartels, G. Hijo. Nitto Hydranautics (Australia)

Historically, RO (Reverse Osmosis) membrane cleanings have been performed in a forward direction, with the cleaning solution being introduced into the feed end of the pressure vessels. This results in the cleaning flow going through the RO membranes in the same direction as normal operation. This works well for many types of cleanings, but there are specific instances when the foulant is concentrated in the front end of the lead RO membranes. Some examples of this might be biofouling, colloidal fouling, or deposition of particulates. Cleaning in a forward direction can prove to have minimal effect at removing these front end foulants, and it actually can make matters worse by pushing foulant and/or debris further into the lead membranes. In these cases, it has been shown that reversing the direction of the cleaning flow can be beneficial in removing the foulant and returning the RO system to normal performance. Some of the major RO membrane manufacturers strongly discourage reverse cleaning due to concerns about telescoping the RO elements, since there is no support structure at the feed end of the pressure vessels. This paper will discuss the precautions that should be implemented to perform reverse cleaning safely, along with studies showing the effectiveness of reverse cleaning. This paper will look at some of the major desalination plants that have implemented the method, and we will look at how some of the larger desalination plants were able to convert their cleaning systems to be able to reverse clean simply. Finally, we will look at alternatives to reverse cleaning, such as reverse flushing, and rotations of lead and tail elements.

**24 June 2021 (Thursday)**

**4.00pm-5.30pm (SGT) (GMT +8)**

**Session 2.3 – Membranes - Fast Forward**

### **A Novel Hollow Fiber Nanofiltration Membrane For Domestic Water Application**

ET. Saw, Y. Tang, J. Liu, W. Wang. Century Water Systems & Technologies Pte Ltd (Singapore)

Nanofiltration (NF) is defined as a filtration technology involving a pressure driven membrane with pore size in the range of about 0.5nm to 5nm in diameter. NF membrane has good potential in the water treatment area. One of the important applications for NF membrane is to remove hardness from source water to provide healthy water for drinking. So far, most commercially available NF membranes are made from interfacial polymerization and exhibited negative charge. This kind of NF membrane is unsuitable for hardness removal. A novel NF hollow fiber membrane has been designed and developed by Century Water Systems & Technologies Pte. Ltd. This novel hollow-fiber NF membrane has positive-charged surface demonstrating higher flux and higher rejection of  $Mg^{2+}$  and  $Ca^{2+}$  up to 94%. This hollow-fiber NF membrane also exhibits advantage as higher packing membrane area and lower operation pressure while treat the same sources of water.

### **Effect Of Chlorosulfamate-based Agent In Controlling Biofilm Formation And Its Impact On Reverse Osmosis (RO) Membrane Degradation**

JS. Ho. Nanyang Technological University (Singapore)

Chlorosulfamate has been proven to penetrate biofilm more readily than the alkaline hypochlorite and this makes it a suitable candidate as biofouling control agent. In this study, a short-term intermittent dosing regime was evaluated using the batch test. The results demonstrated that 0.5 h exposure of chlorosulfamate-based agent and 3.5 h break cycle could effectively suppress the bacterial cell growth and protein production on the membrane surface. This short-term intermittent dosing strategy could potentially reduce the chemical cost and discharge levels, if being applied in the seawater reverse osmosis (SWRO) desalination process. Another important feature which makes the chlorosulfamate-based agent an ideal candidate for biofouling control is its negligible impact on the polyamide skin layer of RO membrane as shown in the accelerated exposure test.

### **Monitoring The Integrity Of Reverse Osmosis Membranes Using Novel Indigenous Freshwater Viruses And Bacteriophages**

E. Cornelissen, T. da Silva, B. Blankert, L. Heijnen, E. Beerendonk, L. Hornstra, G. Medema. KWR Water Research Institute. Ghent University (Netherlands)

The lack of a fast and easy membrane integrity test method without dosing of surrogates with a log removal value (LRV) >3 hampers the implementation of NF/RO membranes. This study describes the use of indigenous viruses, naturally present in surface waters to monitor the integrity of RO membranes in a pilot installation. Natural viruses were identified by using metagenomics and qPCR primers in surface water in the feed and permeate of a pilot RO installation. The LRV of these natural viruses was compared to LRV of spiked MS2 and on-line conductivity. The natural viruses concentration in the source water was >7 comparable to spiked MS2. After inflicting damage to the membrane element, both natural viruses and MS2 detected the damage with a nearly identical LRV decrease. This novel method enables monitoring of RO membrane integrity at high sensitivity (LRV > 7), without the addition of chemical or biological virus surrogates.

### **Optimization Of Pretreatment To Mitigate Membrane Fouling In Pressure Retarded Osmosis Process For Water Reuse And Desalination**

S. Lee, J. Ju, Y. Choi, DY. Wi, TS. Park, Y. Park, SH. Lim, H. Kwon. Kookmin University (Korea, Republic of)

Pressure retarded osmosis (PRO) aims at the extraction of osmotic energy from the brine in an integrated system of wastewater reclamation and seawater desalination. However, the control of the fouling of the PRO membrane is inevitably required if treated wastewater is used as the feed water. In this study, computational and statistical techniques were applied as innovative approaches to optimize the PRO pretreatment consisting of coagulation and ultrafiltration (UF). Response surface methodology (RSM) and artificial neural network (ANN) were applied to optimize the pretreatment conditions. A brine of a brackish water reverse osmosis (BWRO) membrane process in a wastewater reclamation plant was used as the feed water. Using poly-aluminum chloride (PACl) and iron (III) chloride, a series of experiments tests were carried out to measure the removals of pollutants and specific cake resistances under various conditions. The flux and power density for the PRO membrane using the pretreated wastewater were also measured. Based on the results of the optimization, the optimum design and operation parameters of the coagulation-UF pretreatment were obtained for the PRO membrane.

**25 June 2021 (Friday)**

**4.00pm-5.30pm (SGT) (GMT +8)**

**Session 2.4 – Expanding Ceramic Membrane Applications**

### **Chemical-grafting Of Graphene Oxide Quantum Dots (GOQDs) Onto Ceramic Microfiltration Membranes For Anti-organic Fouling Potential**

Q. Gu, T. Ng, I. Zain, X. Liu, L. Zhang, Z. Zhang, Z. Lyu, Z. He, HY. Ng, J. Wang. National University of Singapore (Singapore)

Surface modification of ceramic membranes is an effective pathway to improve their fouling resistance. In this work, graphene oxide quantum dots (GOQDs) were prepared and then immobilized onto the (3-aminopropyl) triethoxysilane (APTES) functionalized alumina membrane surface by covalent bonding. The ceramic membranes modified by GOQDs remain a porous structure with reduced surface roughness and improved hydrophilicity. As a result, the GOQDs modified ceramic membranes show improved fouling resistance in HA solution under submerged conditions.

### **Long-Term (6-7 Years) Operation Experience Of Ceramic Membrane Microfiltration Plant In Korea**

YI. Song, Clean Water Supply Facilities Maintenance Department, K-water (South Korea)

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

### **Reuse Of WWTP Effluent For High Quality Applications By Applying Ozonation For Pharmaceutical Control And Flux Enhancement Of Ceramic Membrane Filtration**

M. Spruijt, B. Martijn, M. Hoekstra, J. Kruithof. PWNT (Netherlands)

In a joint research effort, PWN Water Supply Company North-Holland (PWN), PWN Technologies (PWNT) and Water Authority Hollands Noorderkwartier (HHNK) investigated the feasibility of ozonation for pharmaceutical control and flux enhancement of Ceramic Membrane Filtration (CMF). A bench-scale equipment was developed to conduct ozone experiments for pharmaceutical control while a pilot plant was developed to study flux enhancement of CMF. For an ozone dose of 7 mg/L, most pharmaceuticals were degraded for more than 99%. By applying this ozone dose of 7 mg/L, the CMF flux was enhanced by 100% compared to the flux achieved for untreated WWTP effluent. Because of these very positive results, the O3/CMF concept will be tested full-scale in a demonstration plant.

### **Upgrading Of Choa Chu Kang Waterworks With Ozonated Ceramic Microfiltration**

V. Lam, H. Shorney-Darby, M. Mun, Y. Wang. PWNT (Singapore)

This paper provides an overview of planning and implementation of 180 Mld of ceramic microfiltration (CeraMac® by PWNT) at Choa Chu Kang Waterworks (CCKWW) in Singapore. CCKWW is the largest full-scale ceramic microfiltration water plant in the world. The technical approach, initial performance and the lessons learned will be discussed, and the paper will include recommendations for future projects. The focus is on providing a roadmap on how new innovative technologies can be evaluated and implemented at water utilities.

**28 June 2021 (Monday)**

**7.00pm-8.30pm (SGT) (GMT +8)**

**Session 2.5 – Emerging Contaminants - Practice and Science**

### **A Novel Kinetic Ozonation Model For Prediction Of Bromate Formation, Bromate Mitigation And Trace Organic Contaminant Removal**

W. Audenaert, G. Bellandi, M. Pearce, I. Takacs. AM-TEAM (Belgium)

A novel kinetic ozonation model is presented that predicts trace organic contaminant (TrOC) removal and bromate formation in real water and wastewater matrices. The model was developed in the framework of the large scale indirect potable reuse project SWIFT ([swiftva.com](http://swiftva.com)) by the utility HRSD (VA, US). The model was developed and calibrated based on real plant data. Based prediction of ozone and hydroxyl radicals (HO\*), and equations describing the interaction with the bulk organic matrix, oxidation of TrOCs of interest can be assessed. Bromate is calculated based on ozone and HO\* exposure. Different bromate suppression strategies, such as monochloramine addition, can be assessed with the model. The model will be used for optimal train configuration and better reactor design, maximizing TrOC removal while minimizing bromate formation.

### **Mitigating PFAS - An Emerging Concern For The Global Community, Demanding Technical Solutions**

K. Amstaetter, R. Bufler, D. Chiang, J. Frangos. CDM Smith Consult GmbH (Germany)

CDM Smith is working with its global network of specialists on technical and regulatory solutions for handling the emerging compounds Per- and polyfluoroalkyl substances (PFAS). We are leading in development of fate and transport characterization, novel treatment techniques to clean-up water, designing treatment plants for drinking water, groundwater, waste water and solid waste landfill leachate and support authorities in decision-making for legal regulations.

### **Modified SPO Staining Method And A Case Study Of One Singapore's Freshwater Catchment**

J. Li, H. Liu, EM. de Souza, J. Wu, J. Chen. National University of Singapore (Singapore)

The direct SPO staining method, which is a modified version of our previous reported method, was applied to quantify MPs in the surface water of one freshwater catchment in Singapore. The abundance of MPs in this reservoir was comparable to other researches on freshwater systems, and the size of the majority of MPs was in submicron range. Analysis on chemical composition of selected MPs has revealed that the three dominant MPs types-PP, PS and PE, correspond to the top three manufactured light plastic types. Though our study first brings insight into MPs pollution in Singapore's freshwater systems, the number may not represent the realistic concentration as the size cut-off at 201µm due to collection knit and identification limitation. Ongoing efforts should be made on the optimization of comprehensive sample collection methods and on the incorporation of nanotechnology to assess the realistic abundance of microplastics.

## **State Of The Art On Suspended Ion Exchange (SIX®): Essential Design Parameters And Practical Regulations For A Full-scale Treatment Plant**

E. Koreman, M. Sijm, E. Vaudevire. PWNT (Netherlands)

Extensive research at the PWNT R&D department (Andijk, The Netherlands) has provided a solid basis for an appropriate design and proper operation of (full scale) Suspended Ion Exchange (SIX<sup>®</sup>) treatment systems, allowing reduction of Dissolved Organic Matter (DOM) and color with 60% or more. With resin dosages between 10 and 25 mL/L a “near equilibrium sorption” state is reached within about 25 - 30 minutes contact time. A series of five completely mixed tank reactors is sufficient to achieve satisfactory results. DOM adsorption kinetics can be accurately described according to a first order Lagergren differential equation. The (chloride) counter anion demand during regeneration is mainly determined by both alkalinity and sulphate anions. As a result, SIX<sup>®</sup> is in particular ideally suited for the treatment of ‘peaty waters’ (high DOC and color) with low anion content, because of limited regenerant volumina, needed for a proper regeneration of the resin.



**29 June 2021 (Tuesday)**

**7.00pm-8.30pm (SGT) (GMT +8)**

**Session 2.6 – Integrated Water Reuse**

**Improvement Of The Resilience Of NEWater Treatment Processes - A 1.7 MGD Demo Plant Of Low Pressure UV Based Advanced Oxidation Processes In Singapore**

Y. Zhang, MX. Tan, J. Scheideler, J. Chin, PC. Siow, PW. Chue, E. Huang, KY. Lim, D. Lee, BR. Liu, FK. Chwee, B. Viswanath, GR. Ong, YH. Lou, AN. Puah, MH. Lim, Xylem Water Solutions Singapore Pte Ltd (Singapore)

A two year comprehensive Low Pressure UV based Advanced Oxidation Processes (AOP) study has come to completion in December 2019 by Xylem and PUB. The project is situated at Singapore's national water agency at one of the NEWater Factories in Singapore, from designing, building and operating a 1.7 MGD demo plant in real world conditions. The study focused on oxidative removal of over 20 spiked organic contaminants by using UV based AOP (UV/HOCl and UV/H<sub>2</sub>O<sub>2</sub>) in the process of NEWater production after Reverse Osmosis (RO) system. Target compounds selected include disinfection by-products (DBPs), Pharmaceuticals and Personal Care Products (PPCPs), Volatile Organic Compounds (VOCs) and Artificial Sweeteners. Variations of different operational parameters combination like UV dose, chemical dose and pH conditions were systematically studied for the evaluation of optimized operation conditions for AOP treatment plants. Results indicate that UV based AOP technology has the capability of removing certain targeted compounds effectively, without significantly changing the NEWater quality in terms of the generation of unwanted oxidation by products.

**Innovative Chloramine Free Water Reuse Technology, 85% Recovery, 28 LMH, Single Stage, 100% UVT, Water Cost Saving 20%**

B. Liberman, L. Eshed, G. Greenberg. IDE Technologies (Israel)

Implementation of the new wastewater desalination technology as demonstrated in operation in Pismo Beach CA for nine months, from October 2018. The source of water is the secondary effluent of a municipal wastewater plant. The Unit operated with average flux of 28 LMH, which is 50% higher than the standard 18 LMH. Specific flux was 0.12 GFD/PSI, about 25% higher than that of the well-operated Orange County Waste Water Reuse Facility, which operates in the same recovery at specific flux of 0.09-0.1 gfd/psi. This indicates that the new WWRO technology is 25% more energy efficient than the standard conventional RO process. Operation was conducted at 86% recovery in a single RO stage. No chloramine was dosed, thus no NDMA components developed. Chloramine-free operation generates permeate with a UVT value of about 100%, thereby saving 30-40% on CAPEX and OPEX in the final UV/AOP stage.

### **Membrane Bioreactor For Indirect And Direct Potable Reuse Applications To Treat Primary Or Non-nitrified Secondary Wastewater Effluent**

S. Liang, J. Lehman, H. Collins, M. Chaudhuri, J. Bednarski. Metropolitan Water District of Southern California (United States)

Metropolitan and the Sanitation Districts are partnering on implementation of a potential Regional Recycled Water Program (Program) to develop a drought-resistant water source for Metropolitan's member agencies. This Program would comply with regulatory requirements for indirect potable reuse (IPR) through groundwater replenishment and include a new advanced water treatment facility producing an ultimate flow of 568 MLD. The full-scale facility would treat primary or non-nitrified secondary effluent from the Sanitation Districts' wastewater treatment plant using an advanced water treatment train comprised of a membrane bioreactor, reverse osmosis, and advanced oxidation driven with ultraviolet light. The current focus of the Program is IPR through groundwater replenishment; however, an option to deliver advanced treated water to Metropolitan's water treatment plants as direct potable reuse (DPR) through raw water augmentation will also be evaluated. The 1.9 MLD advanced water treatment (AWT) demonstration facility will be operated for regulatory acceptance of MBR in a potable reuse AWT train for IPR and DPR in California.

### **Perspective Of Future Of Water Reuse**

I. Law. IBL Solutions (Australia)

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

**30 June 2021 (Wednesday)**

**7.00pm-8.30pm (SGT) (GMT +8)**

**Session 2.7 – Intelligent Plant of the Future**

**Advanced 3D Modelling For Virtual Piloting: Accelerating The Development Of The Next Generation Water And Wastewater Treatment Technologies**

W. Audenaert, U. Rehman, J. Plooi, I. Nopens. AM-TEAM (Belgium)

Virtual design and virtual piloting based on advanced computational fluid dynamics (CFD) has a great potential to accelerate the development of new water and wastewater treatment technologies. Advanced CFD incorporates process phenomena such as bubbles, particles and (bio)chemical reactions. This novel type of modelling is used to reduce, replace or complement 'real-life' testing with significant savings in time and cost as a result. Three different examples from the drinking and wastewater fields were described to illustrate the practical application.

**Improving Operational Efficiency Through Alarm Management In Water Treatment Processes Using Artificial Intelligence**

K. Ghosh. Yokogawa Engineering Asia Pte Ltd. (Singapore)

Water Treatment Plants are controlled by modern industrial process control systems like SCADA or DCS. These systems usually generate far too many alarms than needed. Many of the alarms are nuisance in nature and do not indicate any real abnormality. The true alarms which requires prompt operator actions to normalize the process are often buried in the pool of nuisance alarms causing significant challenge for operator to take appropriate corrective actions in a timely manner. In this paper, we propose an AI based pattern mining and advisory system to improve operational efficiency in alarm management by providing intelligent decision support to the operators. The identified alarm patterns bring out actionable insights in data by (i) identifying nuisance, chattering, redundant, and consequential Alarms (ii) Alarm response procedure (iii) prediction of Alarms. The efficacy of the proposed method for systematically improving alarm management in an actual plant environment is currently being studied in a water treatment plant in Singapore with promising results.

### **Machine Learning For Reverse Osmosis Shows Up To 18% Energy Savings**

M. Dixon, N. Palmer, J. Quaintance, K. Brockman, N. Herold, T. Pritchard, H. Le, C. MacLean.  
Synauta (Canada)

Seawater Reverse Osmosis (RO) requires a lot of energy to produce water and costs plant owners millions of dollars every year. Optimizing a plant manually, to match the design conditions, takes time that operators and control room operators do not always have. Additionally, optimization is made more difficult when a plant has multiple trains to track performance and optimize manually. Synauta's patent pending technology helps plant operators produce the right quantity and quality of water, without the distraction of lengthy calculations. Where math has limitations, Machine Learning is accurate. Machine Learning can also be codified and deployed to SCADA to predict variations/trends in water temperature and salinity and undertake multiple set point changes per day, ultimately minimizing energy use and adapting to consistently fluctuating feedwater conditions. To achieve energy savings, Synauta alters the RO plant recovery. By frequently analyzing plant operating conditions the recovery can be varied to achieve optimal energy use while still conforming to the main plant design constraints, such as lead element recovery, lead element flux constraints.

### **Next Generation Of Process Monitoring And Diagnostics: Applications Of AI And Machine Learning To Enable Early Equipment Fault Prediction And Diagnostics**

A. Minisankar, K. Ghosh, GK. Sivaprakasam. Yokogawa Engineering Asia Pte Ltd (Singapore)

Water treatment plants are a conglomeration of different unit processes, controls and associated auxiliary equipment. Rotating equipment forms an integral part of any water treatment plant. Late/missed detection of equipment failures in water treatment plant results in unexpected down time or plant shut down disrupting the water supply chain. After detecting a fault, finding the root cause and deciding the right course of action is time consuming and depends on the level of expertise of the plant operators. Yokogawa Singapore is developing a Machine-learning based Early Fault Detection & Diagnosis system to monitor a rotating equipment in operation, detect a fault at initiation, pinpoint the root cause, and alert for corrective maintenance with suggested remedial actions. It builds a baseline machine learning model of the equipment performance under normal operation and uses it to monitor its health status in real time and predict a fault much before it is observed. The diagnostics tool identifies the most probable root cause based on previous equipment failure patterns and provides the possible failure resolution methods based on the historical maintenance records.

## **Optimized Performance Of Water And Wastewater Treatment Systems Utilizing Artificial Intelligence And Digital Twin Technology**

R. Woodling, S. Bhattacharjee. IntelliFlux Controls inc (United States)

IntelliFlux embeds the entire Industry 4.0 decision automation stack in a seamless software package that is customizable and specifically developed for water treatment processes. It is not just adaptive or feedback process control, but rather the concepts of IoT based multivariate process optimization, interoperability of different unit operations in a plant, ability to provide dynamic optimization by mapping performance against digital twins of the existing process plant, high level decision support through advanced analytics, and full spectrum decision automation, ranging from immediate response to catastrophic excursions to long term trend based proactive control. Intelliflux has demonstrated a substantial operational savings while providing equal to or better then designed quality with variable influent conditions. Optimized operations will be discussed which includes quality of product, system stability, savings on power, water, equipment, and chemicals compared to baseline operations in several types of treatment processes.

**01 July 2021 (Thursday)**

**7.00pm-8.30pm (SGT) (GMT +8)**

**Session 2.8 – Source Control in Advanced Reuse Application**

**DPR Research: Mitigating Chemical Peaks in Purified Water**

J. Debroux. Kennedy/Jenks Consultants (United States)

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

**Melbourne Water's Sewage Quality Risk Assessment Tool (SQRAT)**

J. Blackbeard. Melbourne Water (Australia)

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

**Singapore's Initiatives And Experiences In Using NEWater To Meet Singapore's Water Demand**

L.Goh. PUB, Singapore's National Water Agency (Singapore)

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

**Source Control In Advanced Reuse Applications - International trends**

I. Law. IBL Solutions (Australia)

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

**22 June 2021 (Tuesday)**

**4.00pm-5.30pm (SGT) (GMT +8)**

**Session 3.1 – Decentralised Water Treatment**

### **Innovations in Decentralised Wastewater Treatment**

S. Pillay. Water Research Commission of South Africa (South Africa)

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

### **Integration Of MBR And Hybrid Constructed Wetland For Enhanced Treatment Of Rural Domestic Sewage**

J. Zhang, J. Zhang, B. Wu, W. Yong, C. Xiong. CITIC Envirotech Ltd (Singapore)

Decentralized wastewater treatment systems have drawn increasing attention in recent years, especially in the rural communities of China. In this study, a combined MBR and hybrid constructed wetlands (CWs) system was proposed to achieve the aforementioned goals. The combination leveraged the ability of MBRs to remove organic pollutants and all suspended solids effectively. The CWs are able to achieve high NH<sub>3</sub>-N removal which contributes to substantial total nitrogen (TN) removal in a cost-effective manner. The combined MBR and hybrid CWs system could be an effective and affordable technology for wastewater management in rural areas and developing countries.

### **IWA Non-Sewered Sanitation Network**

K. Vairavamoorthy. International Water Association (Sri Lanka)

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

### **Wastewater Treatment In The Philippines, A Review Stand Alone System In Buildings**

J. Baring. Floijess Watertech Inc. (Philippines)

The absence of Centralized Wastewater Treatment in most areas in the Philippines and increasing regulatory pressure lead to the establishment of stand alone treatment systems for existing and new buildings to comply with government regulation. Steps have been taken to answer the challenges arising from existing buildings that do not have space allocations for treatment facility. Innovations have been made in response to this concern to provide respectable installations. The present paper therefore articulates how current installations of decentralized systems in the Philippines respond to this urgent environmental issue by enumerating practical experience Further it will take on performance comparison for a new stand alone system on new building construction against retrofit for existing building. Another important consideration in the stand alone system is on the stream flow separation against combined flow system treatment facility, its capabilities and limitations.

**22 June 2021 (Tuesday)**

**4.00pm-5.30pm (SGT) (GMT +8)**

**Session 3.2 – Resource Efficient Treatment I**

**Achieving Simultaneously Anaerobic Digestion And Low-carbon Denitrogenation In Sewage Mainstream By Integrating Anaerobic Membrane Bioreactors With Nitrification-anammox**

Z. Lei, S. Yang, R. Chen. Xi'an University of Architecture and Technology (China)

A new sewage treatment process aims to achieve efficient energy recovery with simultaneously low-carbon denitrogenation was constructed by coupling AnMBR with nitrification-Anammox, and the feasibility was investigated based on pollutants removal efficiency and dynamics analysis. The results indicate COD and N removal efficiency were averaged at 97% and 75%, respectively, accompanying a COD converted to methane ratio of over 83%. AnMBR and nitrification reactors contributed to almost all COD removal, while the denitrogenation was mainly achieved in the anammox reactor (>90%). In AnMBR, Anaerolineales, Bacteroidales and Clostridiales contributed to the producing of acetate and hydrogen; Methanothrix (58.43%) and Methanolinea (29.98%) were the main generator for methane production. Nitrosomonas and Candidatus Brocadia were the main functional microbes in the nitrification and anammox reactors, respectively. Results of this study demonstrate the feasibility of AnMBR coupling nitrification-Anammox for sewage treatment and will expected to put forward it's future development.

**Process Optimization And Energy Efficiency**

C. Borges, R. Brice, V. Tang, J. Bishop, J. Scheri. Mott Macdonald (United Kingdom)

Water industry operations are energy intensive and wastewater processes are known to use approximately half of the total operational energy of a water company. However, typically an annual energy saving potential of 15 to 30% can be achieved by optimisation of operations. The Standard Aeration Efficiency (SAE) Calculator and the Clarifier Efficiency tool are part of a set of stand-alone, real-time applications Mott MacDonald is investing in to provide dynamic diagnostics targeting typical pain-points in wastewater treatment plant (WWTP) operations. This paper will present two case studies of this approach. At Rotorua WWTP (New Zealand) the SAE provided an evidence-based approach to reduce diffuser cleaning frequency and deferral of diffusers replacement. At Two Bridges WWTP (USA), the Clarifier tool helps operators managing the risk of biomass wash-out and maximize treatment during storm conditions, by understanding in real time the used vs residual solids capacity in the system.



### **Side-stream Nitrogen Removal Implementation At Changi Water Reclamation Plant**

D. Lye, J. Tan. PUB, Singapore's National Water Agency (Singapore)

Side-stream nitrogen removal using anaerobic ammonium oxidation (ANAMMOX) or deammonification has been widely recognised to be a viable alternative process for nitrogen removal. Deammonification is an energy efficient process alternative to the conventional nitrification and denitrification processes, which allows used water treatment plants to reduce the amount of aeration energy consumed for nitrogen removal. Deammonification involves two process steps -- the partial nitrification of ammonium and the subsequent anaerobic oxidation of the residual ammonium by nitrite to nitrogen gas. Changi Water Reclamation Plant (CWRP), PUB's largest used water treatment plant in Singapore, receives and treats 920,000 cubic metres per day (CMD) of used water in Singapore. In 2013, PUB conducted a pilot investigation at CWRP to assess the feasibility of implementing a full-scale side stream facility using the deammonification process to treat its nitrogen rich dewatering centrate (DC).

### **Ultralow Energy - No Bubble Deammonification**

G. Kicsi, N. Hu. SUEZ (Singapore)

Deammonification is commercially applied to treat ammonia rich digestate from the side stream of water resource recovery facilities (WRRFs) however its broader adoption is challenged by process complexity, inefficient oxygen transfer, and greenhouse gas (GHG) emissions. A new solution called ZeeNAMMOX overcomes these challenges by leveraging the counter-diffusion benefits of membrane aerated biofilm reactor (MABR) technology to enable a resilient and energy efficient deammonification process. The diffusion of N<sub>2</sub>O into the lumen captures any N<sub>2</sub>O produced and provides the ability to reduce GHG emissions of this efficient process. Two pilots employing this solution were operated to treat digestate and demonstrated the performance of ZeeNAMMOX.

**22 June 2021 (Tuesday)**

**7.00pm-8.30pm (SGT) (GMT +8)**

**Session 3.3 – Resource Efficient Treatment II**

### **Carbon Management In Water And Wastewater Infrastructure**

M. Manidaki. Mott Macdonald (United Kingdom)

Carbon emissions (or GHG emissions) can be a good proxy for resource efficiency. Evidence suggests that reducing carbon emissions in infrastructure delivery also reduces costs, promotes collaboration across the supply chain and unlocks innovation. Leading water and wastewater infrastructure owners in different parts of the world are realising that reducing carbon is not just about building new assets in a more intelligent way, it is also about demanding better performance from their existing asset base. The paper gives an overview of how different asset owners and their supply chain partners in different parts of the world (UK, Middle East and Australasia) have been adopting carbon management methods and processes, as outlined in the Infrastructure Carbon Review and PAS 2080 (both authored by Mott MacDonald), to successfully reduce whole life carbon and cost across their capital programmes and promote innovation.

### **In-sewer Purification Pipe Technology In Wastewater Management**

TJ. Sotelo, R. Lyu, H. Satoh. The University of Tokyo (Japan)

The contribution of in-sewer purification pipes to wastewater treatment in a small model community was evaluated. Treatment capacity of double-layer and single-layer in-sewer purification pipes were assessed from literature data and were found to treat approximately 15 g COD m<sup>-1</sup> day<sup>-1</sup> and 6 g COD m<sup>-1</sup> day<sup>-1</sup>, respectively. The data was then used to evaluate organic pollutant removal in a model community where double-layer in-sewer purification pipes were applied to downstream sewer trunk lines and the single-layer design was applied to upstream sewer pipes. Community-level application of in-sewer purification pipes gave approximately 56% organic pollutant reduction. Further household-level application of single-layer pipes yielded 85% organic pollutant reduction. The results highlight potential contribution of in-sewer purification technology to wastewater management which promote water reuse.

### **LESSWATT Protocol For Minimisation Of WWTPs Carbon Footprint**

I. Nopens, Y. Amerlinck, A. Amaral, C. De Mulder, A. Di Nisio, G. Bellandi, R. Gori, C. Caretti, F. Spennati, U. Rehman, J. Porro, S. Daneshgar. Ghent University (Belgium)

In view of reducing WWTP's carbon footprint, the EU-Life project Lesswatt is developing a protocol for dedicated model formulation and data collection in view of optimising for both energy expenditure and N<sub>2</sub>O emissions. The protocol builds on existing protocols and expertise derived from modelling the Eindhoven WWTP. However, for the objective at hand, more emphasis is needed for a good hydrodynamic model of the bioreactors, preferably using a compartmental model based on either computational fluid dynamics (CFD) or expert knowledge. Moreover, the protocol includes a risk-based approach for N<sub>2</sub>O prediction. From an experimental viewpoint, it extends earlier protocols by measuring local oxygen transfer efficiencies (OTE) and dissolved oxygen (DO) using the Lessdrone, a dedicated device that facilitates this. Finally, the protocol comes with an optimisation step. A first version of the protocol is presented based on a past case and is applied to another combined municipal-industrial WWTP.

**Resource efficiency in NYC's Advanced Nitrogen Removal Program**

P. Elardo. New York City Department of Environmental Protection (DEP) (United States)

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

**23 June 2021 (Wednesday)**

**4.00pm-5.30pm (SGT) (GMT +8)**

**Session 3.4 – Intensification of Anaerobic Digestion**

**Achieving Simultaneously Anaerobic Digestion And Low-carbon Denitrogenation In Sewage Mainstream By Integrating Anaerobic Membrane Bioreactors With Nitrification-anammox**

Z. Lei, S. Yang, R. Chen. Xi'an University of Architecture and Technology (China)

Domestic wastewater treatment methods are energy intensive. To offset the energy used, Anaerobic Digestion (AD) is regularly implemented to capture renewable energy from the wastewater sludge. In conventional practice, energy captured from wastewater sludge, if converted into renewable electricity, could amount to 50% of the wastewater treatment plants' (WWTP) parasitic electrical load. AD infrastructure built at WWTPs are designed to process sludge inventories from that respective plant. Due to the dilute nature of the sludge, the digestion infrastructure can be underutilized. Progressive plant owners and communities are viewing these underutilized assets as an opportunity to recover valuable resources from not only wastewater sludge, but other organic materials. This paper outlines the transformation of one of the Bristol Wastewater Treatment Works (WwTW) at Avonmouth in the UK, serving a population equivalent of over 800,000 people, into an advanced anaerobic digestion energy centre treating both Biosolids and Biowaste.

**Assessing Resilience Of A Regional Sludge Strategy Incorporating Advanced Anaerobic Digestion (AAD)**

D. Buxton. Mott MacDonald Ltd (United Kingdom)

Sustainable management and disposal of wastewater sludge is a key issue facing all water utilities. Tightening nutrient and heavy metal limits on agricultural use are adding to the increasing pressure placed on companies to be more self-sufficient with their energy use. Many are turning to advanced solutions, leading to more centralisation of sludge treatment at facilities designed to use the latest technology to maximise resource recovery, thus supporting principles of a circular economy. However, one factor that must be considered when centralising treatment is resilience to ongoing operations. As part of the North Wales Sludge Strategy, a detailed resilience study of both the catchment and the Advanced Anaerobic Digestion facility were undertaken to define key failure scenarios, test arrangements and develop engineering solutions. The outcome was the identification of key areas that require an alternative approach, enabling the team to generate a template for other sludge strategies to follow.

### **Biological Hydrolysis Pretreatment For Enhanced Sludge Anaerobic Digestion And 'Class A' Biosolids**

Y. Hong, M. Theodoulou, A. Bentham, T. Robertson, S. Chang. SUEZ Water Technologies & Solutions (Canada)

This paper will outline the SUEZ Water technologies & Solutions' biological hydrolysis (BH) pretreatment technology, and the performance of its demonstration pilot on the aspects of volatile solid reduction (VSR), biogas production and pathogen inactivation/regrowth after anaerobic digestion with municipal sludge. The performance of this demonstration pilot is compared directly to a nearby wastewater treatment plant's full-scale conventional anaerobic digester with same feeding sludge. The results show that the BH pretreatment technology is able to increase the digester efficiency, enhance biogas production and produce Class A biosolids. Metagenomic sequencing and microbial community analysis are performed to understand BH pretreatment impacts on anaerobic digestion.

### **Integration Of Sludge Ultra-dewatering Into The Energy Positive WWTP Of Tomorrow**

M. Choo-Kun, M. Chevrel, P. Camacho, JL. Bourdais, A. Poignant, A. Fournot-McGill. SUEZ (France)

The Dehydri Ultra technology was recently developed to achieve ultra-dewatering of wastewater sludge, moving towards maximum biosolid reduction. Concept, process and technology were proved on a 24 000 PE demonstration unit. The technology is based on the thermo-chemical reaction of HydroThermal Carbonization (HTC) coupled with post-dewatering by piston press. High drynesses can be reached with such a process: up to 70% Dry Solids (DS) with three to four times less energy demand than thermal drying. While increasing the hydrophobicity of the dewatered sludge's organic matter, this reaction concentrates carbon and thus the inherent calorific value of sludge final cake (He, 2013). Integrating ultra-dewatering into tomorrow's WWTP reduces up to four times biosolid disposal compared to conventional dewatering, without external thermal energy supply if filtrates from post-dewatering are anaerobically digested. Among thirteen typical sludge treatment lines, it is positioned among the first for overall energy balance and biosolid disposal.

**23 June 2021 (Wednesday)**

**7.00pm-8.30pm (SGT) (GMT +8)**

**Session 3.5 – Advancement in Solids Treatment**

### **Anaerobic Co-digestion Of Food Waste And Municipal Wastewater Treatment Plant Sludge At Demo Scale**

J. Josse, YKK. Koh, XQ. King, J. Low, Y. Gu, J. Oh. Anaergia Inc. (United States)

Supported under TechPioneer Scheme through EDB and PUB, this is the first demonstration project in Singapore to co-digest source segregated food waste (FW) with thickened surplus activated sludge (TSAS) from a municipal wastewater treatment plant (WWTP). The team previously reported that co-digestion exhibited a promising performance with respect to specific biogas yield (SBY), with about 2 times higher SBY than that of pure TSAS digestion. The team has successfully simulated one of the feeding conditions -- Design 2027 of Tuas Nexus and demonstrated that co-digestion of TSAS with FW yields higher gas production and a significantly increased SBY than that of dedicated TSAS digestion only. The team is currently simulating the Design-MML (Maximum Monthly Load) feeding condition of the Tuas Nexus. Based on the preliminary data obtained up to date, the process is stable with significantly increased SBY compared to that of dedicated TSAS digestion only.

### **Energy and Resource Recovery in Solids Treatment**

C. Peot. DC Water (USA)

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

### **New Technologies And Methods For Optimizing Wastewater Treatment Plant Processes**

H. Karaila. Valmet (Finland)

Population growth and the expansion of urban areas has led to significant increases in the volume of waste water and created an urgent need for more effective and affordable wastewater treatment. The removal of solids and subsequent sludge treatment account for some 40 to 50% of the total wastewater treatment costs but traditionally, because of the lack of reliable and accurate measurements, the only way to manage this key part of the process has been manual control based on infrequent laboratory analysis. New measurements and controls for wastewater treatment are now providing solutions for both existing and new treatment plants by improving efficiency and maximizing capacity while saving chemicals and improving worker safety. This paper describes the commercial application of the new measurement technologies and optimization controls from installations in South Africa and Finland.

### **Thermal Hydrolysis Process For Enhancement Of Anaerobic Digestion**

L. Yu, B. Jeyanathan, SL. Low, Z. Ibrahim, R. Tan, G. Tao, W. Lay, SC. Chua. PUB, Singapore's National Water Agency (Singapore)

Thermal Hydrolysis Process (THP) has been implemented in Jurong Water Reclamation Plant (JWRP) to enhance sludge digestion.

**24 June 2021 (Thursday)**

**4.00pm-5.30pm (SGT) (GMT +8)**

**Session 3.6 – Membrane Bioreactor Processes**

**From Validation To Full-Scale Design: Dedicated Zoo Animal Wastewater Treatment And Reuse**

S. Athreya. Binnies (Singapore)

Mandai Park Development (MPD) desires to construct two dedicated animal wastewater treatment plants (DAWTPs) in the newly integrated Mandai Precinct to treat animal wastewater. To align with the project's sustainability initiative, the DAWTPs will be designed to produce high-quality effluent suitable for non-potable applications, allowing controlled reuse purposes within the facilities. Considering the unique characteristics of the animal wastewater and concerns associated with the pathogens in the wastewater, a multiple-barrier approach was adopted in developing the treatment technologies including membrane bioreactor (MBR), ultra-violet (UV) and chlorine disinfection. Furthermore, an MBR pilot was constructed and operated for 3 months with challenge testing of indicator organisms conducted to validate the log reduction performance of the proposed MBR system. UV inactivation studies using collimated beam testing were also performed. The full paper will present the testing protocols, results, and lessons learnt from the pilot and the translation of the validation results into full-scale design.

**MBRs: Academic Research vs Practitioner Needs**

S. Judd. Cranfield University (United Kingdom)

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

**Performance Of Newly Developed Intermittent Aerator For Flat-sheet Ceramic Membrane In Industrial MBR System**

SC. Lee, T. Xia, H. Noguchi, T. Niwa, W. Lay, SC. Chye, L. Yu, SL. Lim, MJ. Nassir, G. Tao, C. Gudipati, ST. Ooi, A. Dhalla. Meiden Singapore (Singapore)

An intermittent aerator was developed to supply large bubble at the bottom of flat-sheet membrane with a few second of interval. Performance tests for the intermittent aerator were conducted using a pilot system with two cassettes in a membrane tank of the 1-MGD DEMO plant at Jurong Water Reclamation Plant (JWRP). The present study has been undertaken to evaluate performance efficiency of the intermittent aerator by decreasing the membrane aeration flow rate required to sustain the flux. Stable operation with estimated 43 % potential reduction in the overall operating cost could be achieved with this improvement.

## **The Resource Efficient Integrated Membrane Bioreactor System**

G. Tao. PUB, Singapore's National Water Agency (Singapore)

Integrated Validation and Demonstration Plant (IVP Demo) was commissioned in 2017. The fully automated plant with a domestic used water treatment capacity of 12,500 m<sup>3</sup>/d (peak 18,750 m<sup>3</sup>/d) simulates the process selected for the future Tuas Water Reclamation Plant (initial domestic used water treatment capacity of 650,000 m<sup>3</sup>/d). IVP Demo consists of an enhanced primary treatment with biosorption, a compact lamella plate primary clarifier and a 5-pass step-feed low energy membrane bioreactor (MBR). The results from over two years of continuous operation and demonstration study indicate that the integrated system is reliable and energy and resource efficient. The MBR filtrate had a typical turbidity less than 0.1 NTU. Enhanced biological nitrogen and phosphorus removal was achieved without external carbon addition and without pH adjustment in tropical climate conditions. MBR energy consumption was less than 0.25 kWh/m<sup>3</sup> including membrane scouring energy of 0.04 kWh/m<sup>3</sup>, and the nett process energy consumption (process energy consumption - energy generation) was less than 0.05 kWh/m<sup>3</sup>. Using MBR filtrate as feed, the RO permeate had a low TOC of 24.1 to 31.3 ppb.



**24 June 2021 (Thursday)**

**7.00pm-8.30pm (SGT) (GMT +8)**

**Session 3.7 – Nutrient Removal**

### **A Systematic Approach To Select Biological Nutrient Removal Technologies To Retrofit Manila Water's 36 Sewage Treatment Facilities**

SH. Koh, E. Polloso, L. Hayag, J. Teodoro, A. Shaw, J. Barnard, YS. Tse. Binnies (Singapore)

In response to the Supreme Court's order to clean up Manila Bay and to restore its waters to be fit for swimming and other forms of contact recreation, water concessionaires in Metro Manila are faced with the urgency of converting their existing sewage treatment plants (STPs) into Biological Nutrient Removal (BNR) facilities to meet the latest discharge standards. Manila Water Company Incorporated (MWCI), water concessionaire of the East zone, currently owns and operates approximately forty STPs. To balance the need for a comprehensive consideration of all relevant processes and the constraint of needing to make good decisions in a timely manner, a systematic process options screening approach has been adopted. The result is an efficient process that categorises the STPs into suitable groups considering their unique sewage characteristics, footprint/location constraints, and treatment capacities/technologies, and then selects suitable long-list and short-list options to that category for further evaluation into a final concept.

### **Denitrifying PAOs For Low-Carbon And Low-Energy Nutrient Removal At The Ejby Mølle WRRF**

N. Uri Carreno, T. Constantine, P. Nielsen, F. Szép, K. Chandran, C. Hoar, C. DeBarbadillo. VCS Denmark (Denmark)

The Ejby Mølle WRRF in Odense, Denmark, is an example of utility challenging itself in trying to utilize the latest technologies to enhance its overall efficiency. Some of the efforts towards achieving low-energy and low-carbon nutrient removal include: low dissolved oxygen and alternating aeration, anammox seeding from a sidestream anammox reactor, mainstream hydrocyclones and chemically enhanced primary treatment, among others. This paper presents results from a WERF study on low-carbon and low-energy nutrient removal technologies for nitrogen and phosphorus removal. During this study, different experiments were made at Ejby Mølle during the transition winter-summer-winter operation in 2018 to investigate the seasonal differences in nitrogen and phosphorus removal. It was found that during the summer months, nitrite accumulates in the reactors and simultaneous nitrification-denitrification can be observed. Ex-situ activity tests confirmed the presence denitrifying PAOs capable of using both nitrite and nitrate and 16S amplicon sequencing results from that period show relatively high abundance of both putative DPAOs and anammox.

### **Going For Mainstream Anammox For Municipal Wastewater Treatment Via Partial Denitrification Providing Nitrite**

R. Du, Y. Peng. Beijing University of Technology (China)

Partial-denitrification (PD) has been proposed as a promising alternative for stably efficient production of  $\text{NO}_2^-$ -N from nitrate ( $\text{NO}_3^-$ -N) reduction for anammox process. In this study, an innovative PD coupling with anammox (PD-AMX) process was developed for mainstream municipal wastewater treatment. With the influent  $\text{NH}_4^+$ -N of 53.68 mg/L, total nitrogen (TN) removal achieved a relatively high level of 94.8% with a significantly low effluent TN concentration below 5 mg/L. Moreover, the aeration energy and  $\text{N}_2\text{O}$  production would be efficiently reduced compared to the traditional biological nitrogen removal process. Genus *Thauera* possibly responsible for PD coexisted stably with the anammox bacteria (*Candidatus Brocadia*). The novel integration of PD and anammox provides a promising approach towards an energy-efficient mainstream treatment.

### **Innovative Process For Granulation Of Conventional Continuous Flow Activated Sludge – A Novel Cost Effective Infra-Stretching Concept To Treat More Flow And Remove/ Recover More Nutrients Without Expanding Your Plant**

B. Stinson. AECOM (United States)

In a collaborative effort between AECOM and the City of Penticton, British Columbia, the formation of granular sludge was examined in the full-scale continuous flow activated sludge wastewater treatment plant in Penticton (began in 2018 and is ongoing). The Westbank process was the baseline configuration, but minor modifications were made to induce and enhance granule formation and provide retention within the process. This paper will share the details on the various process flow configurations tested, successes and failures, lessons learned and future work. Aerobic granulation was demonstrated feasible under continuous flow providing adequate treatment effluent TP < 0.3 mg/L and TN < 6 mg/L.

### **Maximising AOB Activity The Key To Optimised Performance In Shortcut Nitrogen Demonstration Trial**

A. Vellacott. Jacobs (Australia)

A 160kL/d capacity shortcut nitrogen removal demonstration plant, operated in anoxic/oxic mode with secondary clarification has operated since June 2017 at Melbourne Water's Western Treatment Plant (WTP). There have been four key periods (I - IV) exhibiting a high level of NOB out-selection. An extended six-month period out-selection was seen in Period IV. Initially reduced efficiency in Period IV(a), with an average 77% TN removal, 'COD efficiency' of 10.2 kgCOD/kgTN removed, despite a high level of NOB out-selection (NOB:AOB activity ratio of 0.35) due to reduced maximum AOB activity (average 108mgN/L/d) limiting ammonia oxidation. Maximum AOB activity increased to average of 229mgN/L/d in Period IV(b) and an increased average TN removal of 86% occurred with an average 'COD efficiency' of 6.1kgCOD/kgTN removed. When NOB out-selection results in low maximum AOB activity, plant capacity to remove TN is reduced, resulting in poorer effluent quality despite a high level of NOB out-selection.

**25 June 2021 (Friday)**

**4.00pm-5.30pm (SGT) (GMT +8)**

**Session 3.8 – Process Intensification: Integrated Approaches**

**Costs And Considerations When Implementing Process Intensification Technologies At A Wastewater Treatment Facility.**

T. Koodie, T. Chan, Z. Bhungara. Binnies (United Kingdom)

Rapid population growth and changing weather patterns are placing an increasing pressure on many existing wastewater treatment facilities globally while at the same time we strive to meet tighter environmental challenges. The scale of these future challenges for many of our major cities means process intensification (PI) technologies have come to the fore. While absolute costs are very much site specific, a unit cost analysis of various PI technologies is a useful guide. The aim of this presentation will be to compare unit costs for a variety of wastewater treatment technologies that offer the benefits of PI. In addition, the presentation will also highlight some of the critical factors that need to be considered before selecting a final treatment solution and propose a selection approach that can incorporate technical, commercial and strategic needs that match an organisations desired risk profile. Case studies will be presented to illustrate the impact of selection criteria when making investment decisions.

**Performance Tracking Of RO Units In A Hybrid RO-EDR Configuration Treating Municipal Wastewater At 90% Recovery**

K. Wee, G. Gunasheela, KK. Kee, B. Abolmaali. SUEZ Water Technologies & Solutions (Singapore)

SUEZ Water Technologies and Solutions (WTS) piloted a novel hybrid desalination process based on electrodialysis reversal (EDR) and reverse osmosis (RO) at a local water reclamation plant in Singapore. The pilot was run in two phases to demonstrate an overall recovery achieving 90% with the proposed process. During the first phase, RO1 and RO2 were operating at 75% and 65% recovery respectively, in tandem with the EDR which reduced the salt content such as total hardness (calcium, magnesium) in RO1 concentrate prior to entering RO2. Despite the elevated concentrations of silica and dissolved organics, RO2 continued to operate very stably. The operating data of both RO1 and RO2 were normalized using the MUNOS program (Eriksson, 2015) to track the change in RO performance in term of absolute numbers, i.e. water and salt permeabilities of RO membranes, and to estimate fouling allowance or safety factor in full scale RO design or simulation.

### **Process Intensification Of Continuous Bioreactors Across Europe: Upgrading Conventional Activated Sludge Towards New Densified Biomass**

S. Donnaz, C. Roche, B. Wett, S. Murthy. SUEZ International (France)

Alternatives for Brownfield retrofitting increasingly deserve to be considered in comparison with Greenfield expansion scenarios. Key advantage of valuing existing assets has led to the development of new biological process designs and technologies in the fields of continuous bioreactors. This paper deals with full-scale demonstrations implemented across Europe, through major WWTP in France, Spain and Poland. Outstanding performance results will be shared including detailed demonstration of the controlled-shift of microbiome implemented to achieve the new specific definition of densified biomass, together with key process results obtained with the densified biomass. Process configuration and methodology will be shared including how to assess, control and transform activated sludge to densified biomass. Operational performance results and rationale for site selection will be detailed over the trial periods for each site, such as carbon, nitrogen and phosphorus removal efficiencies, process operation parameters, Mixed Liquor Suspended Solids concentration, Sludge Volume Index (SVI), Initial settling Velocities, SVI30/SVI5, Aggregates > 200  $\mu\text{m}$ ...

### **The Application Of Computational Fluid Dynamics With Integrated Biokinetics To Accelerate Process Innovation In The Water Industry**

W. Audenaert, U. Rehman, I. Nopens AM-TEAM (Belgium)

This abstract gives three different full-scale examples of the application of computational fluid dynamics (CFD) with integrated biokinetics. The examples relate to bioreactor aeration, scale-up of a novel MBR technology and enhanced biological phosphorus removal (EBPR). CFD-biokinetic modelling has led to novel applications of CFD models, whereby concentrations (e.g. ammonia, COD, nitrates, phosphorus) are simulated in 3D in bioreactors. Utilities and technology companies start embracing these models to (partially) replace or reduce physical trialing. The concept of 'virtual piloting' is rapidly emerging and can reduce the technology development cycle drastically and can lead to disruptive new designs. On the other hand, the models give new insights to be used for energy saving, effluent quality improvement and better reactor design.

**25 June 2021 (Friday)**

**7.00pm-8.30pm (SGT) (GMT +8)**

**Session 3.9 – Biofilm Processes**

### **MABR - An Innovative Solution For Resilient Wastewater Treatment**

D. Christenson, D. Houweling, Dwight, J. Peeters, A. Shaw, L. Stadler. SUEZ Water Technologies & Solutions (Canada)

Climate change is resulting in more challenging conditions for wastewater treatment plants, including extreme flow and load events, large variations in temperature and the risk of process upsets such as extended power outages. Resilient treatment solutions are an important component of managing this new reality. The membrane aerated biofilm reactor (MABR) is an innovative biofilm treatment technology that has unique features that make it resilient to peak flows, temperature change, and shutdown events. In this paper, the authors discuss and present evidence that the unique features of an MABR make it more resilient than conventional treatment. Data from a pilot study and a full-scale MABR installation are analyzed to demonstrate the resiliency of the technology. Future work includes side-by-side testing of MABR, moving bed biofilm reactor (MBBR), and conventional treatment under high-flow conditions. This work will be started in early 2020.

### **Maximizing Asset Capacity And Performance Via Process Intensification Using MABR Technology**

W. Bagg, E. Joubert, A. McNeil, J. Peeters. Water Corporation (Australia)

Following extensive investigation Water Corporation has identified Membrane Aerated Biofilm Reactor (MABR) as the preferred technology to increase secondary treatment capacity at two large Perth Metro facilities. The innovative technology has the potential when retrofitted into existing process volume to intensify secondary treatment capability and reduce process aeration demand and greenhouse gas emissions. Starting in mid-2020, a two-year pilot trial at the new Subiaco Water Research & Innovation Precinct (WR&IP) will test MABR suitability and confirm location-specific system design requirements. The trial is the first of its kind in Australia and will be supported by local and international experts.

### **Quick And Compact Package Type DHS Pilot Plant In Khon Kaen City, Thailand**

Y. Kirishima. NJS Consultants Co., Ltd. (Japan)

Khon Kaen, which is a major and a rapidly growing city in North-East Thailand, has an existing sewage treatment system using aerated lagoons with a large footprint (area). However, the efficiency and the capacity are shortening due to the population increase and other causes.

Downflow Hanging Sponge (DHS) reactor is an economical and an ecological wastewater treatment technology originated in Japan. This project aims to achieve the discharge standard in Thailand using DHS reactor with short hydraulic retention time (HRT), and to demonstrate its compactness, odorless, efficiency and quick installation.

The pilot plant, which is a combination of a primary sedimentation (hereinafter PS) tank and DHS reactor with the capacity of 160 m<sup>3</sup> per day when operating HRT 30 minutes for sponge media volume, achieved the compactness, odorless and stable effluent quality within two (2) weeks after installation.

### Testing MABR technology at Ejby Mølle

N. Uri Carreno, T. Constantine, P. Nielsen, J. Sandino, A. Willoughby. VCS Denmark (Denmark)

Utilities around the world are increasingly being challenged to "do more with less", and this is particularly true with respect to both energy efficiency and process intensification, while still achieving or improving upon effluent targets. Membrane aerated biofilm reactor (MABR) technology has emerged as a highly attractive technology that promises to achieve both of these goals. Since June 2018, VCS Denmark has been testing four full-scale MABR units in a hybrid (IFAS type) configuration. The demonstration is equipped with several online instruments that allow for continuous data acquisition of nitrification rates and oxygen transfer rates, among others. Visual inspection of the units every three months and periodic intense testing such as batch tests or argon transfer tests are also major components of the study. During the first year of operation, MABR has demonstrated to be capable of complete simultaneous nitrification-denitrification. Despite challenging conditions during the start-up, the oxygen transfer efficiency and the nitrification rates continue to improve.

**28 June 2021 (Monday)**

**4.00pm-5.30pm (SGT) (GMT +8)**

**Session 3.10 – Advanced Modelling, Sensing & Control I - Outside the Fence**

### **A System Thinking Approach To Asset Optimization**

G. Simpson, T. Önnérth. Veolia Water Malaysia (Malaysia)

AQUAVISTA™ is a comprehensive digital solutions package offered by Veolia. The AQUAVISTA™ Plant module is a holistic solution Software As A Service (SaaS) offering real-time optimization through state-of-the-art online control, monitoring and forecasting principles. This system utilizes real time and forecasted information to meet operational targets. Benefits include reduced overall capital and operations costs, increased hydraulic capacity, and improved operation in terms of efficiency, stability, and safety. The savings are achieved through prioritization of the optimal performance during all load situations without compromising a compliant effluent quality. This paper demonstrates how AQUAVISTA™ Plant, using an integrated Plant/Network systems approach, can improve the overall performance of the entire sewage system by combining forecasts of the upstream urban drainage system with information from the wastewater treatment plant and provide insights on this approach implemented with the municipality of Kolding's (Denmark), which manages the treatment of 15 million m<sup>3</sup> of wastewater per year.

### **An Overall View Of Management Decision Impacts On Wastewater System Emissions Using Integrated Urban Wastewater Modelling**

T. Maruejols, J. Ledergerber, P. Vanrolleghem. LyRE – SUEZ Group (France)

An integrated wastewater system model was developed to assess the overall impact of urban wastewater management decisions on the environment. The model reproduces flowrate and particulate pollutant fluxes through the catchment, the sewer and the treatment facility. The model was developed for the Clos de Hilde catchment in Bordeaux (France). It was calibrated and validated based on continuous monitoring data. A global sensitivity analysis allowed targeting the most influential control handles that can affect the pollutant emissions. The reference scenario results show the distribution of pollutant fluxes emitted to the receiving body. This scenario will be further compared to alternative management scenario in order to understand impacts on the environment of various strategies.

### **Efficient Integrated Real-time Control In Urban Drainage And Sanitation Systems For Environmental Protection**

J. Meseguer, B. Joseph-Duran, X. Bernat, G. Cembrano, T. Maruéjols, M. Martínez, R. Guasch, P. Rouge. Cetaqua – SUEZ Group (Spain)

The main goal of the LIFE EFFIDRAIN project is to demonstrate integrated real-time control (RTC) strategies for Urban Drainage Networks (UDNs) and Wastewater Treatment Plants (WWTPs) to better protect the environment from UDN and WWTP impacts, through the use of real-time water quantity and quality data. This paper presents results of LIFE EFFIDRAIN developed RTC methods tested in two complementary pilot sites (Bordeaux (France) and Badalona (Spain)). Performance of these methods has been obtained using a simulation setup able to reproduce the hydraulic and quality dynamics taking place in the real pilots. Final results shows, developed RTC methods are able to reduce the polluting load of any unavoidable Combined Sewer Overflow (CSO) in a wide range of scenarios

### **Increasing Resilience of Collection Infrastructure with Real-Time Decision Support Systems**

L. Montestruque. Xylem Inc. (United States)

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



**28 June 2021 (Monday)**

**7.00pm-8.30pm (SGT) (GMT +8)**

**Session 3.11 – Advanced Modelling, Sensing & Control II - Inside the Fence**

### **Building A Smart Water Reclamation Plant**

KM. Phua, K. Koh, G. Tao, WJ. Chan, J. Ng, L. Tai. PUB, Singapore's National Water Agency (Singapore)

PUB commissioned the Integrated Validation and Demonstration Plant (IVP) in August 2017 to test and validate process technologies and automated plant operations for the future Tuas Water Reclamation Plant (TWRP). Riding on the existing infrastructure, the Smart WRP project seeks to further enhance the capabilities of IVP through the implementation of various Industry 4.0 technologies identified in PUB's technological roadmap to achieve our mission in 4 key strategic aims: energy efficiency, effluent quality, workforce productivity and personnel safety & plant security. This includes the incorporation of commercially available products within the existing plant, such as wireless process sensing, wireless equipment condition monitoring, advanced process control, facial recognition for access controls and a real-time location and safety monitoring system. Simultaneously, through the R&D project, PUB seeks to co-develop and validate the usefulness of novel and emerging solutions such as autonomous robot for sample collection, augmented reality glasses for operations and maintenance work, digital twin for simulations and machine learning for video-based water quality monitoring.

### **Sustainable And Efficient Aeration Control -- Improved Quality And Energy Savings With Next Generation Of Self-learning AI Process Controller**

M. Charatjan, H. Hermann. Binder GmbH (Germany)

The main challenges in aeration control are stable control results independent of changing load situations and other interferences. Standard PI- or PID-controllers work well in static systems, but the aeration process is subject to load changes and requires a dynamic adjustment. A smart advanced aeration controller was developed especially for this application. It was tested and used in several plants, using air flow rate beside DO-concentration as the control variable. Based on a PID-controller, the static P-part was changed to a self-learning and self-adjusting type, considering in each control step the remaining offset of last steps. In addition, a multiple I-part looking at near and distant past was introduced to improve the dynamic behaviour. Considering further process parameters e.g. water temperature, salinity and others to damp/ amplify the control result, results are automatically adjusted to actual load. Configuration of the controller can be done for best control accuracy or lowest energy costs or a compromise of both.

### **The Implementation Of A Whole Plant Digital Twin Simulation For Changi WRP**

YP. Mak, KYA. Tan, B. Johnson, J. Curl, R. Kadiyala. Jacobs International Consultants (Singapore)

Currently, a whole plant dynamic simulation model, called "Digital Twin" is being developed for CWRP. The Digital Twin intends to fully integrate the individual hydraulic, process and control aspects of CWRP into a single integrated model with predictive capabilities to forewarn operators of potential process deviations and poor effluent quality. The model development will include real-time data integration, analytics and validation for model use. Sumo<sup>®</sup> by Dynamita is used for process simulation, while REPLICA<sup>™</sup> is used for control system and hydraulic modelling. The integrated model will also have machine learning component to automatically adjust model calibration within defined ranges to better match the observed performance. The model is expected to assist in simulating various operational scenarios of the treatment system to enhance water quality, optimize energy and chemical consumption of the plant.

### **The Use Of Advanced Real Time Analytics To Optimize The Aeration Energy Usage At Cuxhaven WWTP**

J. Gebhardt, D. Mak, A. Nink. Xylem (United States)

EWE WASSER wanted to optimize the operation of the Cuxhaven Wastewater Treatment Plant (WWTP) to reduce energy consumption, improve safety, and increase the certainty of regulatory compliance. To do this, it went beyond static setpoint controllers (such as PIDs) and implemented a control system based on how to best treat the particular wastewater coming into the plant at that moment. The BLU-X Treatment system was used to build models using Neural Networks (NN) of the carbon-, nitrogen- and phosphorous-elimination processes based on the data from the existing SCADA system. With this information, the system then created an optimization strategy for reducing aeration energy use within the WWTP based on the plant's needs at that moment and in the near term future. Implementing this solution reduced the aeration energy consumption by 26% (1.1 million kWh annually) while continuously maintaining regulatory compliance since its installation in 2017.

**29 June 2021 (Tuesday)**

**4.00pm-5.30pm (SGT) (GMT +8)**

**Session 3.12 – Used Water Asset Management**

### **Designing A Robotic Platform For Large Diameter Sewerage System**

H. Dinh, WC. Law, B. Burhan, SH. Yeo, GL. Seet. Nanyang Technological University (Singapore)

The environment in sewerage tunnels are frequently challenging for humans. It is desirable to exclude humans or to minimize human exposure. Frequently robots are challenged by obstacles and access restrictions. Robot deployment in deep large bore tunnels, is a challenging problem to resolve. Where human access is possible, inspection and maintenance tasks are frequently performed with human operators. Robot, in the long term, promises to offer a safer and more cost-effective solution. This paper describes a robotic solution for the inspection of deep large-bore sewer tunnels in Singapore, where tunnels may be 20 to 50 meters below the surface. The robotic platform includes a mobile robot and an umbilical cable management system that allows the system to capture the tunnel-surface images with incursions of up to 500 meters. The system offers the capability of stitching, the captured video images, to form a full map of the tunnel. This enhances the ease and capability of inspection. The system has been deployed and repeatedly verified in existing and operational segments of sewerage tunnels in Singapore.

### **Efficient Operating Conditions For Variable Frequency Drive Based Vertical Pumps Under Structural Looseness Due To Ageing**

SC. Athikessavan, A. Vijaya Bhaskar, E. Jeyasankar, SK. Panda, S. Mulpuri, P. Chella, SS. Muthuraj. National University of Singapore (Singapore)

Variable speed operation of vertical pumps in wastewater treatment plants increases the likelihood of resonance conditions which in turn increases the overall vibration level of motors and pumps. Such resonance conditions are aided by structural looseness due to ageing. Although structural overhauling due to ageing is inevitable, identifying the range of safe operating speeds by conducting the impact test and then operating pumps close to the Best Efficiency Point (BEP) can reduce OPEX and also fully utilizes lifespan of motors and pumps until a major repair-work is scheduled. This paper provides insights about vibration spectrum of a decade old, four 450 kW, LV motor-pump setups under the impact test. The safe operating speeds of all the motors with maximum efficiencies are selected based on the impact test which can provide an additional overall flow rate of 200 m<sup>3</sup>/hour with a total cost savings of up to S\$36 k/annum.

### **Improving Used Water Plant Resiliency And Asset Performance Through Condition Based Smart Digital Pressure Monitoring Trial For Aeration Diffusers At Ulu Pandan Integrated Validation Plant**

PC. Siow. Xylem Water Solutions Singapore Ptd Ltd (Singapore)

Fine Bubble Aeration Grid's Dynamic Wet Pressure (DWP) Monitoring is a critical operational activity for Water Reclamation Plants (WRP). In the Ulu Pandan Integrated Validation and Demonstration Plant (IVP) of PUB, Singapore's National Water Agency, a digital version of DWP Measuring Device (DPM) has been introduced and comparison is made against the current analogue Pressure Monitoring System (PMS). From the trial monitoring, it is observed that the digital DPM has many advantages over the analogue version from the aspect of reliability and accuracy, efficacy of automated trend monitoring and as an asset resiliency and performance improvement enabler.

### **Prioritizing Investments -- How One Danish Water Utility Is Taking A Holistic, Multiple-Bottom-Line Approach To Future Planning**

N. Kroghsbo, PH. Nielsen, P. Hallager, N. Askjær. VCS Denmark (Denmark)

VCS Denmark (VCS) is a progressive water and wastewater utility in Odense and Nordfyn municipalities in Denmark who operate, maintain, and manage an extensive sewer system. With an annual investment of DKK 150-200 million (US\$23-30 million), VCS funds many different projects, but is limited by both financial and resource constraints. For this reason, as well as their corporate commitment to following sustainable development tenets, they have implemented a proactive, systematic planning process to optimize their yearly investments. Not only driven by economic considerations, this system takes a holistic, long-term approach with a multiple bottom line. This paper will discuss how this forward thinking utility addresses the challenges of planning in a dynamic utility and municipal environment.

**29 June 2021 (Tuesday)**

**7.00pm-8.30pm (SGT) (GMT +8)**  
**Session 3.13 – Microbial Ecology**

**Anaerobic Microbial Consortium In Anaerobic Membrane Bioreactor For Municipal Wastewater Treatment And The Use Of Bacteriophages To Tackle Membrane Fouling**

P. Hong. King Abdullah University of Science and Technology (Saudi Arabia)

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

**Managing Emerging Contaminants In Biological Treatment When Developing A Broad Reuse Portfolio**

S. Sathyamoorthy, C. Hoar, CA. Ramsburg, K. Chandran. Binnies (United States)

Widespread application of energy intensive processes abiotic processes to manage emerging contaminants will ultimately be unsustainable. This is particularly relevant in water scarce regions where infrastructure may not be as well developed. There is a need to better understand of the fate of ECs in biological treatment processes. Our research focuses on two pathways relevant to microconstituent removal: cometabolism and the links between microbial community structure and catabolism. Results suggest that ammonia oxidizing bacteria play a role in the cometabolism of certain ECs. Results assessing catabolism using DNA stable isotope probing (DNA-SIP) suggest that only a small subset of the microbial community capable of biodegradation can catabolize BPA or other ECs. Results from our research hold utility to develop a more comprehensive framework of understanding of the fate of microconstituents in biological wastewater treatment processes.

**Microbial Acclimation Towards Substrate Overloading Via Recurring solids Retention Time Reduction**

AF. Mohidin Batcha, TCA. Ng, AA. Cokro, Y. Lu, S. Wuertz. Nanyang Technological University (Singapore)

Anaerobic digestion (AD) is a biological degradation process for treating organic wastes to produce renewable energy. Anaerobic digesters are generally operated at long solids retention time (SRT) to ensure stable digester operation. In this study, we investigated the prospect of evolving a resilient and robust AD microbiome through repeated severe SRT perturbations. We postulated that microbial communities may adapt to and recover from recurring severe SRT perturbations.

**Microbial Ecology Of Anaerobic Carbon Conversion**

C. Wilson. Hampton Roads Sanitation District (HRSD) (United States)

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

## **Optimization Of Nutrient Removal Processes And Microbial Activities In A Demonstration Water Reclamation Plant**

Q. Wang, G. Tao, S.L. Low, J. He. National University of Singapore (Singapore)

Characterization of the underlying mechanisms for nutrients removal and linking bioreactor performance with operational conditions can help to inform the design and development of future full-scale facilities. In this study, we compared the microbial community structures with the variation of operational parameters and the nutrient removal mechanisms. Nitrosomonas and Nitrospira were the dominant AOB and NOB genera, respectively. Much higher NOB relative abundance than AOB showed the less possibility of partial nitrification. Even though over 0.4% of anammox bacteria with the dominant genus of Brocadia was found, how these bacteria in different abundance contribute to nitrogen loss has yet to be studied. The alternating aerobic/anoxic condition provides around 1 mg/L in the aerobic zones, creating an environment that possibly favors the generation of nitrate. To date, the main nitrogen removal mechanism was nitrification/denitrification, and nitrification/partial denitrification as supported by the ammonium converted mostly to nitrate and the low C/N ratio in reactor B resulting in the lower TIN removal efficiency as well as the residual nitrite found in the effluent.

**30 June 2021 (Wednesday)**

**4.00pm-5.30pm (SGT) (GMT +8)**

**Session 3.14 – Industrial Wastewater Treatment and Reuse**

### **Application Of Ultrafiltration Coupling Processes To Tackle Challenges In Industrial Wastewater Treatment**

J. Liu. CITIC Envirotech Ltd (Singapore)

Application of innovative intensified technologies for wastewater treatment appears to be the future trend in water industry. This paper discusses two of such kind technologies both involving membrane filtration. One is the uprising Membrane Bioreactor ("MBR") where biomass is enriched in the bioreactor by ultrafiltration membrane. Another example is the novel combination of Fenton Oxidation and ultrafiltration process where iron catalyst (iron sludge) is well kept in the system. As a case study to demonstrate the remarkable performance of those technologies, a commercial operating industrial wastewater treatment plant was examined. It is the aim of this paper to provide insight to the process and explain the phenomenon observed.

### **Demonstrative-scale SIAM Technology Trials In Dairy And Slaughterhouse Factories**

A. Silva-Teira, X. Bernat, J. Dominguez, L. Rodriguez-Hernandez, B. Saenz, J. Malige, JM. Garrido, A. Arias. Cetaqua - SUEZ Group (Spain)

Water reclamation and energy-efficient systems were the main drivers on SIAM (Spanish acronym of methanogenic Anaerobic reactor and Membrane bioreactor Integrated System) birth. Industrial wastewaters from different sectors were explored and prioritized by the physico-chemical characteristics and the water flows generated to be treated. Once selected the sectors, this technology has been demonstrated with dairy and slaughterhouse industrial wastewaters in two pilot-plants of 4 and 3 m<sup>3</sup>, respectively. Effluent characteristics complied: in-force discharge limits, the latest revision of the best available techniques (BAT) for food, drink and milk industries, reuse quality standards (excluding the productive process in which the reuse is forbidden), with competitive design parameters in both pilot trials. Environmental studies, life cycle analysis (LCA) and economic estimations indicated that this SIAM technology was more beneficial than the conventional activated sludge (CAS) systems.

### **Development Of Potato Chip Process Water Treatment & Reuse Technology**

R. Verma, SK. Kota, S. Gupta, A. Sathyagal, A. Anand. PepsiCo Inc. (United States)

Water stress in the Channo (India) snacks plant location necessitated a wastewater treatment and reuse solution to ensure business continuity. The objectives of this work were to design a treatment system that maximized treated water use in the plant while meeting Quality and Food Safety requirements for reuse water in process applications. A treat-in-place concept with a fit-for-purpose treatment was developed where process wastewater generated from a unit operation gets treated separately to the quality required for its reuse and then recycled back to the same unit operation. The designed system has been installed and operational since late 2018. It has reduced the plants' ground water usage by 30+% to date, with further reduction to 50% expected by late 2019. The treat-in-place concept reduced the capital cost by 30% and operational costs by 10% compared to a centralized system treating to potable quality water.

### **Evaluation Of Toxicity In Industrial Wastewater Treated By Electro-Fenton**

R. Muzzi, H. Olvera-Vargas, O. García-Rodríguez, R. Marks, O. Lefebvre. National University of Singapore (Singapore)

Electrochemical advanced oxidation processes (EAOPs) offer an interesting possibility for industrial wastewater treatment, owing to their capacity to treat a wide range of chemicals at various concentrations. However, with the objective of integrating them within conventional biological treatment trains, the potential toxicity of the treatment must be considered. For this study, the effect of electrochemical degradation on the toxicity of a real wastewater, obtained from a Singapore membrane production facility, was investigated with a new methodology that makes use of three bioreporter bacterial strains, that bioluminesce specifically when exposed to DNA, protein and membrane damage. The observed effect is that, as the electrochemical treatment proceeds, the total organic carbon (TOC) decreases; however, the oxidation of the parent species gives rise to intermediate chemicals that increase then overall toxicity. The result suggest the need for a more prolonged treatment in order to get rid of this residual toxicity.

### **TERI Advanced Oxidation Technology As An Integrated Approach To Treat Wastewater And Achieve ZLD: Case Studies From India**

N. Bahadur, N. Bhargava. The Energy and Resources Institute (TERI) (India)

In India, wastewater treatment suffers from two major limitations: (i) similar treatment of wastewater streams having different nature and constitution (ii) the effluent remains 'inadequately' treated, probably because of use of conventional, costlier and redundant approaches. As the result re-use, re-cycle and achieving ZLD is not possible in true sense. In this pursuit TERI has developed a novel and patented 'Advanced Oxidation Technology', which aims at complete end-to-end treatment of wastewater effluent streams having high color, COD, BOD, TOC, dissolved organics, non-biodegradable and persistent organic pollutants (POPs), generated from highly polluting industries and/or mixed streams having municipal sewage. The protocol involves innovative primary treatment, followed by Heterogenous Photocatalysis (HP) involving nano-TiO<sub>2</sub>/UV as secondary treatment and suitable filtration leading to treated water meeting process water quality enhancing water re-use efficiency and enable Zero Liquid Discharge (ZLD); These are discussed in the light of successful case studies developed at a pilot scale.



**01 July 2021 (Thursday)**

**7.00pm-8.30pm (SGT) (GMT +8)**

**Session 3.15 – Wastewater Treatment for Developing Countries**

### **Co-treatment Of Faecal Sludge With Wastewater In Bijnor, India To Achieve Sanitation For All -- A Case Study**

S. Padhi, S. Rohilla. Centre for Science and Environment (India)

Wastewater (WW) and Faecal Sludge (FS) management is an integral component of improved city-wide sanitation. Cities/towns that have Sewage Treatment Plants (STPs) with adequate spare capacity are presented with a low hanging fruit of utilising existing infrastructure to manage faecal sludge and septage (FSS) at the STP. Though, FSS is more concentrated in strength than domestic sewage, its constituents are similar to municipal WW thereby making it amenable for co-treatment. In fact, co-treatment of FSS with domestic sewage at an STP can prove to be a cost-effective option in terms of both capital as well as operational expenditure. In this regard Shit Flow Diagram of Bijnor city, a small town in Ganga basin, India, was developed to understand the gaps along the sanitation service chain. Thereafter, characterisation of WW and FS was done and analysed to study the feasibility for co-treatment of FSS at the upcoming STP.

### **Using ISO/DIS 31800:2019 As A Guideline For Resource Recovery Of A Faecal Sludge Treatment Unit In India**

C. Chan, RA. Kumar, MY. Chan. TÜV SÜD PSB (Singapore)

As cities grow, consumption of energy and resources increase. The approach to capture and recover valuable resources becomes crucial in being sustainable. In recent years, advancement in decentralised faecal waste treatment technologies with resource recovery capabilities are emerging rapidly. Development of an International ISO standard was therefore started to ensure the economic viability of these technologies and turn waste into valuable resources, such as renewable energy by products and/or agriculture products. Specifically, one of the key requirements in the ISO/DIS 31800 is for such faecal sludge treatment unit (FSTU) to be energy independent or sustainable. This paper presents the possibility of energy and by-product recovery, based on a pyrolysis technology in Warangal, Telangana, India, testing with the help of the ISO/DIS 31800.

### **Why Biological Filtration Systems Are The Best Solutions For Wastewater Treatment Under Most Conditions**

R. Chhabra. Transchem Agritech Pvt Ltd (India)

Trans Bio-Filter is a green technology using very low power which treats wide range of wastewater and converts the treated water into diluted vermiwash which can further be used for irrigation purposes and promotes organic farming. Municipal sewage can be treated for process reuse and reject of membrane system can be effectively used in agriculture as Vermiwash. Biological trickling filter through Vermifiltration is an age-old technology and is being used for treatment of sewage across the world. The emerging trend is to treat wastewater at its source with a decentralized approach since water transportation costs are 70-82% of governments in most countries.

**23 June 2021 (Wednesday)**

**4.00pm-5.30pm (SGT) (GMT +8)**

**Session 4.1 – Water Circular Economy in Cities of the Future I**

### **Energy And New Resources Out Of Water To Create A Circular Economy For A Metropolitan Area**

A. Strucker. Waternet (Netherlands)

In 2050 70% of the people on this planet will live in metropolitan areas. City-planners, policymakers, city-administrators, together with all stakeholders involved will have to face the big challenges to realize a liveable city with the ambition to incorporate the Sustainable Development Goals (SDG's) of the United Nations. The approach has to focus on both the short term and the long term. Water is an important driver in the city transition to become an economic and sustainable region. Water can also play an important role from a circular economy perspective. A water utility can connect stakeholders like knowledge institutes, market parties and governments to realize new circular business models. The government owned water cycle company Waternet shows the importance of this role in the Amsterdam Metropolitan Area. Examples of the water related impact is heating and cooling buildings with water, resource recovery -- phosphate, cellulose, calcite, biomass -, smart asset management solutions. The Amsterdam approach can inspire other metropolitan areas.

### **Framing of Circular Economy White Paper**

S. Tahir. Arup London (United Kingdom)

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

### **Impact And Opportunities For The Urban Water Cycle Of The 'fully Circular In 2050' Target Of The Netherlands - Circular Water 2050**

K. Roest, L. Snip, A. De Jong, H. Van Alphen, A. Segrave, B. Römgens KWR Water Research Institute (Netherlands)

The project's aim is to develop a vision and roadmap(s) for the water sector, with a view to the national 'A Circular Economy in the Netherlands by 2050' program. This involves the raw material efficiency in the urban water cycle, including the extraction and reuse of raw materials. The incoming and outgoing substance flows of the current water chain in the Netherlands have been mapped. The material flows are presented in the form of Sankey diagrams. An overview of possible conceptual and technological innovations that can be relevant for the water cycle in 2050 has been produced. Finally a circular system integration is needed. We investigated, described, discussed, defined and established what is meant in the water cycle with fully circular in 2050 and how this can look like in practice.

### **Role of water utility (broader perspectives on city-scale circular economy)**

X. Litrico. SUEZ (France)

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

**24 June 2021 (Thursday)**

**4.00pm-5.30pm (SGT) (GMT +8)**

**Session 4.2 – Water Circular Economy in Cities of the Future II**

**Achieving Water Resilience Amidst Climate Change Via Closed Loop - Circular Water System Innovations & Technologies For Urban & Rural Water Sensitive Design To Ensure Water For All.**

S. Samuel, ECOSOFTT Pte Ltd. A Social Enterprise (Singapore)

The gap in demand and supply for water will be an estimated 40% by 2030. There will be an increase in population from 7 to 10 billion within this century. Almost 60% are expected to live in city like conditions. Food production alone will see an increase in demand for water by 70%. With almost 2/3rds of the world's population living in water stressed conditions, water shortage, scarcity and quality are issues faced by both the developing and developed world. The gap in demand and supply can be met via the following strategic options (a) increasing supply, (b) reducing demand and (c) becoming more efficient with the use and management of water as a resource. Closed loop- circular water systems will play an important part in water resilience, security and sustainability that will cut across various scenarios. It looks at water 'end to end' in a local context and provide 'fit for purpose water' using closed loop-circular water systems (urban and rural) backed up by innovations in technologies, design, social engineering, business models and conserving sources to ensure water for all.

**Tuas Nexus - An Example of Industrial Ecology**

C. Lim. PUB Singapore (Singapore)

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

**Owner And Operator Benefits Of The Digital Delivery Of Infrastructure (Digital Application To Operation And Maintenance)**

C. Newbery, L. Connor Jacobs (Singapore)

The design of many infrastructure projects is being transformed using digital processes, moving from 2D drawings to 3D models and the incorporation of design and construction data to form Asset Information Models. Current practices and processes tend to concentrate on the relatively short design and construction phases, rather than the longer operational phase of the project. While hazard and safety reviews for the operational phase, such as HAZOP, HAZID and DfS, are developed and formalised into structured studies to ensure completeness and standardisation, the same frameworks do not exist for the review for operational and maintenance tasks. As part of the development of major water treatment facilities in Singapore, a formalised study framework has been developed to guide teams through a review of designs to highlight and address issues with carrying out operational and maintenance tasks efficiently and safely. These studies have been termed ALMOP studies, standing for Access, Lifting and Maintenance studies.

**Designing Water Sensitive Cities of the Future**

S. Kenway. Advance Water Management Centre of the University of Queensland (Australia)

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

**25 June 2021 (Friday)**

**4.00pm-5.30pm (SGT) (GMT +8)**

**Session 4.3 – Hybrid Blue/Green/Grey Infrastructure**

### **CWOS: Next Phase In Smart Stormwater Management**

O. Pison, A. Mahadevan. SUEZ Singapore (Singapore)

As part of an R&D partnership between PUB and SUEZ, a real-time stormwater management system based on Aquadvanced Urban Drainage has been designed, developed and deployed since November 2016. The Catchment and Waterways Operational System (CWOS) has shown significant benefits in anticipating Marina Barrage operations for flood control and monitoring water quality. With the successful implementation of the system, a new phase of the project has commenced which aims to further the efforts already undertaken to improve existing systemic workflows. The project will particularly focus on developing and integrating multiple data sources with advanced analytics to improve operational efficiency specifically in terms of inter-reservoir/catchment transfer operations with the objective of water conservation.

### **Developing New Blue-Green Futures: Multifunctional Infrastructure To Address Water Challenges**

E. O'Donnell, N. Dolman, N. Netusil, F. Chan. Royal HaskoningDHV (Netherlands)

There is a recognised need for a fundamental change in how cities tackle urban water challenges and develop visions for 'Blue-Green' urban futures; where multifunctional Blue-Green infrastructure (BGI, including green roofs, swales, rain gardens and ponds) creates environmental and societal co-benefits and is delivered by cross-organisational collaborations. The aim of this interdisciplinary proposal is to explore how Blue-Green futures may be developed as new forms of environmentally sustainable urban governance. We will investigate how socio-political barriers to implementation of BGI may be overcome and how mechanisms for co-creating Blue-Green visions (e.g. social learning frameworks) may increase the adaptive capacity of decision-makers and lead to concerted action. We will devise an international 'best-practice' model based on an evaluation of Blue-Green visions in four case study cities (Newcastle, UK; Rotterdam, the Netherlands; Ningbo, China; and Portland, Oregon, USA). Cross-country learning will inform new Blue-Green visions for the UK and other global cities.

### **Hybrid Blue/Green/Grey Infrastructure**

J. Wang. Water Sensitive Cities Institute (Australia)

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

## **Realising Dying Wisdom: Contribution Of Green Infrastructure In Making The City Flood Resilient**

B. Luthra, S. Rohilla. Centre For Science and Environment (India)

In India, urbanisation is increasing as cities offer opportunities for economic growth. This accompanied with concretization generates more runoff discharge making most of the cities suffer from urban flooding during monsoon. This consequences to loss of life and property. Indian towns have a rich tradition of managing the stormwater based on the local context. But the modern stormwater management, that relies heavily on the cost intensive grey infrastructural solutions, has a tendency to take stormwater away from the city. In this regard the case of Bodhgaya city, a small town in India, which enjoys immense religious and cultural significance is considered as the study area. Bodhgaya, historically had green infrastructure (GI) to manage water, but unplanned growth has made all systems defunct and has also contributed to water logging. This study aims to analyze the approach of sustainable stormwater management through GI solutions to overcome the emerging water management crisis.

**28 June 2021 (Monday)**

**4.00pm-5.30pm (SGT) (GMT +8)**

**Session 4.4 – Water for Liveability**

### **Amsterdam And The City Swim (ACS)**

S. Holthuijsen. Waternet (Netherlands)

Over the years, water quality in the surface water in and around Amsterdam has improved enormously. Nowadays, inhabitants of Amsterdam see beautiful water. They have the idea that swimming in this sparkling water is completely safe. They jump in on a nice summer day. More and more, events are organized in dense cities. This is a great opportunity to show the value of water. However, combined sewer systems, overflows and false connections are still existing assets in these cities and the functioning can and/or will affect the water quality. Monitoring shows many time frames during a summer season in which water quality sustains swimming. We have developed a monitoring network to provide people with the basic information on the momentaneous water quality. In this presentation Waternet explains the history of water quality in Amsterdam, in relation to the success of the City Swim since 2012, and the annulation in 2018, based on operational monitoring data.

### **Potential Of Floating Urban Development For Coastal Cities. A Global Analysis Of Flood Risk And Population Growth**

B. Dal Bo Zanon, B. Roeffen, K. Czapiewska, R. De Graaf-van Dinther. Rotterdam University of Applied Sciences (Netherlands)

Population growth and urbanization mainly take place in vulnerable coastal areas. This article presents a global overview of these areas with both rapid population growth and high flood risk, in order to identify coastal areas that could benefit most from floating urban development. After identifying the most promising locations, a research by design case study is presented in an area where floating projects are already present to further test medium and large-scale concepts. A large scale floating maritime spatial project is shown, which integrates urban and ecosystem development with food and energy production in the North Sea. This plan provides a spatial concept for floating urban expansion in front of the coast of the Netherlands which may serve as a stepping stone towards global implementation of floating developments.

### **Safeswim: A Predictive Digital Twin For Recreational Water Quality In Auckland, New Zealand**

A. Osti, S. Couper, N. Brown, M. Neale. Mott MacDonald (New Zealand)

What if we could create the most livable city on the planet? Auckland is globally renowned for its beaches and waterways, but after rainfall the wastewater network can be overwhelmed, leading to sewer overflows. Following an independent review in 2016, Auckland Council set out a new strategy for its recreational water quality programme (Safeswim) to deliver international best practice management of public health risks around recreational bathing. Safeswim has delivered a public facing web platform that has given over 500,000 Aucklanders or visitors the confidence to make the most informed decision possible on health risks around swimming at 109 beaches across the city. This was achieved through integration of 10 key real-time data streams, requiring daily processing of over 8.5 billion data points, to feed a suite of real-time water quality models, ultimately delivering best-practice water quality predictions and attracting \$400 million in targeted funding for water quality outcomes.

### **Semarang 2040: Re-orienting Central Java's Relationship With Water To Ensure An Economic Future**

T. Bunt, P. Letitre, B. Beagen, S. Carpaij. One Architecture (USA)

Semarang, Indonesia today is at the tipping point of environmental risk and unchecked development. Groundwater extraction has led to aquifer depletion and unprecedented subsidence rates, which in turn exacerbate flood risk. Meanwhile, the city is rapidly growing in vulnerable areas, undergoing substantial economic expansion accompanied by major capital investments in infrastructure and industry, putting the city's future viability at existential risk. At current trajectories, large portions of Semarang will be more than 2 meters below sea level within 20 years. Under a 1-year exercise commissioned by the Netherlands Enterprise Agency, a multidisciplinary group (anchored by geo-hydrologists, urban designers, and ecologists) developed a comprehensive framework for long-term resilience based on a combination of physical adaptation (through hybridized green/gray infrastructure), industrial reorganization (enabling water-neutral, circular economic models), and neighborhood scale capacity-building. The 2040 plan fundamentally reorients Central Java's relationship to water, and shifts the political focus from combating risk to seizing opportunity.

### **Solutions To Water Scarcity: Shift From An Infrastructure Strategy To A Performance And Digitalization Approach. Case Study Of Bangalore**

V. Joshi. SUEZ India (India)

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

**29 June 2021 (Tuesday)**

**4.00pm-5.30pm (SGT) (GMT +8)**

**Session 4.5 – Basin Connected Cities**

### **An Integrated Approach To Coastal Climate Resilience**

A. Hosking, J. Bird, P. King, M. Wilson, C. Schelpe, C. Clifton. Jacobs (United Kingdom)

Coastal cities globally face many challenges in delivering a safe, affordable and resilient environment for their residents and economy. Added to the pressure of increasing populations and aging infrastructure, is the accelerating impact of climate change, which in the coastal context includes the challenge of sea level rise and coastal storms. Whilst these are essentially independent challenges, they manifest in impacts, such as flooding, to the places and assets used by communities and businesses. Focusing on resilient outcomes for these places, drives us towards a more integrated approach whereby these challenges are addressed in the context of the wider needs and objectives of the affected areas. Drawing lessons from major coastal city resilience programs around the world, the paper describes how multi-disciplinary approaches support the delivery of comprehensive resilience outcomes, beyond their core flood risk management drivers.

### **Bangladesh Delta Plan 2100: Bangladesh In The 21<sup>st</sup> Century**

G. Choudhury. Bangladesh Delta Plan 2100 Formulation Project (Bangladesh)

Bangladesh delta, the largest dynamic delta of the world, faces rigorous challenges like increased flooding, freshwater unavailability, drought, groundwater decline, erosion, sedimentation, retarded drainage, waterlogging, salinity intrusion, deteriorated water quality, decreased trans-boundary water flows, sea-level rise, increased frequency of cyclonic storm and associated surges, etc. Other challenges are population growth, rapid industrialization, and unplanned urbanization. In view of long-term challenges presented by climate change and natural hazards, the Government has formulated a techno-economic, long-term holistic, water-centric integrated Bangladesh Delta Plan 2100. It is the first country in the world to develop a comprehensive 100-year plan for its entire delta for 'achieving safe, climate-resilient and prosperous delta' for a period up to 2100. Its mission is to ensure long-term water and food security, economic growth, environmental sustainability, while effectively coping with natural disasters, climate change and other delta issues to robust, adaptive and integrated strategies and equitable water governance.

### **Basin connected cities [Presentation Title is subjected to changes]**

K. Cross. IWA (Thailand)

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



## **The Integration Of Infrastructure Hardening And Longer Term Equitable Resilience Strategies In The New York City And New Jersey Region**

E. Westerhof. Arcadis U.S., Inc. (United States)

The tidally influenced NY/NJ Hudson River is a coastline environment and a coastal watershed that supports one of the densest inter-connected infrastructure assets in the US. The extensive transportation infrastructure that supports the daily mobility of millions of daily commuters and drives the national economy is extremely vulnerable to natural hazards. Hurricane Sandy in 2012 disrupted not only the transportation and grid infrastructure, it triggered an array of cascading impacts. Both New Jersey (NJ) and New York (NY) have adopted an approach to harden their critical assets, in conjunction with longer term planning efforts with several billion dollars in capital expenses. Multi-purpose levees, flood gates and tunnel closure systems are being designed and installed to safeguard daily commuters and New York's global business interests. Social Cost Benefit Analyses helps guide the extremely complex resilience transformation, allowing the city to allocate benefits to specific stakeholders and develop a state-of-the-art coastal plan that is inclusive and equitable.

**01 July 2021 (Thursday)**

**4.00pm-5.30pm (SGT) (GMT +8)**

**Session 4.6 – Social Resilience of Communities to Climate Extremes**

### **A Smart Transition To Water Resilient Communities**

C. Port, J. Cullis, D. Romain, M. Cobeldick, K. Werksman. Aurecon (Australia)

Record droughts have been experienced by many cities around the world in recent years. This has required communities to make rapid changes in water use to ensure the preservation of water supplies. In each case it has been found that background knowledge of water consumption by the public was low and highlighted the challenge of adapting to a changing climate and the opportunity for further engagement with communities on the contributions they could make towards reducing demand from potable water systems. This paper will look at the experiences of Cape Town, Sydney and Auckland and how the use of smart technology and digital tools has helped engage communities around the challenge of climate change on water supplies, build awareness of water consumption and highlight personalised and tangible ways customers can save water. While this provided customers and communities the opportunity to contribute to the drought response, there is now the opportunity to develop this further in building climate resilience.

### **Wastewater Reuse Certificates - A Tradeable Permit Mechanism Using IoT, ML, AI, And Blockchain**

R. Khemka. World Bank (India)

Conventional environmental regulations, such as command-and-control, have proven inadequate in pollution prevention in emerging economies. As an example, in the Indian state of Maharashtra, no more than 50% of wastewater is treated in even large urban centers. With poor enforcement of wastewater treatment standards and the lack of a business case for reuse, there is little incentive for municipalities and industries to treat and reuse wastewater. In this context, 2030 Water Resources Group of the World Bank aims to accelerate wastewater treatment and support greater reuse through a market-based structure. We have proposed a new tradeable permit entitled Wastewater Reuse Certificates to enable the transfer of credits from over-achieving municipalities and industries, to under-achievers, vis-à-vis reuse targets established through a regulatory process. The certificates are intended to be transacted using immutable distributed ledger technology for issuance, creation of a repository, and trading. The use of blockchain algorithms are resulting in increased transparency, reduced frauds, and smart contracts.

### **Water Resilience Through Community Approach**

S. Kesarwani, S. Kumar, S. Halder. Gurujal Society, District Administration of Gurugram (India)

The District of Gurugram in the State of Haryana, India faces an unprecedented challenge of water crisis and water mis-management. Groundwater is currently being extracted at a rate of 308% and a projected water demand to increase by at least 6% by the year 2021 from 2005. As per the Revenue Records, the number of ponds decreased from 647 in 1956 to 128 in 2018. Alongside the 22+ departments that work with mandates related to water management, Gurujal is an initiative by District Administration to streamline and implement scientific, holistic and sustainable efforts towards water conservation issues. Gurujal operates on a Public Private Partnership (PPP) model that works on multilateral ties involving key stakeholders in the decision-making process, thereby institutionalizing a participatory approach to water management. Enabling key stakeholders at a ground level has been instrumental in bringing about water sensitivity and awareness has been initiated amongst citizens of Gurugram.

### **WaterUP: Empowering Local Communities Through Sustainable Water Management**

D. Hetherington, L. Bingham. Arup (United Kingdom)

Community driven, decentralised water management can effectively decrease global water challenges whilst delivering environmental and socioeconomic resilience. Given ~2.4 billion people live with water shortages, educating communities to better manage water resources is critical. Arup-developed software has been used to map and analyse the use of sustainable, traditionally engineered techniques to capture and store seasonal rainfall and recharge aquifers in semi-arid regions. WaterUp is a community engagement project run in partnership between the global consultancy firm Arup and the UK based NGO The Flow Partnership, with support from multiple other charitable and academic organisations. The project focuses on upskilling rural communities, improving their knowledge and understanding of sustainable water resource management techniques and practices. A pioneering language-neutral, digitally enabled educational film for rural communities has been developed. This free and globally accessible film will empower communities to better manage water resources, restore catchments and make meaningful progress towards achieving SDG6.

**22 June 2021 (Tuesday)**

**7.00pm-8.30pm (SGT) (GMT +8)**

**Session 5.1 – Systems Approaches and Enabling Environment**

### **An Innovation Framework For The Philippine Water Market**

J. Zheng, M. Benett, Y. Villa. Isle Utilities (Singapore)

An innovation framework aims to increase the adoption of fit-for-purpose solutions that address key challenges and deliver business value. Isle Utilities co-developed an innovation framework for the Philippine water market which resulted in targeted identification of technology innovation opportunities for utilities. The framework is adapted from the generic process of “generate, evaluate, implement” and substantiated with processes, decision tools, and working groups that are tailored for the context and needs of the Philippine market. Following a cycle of assessments and consensus building activities, a number of technologies were trialed. Among the trials is a geospatial analytics solution for environmental water quality monitoring which supports the holistic management of critical catchments. The trial resulted in the development of a business case for using satellite Earth observation techniques to complement field sampling and laboratory analysis, and generated insights on the appropriate tools for planning versus operations.

### **Sath Diyawara - Strategic Approach To Mitigate Water Quality Prone Chronic Kidney Disease (CKD) Of Sri Lanka**

S. Ragunathan, D. Ganegoda, M. Wickramasinghe. Puritas (Private) Limited (Sri Lanka)

Chronic Kidney Disease (CKD) is a deadly disease among farmers in North Central Province of Sri Lanka, attributed to various drinking water parameters, sanitation, behavioral and agricultural malpractices. Consumption of purified drinking water and best practices can retard the disease. Project Sath Diyawara was designed, implemented and progressing successfully, creating equal access for safe drinking water and minimize environmental water pollution in vulnerable areas. This was achieved through provision of a centralized reverse osmosis (RO) plant (10 m3/day) per village, establishing a mechanism to transport purified water towards end-users and attempts on knowledge dissemination. RO reject water is treated with Activated Alumina to remove heavy metals and fluoride before releasing to the environment. Mineral addition is carried out for permeate to maintain the taste. Project is self-sustainable and earlier locations are in operation for more than 5 years expanding it to 21 locations (catering 27 villages) by year 2019.

### **The Systems Approach To Sustainable Water And Sanitation Service Delivery [Presentation Title is subjected to changes]**

P. Moriarty. IRC (The Netherlands)

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

## **Water And Sanitation Safety In The Control Of Acute Watery Diarrhoea And Cholera**

P. Byleveld. Australian Red Cross (Australia)

Outbreaks of diarrhoea and cholera are often closely associated with inadequate access to safe water and poor sanitation arrangements. In recent years devastating outbreaks of acute watery diarrhoea and cholera have affected the Horn of Africa and Yemen. Prevention and control of diarrhea and cholera needs a coordinated multidisciplinary approach with collaboration across the health, water, sanitation and hygiene and other related sectors. Responding organisations must make pragmatic decisions to meet the basic needs, including hygiene promotion, safe drinking water and management of excreta. This requires careful consideration of needs and risks in each context, and applying the most relevant elements of water and sanitation safety planning. Effective engagement with communities will help ensure the long-term sustainability of the responses.

**23 June 2021 (Wednesday)**

**7.00pm-8.30pm (SGT) (GMT +8)**

**Session 5.2 – Source Tracking**

### **Detection Of Antibiotic Resistant Opportunistic Pathogens And Resistant Genes In Domestic Wastewater And Various Surface Waters Impacted By Anthropogenic And Farming Activities.**

F. Charles, L. Glass-Haller, SG. Goh, H. Chen, H. Tran, F. Charles, W. Li, K. Gin. National University of Singapore (Singapore)

The Singapore National Action Plan to tackle antimicrobial resistance adopts a One Health approach which encompasses the Agricultural and Food sectors, the Public Health sector as well as the Environmental sector. The main objective of this study was to assess and compare the prevalence of antimicrobial resistance (AR) determinants (antibiotic residues, antibiotic resistant opportunistic pathogens and antibiotic resistant genes) in various water compartments, such as community sewage, wastewater discharge from veterinary and animal centers, sea water from aquaculture farms and coastal beaches as well as less-impacted freshwater bodies. We identified quite significant differences between water sample types with specific AR indicators prevailing at higher abundances in domestic sewage from healthy communities and animal center than in freshwater and marine environments. *Escherichia coli* resistant to extended-spectrum cephalosporins were detected in higher concentrations in wastewater (103 and 104 CFU/100mL) than in freshwater and marine samples (below 15 CFU/100ml). The presence of carbapenem-resistant *E. coli* was detected in all water compartment.

### **Host-Specific Viruses As MST Tools**

A. Farnleitner. Vienna University of Technology (Austria)

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

### **Microbial Source Tracking In Watersheds And Reservoirs In Singapore Using PhyloChip And Machine-learning Classifications**

S. Zhao, M. Rogers, J. He. National University of Singapore (Singapore)

The spread of disease by enteric pathogens associated with faecal contamination is a major concern for the management of urban watersheds, waterways and water distribution systems. The technical limitations of conventional microbial source tracking methods, particularly in tropical climates, which are based upon detection of faecal indicator bacteria, result in several disadvantages to their use in Singapore. In this study, faecal contamination of samples collected from local watersheds, waterways and reservoirs in Singapore have been investigated using PhyloChip and a machine-learning classification algorithm trained using a database with known faecal samples obtained locally and from overseas. Increased levels of faecal contamination in waterbodies in urban areas were correlated proximity to high density residential and intense agricultural areas as well as to weather. This integrated approach will be used to detect faecal contamination and track the types of contamination sources in watersheds in Singapore.

### **Quantitative Microbial Risk Assessment Of Viral Pathogens For Recreational Uses In Singapore's Reservoirs**

SG. Goh, N. Saeidi, X. Gu, GG. Vergara, M. Kitajima, A. Kushmaro, K. Gin. National University of Singapore (Singapore)

In the interest of public health and safety, this study assessed the illness risks associated with the presence of four enteric viruses (norovirus, human adenovirus, rotavirus and enterovirus) for recreational water activities at 7 reservoirs in Singapore. Apart from serving as a reservoir for potable water usage, these reservoirs also serve as recreational reservoirs where various water recreational activities are carried out. A total of 231 water samples were collected throughout the two year study. Based on the occurrence data obtained, quantitative microbial risk assessment (QMRA) showed that norovirus has the highest illness risk compared to human adenovirus, rotavirus and enterovirus. Nevertheless, the mean probability of illness from norovirus was below the USEPA allowable guideline limit of 0.036 (36/1000) for secondary contact recreational water activities. Although the risk from norovirus for primary contact recreational water activities exceeded the USEPA guideline level, Singapore's reservoirs are currently not open for primary contact recreational water activities.

**25 June 2021 (Friday)**

**7.00pm-8.30pm (SGT) (GMT +8)**

**Session 5.3 – Wastewater Monitoring and Management**

### **The Use Of Wastewater As Information Source In The Current COVID-19 Pandemic**

G. Medema. KWR Watercycle Research Institute (The Netherlands)

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

### **Wastewater-based Epidemiology For SARS-CoV-2 Virus In South Korea: Post-COVID-19 Outbreak In Daegu City Case**

LH. Kim, YS. Shim, Z. Yun, SP. Kim. Korea University (Republic of Korea)

This study evaluated severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in wastewater samples at the city of Daegu, South Korea, where the first large outbreak of COVID-19 occurred from February 18th to April 1st, 2020 (over 6,700 cases). After the outbreak of COVID-19, the new cases were going down to zero. We obtained influent and sludge samples from 8 wastewater treatment plants (WWTPs) on May 29th with zero new cases in Daegu. We (i) analyzed RNA concentrations and (ii) characterized wastewater quality regarding chemical (pH, conductivity, COD, TN, TP) and biological (total cell numbers, enteric pathogens) parameters to check relationship with the COVID-19 virus concentration. Results showed that COVID-19 RNA was detected even with no new cases, and higher RNA concentration was observed in the sludge sample than the influent. Besides, correlations between RNA concentration and bacterial cell numbers of wastewater was observed. The results indicate the importance of the COVID-19 virus monitoring in the post-COVID-19 era and risk assessment of the wastewater samples to prevent a new pandemic.

### **Water Management For Sustainable Development**

M. Elokka. Egyptian Public Authority For Drainage Projects (EPADP) (Egypt)

Water (irrigation/drainage) management and its improvement could be seen as a typical solution example of challenges for better use of land and increasing the irrigated area for more food security. The main objective of the manuscript is to enhance the drainage water quality, control, benefits and efficiency of improving drainage water system for sustainable performance and to extend the reuse of drainage water as a non-conventional water resource to reduce the gap between limited fresh water resources and water demand. Results have reassessed the availability of drainage water resources required to meet the demand of the quantity and quality of water needed for irrigation. It is important to promote the drainage water reuse in combination with hardware and software aspects, namely facility and equipment installment, institutional improvement and environmental awareness creation. The results would be used to make viable solutions for water saving to improve irrigation practices and crop productivity.



**28 June 2021 (Monday)**

**7.00pm-8.30pm (SGT) (GMT +8)**

**Session 5.4 – Water Resources in Catchments/ Reservoirs**

### **A 'Risk Index' Approach To Catchment-Scale Microbial Modelling**

L. Cetin, P. Pedruco, S. Easton. Jacobs (Australia)

Catchment runoff is a significant conveyor of microbial loads in anthropogenically altered catchments; transported to stormwater systems by leakage or wet-weather overflows, faecal deposition from pets, livestock and waterfowl, and via wash-off through increased runoff from expanding impervious areas. Population growth, urban intensification, and agricultural expansion in drinking water catchments will exacerbate these source loads in the coming decades. Risk-based assessment frameworks are employed to develop waterway management strategies and policies that minimise risks to human health from pathogenic sources. As part of a risk assessment framework, 'Risk index' modelling frameworks provide a powerful tool to investigate catchment management strategies for mitigating these pollution sources. This paper discusses an integrated catchment-river modelling framework that predicts microbial levels by differentiating the major sources of pathogens from the catchment delivered to receiving waters via different hydrological pathways. The modelling framework provides a quantitative risk assessment for compliance with regulatory water quality objectives.

### **Development Of Emission Model For Marina Reservoir Catchment**

G. Pijcke, J. Zhang, Y. Zhang, T. Troost, J. van Gils, M. Weeber, A. Markus, MT. Nguyen, MCH. Sim, A. Mahadevan, KX. Chong. Hydroinformatics Institute Pte Ltd (Singapore)

Understanding the origins and transport of pollutant emissions received by water bodies is key knowledge for water managers in charge of the health of local, regional or national water resources. Emission models are tools that can aid managers in deciding on effective pollution source control and mitigation measures, however, many such tools lack functionality to evaluate "what-if" scenarios, do not have a consistent link with hydrological processes and do not explicitly consider the spatial distribution of emission sources. A new emission model, capable of dealing with these limitations, was developed and applied to the Marina Reservoir Catchment in Singapore. Sources were quantified based on available data and the model calibrated using water sampling data for the year 2017. The model is successful in resolving the spatial and temporal dynamics of the emissions and quantifies the absolute and relative contribution of individual sources and sub-catchments in the Marina Reservoir Catchment.

### **Rapid Monitoring Of Algal Bloom Dynamics With Flow Cytometry**

F. Mao, ZY. Sim, Y. He, K. Gin. National University of Singapore (Singapore)

Cyanobacterial blooms are currently a global threat. However, little is known about the composition and variation of the microorganism community during algal blooms. This study was conducted to monitor phytoplankton dynamics during a bloom event. Flow cytometry analysis of phytoplankton indicated the presence of eight phytoplankton groups assigned to nano-eukaryotes (nano-EU), pico/nano-eukaryotes (Pico/Nano-EU), cryptophyte-like cells (CRPTO); Microcystis-like cells (MIC); pico-eukaryotes (pico-EU), Synechococcus-like cells high in phycoerythrin (SYN-PE1); Synechococcus-like cells low in phycoerythrin (SYN-PE2), Synechococcus-like cells high in phycocyanin (SYN-PC). Regarding median percentage, the phytoplankton community was dominated by SYN-PC, followed by SYN-PE2 and Pico-EU. Redundancy analysis (RDA) was applied to study the correlations between abiotic (i.e., light, temperature and nutrient) and biotic (i.e., phytoplankton abundance) factors.

### **River Basin Management Integrating Water Quality and Human Health – How Food Systems Can Help [Presentation Title is subjected to changes]**

M. Smith. International Water Management Institute (IWMI) (Sri Lanka)

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

**30 June 2021 (Wednesday)**

**7.00pm-8.30pm (SGT) (GMT +8)**

**Session 5.5 – Water Quality in Distribution Systems and Buildings**

### **Estimating The Burden And Direct Healthcare Costs Of Infectious Waterborne Disease In The United States**

S. A. Collier, L. Deng, K. M. Benedic, K. E. Fullerto, J. S. Yoder, M. J. Beach. Centers for Disease Control and Prevention (CDC) (United States)

The routine treatment of drinking water is one of the greatest US public health achievements of the twentieth century and provides a safe, reliable water supply. The reliable provision of safe water has led to water use in complex and diverse ways (e.g. heating and cooling systems in large buildings, agriculture and food production, medical treatment). This paper discusses CDC's efforts to estimate the waterborne disease burden and associated direct healthcare costs of 17 selected diseases in the United States using disease surveillance and health insurance billing data. This study found that over 7 million illnesses, including 600,000 emergency department visits, 120,000 hospital stays and 7,000 deaths, are due to waterborne disease every year in the United States and result in \$3.2 billion dollars in healthcare costs. Hospitalizations and deaths were predominantly caused by biofilm-associated pathogens found in plumbing (non-tuberculous mycobacteria, *Pseudomonas*, *Legionella*) costing US\$2.6 billion annually.

### **Online Flow Cytometric Fingerprinting For Microbial Water Quality Management In A Full-scale Drinking Water Tower.**

J. Favere, B. Buysschaert, N. Boon, B. De Gusseme. Ghent University (Belgium)

Biological instability caused by microbial regrowth during drinking water distribution may result in a variety of problems. In order to anticipate to events of biological instability, more frequent measuring is necessary and relevant parameters for operational control need to be developed. In this research, online flow cytometry was used to measure biological stability of a full-scale water tower during normal and disturbed flow regime. Based on cytometric fingerprints, the Bray-Curtis (BC) dissimilarity was calculated and a threshold for event detection was set. Drastic microbial water quality changes were reflected in the BC dissimilarity in the studied water tower. The BC dissimilarity is therefore proposed as indicator for microbial water quality changes. When used in an online setup, it can be included as straightforward parameter during full-scale operation of drinking water distribution and combined with the cell concentration, it can provide an early-warning for biological instability.

### **Risk Exposure During Showering & Water-saving Showers**

H. Niculita-Hirzel, S. Goecke, N. Msellem, G. Suarez, L. Amgwerd. Center for Primary Care and Public Health, Unisanté (Switzerland)

Eco-friendly showers aim to lower energy and water consumption by generating smaller water droplets than traditional systems. To evaluate the risk for the users to inhale the water droplets emitted and, with them, Legionella, we modelled the behaviour of water droplets aerosolized by such shower systems and confronted the model to reality in a real-size shower stall. The model revealed how the shower system's characteristics - geometry, pressure, flow rate and spray coverage - affected the droplets' distribution and density. The experimental count of inhalable droplets confirmed the difference between the spray patterns -- continuous flow, biphasic continuous flow and spray atomization - and let us identified the technical features that make the shower heads using the spray atomization technology secure for the users. When developing eco-friendly shower systems, the technical characteristics retained have to reduce water and energy consumption without increasing the risk of exposure for the users.

### **WSPs for Distribution and Plumbing Systems [Presentation Title is subjected to changes]**

D. Cunliffe. SA Health (Australia)

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

**01 July 2021 (Thursday)**

**7.00pm-8.30pm (SGT) (GMT +8)**

**Session 5.6 – Bio-sensing**

**An Overview Of Biosensor Technologies For Virus Detection In Water And Wastewater  
[Presentation Title is subjected to changes]**

M. Kitajima. Hokkaido University (Japan)

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

**Examining The Biological Relevance Of The Environmental Fields Estimated Using Adaptive Monitoring Frameworks**

R. Mishra, A. Bandla, K. Teong Beng, M. Chitre, S. Swarup. National University of Singapore (Singapore)

In this work, we examine the biological relevance of the fields estimated using an adaptive monitoring algorithm. DNA analysis provides a versatile method to study the composition of microbial communities in water bodies. Analyzing these samples across diverse water parameter conditions would reveal important insights on the environmental conditions that certain microbial species thrives in. Given that DNA sequencing is costly, it is economically crucial to maximize the relevance of each sample collected to test a hypothesis. We employ a multi-robot adaptive framework using the robots called NUSwan to estimate environmental fields. We select points of interest and examine the quality of the samples using the standard lab-based methods. Our experiments show that the fields estimated using the adaptive frameworks provide good scientific information to support scientific studies. This proves a strong use case of adaptive frameworks in environmental monitoring.

**Remote Sensing, And Novel In-situ Monitoring For Spatial Mapping Of Chlorophyll-a And Cyanobacteria Concentrations In The Paterwoldsemeer, The Netherlands**

R. Lima, N. van der Vliet, F. Boogaard, M. Dionisio Pires, A. Hommersom, R. de Graaf-van Dinther. Indymo, MARE (Netherlands)

Associated with climate change, the increasing proliferation of toxic blue-green algae (cyanobacteria) is a threat for the health of the population and animals and for the ecosystem in The Netherlands. This research collected data from multiple sources, including remote sensing (Sentinel-2) and in-situ techniques (algae sensor installed on an aquatic drone, and hand-held spectrometer). Results from the different algae measuring techniques were compared, and the in-situ methods were used to assess the suitability of remote sensing data for the assessment of the spatial variations of algal concentrations. Aspects such as the effects of the proximity of pixels to the side-banks were investigated. The collected data is also being used for the calibration of algae forecasting models.

## **Tracking Short-term Microbial Dynamics Throughout Drinking Water Distribution Systems In Realtime 24/7 With Online Flow Cytometry**

M. Besmer, S. Teng, YJ. Lee, LK. Yong, R. Hu. onCyt Microbiology AG (Switzerland)

Providing safe drinking water remains a top challenge with rapidly rising water demands, increasing environmental pollution, and more extreme climatic conditions. Such complex challenges can only be met by comprehensive risk management strategies based on resilient treatment/distribution systems/processes. Consequently, water quality monitoring is rapidly moving towards informing the underlying engineering/operational practices with sensor data. However, until recently this completely omitted a crucial driver for water quality and infrastructure deterioration: microorganisms - primarily due to methodological constraints of slow and inaccurate detection methods. To overcome this gap, the laser-based detection method of flow cytometry was adapted from medical applications and later fully automated to be operated on site 24/7, measuring bacterial concentrations and viability every 20 minutes in real time. We studied a full-scale distribution system across subsequent service reservoir and downstream distribution mains. Varying short-term fluctuations of bacterial concentrations were observed at all locations and could be linked to other chemical/physical online sensor measurements.

**23 June 2021 (Wednesday)**

**6.00pm-6.30pm (SGT) (GMT +8)**

**Poster Session 1**

**A Solution To Cyanobacterial Blooms: Insights From Thousands Of Field Applications Using The Lake Guard® Technology**

M. Harel. BlueGreen Water Technologies (Israel)

Cyanobacterial blooms are bacterial infections of waterbodies that, when left untreated, as most of them are, can intensify from year to year, destroying the ecological fabric, and contaminating the water to the extent that prevents its safe use. For years, cyanobacterial outbreaks have been regarded as if they were acts of God that cannot be avoided or contained, while they continued to jeopardize the livelihoods and health of hundreds of millions of people by impeding their access to clean water.

**A Strategy For Saving Energy In Moving Bed Biofilm Reactor Process By Combination Of Submerged Mixer And Aerator**

S. Chung, D. Lee, JH. Choi, J. Chung. Samsung Engineering (Korea, Republic of)

The conventional moving bed biofilm reactor (MBBR) is an aeration-intensive process not only for supplements of oxygen but also the circulation of biofilm-attached media. In this study, authors suggested a way to improve this energy-intensiveness in MBBR by introducing a hybrid mixing concept with submerged mixer and aerator. The various configurations of mixers and intensities of aeration were investigated by computational fluid dynamics (CFD) analysis. As a result, the best combination was determined for a completely-mixed state with the least energy consumption. This concept was verified in a pilot plant for treatment of domestic municipal wastewater. The pilot test results showed that removal efficiency with hybrid mixing concept was no less than that with aeration only. The economic analysis result indicated that the saving in the power cost with this concept was about 68% of that with aeration only.

**Advanced Solutions For Recycling In Textile Dyeing Industry**

M. Sharma, D. Chatterjee, M. Mohammad, V. M, J. Schloss. SUEZ Water Technologies & Solutions (India)

Key challenge with treatment of textile effluents is that there is no one solution or treatment scheme which is effective to treat this tough effluent. The solution needs to be a combination of technologies such as pretreatment chemicals for dye removal; membrane-bio-reactor for organic biodegradation; UF/NF/RO membranes for removal or concentration of different salts; thermal solutions for zero liquid discharge and ozonation or advanced oxidation processes for recalcitrant organic removal.

### **Application Of TIPS PVDF Submerged Ultrafiltration Membrane**

L. He, Y. Lin Yakai, J. Zhang, Y. Tian, T. Poschmann, J. Ye. Beijing Scinor Membrane Technology Co.,Ltd. (China)

The investigation of TIPS PVDF submerged ultrafiltration membrane that applied in Municipal Water Treatment Plant shows that TIPS PVDF membrane has good removal rate of bacterial with LRV  $\geq 4\log$ . Besides, TIPS PVDF can be operated stably under operating flux of 42 LMH, the trans-membrane pressure (TMP) fluctuated within 2-8psi, the turbidity of permeate is lower than 0.1 NTU. The investigation also shows the relative low overall operating cost with 0.03~0.045 RMB/ton, Moreover, there was no fiber break during long-term operation due to its good mechanical properties.

### **Bacterial Community Dynamics Of Biofilms In Two University Campus-based Drinking Water Distribution Networks**

D. Cheng, M. Leifels, C. Miccolis, E. Hill, S. Wuertz, J. Thompson, U. Szewzyk, A. Whittle. Singapore Centre for Environmental Life Sciences Engineering (Singapore)

Two campus testbeds equipped with online sensors for monitoring hydraulic and water quality parameters were used to study factors influencing the microbial community within the drinking water distribution systems (DWDS). Here we compare microbial analyses using next generation sequencing on mature biofilms collected from the pipe walls and on 'young' biofilms extracted from sensor surfaces. The relative abundance of specific family level taxa including Mycobacteriaceae, Methylobacteriaceae, Rhodospirillaceae, Nitrosomonadaceae and Moraxellaceae were consistent between mature and young biofilms (pipe coupon samples vs sensor surfaces) on each campus. The community of very young biofilms on sensor surfaces gradually shifted from Firmicutes to Alphaproteobacteria, and a change in conductivity coincided with changes in nascent communities of both young and mature biofilms regardless of testbed location, suggesting an effect of source water.

### **Benchmarking Study Of Newly Developed Aquaporin Inside™ LE-BWRO Membrane**

XT. Nguyen, MS. Lee, WH. Ho, Y. Zhao. Aquaporin Asia (Singapore)

The idea behind the Aquaporin Inside™ Technology is to incorporate aquaporin proteins into industrial water treatment membranes where the presence of aquaporin protein results in higher water production per operational energy input and higher quality of the produced water compared to conventional membrane technologies. The performance of newly developed Aquaporin Inside™ low-energy high-flux BWRO and the other LE-BWRO membrane from established manufacturer will be evaluated in a crossflow RO setup by using standard NaCl solution and MBR permeate as RO feed. This study allows transparency and accountability in performance benchmarking of different LE-BWRO membrane from industry incumbents. The outcome of the benchmarking study will be shared in the presentation.



### **Corrosion Monitoring With Coupled Multielectrode Array Sensors For Predictive Maintenance Of Water Network**

Q. Li, L. Yang. PUB, Singapore's National Water Agency (Singapore)

Coupled multielectrode array sensors (CMAS) were used to map the soil corrosivity within an area of interest (AOI) and determine material/engineering recommendations for predictive maintenance of water network. The geotagged soil corrosivity data was used to investigate the contribution of environmental corrosion to water main leaks. The methodology of using CMAS, with historical information of water main in Geographic Information System (GIS), was also developed to effectively determine the extent of corrosion hotspot and reduce time and resources used to repair/replace those stretches of water main with lower risk of corrosion failure.

### **Delivering Water From Source To Tap, In Chittagong Hilly Region Of Bangladesh**

M. Hossain, MM. Hossain, MA. Siddiquee, M. Azaz. Bangladesh River Travelers Network (Bangladesh)

Water is 'Elixir of Life' for us and our mother Earth. As the SDG Agenda 2030 in which Goal 6 is on Clean Water and Sanitation and other Goals 13, 14, and 15 are interlinked for water. In the hill areas of Bangladesh the only sources of water is streams, and rivers for drinking, irrigation and household. The Chittagong hilly district are facing population growth, tourism, urbanization, deforestation, illegal rock extraction from streams, and the associated consumerist culture, have interfered with the natural hydrological cycle of rainfall, soil moisture, groundwater, surface water and storage of all sizes. In all the hilly region of Bangladesh, Chittagong hill tracts zone is very poor and undeveloped zone due to lack of facilities. Presently in this region source of water for drinking and irrigation is surface water (Streams, rivers and Rainwater). The Current Streams and rivers, only water sources are getting dry. This study have been undertaken to find out the possible sources of water and analyzes the current sources and found out the potential water management for future water sustainability. In order to undertake this study field survey, GIS map analysis and secondary government studies are taken into account. The rain water harvesting technology is rarely practiced and stream water is available only for the people living close to river banks. As climate change and anthropogenic causes the rain water reduced and hilly streams are getting dry that causing an alarming future water management sustainability. The introduction of new technology and water conservation, and traditional technologies there are some new technologies should be developed for water conservation and filtration for drinking such as life straw, life sack should be introduced. This study will highlight the indigenous culture based new approach and solution for better water management techniques for hilly water sources to tap.

### **Deploying Unmanned Water Quality Monitoring Tools In Developing Countries: Quick Scans And Stakeholder Engagement**

R. Lima, F. Boogaard, D. Setyorini, R. de Graaf-van Dinther. Indymo (Netherlands)

There is an urgency for the development of methods that are capable of monitoring water systems that subject to climate change and increase of anthropogenic pressure, and where information about water systems is scarce (lack of monitoring programs). Updated and real-time detailed data is necessary to support water and soil management strategies. This study evaluates the implementation of novel techniques in developing countries. Multiple state of the art sensors were deployed from bridges, and installed on mobile platforms (e.g. boats / drones) to assess spatial data variability. In addition, continuous measurement using data loggers were performed in strategic locations. The monitoring campaign took place in different water systems in Indonesia, Mali, Vietnam, and Myanmar. Results from the multiple methods provided new insights into spatial variation of water quality, contrasting with traditional point sampling. Feedback from water authorities and other stakeholders indicate that collected data can be used to support management actions in developing countries, and that such increasingly accessible technologies contribute to creating awareness to water related issues.

### **Development Of Low Energy Brackish Water Reverse Osmosis Membranes With Aquaporin Inside™ Technology**

A. Azman, WH. Ho, Z. Yang. Aquaporin Asia Pte Ltd (Singapore)

In this study, Thin film composite type (TFC) brackish water RO membrane was developed with the incorporation of Aquaporin proteins into the active layer via interfacial polymerization process. The results showed that further increase in water permeability was possible by modifying the integrated Aquaporin formulation and increasing the formulation loading. This optimized Aquaporin-based biomimetic membrane was characterized by SEM, AFM and contact angle techniques. The successful development, scale-up and pilot-test of the latest Aquaporin Inside™ low-energy high-flux BWRO membrane demonstrated about 30% higher separation efficiency (A/B value) to market-competitive membranes.

### **Digital Twins For Sustainable Water Infrastructure Development In Cities Of The Future -- An Intellection Of The Opportunities Available In Singapore**

S. Barthbiban, J. Tong, S. Barthbiban, D. Dean, R. Wood. Mott Macdonald (Singapore)

Development of sustainable, climate resilient, water infrastructure in an urban context is increasingly becoming a challenge for Water Companies/Municipalities due to congested land use, especially in relation to the underground environment and climate change impacts. A more holistic approach to water infrastructure development and planning is therefore becoming a necessity. With the more widespread application of dynamic digital technologies for water infrastructure assets, 'Digital Twins' based on geometric modelling, Artificial Intelligence and Machine Learning can assist in facilitating more sustainable water infrastructure development. This paper explores the opportunities available in Singapore for the development of infrastructure asset Digital Twins for sustainable development.

## **Empowering Water Communities: Co-Engendering Solutions For Water Security And Social Resilience**

C. Ong, WK. Lim. Institute of Water Policy (Singapore)

What roles can urban communities play in the co-production of water infrastructures for achieving both water security and social resilience? In addition, can local urban communities via decentralized water infrastructures, contribute to the creation of water-wise communities? Inspired by the concepts of 'soft energy paths' and 'intentional infrastructures,' we explore how local water communities and their involvement in sustainable water interventions, can foster greater social cohesion and citizen empowerment, besides improving water security and quality. We argue that decentralized community infrastructures should have a place in urban, developed cities, and co-exist alongside dominant hydraulic infrastructures. Using a case study approach, we analyze four cases of 'water communities' from developed economies. Our findings demonstrate that deep community involvement in decentralized water infrastructures, accrues multiple benefits to local communities, including greater ecological consciousness, public education, improved equity (health, food access, economic), job creation, community asset building, ownership of infrastructures, and inter-agency collaborations.

## **High Recovery, Energy-efficient Brackish Water Desalination Using High-permeable And Anti-fouling Hollow Fiber Membrane**

F. Li, C. Fang, S. Zhang. National University of Singapore (Singapore)

Though there have been arguments about the energy efficiency in reverse osmosis desalination that can be achieved by further increase of water permeability, we show here that high permeability and good fouling resistance can save much energy in treating local wastewater feeds. In this research, experiments and simulations were conducted to explore the potential application of high-permeable hollow fiber membrane in brackish water desalination. Anti-fouling hollow fiber membrane with high permeability (7 LMH/Bar) was successfully fabricated. It shows excellent anti-fouling performance when local wastewater was used as the feed. Results show that at relatively low salinity, the specific energy consumption (SEC) values can be significantly reduced by using high-permeable membranes. A total of 63.3% reduction of SEC could be achieved when permeability is increased from 2 to 7 LMH/Bar. This research demonstrates that the anti-fouling and high-permeable hollow fiber membrane has potential to reduce the cost during brackish water desalination.

## **Influence Of Solids Retention Time On Process Performance And Microbial Community Dynamics In Mesophilic Anaerobic Digestion Of Sludge**

AA. Cokro, A. Ng, E. Santillan, K. Arumugam, R. Williams, S. Wuertz. Singapore Centre for Environmental Life Sciences Engineering (Singapore)

The effects of step-wise solids retention time (SRT) reduction from 30 to 15 days on process performance and microbial community were investigated in four mesophilic anaerobic digesters (MAD) treating mixed sewage sludge. The reactors were grouped into two clusters (Clusters 1 and 2) each consisting of two replicate reactors. In Cluster 1, the observed average volatile solids (VS) removal was  $46 \pm 13 \%$ ,  $52 \pm 6 \%$ , and  $45 \pm 6 \%$  while average methane yield was  $602 \pm 212$ ,  $474 \pm 137$ , and  $502 \pm 100$  mL CH<sub>4</sub>/g VS when the SRT was 30, 25, and 15 days, respectively. Metagenomics and multivariate analysis showed that the abundance of bacteria and archaea (i.e., methanogens) was not impacted by the reduction in SRT. Hence the latter did not negatively affect digestion of sewage sludge, and it was not a driver for community structure within the range used in the study.

### **Long-Term Infiltration Performance Evaluation Of DutchBio-swales And Permeable Pavements Using The Full-Scale Infiltration Method**

F. Boogaard, R. Graaf. HUAS (Netherlands)

This research mapped over 500 locations with permeable pavement and bioswales in The Netherlands. The hydraulic performance of a selection of these infiltration facilities is researched using a newly developed, full-scale infiltration testing (FSIT) procedure to determine the saturated surface infiltration rate of existing infiltration facilities in The Netherlands that have been in service for a number of years (10 to 20 years). The results show that about 75% of the permeable pavements tested in this study had an infiltration capacity lower than 194 mm/h (guideline for new installed permeable pavement). Only 5% of the swales showed an unsaturated infiltration capacity lower than needed to be empty in 24 hours. Improved maintenance methods are needed to mitigate the effects of clogging of permeable pavements. The recommendations and results of this study should help international stormwater managers with the planning, testing, and scheduling of maintenance requirements for permeable pavements with more confidence so that they will continue to perform satisfactorily over their intended design life.

### **Media In Moving Bed Biofilm Reactors For Wastewater Treatment: What Factors Are Important?**

T. Stephenson. Cranfield University (United Kingdom)

Multiple studies of a wide range of bespoke carrier media for moving bed biofilm reactors (MBBRs) for wastewater treatment are presented. The factor impacting on performance - reactor conditions and media properties - were investigated.

### **Meeting The Mammoth Challenge Of Providing Sustainable Water Supply Up To Habitation Tapping Points For The Continuously Draught Affected 20 Million Population Spread Over 65000 Square Kilometre, Marathwada Region, Maharashtra, India.**

A. Singh, P. Velrasu. Maharashtra Jeevan Pradhikaran (India)

Marathwada region is one of the most draughts affected area in Maharashtra State, India. For years, this region received an erratic and uneven rainfall, resulting in very low average yield of 57%, lowest being 15%. This has resulted great troubles in supply of drinking water urban and rural population. To address the water security risks and improve reliability, the all key water resources need be interconnected with bi-directional flow arrangements, creating a loop system. The planning involves development of hydraulic model of 1300 KM primary main network and 3200 KM secondary network, covering main and booster pumping stations, inter-connectivity creating key water resource level loops, bi-directional flow arrangements; which are first of its kind. Independent tertiary network 32000 KM shall be modelled in parallel. This will help to improve water security and sustainability of the region. The major benefits are improving health and hygiene of 20 Million population by providing safe and sustainable water and thus boost the economy of the region.

### **Membrane Fouling Control In A MBR System Under Higher MLSS Concentration**

Z. Peng, J. Liu. CITIC Envirotech Ltd (Singapore)

Membrane bioreactor (MBR) combines the activated sludge process (ASP) with the microfiltration or ultrafiltration process, which is considered as an effective treatment technology and is widely used for municipal and industrial wastewater treatment. The MBR can achieve better and stable effluent (permeate) quality over a wide range of sludge concentration compared to conventional ASP. However, the limitation of MBR comes from membrane fouling during the filtration process, especially at higher mixed liquor suspended solids (MLSS). Membrane fouling needs extensive cleaning especially strong chemicals to recover membrane filtration performance and filtration quality. This paper is focused on the development of a cleaning strategy to handle such membrane fouling under higher MLSS happened at a large-scale sewage treatment plant (STP). It is found that by the combination of different kind of physical & chemical cleaning protocol, the MBR system equipped with stronger TIPS PVDF membrane can sustain the chemical cleaning agents, recover its production capacity, and maintain its product quality under such higher MLSS.

### **New Method For Integrity Monitoring Of Membrane Bioreactors**

S. Katz, P. Cote, D. Mosqueda-Jimenez. SUEZ Water Technologies & Solutions (Canada)

Monitoring pathogen removal is a challenge in the implementation of membrane bioreactor (MBR) systems in potable reuse applications. A method called "Solids-LRV" involves using total suspended solids (TSS) as a surrogate parameter to estimate the log removal value (LRV) of pathogens. The Solids-LRV method is based on the standard method for TSS with a modification for the volume of sample collected allowing for 3 orders of magnitude more resolution. Validation experiments indicated that the Solids-LRV test can be performed daily with simple and low-cost equipment. The baseline average LRV was 5.84, when expressed based on the solids in the membrane tank, which was reduced to 3.72 for the system when applying conservative volume concentration factors. A nylon filter was selected based on having the best performance and was easiest to work with. When membrane integrity was intentionally compromised the solids LRV value reduced from the baseline and later returned once the fibers had healed themselves. The proposed method is intended to complement turbidity and augment system monitoring with the goal of providing an indication of pathogen reduction.

### **Novel Method For Selective Enrichment Of *Nitrososphaera Viennensis*-like Ammonia-oxidizing Archaea Over Ammonia-oxidizing Bacteria From Freshwater Environments**

Y. Woo, MC. Cruz, S. Wuertz. Singapore Centre for Environmental Life Sciences Engineering (Singapore)

The use of chloramination for residual disinfection is known to increase the risk of nitrification in drinking water distribution systems (DWDS), which is caused by ammonia-oxidizing nitrifiers and nitrite-oxidizing nitrifiers. Ammonia-oxidizing bacteria (AOB) are more commonly detected than ammonia-oxidizing archaea (AOA) in both bulk waters and biofilms of DWDS. AOA are generally less studied than AOB because they are difficult to cultivate. We enriched a *Nitrososphaera viennensis*-like AOA strain over the co-cultured AOB *Nitrosomonas* by using dimethylthiourea and pyruvate to stimulate AOA growth while inhibiting the growth of AOB. This strategy promoted the wash out of AOB from the enrichment culture. The method does not require filtration and/or the use of antibiotic treatment, and shortens the time required to enrich AOA from DWDS and other natural and technical environmental settings.

### **O&M Start Up: Maintenance Challenges**

O. Rodríguez García. Acciona Agua (Qatar)

After every desalination plant commissioning, there is a start-up period where any plant needs to be stabilized, adjusted and normalized from the operation and maintenance point of view. This paper will cover a compilation of some of the maintenance challenges faced during the O&M start up period in different SWRO Plants and the solutions proposed and implemented in each maintenance area: Mechanical issues as ERD booster pump axial displacement due to inadequate bearing selection in the pump design; or ERI blockage due to scaling between rotor and stator. Electrical issues as medium voltage VSD switching frequency causing trip of the pumps. Instrumentation issues as HVAC was initially not connected to the DCS. This could have eventually lead partial or complete plant trips in case of undetected HVAC failures.

### **Portland Cement Based Calcium Aluminate Cement (Cac) Concretes For Corrosion Resistant Sewer Application**

M. Schmid, BK. Yeo, G. Walenta. Calucem Pte Ltd (Singapore)

Two microbially induced corrosion resistant concretes with 100 years lifetime target have been developed. The concretes contain Portland cement, Calcium Aluminate cement, Granulated Blast Furnace Slag, Silica Fume and admixtures. They exhibit long slump retention, high early and constant high strength when stored at standard and elevated temperatures. Both concretes comply with the special requirements for acid resistant concrete and exhibit low corrosion in microbially corrosion tests.

### **Relationships Of Water And Mineral Ion Channels With Mineral Balance**

SY. Chew. Pro-health Water Technologies Pte Ltd (Singapore)

The Nobel Prize in Chemistry for 2003 was won by Peter Agre for the discovery of water channels and Roderick MacKinnon who has elucidated the structural and mechanistic basis for ion channel function. With the background, the objectives of the abstract is to expand on the water and mineral ion channels and the biological cell performances based on empirical studies, findings and conclusions.

### **Review of 100 Commercial MABR Installations in China**

G. Yogev, L. Dagai, X. Chen, M. Qi, H. Zhang. Fluence Corporation (Israel)

Over the past 4 years, Fluence Corporation has been focusing on providing decentralized waste water treatment solutions to the Chinese market with around 200 MABR installations in China at different stages by 2020. Through this paper, we reviewed some of the installed plants and figured MABR solution's performance on nutrient removal and energy consumption saving with the proof from actual operation experience.

### **Smart Asset Management Using Acoustic And Vibration Sensors To Detect And Distinguish Between Cavitation And Aeration**

A. Gulam. Adzaan Consulting Pte Ltd (Singapore)

This study focusses on the hydraulic phenomena of cavitation and aeration and subsequently to detect and distinguish between them using smart technology. In the course of our work, we have noticed that there is much confusion about cavitation and aeration. Although their symptoms are similar (increases in noise & vibration), they have completely distinct causes. Cavitation is the formation of bubbles of 'vapour' while aeration is the formation of bubbles of 'air'. In this study, an in-house scaled model will be used to experimentally simulate these two phenomena. Noise and vibration measurements will be analyzed to see if there are distinct differences between the two phenomena. CFD analysis is to provide insight into the causes of cavitation and aeration. The experimental and CFD findings will be put into a smart asset management platform where the phenomena can be identified and differentiated. This allows the asset owner to schedule timely interventions

### **Sustainable Predictive Maintenance At PUB For Improved Reliability Of Water Supply System**

ES. Tan, D. Ahmet, V. Goh. Public Utilities Board (Singapore)

This study provides a brief details of an early alert system of impending failure for rotating machinery and its implementation in various water installations in the Public Utilities Board, Singapore. The aim is to achieve a sustainable predictive maintenance for improved reliability and availability of water supply services.

### **Sustained Organic Loading Perturbation Favors Nitrite Accumulation In Bioreactors With Variable Resistance And Resilience Of Nitrification And Nitrifiers**

E. Santillan, WX. Phua, F. Constancias, S. Wuertz. Singapore Centre for Environmental Life Sciences Engineering (SCELSE) | Nanyang Technological University (Singapore)

Partial nitrification is an important step in the removal of nitrogen via anaerobic ammonium oxidation. Sustained disturbances can lead systems to alternative stable states that may not be reversible. We tested the effect of a sustained organic loading disturbance to inhibit nitrite oxidation, as well as its reversibility. Using replicate lab-scale activated sludge bioreactors, we demonstrated stable and reproducible nitrite accumulation (~77%) at tropical temperatures based on a combination of high F:M and C:N in the influent. The resilience of the nitrification function differed from nitrifying community structure resilience, as reactors with recovered function after reversing the disturbance remained distinct in terms of the predominant nitrite oxidizers present. Overall, the ammonia oxidizing bacteria were more diverse and resilient than the nitrite oxidizing bacteria. We showed that functional recovery and resilience can vary across replicate reactors, and that nitrification recovery need not coincide with a return to the initial nitrifying community structure.



### **Tailor-made Procurement Features To Facilitate Operation Of The Tseung Kwan O Desalination Plant In Hong Kong**

CK. Lee, SCC. Ko. Water Supplies Department, Government of the Hong Kong Special Administrative Region (China)

The Tseung Kwan O desalination plant will be the first seawater reverse osmosis desalination plant in Hong Kong. With the in-depth studies conducted to conclude the technical feasibility in local context and the procurement features tailor-made to ensure smooth operation of the desalination plant, it is believed that the Tseung Kwan O desalination plant will serve its purpose to provide a strategic new water resource to better Hong Kong in combating various challenges.

### **Taking MABRs Out Of The Box And Into Practice -- BNR Intensification With Bubbleless Aeration**

S. Sathymoorthy, Y. Tse, K. Gordon, D. Coutts. Binnies (United States)

The MABR is a promising biological nutrient removal (BNR) intensification technology. Our research evaluates the BNR performance of a pilot scale hybrid MABR suspended growth (MABR SG) system. Results suggest that a hybrid MABR-SG system can be operated to achieve a total nitrogen of 10 12 mg N/L at a lower SRT compared to conventional SG processes. When employed downstream of a carbon diversion process, there is evidence of some denitrification using endogenous biodegradable carbon from within the MABR biofilm. Evaluation of the oxygen utilization suggests that the MABR is approximately twice as efficient as fine bubble aeration diffusers. Results from our research suggest that MABR technology holds potential to sustainably enhance and intensify BNR processes.

### **Water Leadership And Conservation**

DK. Meejuri, SS. Katragadda, M. Chary, P. Venkata Krishna. HMWSSB (India)

Hyderabad Metropolitan Water Supply And Sewerage Board (HMWSSB) started to focus on conserving non revenue water and to utilize in other water-stressed areas by instituting a water leadership and conservation network (walc) for educating the citizens with behavioral change on prevention of wastage of water through public participation by involving the residential welfare associations, women self help groups communities, celebrities, employees and public representatives. Hmwssb has carried out the analysis on unaccounted for water (ufw) and non-revenue water (nrw) wherein it is observed that about 40% of water is unaccounted in the revenue billing system. After detailed analysis, it was noticed that about 40% of ufw. Minimum about 5%. Ie. About 20 mgd of water appears to be a physical loss which is mostly happening at the supply areas at customer locations. The impact of such physical losses/ wastage at the customer point is leading to damages to the roads, contamination of water and causing unhygienic conditions in the area apart from the indirect economic loss of substantial amount towards power expenditure for lifting such water from the source to the customer point.



**24 June 2021 (Thursday)**

**6.00pm-6.30pm (SGT) (GMT +8)**

**Poster Session 2**

### **An Integrated Approach To Smart Water Remineralization**

SY. Chew. Pro-health Water Technologies Pte Ltd (Singapore)

The provision of high quality urban water services, the assets of which are often conceptualised as 'blue infrastructure', is essential for public health and quality of life in the cities. On the other hand, parks, recreation grounds, gardens, green roofs and in general 'green infrastructure', provide a range of (urban) ecosystem services (including quality of life and aesthetics) and could also be thought of as inter alia contributors to the mitigation of disaster-relief operations so as to support affected nations or areas in a risk-based, comprehensive emergency management system, improvement of biodiversity, amenity values and human health. Currently, these 'blue' and 'green' assets/infrastructure are planned to operate as two separate systems despite the obvious interactions between them (for example, provision of potable mineral water from mountain top to blue and green areas)

### **Antimony Recovery Via Nitrogen-doped Graphene Adsorbents For Energy Storage**

L. Guo. Singapore University of Technology and Design (Singapore)

Antimony and its compounds are widely applied in flame retardants, catalysts, pigments and batteries...Yet the pollution of the Sb wastes and the scarcity of Sb resources in nature are two great challenges to humankind. Therefore, we hereby propose an efficient adsorbent nitrogen-doped graphene (NGO) for antimony removal and recovery in wastewater simultaneously. The nitrogen doped graphene is synthesized with a simple hydrothermal method. The chemical bonding between the Sb species and NGO facilitates the Sb removal performance and the stability of the post-adsorbents, which in turn improves the energy storage performance of the as-prepared electrodes. An efficient antimony adsorption capacity of 118 mg/g and rejection rate of over 98% has been achieved. Meanwhile, the post-adsorbent SbOx@NGO has accomplished a high specific capacity of 380 mAh g<sup>-1</sup> with 0.04% capacity decay per cycle. This work has provided a promising solution to the scarcity and pollution of antimony species.

### **Automated Catchment Nutrient Load Calculation In An Operational Framework**

J. Wang, A. Mahadevan. PUB, Singapore's National Water Agency (Singapore)

Catchment nutrient loading analysis is a crucial step in devising effective and targeted source control plans for tackling pollution sources. Computation of nutrient loading is laborious and currently done manually. This study looks into the development of an additional functional unit for catchment loading computation that is to be integrated into an existing real-time operational management system (OMS). Automatic and real-time computation of nutrient loading could be achieved. Such information enables efficient decision-making and caters to operational needs.

### **Beyond Ultra-low Effluent Phosphorus Concentration: The Benefits Of Using Rare Earth Elements In Wastewater Treatment**

M. Haneline, S. Ng. Neo Chemicals & Oxides (United States)

As environmental regulations restrict the discharge of phosphorus, traditional methods of phosphorus removal are proving inadequate. The use of rare earth chloride has been studied and implemented in several municipal and industrial wastewater treatment facilities required to meet a phosphorus discharge limit of 0.5 mg/L or lower. Some facilities have been able to achieve a 0.04 mg/L total phosphorus in the effluent with only the addition of a rare earth chloride. This reduction is due to the unique ability of rare earth chloride to preferentially react with phosphorus to form an insoluble inert rare earth phosphate. Additional benefits such as a reduction in sludge volume, enhanced clarifier performance, and improved dewatering capabilities have been observed at these facilities. These results have been achieved with a fraction of the dose of traditional phosphorus removal chemicals and allowed facilities to meet lower phosphorus discharge limits without additional equipment.

### **Cities Of The Future -- What Role Does Water Play?**

F. Barbour. Mott Macdonald (United Kingdom)

This paper will present the case for a digital twin to allow a more catchment wide management of the water system in response to future pressure on Singapore from changing climate and the growth of Singapore. Initially outlining the problem, some examples of more solutions that could be implemented and then demonstrating the catchment operator model. Examples where the current practice misses out on opportunities will be outlined to demonstrate the benefit in investing in this approach.

### **Efficient 3D Printed Electrodes For Water Desalination -- Membrane Capacitive Deionization**

S. Vafakhah, HY. Yang. Singapore University of Technology and Design (Singapore)

Due to the growth in demand for high efficiency and low energy consumption technology for brackish water desalination, many research efforts have been devoted to exploring new methods to overcome the water scarcity. Reverse osmosis (RO) is one of the conventional techniques used to revitalize freshwater supplies. However, high energy consumption puts restrictions on its application in many areas. Therefore, the development of alternative techniques with low energy consumption is strongly encouraged. Capacitive Deionization (CDI) is an emerging technology that is suitable to remove the salt from brackish water. Despite the successful application of several electrode materials to enhance the salt removal capacity, the necessity of using a binder is a limitation that imposes an extra step in the assembling process. In this study, we investigate the desalination performance of 3D printed free-standing electrodes to use as the binder-free cathode and anode in Membrane CDI.

### **Encouraging Prudent Water Use: Do Prosocial Incentives Encourage Water-Saving Behavior?**

T. Lai, Y. Lu. Institute of Water Policy, Lee Kuan Yew School of Public Policy (Singapore)

With a randomized field experiment, this study examines how smart phone applications, through the use of prosocial incentives and forms of social interaction, may encourage water-saving behavior. In our study, participants report their water meter readings weekly, and receive points according to the degree of their water-saving efforts. In the control group, these points are symbolic, and are not converted into monetary donations. In the first treatment group, points will be converted into monetary donations to social causes in Singapore. Here we test if prosocial incentives will make a difference in water-saving behavior. In the second treatment group, we convert points to monetary donations, but also introduce forms of digital social interactions by allowing participants to "gift" their points, or "steal" points from each other. Through this design, we investigate if such a mechanism will increase the participants' attention, and encourage them to save more water. This experiment may lead to better mobile application designs, and apply core principles of behavioral nudging to influence and encourage prudent water use.

### **Flood Risk Assessment in Ungauged Catchment: Open Data and Open Models**

A. Saha, Y. Zhang, A. Goedbloed, S. Tay, G. Pijcke, R. Karanam. Hydroinformatics Institute (Singapore)

The study presents a scalable framework to utilize high-resolution satellite imagery for flooding assessment together with shallow water hydraulic models to simulate flood models scalable to any region in the world. A case study is presented demonstrating the efficiency of this approach. The methods use clustering for flood delineation with terrain and hydraulic flow-based correction. The hydraulic model used is implemented on GPU with subgrid approach.

### **Fuzzy Logic-based Geographic Network Reconstruction Planning**

Z. Toth, Z. Tóth. Budapest Waterworks Private Company Limited by Shares (Hungary)

In order to operate water supply networks efficiently and economically as well as to utilize available financial resources successfully, the continuous and planned reconstruction of the pipe network is required, with the help of which the network aging and subsequently the faults and pipe bursts become avoidable and manageable. Budapest Waterworks has developed and utilised a condition-driven network reconstruction method, using the so-called network reconstruction planning tool embedded in our geographical information system. The methodology starts with data collection and acquisition, followed by application of the risk assessment model to assess the collected data. From the start of its development in 2002 the application of the condition driven methodology has proven to give more efficient utilization of the available reconstruction funds, lower number of pipe bursts and failures in the public areas and as a result lower rate of NRW.

## **How Water Sensitive Is Your City? Benchmarking And Navigation In Planning For Climate Adaptation Of Midsize Cities In The North Sea Region.**

N. Dolman, G. Özerol, H. Bormann, S. Lijzenga. Royal HaskoningDHV (Netherlands)

How can we benchmark climate action and navigate in climate resiliency pathways? Inspired by the 'Water Sensitive City' approach, a www-based decision support tool (DST) is being developed in the EU-Interreg CATCH project that can primarily support small and medium-sized cities to become water sensitive and climate adaptive. Within the CATCH-project, a partnership of seven 'early adaptor' cities in the North Sea region is established, which already gained experience in developing adaptation measures. They acknowledge the need of an integrative DST that is applicable for midsize cities to assist in taking the right strategic decisions and to develop tailor made, long term adaptation strategies. Recently a test version of the www-based DST has been made available, capturing two guiding functionalities: (1) Self-assessment -- How climate resilient and water sensitive is my city, and (2) Navigate -- How to navigate to a climate resilient and water sensitive future?

## **Improving Industrial Park's Wastewater Treatment At Operator's Eye Level Through IoT And Cloud Computing**

A. Walter. GF Piping Systems (Switzerland)

Wastewater treatment regulations in China are among the most stringent worldwide, especially when it comes to COD removal from industrial wastewater. Government supervised sensors are placed at the water discharge outlet of factories to verify if industrial water users cope with those regulations. Meanwhile, water is not the focus of plant operators. They often lack process knowledge, placing compliance with standards in jeopardy. Industry 4.0 wastewater treatment solutions thus represent an opportunity for the existing 22,000 industrial parks to leverage IoT to optimize their processes. In this paper, we expose a cloud solution that enables operators to leverage the synergies of various industrial streams with a recommendation algorithm's help. We also present the first process modeling steps simplifying operator decisions with the help of soft sensors. Improved insights on critical indicators along the treatment process allow for optimized operating costs and secure completion of regulatory standards.

## **Looking In From Space To Detect Leaks In Rand Water Drinking Water Pipelines Using Satellite Technology**

M. Padayachee. Rand Water (South Africa)

The aim of the study is to validate the performance of satellite technology in detecting leaks in the drinking water pipeline network of Rand Water, South Africa. The use of satellite based technologies to detect leaks in drinking water pipelines using a patented algorithm has been developed and demonstrated by Utilis in many parts of the world and now being tested at Rand Water. Rand Water is the largest water utility in Africa. Our customer base includes metropolitan municipalities, local municipalities, mines and large industries. We have an internationally acknowledged reputation for providing water of high quality that ranks among the best in the world and has consistently met national accredited standards on water quality. Water loss through leakage remains a key challenge at Rand Water and the use of exponential technologies to identify leaks and to reduce leakage is advocated. This aim of this pilot project is to demonstrate proof of concept of the technology in South African conditions. The project will be conducted in 2019 at Rand Water and will span a portion of the network (scan area for pilot is 1000km).

### **Microbubble Ozonation - Biological Activated Carbon System For Reverse Osmosis Concentrate Treatment**

WH. Loh, J. Lakshmi, R. Li, J. Guo, S. Ong, J. Hu. National University of Singapore (Singapore)

Reverse osmosis (RO) has been widely applied as the tertiary treatment in wastewater treatment plant (WWTP) to produce high quality reclaimed water. While RO membranes can remove efficiently most of the organic and inorganic materials, these rejected compounds are concentrated in the RO concentrate (ROC). Many of the organics in ROC are bio-accumulative and disposal via surface discharge may result in adverse implications on the receiving aquatic ecosystem. Hence, proper treatment and management of ROC is required before discharging into the receiving water body. In this study, a combined system of microbubble ozonation-biological activated carbon (BAC) system was used to treat ROC. This combined system was able to achieve about 55.4% of COD removal, meeting the discharge objectives of the study. Further cost analysis was carried out to develop a cost-effective combined system for treatment of ROC.

### **Performance And Prediction Model Of A HA+A/O Process In The Lab-scale Under The Load Shock Of 2,4-dichlorophenol**

Z. Zhang, Y. Yu, H. Xi, Y. Zhou. Chinese Research Academy of Environment Sciences (China)

When 2,4-dichlorophenol (2,4-DCP) is discharged into biological treatment process, it can cause the biotoxicity to sludge and deterioration of contaminations degradation due to the fact that 2,4-DCP is refractory and toxic. The objective was to assess the performance of the hydrolytic acidification-anoxic-oxic (HA+A/O) process with the load shock of 2,4-DCP and innovatively establish the prediction modelling between biotoxicity and COD removal using the theory of system science for the first time. Results indicated that 2,4-DCP concentration of HA+A/O effluent gradually increased from 1.3 to 475.4 mg/L responding to 2,4-DCP removal rate from 98.8 to 4.5%. Meanwhile, with 2,4-DCP concentration 200 mg/L the degradation intermediate products (4-chlorophenol, 4-CP; phenol) of 2,4-DCP reached the highest values of 7.89 mg/L and 5.73 mg/L, respectively and volatile fatty acids (VFA) and oxygen uptake rate (OUR) inhibited rates were over 50%, respectively. Ultimately, the prediction modelling between biological toxicity and COD removal was established using regression method, which exhibited a good fit ( $r^2 = 0.78$ ).

### **Prediction Accuracy And Effectiveness Of ICT Systems For Urban Flood Control**

Y. Sakae, T. Matsuura. NJS Co.,Ltd. (Japan)

This study was carried out to evaluate the prediction accuracy and effectiveness of "ICT operation support system for urban flood control facilities" which is installed in Eba catchment area in Hiroshima city. This system consists of Real-time monitoring technology for the facilities, rainfall data from eXtended RADar Information Network (XRAIN), and Real-time flood prediction technology. Effective existing urban flood control facilities management will be possible on the information. High prediction accuracy is necessary for effective facility management on the ICT operation support system. In this study, the prediction accuracy and effectiveness of ICT operation support system were evaluated based on the past rainfall record from XRAIN.

### **Replaceable Skin Layer Membranes™- Manipulating The Electric Double Layer On Colloidal Solids To Create 10-fold Improvement In Flux Rates**

D. Bromley. DBE Hytec Ltd (Canada)

All conventional low pressure and dynamic membrane configurations rely on pore size (barrier) of the membrane surface for the separation of solids. The Replaceable Skin Layer Membranes™ (RSL Membranes™) do not rely on the barrier approach for the separation of solids. In fact, the actual pore size of the replaceable skin layer is 100 times larger than the solids being separated. RSL Membranes accomplish the separation of solids by using a highly ionic powder for the skin layer that manipulates the electric double layer (EDL) around the colloidal solid. Through this EDL manipulation, solids are repelled from each other as would be typical for stable solids in suspension. However, these same colloidal solids also repel from the replaceable skin layer powder on the surface of the membrane substrate due to the EDL created by the highly ionic RSL powder. The theory behind this phenomenon is called the DVLO Theory. The data has confirmed the impact on flux rate and energy reduction is 10-fold.

### **Seawater Desalination y Reverse Osmosis: Current Development and Future Challenges in Membrane Fabrication – A Review**

YJ. Lim, K. Goh, M. Kurihara, R. Wang. Nanyang Technological University (Singapore)

Seawater reverse osmosis (SWRO) is the key technology driving an energy-efficient and cost-effective desalination process. At the center of this technology are the thin film composite (TFC) membranes, which not only promise a stable operation but also high separation performances. The objective of this review is to consolidate recent advances in SWRO membranes from the standpoint of membrane materials, fabrication methodologies and applications. A comprehensive review of the membrane development is presented based on findings reported in research papers and patents. Lastly, we put together an outlook (long/short term strategies), featuring our perspectives on SWRO membrane development.

### **Selection And Operation Of SWRO Energy Recovery Devices For Maximum Operational Flexibility And Reliability**

E. Tynes. Energy Recovery (United States)

The most critical unit operation in a desalination plant is the SWRO train. From an equipment standpoint the most critical pieces of equipment are the high-pressure pump and the energy recovery devices (ERDs) as they are the highest power delivering or recovering units in the plant. A typical high-pressure pump and ERD system will deliver or recover on the order of 1-2 MW each in train in a large-scale desalination plant. Pump and motor design operation and maintenance are well known and techniques from pump users in other industries can be used in SWRO applications. Energy recovery systems, particularly systems that use the most efficient and state of the art positive displacement systems, is less understood, as they are unique to SWRO. An energy recovery system for a plant with variable production must be made up of ERDs that can operate in variable service conditions, and are simple to operate and maintain, and are able to be easily taken out and put back into service. By the end of 2020 Singapore will have five large scale desalination plants, The newest plants have been designed to operate at various capacities, thus it was necessary to select ERDs suited to this.

## **Shouldn't Ground Water Be Stable And Easy To Treat? Or Why Full Cycle Water Quality Monitoring Matters**

V. Malkov. Hach (United States)

Water utilities worldwide are looking for alternative water sources to address population growth and freshwater scarcity. Utilities are trying to accommodate various types of ground water, including brackish, as well as reclaimed water. The alternative water sources may help with water supply, but they can bring more challenges to the treatment process. Monitoring water quality and comparison between field and online measurements is a common practice and may be revealing. Issues with produced water quality were discovered at a facility in Southern California (USA), where the source ground water was classified as freshwater under influence of agricultural runoff. A comprehensive investigation revealed a multifaceted issue related to the source water quality and the treatment process. On an example of chloramination control, this study revealed trends typical for the industry and highlighted challenges and major misconceptions related to water analysis.

## **Singapore's Smart Shower Programme: Real-Time Feedback And Water Conservation**

ML. Reganon, C. Leong, LF. Goette, J. Buurman, S. Seah, I. Toh. Public Utilities Board (Singapore)

In 2018, Singapore launched the Smart Shower Programme which aimed to install smart shower devices in 10,000 households over two years. These devices provide real-time feedback on water use and intend to encourage conservation during showers, the most water-intensive activity in a typical Singaporean household. Using shower data voluntarily synced by households and a sharp regression discontinuity design, we provide early evidence on the programme's effectiveness. We find that real-time feedback results in water savings of 4.4 liters per shower by encouraging people to take shorter showers. Households who initially used more water during showers also respond more to real-time feedback, by saving more. Smart shower devices have a strong potential to help Singapore achieve its target of 130 liters per person per day by 2030.

## **Smart Filtration Suite, A Data Analytics Solution For Membrane Filtration Systems**

V. Yangali-Quintanilla, D. Dominiak, C. Persner, M. Witte, H. Rehmeier. Grundfos Holding A|S (Denmark)

Smart Filtration Suite (SFS) is the answer to the problems of man-power, efficiency and cost in water treatment and reuse. Our eco-system of intelligent control algorithms effectively enhances capabilities of operators in membrane filtration systems, automates the complex commissioning process and assures significant operating cost savings, both in newly-built and retro-fitted installations. SFS currently includes three control algorithms covering micro- and ultrafiltration, as well as nanofiltration and reverse osmosis. The algorithms target the most challenging aspects of commissioning and process-control, assuring real-time and intelligent operation. The implementation of the algorithms is very flexible -- an inexpensive control box with remote access assures trouble-free installation and the possibility for hassle-free updates. The algorithms make it possible to take full advantage of the capabilities of any filtration system, effectively giving them extra processing capacity and real, tangible savings in terms of energy and chemical consumption, as well as supervision-related man-power.



### **Tai Po Water Treatment Works: A Model Of Sustainability Innovation**

S. Chan. Government of the Hong Kong Special Administrative Region (China)

Water supply is an indispensable part of the livelihood of the people of Hong Kong Special Administrative Region (HKSAR), China and critical to the territory's sustainable and long-term developments. The expansion of the Tai Po Water Treatment Works (Tai Po WTW) forms part of the Water Supplies Department's (WSD's) overall strategy to enhance the resilience of water supply in HKSAR. The output capacity has been increased from 400 million liters per day (MLD) to 800 MLD. Being keenly aware of the responsibility towards sustainability, the plant is designed to merge into the surrounding landscape harmoniously by adopting the stacked design of different treatment processes to minimize the plant footprint. Meanwhile, the plant has been integrating various sustainable features with the continuous emphasis on the sustainable core values of reserving the resources, protecting the environment and caring the people.

### **The Bankable Resilience Tool (BaRT)**

P. Dircke, E. Schellekens. Arcadis (Netherlands)

To implement urban climate resilience strategies successfully and efficiently, and help cities to adapt to a changing climate, financial barriers need to be overcome. This requires identifying and developing investable and bankable opportunities in early stages of project and program development. In this paper, the Bankable Resilience Tool (BaRT) is presented as a valuable tool to overcome these barriers. By monetizing all cost and benefits, including social and ecosystems benefits of blue-green resilience measures per stakeholder, BaRT can remove financial barriers for investors, be used as a decision support tool and accelerate implementation of climate resilience in urban areas.

### **The Water and Resources Refinery® Concept: Innovative Separation Technologies Enabling a Completely New Used Water Approach**

A. van Nieuwenhuijzen, H. Evenblij, J. Dan, F. Visser. Witteveen+Bos Consulting Engineers | AMS-institute (Netherlands)

The Resource Refinery Factory® concept is an innovative water reuse and resource recovery plant ready to create high quality water and produce several circular material streams. To step away from biological treatment process is a paradigm change in used water treatment. The RRF® includes fine screening to recover celluloses, electrocoagulation followed by dissolved air flotation to recover organics and phosphorus, direct nanofiltration and ion exchange unit to recover nitrogen. A large scale pilot test is currently running to proof the concept and first results will be presented. Contrarily to present uwtp's where biological process are applied that destroy the organic components, here only physical processes are applied. The organic matter and nutrients remain intact and can be upcycled to raw materials for several (bio based) value chains. In this way waste water will be used for the production of high quality water for: ecological development & recreation area's; industrial process water; agriculture/ horticulture and the the production/recovery of valuable products; like Cellulose, Ammonium, Phosphorous; Organic biomass (for further up-processing) and Minerals.



### **Towards High Recovery In Water Reclamation Processes: High Performance NF-MBR+RO System**

H. Xu, S. Lee, MF. Tay, K. Jeong, C. Liu, E. Cornelissen, B. Wu, TH. Chong. Nanyang Technological University (Singapore)

A hybrid NF-MBR+RO process was developed to achieve >90% of recovery in water reclamation. The results showed that the NF-MBR achieved superior permeate quality due to enhanced biodegradation and excellent rejection properties of the NF membrane, leading to high RO recovery rate of >90% (i.e., compared to 75% in conventional UF-MBR permeate as RO feed). Furthermore, the salt accumulation (i.e., build-up of divalent ions) observed in the NF-MBR did not have negative impact on the organics removal efficiency and biomass viability. However, more severe NF membrane fouling was observed in the NF-MBR at elevated salt levels, which was attributed to the greater formation of calcium phosphate scale and Ca-polysaccharides complex (i.e., irreversible fouling layer) as well as the cake-enhanced-osmotic-pressure (CEOP) effect. Since the salt accumulation in NF-MBR is a function of sludge retention time (SRT) as well as NF membrane rejection, the NF-MBR membrane fouling and permeate quality can be controlled through manipulation of these parameters.

### **Use Of Simultaneous Absorbance-Transmittance And Excitation-Emission Matrix (A-TEEM) Spectroscopy To Monitor Source Water For Waterworks**

A. Gilmore, L. Chen, S. Teng, C. Kow, E. Mok, N. Afira. HORIBA Instruments Inc. (United States)

Conventional oil-in-water analyzers used by waterworks have hydrocarbon detection limits at mg/L levels and do not identify the type of oil compounds. The primary objective of this study was to develop a more sensitive optical instrument and analysis method to 1) detect trace level (microgram/L range) of organic pollutants in raw and treated water, 2) identify the compounds and 3) alert plant operators. The patented simultaneous Absorbance-Transmittance Excitation Emission Matrix (A-TEEM) instrument method was used to identify and quantify low levels of organic contaminants present in a much higher background of other dissolved organic matter components in raw and treated water. Multivariate regression and machine learning techniques were applied and shown to have potential for alerting plant operators to organic contamination events.

### **Water Quality Monitoring Using Machine Learning**

T. Farahmand, S. Hamilton. Aquatic Informatics (Canada)

Monitoring the water quality of reservoirs increasingly conducted using automated in situ sensors, enabling timelier identification of unexpected values or trends enabling safe management of reservoirs in real-time. However, some critical water quality parameters such as phosphorus, chlorophyll (for detecting various types of algae) and E.coli can only be accurately measured in controlled laboratory conditions which make it impossible to be used in the real-time decision making. We presented a probabilistic machine learning framework for automated estimation of those critical water quality parameters for the safe management of rivers, reservoirs, lakes and public beaches in real-time. The results indicated that our framework using Gaussian Processes (GP) has two main advantages compared to traditional water quality surrogate modeling; 1) it minimizes the efforts to build, test and deploy the model and 2) it performs well for estimating the parameters with uncertainty in real-time capturing the dynamical changes in time and nonlinearities.

### **Water Re-use Optimization Using Turbidity Measurements**

V. Rajasekharan, C. Jackson, R. Leggett. Hach Co (United States)

Increasing water costs, climate change, ageing infrastructure, water scarcity and increasing compliance regulations have led to rise of water re-use in many sectors of the water industry. Even-though water re-use appears like a promising way forward there are several caveats that needs to be addressed before widespread adoption. Towards this end advanced monitoring techniques are required to ensure that the treated water quality meets the strict compliance discharge requirements. To achieve this, we have developed a real time monitoring turbidity solution for wastewater and drinking water effluent to provide the operators with information that they need to assess the effluent quality and provides them with decision to improve the efficiency of the treatment processes. This talk will discuss the turbidity technology that can be used for these purposes.

### **WaterWiSe Test-bed On Two University Campuses For Remote Real Time Water Quality Assessment Of A Tropical Drinking Water Distribution System**

M. Leifels, D. Cheng, S. Wuertz. Nanyang Technological University (Singapore)

The innovative WaterWiSe test-bed allows for the real-time evaluation of physicochemical, biological and hydraulic parameters in two university-based drinking water distribution systems in Singapore through a network of water quality sensors. Initial results revealed the presence of bacteria and archaea associated with monochloramine degradation and pipe corrosion as well as biofilm formation.

**25 June 2021 (Friday)**

**6.00pm-6.30pm (SGT) (GMT +8)**

**Poster Session 3**

### **A Case Study On The Performance Of A Transmission Pipe Leak Monitoring System**

W. Khan, P. Murray, J. Koh. PUB, Singapore's National Water Agency (Singapore)

In 2018, a transmission pipe leak monitoring system was installed on approximately 100 kilometers of mains owned by the Public Utilities Board (PUB) of Singapore. Tracking leak indications in both time and space allows water asset owners to rapidly and effectively deploy their transmission main repair crews. This paper provides a narrative description of the design and deployment for this novel leak monitoring system with advanced detection and notification capabilities. General and site specific deployment considerations are presented. With investment in new technologies there is a need to define, measure, and evaluate the program success. Technology implementation effectiveness is a qualitative measure of project success. Quantitative performance metrics around leak monitoring performance, and value for money are evaluated and presented as well.

### **A Pilot Aquaponics Project On The An Intermediate Floor Of A High Rise Building In Malaysia**

Y. Wong. EcoClean Technology Sdn Bhd (Malaysia)

This is the first of its kind of Aquaponics system in the world, utilizing town water for only once to raise 6000 Tilapia and Jade Perch fishes, 1000 vegetables and 300 panels of vertical sun shading green walls at the intermediate floor of high rise building. The system is fully integrated as the wastewater from the fishes are treated with a specially designed treatment plant and by the very vegetables and green walls themselves before returning to the same channel. Both volcanic aggregates and floating boards in trays are used instead of soil for growing vegetables and green wall plant. The fish channel is created from the building's balcony itself. All the fish and vegetable harvests will travel down by a cargo lift to a " farm-to-plate" restaurant on the lower floor.

### **A Study On Sustainability Reporting Of SGX-Listed Firms**

C. Tortajada, W. Lim, I. Bindal. National University of Singapore (Singapore)

From 2018, companies listed on Singapore Stock Exchange needed to report their environmental, social, and governance (ESG) practices. Following a "comply or explain" approach, company reports must include board statements that describe their sustainability actions, identify ESG factors that affect business strategy, as well as explain their practices and performances, and set sustainability targets. Using the annual and sustainability reports these companies submitted to SGX in 2018, our study aims to understand the sustainability efforts companies had espoused to perform or commit to after the new SGX ruling. Specifically, our ongoing study plans to investigate how sustainability reporting relates to firm industry, business strategy, and financial performance, especially their utility disclosures on water, energy, emissions, and solid waste disclosures, particularly water. Our research has the potential to inform research and policymaking on how businesses can become better members of water-wise communities, particularly in fostering innovative business models and public-private-people partnerships.

### **Advanced Data Treatment: Predictive & Optimization Algorithms For WWTP Operation**

F. Petitpain Perrin, JM. Lestic, E. Fievez, A. Daunay. SUEZ TI (France)

[No executive summary is available]

### **Advanced Oxidation For Carbon And Nitrogen Determination**

V. Rajasekharan, C. Jackson. Hach Co (United States)

Advanced Oxidation (AOP) is well accepted and popular process in the treatment of wastewater and drinking water. When used as an analytical measuring tool, Total Organic Carbon, Total Nitrogen and Total Phosphorus can be simultaneously analyzed with a single oxidation step. We have developed Two Stage Advanced Oxidation (TSAO) method which can recover compounds that are typically challenging to oxidize. This method provides the ability to explore the best oxidation conditions for a variety of matrices. Especially, for total nitrogen recovery this method enables the efficient oxidation of the refractory nitrogen and carbon species by producing on-demand oxidant species to completely mineralize the compounds of interest. This talk would address the characteristics of this method that enables the efficient recovery of the desired analytes.

### **Application Of Deep Learning Models In Radar Rainfall Nowcasting And Flood Forecasting: A Case Study Of Singapore**

KW. Teo, D. Solomatine. Ministry of Sustainability and the Environment (Singapore)

In light of the recent advancement in deep learning many studies have cited promising results of deep learning models (ConvLSTM) on radar rainfall nowcasting. This research was dedicated to pilot study the application of deep learning models (ConvLSTM and its variants) in radar rainfall nowcasting and flood forecasting, for the case of Singapore. The deep learning model adopts a hybrid combination of convolutional neural network (CNN) and recurrent neural network (RNN). Past observed radar images from Meteorological Services Singapore (MSS, NEA) between 2011 and 2015 were processed and used. The deep learning models were used to forecast future water levels at 5 locations in Bedok Catchment of Singapore using observed radar images of last 30 minutes. It was found that the deep learning models can obtain an average Root-Mean-Square-Error of 0.19m across all 5 sensors, indicating its potential as a possible alternative to flood forecasting. The results of this research would also be useful for tropical countries with dynamic weather patterns like Singapore.

### **Assetmanagement And Safe Drinking Water For Amsterdam**

S. Holthuijsen. Waternet (Netherlands)

Traditionally, Amsterdam won its drinking water partly from the dunes. From 1853, the first drinking water companies pumped the water for Amsterdam directly from the deeper layers of the dunes. Due to the increasing demand, the sand bottom was found to dry out and salt water was coming up. From 1940 river water was infiltrated into the dunes. In the seventies it was discovered that this technique polluted the dune bottom. So the water companies proceeded to infiltrate pre-purified river water to great depths into the dunes. Nowadays, Amsterdam's drinking water is mainly coming from the river Rhine. From the assetmanagement point of view we use a so-called 3x5 format as a way of thinking about our assets. We answer 5 questions on 3 levels, object-network-system. It leads to transparent choices for investments and maintenance of our assets. The delivery of drinking water and the associated assets are used to illustrate the method.

### **Case Study - Demonstration Plant Of Water Recycling Of Treated Industrial Wastewater Using Microfiltration/Reverse Osmosis And Activated Carbon Filter For Process Use In A Petrochemical Plant**

F. Tan, BS. Ee, KS. Sim. Petrochemical Corporation of Singapore (Private) Limited (Singapore)

The aim of this case study is to demonstrate a phased approach of carrying out technological and economic assessment in adopting membrane technology for water recycling of treated industrial wastewater for process use. It was co-funded with a grant from National Research Foundation (NRF) Singapore. Due to the large variability of industrial effluents, this demonstration plant was developed in-house following a rigorous Phase 1 - Pilot Plant testing with different configurations of pre-treatment membrane (MF/UF) and material selection for RO membrane. Actual treated wastewater effluent was used for the testing process, particularly on the susceptibility of membranes fouling and formulation of membrane cleaning solutions for membrane flux recovery. Phase 2 demonstration plant was then constructed, followed by trial runs with enhanced cleaning regimes for fouling control, carried out to validate critical parameters such as allowable flux for a pressurised pre-treatment membrane units and RO permeate quality. The implemented treatment system consists of MF/RO and Activated Carbon Filtration (ACF).

### **Colorectal Cancer And Nitrates: Implications For Health And The Economy**

M. Savill, A. Humphrey, J. Mike. Affordable Water (New Zealand)

Nitrate concentrations have been increasing steadily in New Zealand groundwater over the last two decades. This has coincided with an unprecedented increase in intensified dairy farming. Monitoring has demonstrated that increases in nitrate levels in the South Island province of Canterbury were initially mainly confined to shallower bores, but deeper, community supplies are increasingly threatened as nitrate permeates deeper aquifers. Modelling from the Canterbury Regional Council indicates that the Christchurch (population 400,000) urban supply is likely to experience a significant increase in nitrate contamination within 100 years. This is particularly concerning considering a recent population based Danish study which indicated that the risk of colorectal cancer from nitrate in drinking water begins well below the current maximum allowable value (MAV) of 50mg/L nitrate ion (nitrate measured as nitrate ion. This is equivalent to 11.3 mg/L nitrate as nitrogen). Although nitrate leaching is limited using the land-use consenting process, compliance, monitoring and enforcement of land-use rules is difficult. Moreover, such rules may be too little, too late, as nitrate in groundwater can take many years to build and conversely, many years to diminish – the nitrate levels in New Zealand groundwater today are a consequence of farming practices twenty or thirty years ago. If drinking water suppliers are to avoid the expense of nitrate removal, radical measures may be required more urgently, such as destocking intensified farming areas.

### **Deterioration Diagnosis For Underwater Equipment By Vibration Analysis**

J. Nakazawa, Y. Masuya, D. Kawataka, A. Nagao, N. Kanemaru. NJS Co., Ltd. (Japan)

The development of equipment diagnosis technology using Vibration Analysis aims to improve the quality and efficiency of asset management for preventive maintenance of sewage treatment plant equipment. The main function of this development is to comprehend the deterioration signs of sewage facilities and to estimate and identify the cause of deterioration using IoT such as wireless sensors on equipment and a cloud centre, and automatic analysis of photographs taken by an onsite robot. Comprehending deterioration signs is necessary to screen which STP machines are deteriorating. The deterioration causes of the screened STP machines are estimated and identified to be checked by IoT, using information picked up in the previous process. When actually using this system, repair work can be carried out considering the cost and timing. In this paper, we targeted the sludge scraper because it is normally underwater and difficult to comprehend the deterioration signs and report the technology development for identifying deterioration signs and estimating the cause.

### **Driving Economic Prosperity, Through BIM Adoption**

D. Murray, S. Kearney. Mott MacDonald (Singapore)

BIM adoption can improve lives, by reducing poverty in the world's fastest growing communities. That's the view of the UK Foreign & Commonwealth Office (FCO) who have allocated part of the Cross-Government Prosperity Fund (Fund) to the BIM delivery methodology, via the Global Infrastructure Programme (GIP). The Fund aims to remove barriers to economic growth and promote sustainable development in partner countries. The Fund's focus is on middle-income countries (MICs), where 59% of the world's poor live and 60% of global growth will occur by 2030. BIM supports the efficient design, delivery and maintenance of infrastructure and buildings. There is a strong link between infrastructure development and increased prosperity, including supporting gender equality and inclusion. Additionally, the Fund seeks to improve trade links between partner countries and the rest of the world, including the UK.

### **Energy Efficiency And Generation Opportunities For Wastewater Services - Perspective From A Developing Country**

J. Zvimba, E. Musvoto. Water Research Commission (South Africa)

About 55% of energy used in the South African water cycle is for wastewater treatment, with bulk of energy used for aeration. However, up to 15% of wastewater energy demand can be offset by energy generation from sludge, while best practices adoption can deliver energy efficiency gains of 5 to 25% in the water cycle. Advanced process modelling and simulation was applied to evaluate optimal process and aeration control strategies, including investigation and prediction of potential energy consumption and consumption cost pattern by the sector resulting from implementation of optimal process and aeration energy use reduction strategies. Aeration energy consumption and cost savings of 9 -- 45% are achievable through implementation of energy conservation measures without compromising effluent regulatory compliance. Energy savings of 50% and 78% from implementation of simple and complex measures respectively are achievable, while coupling energy efficiency with generation ensures maximum consumption and cost saving benefits are achieved.

### **Fabrication And Evaluation Of High Throughput And Low Energy Consumption Reinforced Membrane**

LM. Goh, ST. Ooi, Z. Thong, MKS. Ng, PW. Li, C. Gudipati. Nanyang Technological University - NTUitive Pte. Ltd. (Singapore)

Overall leaf set thickness in spiral wound membrane module is the key factor affecting performance in terms of product throughput. Despite undergoing a long history of development, the structure of the spiral wound membrane modules remained the same. In order to increase throughput and to simplify the membrane fabrication process, we successfully demonstrated the feasibility of coating the polymer solution directly onto a precisely pre-wetted permeate carrier on an industrial-scale casting line. By combining the permeate carrier and the membrane into a single sheet, we were able to eliminate the need for the typical non-woven support layer and reduce the number of layers in a leaf set of a SWM module. As such, the leaf set thickness was significantly reduced by approximately 10-20%, material cost can be reduced by 10-20%, and the theoretical surface area of the membrane modules could be increased by 30-50%.

### **Full Scale Reality Of Micropollutant Removal With Ozone**

T. Puehmeier, A. Wieland, H. Stapel, S. Bressmer, C. Abegglen. Xylem Services Germany GmbH (Germany)

The term "micropollutant" stands for thousands of man-made substances such as residues of pharmaceuticals, cosmetic products, pesticides and biocides. The conventional sewage treatment does not provide a sufficient barrier to protect drinking water sources from micropollutants discharged with the treated effluent. The realization approach of micropollutant removal processes of two countries (namely Germany and Switzerland) is being addressed. In particular, the micropollutant removal process of one reference -- Werdhoelzli, the largest sewage treatment plant in Switzerland -- is being further explored.

### **Maximum Likelihood Estimation Of Inactivation Kinetic Parameters For *Escherichia coli* In Concentrated Urine**

W. Oishi, D. Sano, I. Kato, O. Nishimura. Tohoku University (Japan)

The present study investigated the inactivation kinetics of *Escherichia coli* and relevant biocidal factors in concentrated urine. The inactivation rate constant was calculated using the maximum likelihood method, which well simulated the measured concentration of *E. coli*. Higher osmotic pressure caused faster inactivation of *E. coli* in hydrolyzed urine, while inactivation rate of *E. coli* was much smaller in non-hydrolyzed urine.



### **Metal-Free Graphitic Carbon Nitride Photocatalyst For Environment Remedy**

D. Lu, FYS. Li. National University of Singapore (Singapore)

Graphitic carbon nitride (GCN) has emerged as a promising metal-free photocatalyst because of its suitable bandgap, low cost of starting material, facile in preparation, highly chemical stable and pollution-free features. However, the photocatalytic activity of GCN is limited by the unsatisfactory photocatalytic efficiency, mainly because of fast recombination of charge carriers and insufficient visible light range absorption. With solvothermal method, red in color graphitic carbon nitride (RGCN) had demonstrated significant improvement in its absorption edge in the visible range. Further carbon doping reduced the charge carrier recombination and improved the activity 5.68 times as compared to GCN.

### **Performance And Mechanism Of Ferrous-Immobilized Alginate Beads Used For Killing Cyanobacteria**

Z. Chen, J. Li, KY. Koh, JP. Chen, CN. Ong. National University of Singapore (Singapore)

Cyanobacterial water blooms have posed many serious risks to water environment and human health. Iron-related technologies have drawn many attentions due to the abundance and variable valence of iron. Herein, we choose environmentally-friendly and biocompatible alginate as an immobilized material to cross-link with ferrous, forming stable organic-metal structure. Ferrous can lose electrons and preliminary experiments have proved that the beads can successfully reduce inorganic contaminate of chromate in a very short period, which means the synthesized beads have a quite strong redox conversion activity. Till now, even though iron immobilized alginate beads have been used in contaminates adsorption in many researches, the redox conversion performance and mechanism of this kind of iron beads have been rarely reported. The application of ferrous cross-linked beads in cyanobacterial removal has not been researched and discussed yet. Therefore, we hope to provide a new material that can kill cyanobacterial and cause no harm to environment. In addition, we aim to elucidate the possible mechanism, proposing an efficient way for algal control.

### **Performance Of Reverse Osmosis Membrane For Water Reuse And Reclamation -- Rejection And Fouling Investigation**

J. Ogier, U. Doelchow, J. Lipnizki, D. Lau. IAB Ionenaustauscher GmbH (Germany)

Chemical pollution of water poses a threat to the environment and human health and the water scarcity is a clear on going challenge for the mankind. Water reclamation is implemented to reduce this water shortage and treat its contamination. Reverse osmosis membrane can provide an efficient step in that water reclamation treatment process. Therefore the performances of ultra-low pressure reverse osmosis membrane were investigated in laboratory and in a pilot-study on the reclamation of municipal waste water for the production of high quality process water. The efficiency of the RO-membranes were evaluated thoroughly in term of contaminants and micro pollutant removal and fouling impact on performances. The results showed a high rejection capacity even under fouling conditions.



### **Protecting And Defending The Amburayan River Basin And Watersheds Through Good Governance And Active Peoples Participation**

W. Lagunilla. Environmental Management Bureau - Cordillera Administrative Region (Philippines)

The Upper Amburayan River Water Quality Management Area (WQMA) within the province of Benguet covers six municipalities. These are Atok, Bakun, Buguias, Kapangan, Kibungan and Tublay. There are 39 barangays within these six municipalities crossed by the Upper Amburayan River System (UARS) with a total of 24,459 households and population of 82,933. The project is implemented in partnership with the national government agencies, covered by local government units, the private sector, the academe and the indigenous people organizations (IPOs). The headwater of the Upper Amburayan River System originates from Cattubo, Atok, Benguet. It traverses the province of La Union and Ilocos Sur and drains to the West Philippine Sea through Tagudin, Ilocos Sur. The Amburayan River is fed by tributaries from the municipalities of Atok, Bakun, Buguias, Kibungan and Tublay. Total length of the main Upper Amburayan River from Atok to Kibungan -- Santol, La Union boundary is 22, 443 meters. To date, high concern and interest on the preservation and protection of the Amburayan River and its watershed is apparent.

### **Prussian Blue @ Reduced Graphene Oxide Aerogel As An Intercalation Anode To Remove Sodium Ions In Hybrid Capacitive Deionization System**

S. Vafakhah, HY. Yang. Singapore University of Technology and Design (Singapore)

With rapid population growth, and spreading environmental pollution, freshwater shortage has become one of the most significant global challenges nowadays. As a result, many research efforts have been devoted to exploring new methods to overcome the water scarcity. Hybrid Capacitive Deionization (HCDI) has been attracting the attention as a high performance, energy-efficient, cost-effectiveness, and environmentally friendly method. In HCDI, desalination is running based on a faradaic reaction with salt ions to boost the removal capacity of the systems. In this study, we introduced an efficient Hybrid Capacitive Deionization (HCDI) system for removal of NaCl from brackish water. In this study, Prussian blue (PB) Nano cubes embedded in a highly conductive reduced graphene oxide aerogel (rGA) has been used as a binder-free intercalation anode to remove Na<sup>+</sup> ions. Furthermore, the real-time intercalation process was verified by In-situ XRD measurements, which confirmed the intercalation and deintercalation processes during charging and discharging, respectively.

### **Reduction Of Energy Consumption In MBR With New High Performance (NHP) Module**

KK. Latt. Toray International Singapore Pte.Ltd. (Singapore)

Membrane bioreactor (MBR) process with low energy consumption was studied using our newly developed MBR module, New High Performance (NHP) module which has a higher membrane packing density compared to the previous MBR module fabricated with rigid plate type membrane element. Energy consumption was reduced by increasing product capacity with higher membrane packing density. In this study, NHP module was operated under higher flux (42 LMH) and investigated a stable operation for about 6 weeks. Maintenance cleaning (MC) with sodium hypochlorite resulted to keep transmembrane pressure (TMP) increasing rate less than 0.05 kPa/day. Aeration energy consumption per product water was reduced 60% in high flux operation. The feature of NHP membrane element is thin and semi-flexible which helps to dislodge the sludge foulant and improve cleaning efficiency with scrubbing air.

### **Seawater RO Facility Optimizes Membrane Performance With Novel Hydro-Optic UV Technology**

Y. Rozenberg, A. Felder. Alantium Technologies (Israel)

A seawater reverse osmosis (SWRO) facility in Asia with a 100,000 m<sup>3</sup>/day drinking water capacity undertook a comparative study to evaluate the disinfection efficacy of a novel hydro-optic (HOD) ultraviolet (UV) technology to provide enhanced protection of the RO elements and positively effect overall RO system and facility performance. Membrane system operation and maintenance from a six-month period prior to and following the installation of the HOD UV technology were evaluated; data was also compared to performance from unprotected RO trains. Following the installation of the HOD UV technology, the facility experienced significant operational improvements, including a 50% decrease in SWRO clean-in-place (CIP) frequency and a 65% decrease in the number of micron filter replacement events. Membrane performance also improved, evident from a 11% decrease in post CIP differential pressure (DP). The HOD UV technology offers the facility a proven and economical non-chemical disinfection treatment approach to protect RO membranes.

### **Siloxane Based Ions Imprinted Sensor For Lead Ions Detection Using Quartz Crystal Microbalance**

S. Li, XH. Lin, Q. Li. National University of Singapore (Singapore)

Traditionally lead ions are tested in laboratory by sophisticated instruments AAS, ICP/AES, and ICP/MS. However, they are lack of mobility for onsite and online monitoring and need well-trained personnel and high maintenance cost. Here we report a selective, sensitive, simple and cost-effective siloxane based ions imprinted sensor for the detection of Pb<sup>2+</sup> ions in water using QCM 1,2. Siloxane monomers, cross-linker, and lead ions template were mixed in water. When siloxane hydrolyzed and condensed to form polysilane, lead ions coordinated by the functional groups were removed to form complementary cavities, which are able to recognize target lead ions. The IIP based lead sensor exhibited high selectivity toward Pb<sup>2+</sup> ions against other interfering ions with a LOD as low as 1ppb. The sensor was well characterized by SEM, FTIR, ICP-AES. The developed siloxane based IIP sensor has great potential for the high through-put monitoring of Pb<sup>2+</sup> ions in water quality control.

### **Technology Interventions & Efficient Pipe Network Management For Unaccounted For Water (UFW) Reduction Under Intermittent Supply Conditions - L&T's Experience In Indian Water Sector**

V. Jayaraman, S. Pandian. L&T Construction (India)

Urbanization has triggered an increasing supply-demand gap in water sector that has necessitated a diligent and efficient utilization of this resource across all economic levels. In developing countries like India, water losses in pipelines pose a major challenge in managing service delivery. Initiatives on non-revenue water reduction for urban cities in India aims at improving the supply, proper utilization, reduce potable water production and to cater the demand of drinking water with available limited resources. Augmentation of water sources and enhancing assets for the utility involves huge capital costs and therefore 'water loss reduction' is emerging as an important step towards sustainable & cost-effective service delivery. Under this backdrop, L&T had undertaken a project for reduction of water losses for Bangalore city for two water zones namely D2A and D2B. The base line losses of 49% was progressively reduced to the current level of 22% by systematic and strategic UFW reduction programme through asset replacement, sensor technologies, GIS framework, leakage detection and rectification

### **Towards A Rapid On-Site Test That Can Detect All Serogroups Of *Legionella Pneumophila***

G. Rankin, M. Connolly. Hydrosense Ltd (United Kingdom)

*Legionella pneumophila* serogroup 1 (lp sg1), is the cause of most fatal outbreaks of legionnaires' disease recorded globally. However, outbreaks from other serogroups are known to occur and, in some geographies, non-lp sg1 bacteria are more prevalent. The development of a test that can rapidly detect all serogroups of *legionella pneumophila* on-site would therefore be of value for reducing global legionella risk. The immediacy and easy to use nature of a rapid legionella pneumophila lateral flow test has the potential to provide accessible, fast actionable results at the site of testing - thus supporting effective water system management and protecting public health. This paper reports the advancements made by the hydrosense ltd technical team in developing a rapid on-site testing method for legionella pneumophila serogroups 1-15 (lp sg1-15) in water. The test is based on the detection of lp sg1-15 antigens using specific antibodies, which have been shown to detect lp serogroups in under 25 minutes.

### **Towards Drinking Water Quality Monitoring Directly At The End-point Of Use: Evaluating An In-pipe Monitoring System For Drinking Water Networks**

C. Wagner, B. Buysschaert, B. De Gusseme, A. Weingartner. s::can Messtechnik GmbH (Austria)

One case study is presented where s::can's technology was used to monitor the drinking water quality directly in the pipeline of a water distribution network. The used monitoring system was installed directly in a high-pressure pipeline and measured turbidity, UV254, color, TOC, DOC, free chlorine, temperature, pressure and conductivity. The in-pipe system proved itself as a valuable tool in Belgium during the burst of the main pipe connecting Sint-Pieters-Leeuw with Brakel. Using the data from the in-pipe system the change in water quality due to the burst and the necessary rerouting of water could be monitored in real time.

### **Trenchless Rehabilitation Of Potable Water Mains**

A. Gross. Primus Line (Germany)

The paper will discuss the challenges faced by network operators with regards to the maintenance of their existing water supply network. Especially in city environments pipe replacement with traditional open trench solutions is highly disruptive to citizens, traffic and businesses. In this context, trenchless technologies can provide significant benefits to water network operators. The paper will present several no-dig rehabilitation solutions as referenced in EN ISO 11295:2018 for the renovation of underground water supply networks. In particular, the paper will show the renovation with inserted hoses. The lining material is fabric-reinforced and covered with a polyethylene inside and outside coating complying with the highest international standards for the transfer of potable water. The paper will show the methodology for a minimum life span of 50 years. Furthermore, the installation approach from pipe preparation, CCTV pipe inspection, mechanical pipe cleaning and liner installation is shown. The paper concludes with case studies from WSD in Hong Kong, Sydney Water and Queensland Urban Utilities from Australia, The Macao Water Supply Company and Canal de Isabel II from Spain.

## **Wastewater Treatment In Mumbai: Moving From Fit To Purpose To Zero Liquid Discharge**

M. Kulkarni. Prachi Services Inc (India)

Mumbai is second biggest city in India with a population of around 12.5 million. Water supply and wastewater treatment of Mumbai city is governed by Municipal Corporation of Greater Mumbai (MCGM). Daily water supply of Mumbai is 4000 Million litres. Out of this, 3600 ML is contributed as sewage or wastewater. Mumbai is divided into seven sewerage zones and have seven sewage treatment plants (STPs). Around 2500 ML sewage is planned to be treated in these STPs. The paper describes the journey of Wastewater treatment in Mumbai from fit to purpose in 1979, 2003 to towards zero liquid discharge in 2020.

## **Wetting Characteristics And Progression Of Polyvinylidene Fluoride Hollow Fibre Membrane Contactors**

W. Ge. Memstar (Singapore)

This paper involves the studying of wetting in two Thermally Induced Phase Separation (TIPS) hydrophobic membranes as hollow fibre membrane contactors used for the removal of ammonia from wastewater. By comparing key characteristics and observing the wetting progression, we can avoid the wetting of membranes and optimize ammonia removal. Two dry TIPS membranes with different hydrophobicity and gas flux are characterized for physical and chemical characteristics. Both membranes are deliberately wetted to define wet characteristics to understand the definition of wet membranes. Membranes were then soaked in water for 60 days to observe wetting progression and phenomena. Dry membranes progress to partially wet membranes almost immediately after the first day. Partially wet membranes remain stable for quite some time (30- 60 days) depending on the type of conditions. However, the partially wet status does not affect the transfer of the gas.

**28 June 2021 (Monday)**

**6.00pm-6.30pm (SGT) (GMT +8)**

**Poster Session 4**

**An Effective Measure For Evaluating Sewer Condition: UAV Screening In Comparison With CCTVs And Manhole Cameras**

Y. Inagaki, H. Ikeda, PK. Takeuchi, Y. Yato. NJS Co., Ltd. (Japan)

NJS has searched for a way to inspect sewer pipes efficiently and considered a focus on UAV (Unmanned Aerial Vehicle) to be beneficial. However, one that could stably fly through a confined space, such as a sewer, did not yet exist. Hence, NJS decided to develop a UAV for this purpose. To evaluate the performance, an actual sewer section has been inspected. The result shows that the UAV is capable of inspecting more than 1,000 m a day without personnel needing to enter a manhole. The team has also inspected the same section by CCTV and manhole camera to compare the inspection speed, operator's safety and the reliability of data. From the obtained result, it can be said that UAV is an effective screening method to efficiently conduct CCTV inspection, in other words, to prioritize the sections that need a detailed inspection.

**An Integrated Countercurrent Two-stage Adsorption And Membrane Separation Process For Decontamination Of Radioactive Iodide Water**

X. Zhang, Y. Liu, G. Zhang, P. Gu. Tianjin University (China)

Nowadays, radioactive iodine has been widely employed in medical diagnosis and treatment, which may enter the aqueous environment after such medical applications. In addition, radioiodine has been detected in surface water, drinking water, and seawater in Japan after the accident of the Fukushima nuclear power plant. Faced to such an emerging situation, innovative technology for quickly and adequately treating radioactive iodine-contaminated water is urgently needed, and strategically it should serve as a technology reserve. Therefore, an integrated countercurrent two-stage adsorption and membrane separation process was developed by combining the advantages of enhanced adsorption of soluble radioiodide and membrane filtration for solid-liquid separation. For this purpose, a novel tailored-designed adsorbent was prepared and used. It turned out that about 90% of radioiodide ions could be removed in the integrated system, with less generation of radioactive waste. It is expected that this study may provide a promising technological approach for handling radioactive iodide ions present in various kinds of radioactive waters.

**Appropriate Application Of Nano Filtration Technology For Sea Water Softening**

N. Prabhune, S. Karney, A. Jugade. Thermax Limited (India)

[No executive summary is available]

### **Automated Catchment Nutrient Load Calculation In An Operational Framework**

J. Wang, A. Mahadevan. PUB, Singapore's National Water Agency (Singapore)

Micro-invertebrates such as copepods, cladocerans, nematodes, rotifers and chironomids etc. are ubiquitous in raw water and these micro-invertebrates are monitored as part of the water quality programme by PUB. The monitoring for these micro-invertebrates are usually done through manual analysis under the microscope and requires trained and skilled expertise. An automated micro-invertebrate detector with image analytics capabilities is developed to meet this monitoring requirement. This system provides a new approach to achieve automated, continuous online monitoring with the advantages of being manpower-saving, lower cost, faster, accurate and potentially able to monitor chironomid larvae.

### **Case Study For The Implementation Of A Digital Solution To Optimise Wastewater Treatment Plant Operations**

CMJ. Hui, WPA. Yuen, M. Wu, SZ. Goh, M. He, E. Leow. Sembcorp Utilities Pte Ltd (Singapore)

Virtual Brain (VB) is an intelligent operations management system for process prediction and troubleshooting. Developed by Sembcorp, it allows for centralised monitoring and control of Sembcorp's water facilities around the world. This paper provides an overview of the different modules that make up the product, as well as the implementation efforts in multiple wastewater treatment plants in a timeframe of six months. These digital initiatives allow for efficient management of existing and future assets and optimise monitoring capabilities. Using machine learning and data science modelling, predictive accuracy of up to 80% is achieved. This has also been implemented across all Sembcorp China and Singapore water and wastewater treatment plants in 2019.

### **Catchment Basin And Urban Storm Water Reuse: Cost And Benefits Comparison**

G. Majersky. Liquid Asset Evolution LLC (United States)

This paper discusses the proposed use of urban water storm capture by Molson Coors would have supplied the company with enough water to meet their production needs and sell the unused volume. The proposed method would also save Molson Coors \$3 billion USD at the time of proposal. The proposed method was based on the proximity of two metropolitan areas to the plant. The results of the study on the proposed method resulted in Molson Coors pursuing the project for further study, as well as the realization that capturing urban storm water could spare natural waters additional pollution, as well as provide a circular water source, especially when paired with wastewater reuse. Coastal urban areas would no longer have to consider expensive and wasteful desalination and would create many construction and upstream jobs to fabricate, build and install the system.

### **Conserving Freshwater From Existing Cooling Tower Water System Via Indirect Supplemental Seawater Cooling**

L. Ng, BS. Ee, CK. Eu. Petrochemical Corporation Of Singapore (Singapore)

The Company applied its initiative of supplemental seawater cooling via a cascade loop to cool the hot returning cooling water of its existing cooling tower water system to reduce the evaporative loss of fresh water. This retrofitting project does not require any change in the existing heat exchange equipment as the same cooling tower water is flowing through the existing equipment. It not only conserves substantial quantity of fresh water in making-up to the cooling tower, but also eliminate the concern of metallurgy of using seawater to the existing facilities. The same model can be applied to other similar cooling tower water systems whether large or small that has accessed to seawater. The conservation in fresh water by this initiative will translate to less investment in energy intensive desalination facilities for carbon savings. The main hurdle will be the investment in the once-through seawater supply and return-back-to sea infrastructures.

### **Decentralized Wastewater Treatment Systems - Need Of The Hour**

L. Bajare. Nixie Engineers Pvt Ltd (India)

The world is not running out of water. The real challenge is to provide enough clean water to a rapidly growing global population. Increasingly irregular weather patterns and natural disasters only exacerbate the situation. Centralized waste water treatment systems is the globally accepted practice at the moment. And with its own merits and de-merits like the sewage transfer, the energy associated to it, the infrastructure needed and the funds needed at one go to execute these large projects means we need to find a better solution which lies in DEWATS or Decentralized Waste Water Treatment Systems. DEWATS tells you to treat the waste water at its location where sewage transfer from one location to another is eliminated. Smaller plants need smaller investments and reusing at the same location means clean water transport is also not needed. Such waters if used for toilet flushing, gardening etc, the load on fresh water consumption is also reduced. There are waste water treatment systems developed on these guidelines which are modular in nature and can be shifted from one place to another which seems to be correct solution to the world-wide water crisis.

### **Definition Of Smart Utility: How To Be A Digital Utility And The Framework For An Intelligent Water System (IWS)**

W. Graf, P. Grevatt. The Water Research Foundation (United States)

Terms such as "digital transformation", "smart utility", "digital water", "intelligent water systems" have been the buzzwords that we heard quite often and of interest to water utilities who have either planned and/or contemplated to digitally transform their utilities towards enterprise excellence. Over the years, the concept of digital transformation evolved from simple digitization (paper to electronic), to digitalization (manual to automated) of business processes to improve efficiency utility resources and knowledge management. The Water Research Foundation (WRF) project Definition of Smart Utility: How to be a Digital Utility and the Framework for an Intelligent Water System (IWS) (#5039) -- has been tasked to develop such a framework to define and develop the various elements of an intelligent/smart/digital water utility.



### **Effect of Data Quality on AI Prediction Capability in WWTPs**

A. Sipila, E. Ekklesia, T. Koskinen, S. Pattanayak. Ramboll (Singapore)

Most wastewater treatment plants (WWTPs) adopt reactive approach towards process abnormalities. An artificial intelligence (AI) based preventive tool is being developed for accomplishing proactive operations and decision making in WWTPs. The Platform is based on prediction-solution-guidance structure. Initial trials have found that typical WWTP data are suitable for the Platform algorithm. Moreover, the developed algorithm was able to predict targeted next-day effluent quality parameters, such as phosphorus, ammonia, chemical oxygen demand (COD), nitrate, and sludge volume index (SVI), with promising accuracy. An Early Warning Index (EWI) has been developed for the Platform to evaluate effectiveness of the prediction algorithms to prevent discharge limit violations.

### **Estimating The Cost Of Climate Change To Water Utilities In Victoria, Australia**

K. Karunaratna. Marsden Jacob Associates (Australia)

Climate change has a significant influence on the operations of Victorian water corporations. Victoria's climate has become drier and warmer over the past few decades and water corporations were severely impacted by the recent Millennium Drought. This study provides a consistent approach that can be used by water corporations to quantify the cost of climate change under the BAU pathway. Understanding the cost of climate change for BAU pathway allows water corporations to make investment decisions and select suitable adaptation pathways that are more economically efficient than BAU. The framework; \* focuses on financial costs incurred by the water corporations, \* considers costs in short, medium and long term, \* identifies the BAU expenditure pathway and current climate scenario, \* identifies suitable climate change scenarios to be tested as per the guidelines developed by CSIRO, \* provides a risk based approach for quantifying the costs of climate change, adapted to suit water corporation activities; \* identifies a consistent approach for establishing the levels of service delivered

### **Green Deep Eutectic Solvents For Pulp And Papermaking Industry**

S. Li, LY. Ee. National University of Singapore (Singapore)

The study into preparation and characterization of cellulose prepared by deep eutectic solvents (DES) facilitate a deeper understanding of their favourable characteristics such as low cost of preparation, environmentally-friendly and high degree of cellulose dissolution that show great potential as cost-effective and sustainable solution in the pulping process for papermaking industries. Herein the conference paper, we compare the effectiveness of biomass fractionation using alkaline treatment to shadow kraft process and using prepared choline chloride (ChCl)/urea binary DES. The treated cellulosic fibers are then characterized with Fourier-transform infrared spectroscopy (FT-IR), X-ray diffraction and Scanning Electron Microscopy (SEM) to investigate possible difference in their physicochemical properties. From the study, it was found that molar ratio of 1:2 for ChCl/urea DES was most suitable for the treatment of biomass due to its lower viscosity and hence ease of mixing that would lower cost in industrial scale.



### **High Recovery RO In Potable Reuse Applications**

U. Erdal, Z.Erdal. ARCADIS (United States)

Reducing RO concentrate flows generated from RO based advanced treatment facilities has become a major interest of agencies located in inland areas where a surface discharge of RO concentrate is not possible. To meet this objective, many agencies are considering incorporating a high recovery RO concept into the design. However, depending upon nature of secondary treatment provided at the wastewater treatment plants, high recovery RO may pose challenges to satisfy nitrogen discharge limits in certain potable reuse projects. The findings of this paper are highly valuable for agencies, regulatory agencies, consultants and individuals who are considering a high recovery concept while meeting very stringent nitrogen limits in IPR via reservoir augmentation projects.

### **Improvements In Ceramic MBR System For Industrial Used Water To Achieve Higher Operational Stability And Energy Efficiency**

N. Hiroshi, Q. Yin, T. Xia, SC. Lee, T. Niwa, W. Lay, SC. Chua, L. Yu, SL. Lim, MJ. Nassir, G. Tao, C. Gudipati, ST. Ooi, A. Dhalla. Meiden Singapore (Singapore)

Performance tests for new-type of membrane, new-design cassette, new MC regime and new membrane aeration methods were carried out by using two cassettes in a membrane tank of the 1-MGD MEMO plant at JWRP. New-type membrane has new active layer with higher water permeability. Tubing between permeate pipe and membrane was removed and they were directly connected for the new-design cassette. Larger permeate pipe was also used for new design. Intermittent dosing of hypochlorite was used for new MC regime, which resulted in lower chemical consumption with longer soaking time. Intermittent membrane aeration was tested to reduce energy. Stable operation was achieved for these new items and methods. It was estimated that more than 30% of operating condition can be reduced with new items and methods.

### **Improving Wastewater Treatment Processes Through Advanced Monitoring And Predictive Control**

O. Icke, M. de Koning, J. Wuister, J. Ng, KM. Phua, K. Koh, WJ. Chnag, G. Tao. Royal HaskoningDHV (Netherlands)

Improving wastewater treatment processes is becoming increasingly important, due to more stringent effluent quality requirements, the need to reduce energy consumption and chemical dosing. Additionally, decreasing availability of skilled operators can be demanding for an autopilot solution. This can be achieved by an advanced monitoring and predictive control system. Optimised nutrient removal is obtained by self-learning feedforward algorithm, which uses load prediction and machine learning, finetuned with feedback on ammonium. This is currently being piloted at the Integrated Validation Plant (IVP) of the Public Utilities Board (PUB) in Singapore. Preliminary results with predictive control show that the load prediction has an accuracy of  $\pm 88\%$ . It is also shown that an up to  $\pm 15\%$  reduction of aeration amount compared to conventional control. It is proven that this load prediction-based control leads to stable operation and meeting effluent quality requirements, as an autopilot system.

### **Inactivation of methicillin-resistant *Staphylococcus aureus* by Chlorination, Chloramination, UVC irradiation , and UVC based advanced oxidation processes**

L. Wang, S. Ghosh, Y. Chen, S. Peng, Q. Cai, and J. Hu. Department of Civil and Environmental Engineering, National University of Singapore (Singapore)

The extensive application of antibiotics around the world is fostering the development of antibiotic-resistant bacteria (ARB) and antibiotic-resistant genes (ARGs). Presence of ARB and ARGs in the drinking water treatment system has been identified by various researches. Therefore, removal of ARB and ARGs at drinking water treatment plants has become a significant issue to protect human health. This study assessed the removal efficiency of three commonly used disinfectants (free chlorine, mono-chloramine, and UVC) to inactivate E. coli TOP10 carrying sulfonamide resistant *sul1* genes. The inactivation rate was faster for UVC whereas the chloramine was the least efficient among the three treatment methods. This study also evaluated the impact of various operating conditions such as pH, turbidity and natural organic matter (NOM) on disinfection performance. An effort has been made to develop the disinfection kinetics for chlorination and UVC for ARB removal.

### **Inter-Basin Water Transfer - Planning To Implementation Solution To Water Crisis In India**

U. Joshi. Xylem Water Solutions India Pvt. Ltd. (India)

Year 2019 is a going to be a very critical and decisive year for India in terms of their water infrastructure. We will see many water related problems in different parts of India that have a geographical disadvantage. Sixty percent (60%) of the population will live in urban areas by 2030, which will greatly increase the stress on water resources. The solution to various issues depicted above is to have a Smart Basins (smart, inter connected, sustainable water network) which serves the growing needs of the nation, with drinkable water at the taps and abundant water for agriculture and urban living. There are three phases to create smart basins. 1. Planning, 2. Execution and 3. Maintenance (Sustainability). The planning phase include the understanding the changes in geographic area over the years, Changes in Rain fall patterns, negotiated catchment area depiction, etc. The execution phase will be critical where rejuvenation and creation on basins, connectivity, creating buffer zones will be part of this challenge. The maintenance phase will ensure sustainability of solution.

### **Management Of Anion Exchange Spent Brine Through Secondary Products Creation: Humic Substances And NaCl**

E. Vaudevire, J. Post, W. van der Meer, I. Daniel. PWNT (Netherlands)

This paper highlights the main discoveries from six years of R&D effort toward developing a treatment solution for a waste brine from a drinking water plant using anion exchange for natural organic matter (NOM) removal. Due to the nature of NOM in the brine i.e. humic (HA) and fulvic acid (FA), which find a number of applications in the agriculture industry, their recovery as a secondary product was assessed on pilot scale; in addition to the recovery of monovalent salts for onsite recycling. The research considers the technologies for secondary product extraction, the potential application of HA and FA and the regulatory quality requirements.

### **Opening The Floodgates On Data Lakes -- Enabling Utility-driven Innovation**

D. Nicklin, M. Hensley. Xylem (United Kingdom)

Utilities today have access to more options for the measurement, acquisition, storage and use of data than ever before. From SCADA, to real-time sensors in the water utility network, to smart meters and beyond, the question facing utilities today is less about how to get the data they need and more about how to manage it and what to do with it to improve their ability to serve their customers. As other industries have adopted the utilization of "big data" to drive decision making and expand the ways in which they can serve their customers water utilities are starting to take the plunge into adopting data as a resource and not just a means to a "billing customers" end. Unlocking these benefits comes with its own set of challenges from the how-to create such an environment, how to maintain and support this new data ecosystem that can rapidly accumulate petabytes of information, and how to securely protect the data while using it to foster innovation via interaction with partners and universities with skills potentially developed outside the water sector. The challenges are great but the potential benefits to the utility, its customers and society in general, are much greater.

### **Phytoplankton Monitoring Based On Deep Learning**

H. Liu, Y. Wang, H. Liu, S. Hu, Y. Peng. Zweec Analytics Pte Ltd (Singapore)

Phytoplankton, or planktonic algae, are the main primary producer in water bodies, and their quantity, species, and distribution have a decisive influence on the aquatic ecosystems. Regular monitoring of phytoplankton in terms of identification and enumeration is an important means for the diagnosis and maintenance of aquatic ecosystem's health. However, currently, the frequency and timeliness of such monitoring by manual microscopic examination method are limited severely by a shortage of algae identification professionals. Harnessing the recent progress Deep Learning, we are developing an intelligent planktonic algae recognition and counting system using microscopic images from the Yangtze river basin as a training database. The preliminary training and test on 6 common freshwater algae genera reached a recognition accuracy of 76%, which proved that the deep learning-based phytoplankton monitoring is practical and can evolve to solve the manpower problem in this field.

### **Pilot-scale Performance Of In-line Coagulation And Ceramic Microfiltration For Three Sites In Scotland With Low Alkalinity And Highly Coloured Water Sources**

H. Shorney-Darby, G. Moore, N. Booker, S. Sutherland, S. Sanchez Lopez, P. Finkbeiner, J. Zheng. PWNT (Netherlands)

This paper summarizes three pilot studies at different locations in Scotland from 2016 to 2020, where the source waters had low alkalinity, high colour, and low water temperature. These studies included in-line coagulation and adsorption (ILCA®; PWNT) and ceramic membrane microfiltration. One site had upstream suspended ion exchange for further removal of organics in the treatment train. The performance of the membrane in terms of flux and permeability after cleaning will be compared, and the finished water quality will be highlighted.

### **Policy Strategies For Public Acceptance Of Potable Water Reuse**

C. Tortajada, I. Bindal. Lee Kuan Yew School of Public Policy, National University of Singapore (Singapore)

All over the world, there is an increasing demand for water available in the necessary quantities and qualities for growing numbers of uses and users. Water resources, however, are every time scarcer, and more polluted, mismanaged and misgoverned, limiting the amount of water that can be provided for any use. With extreme events resulting from climate variability and change, coupled with population growth, the availability of water has become a serious concern globally. Based on several case studies, this presentation discusses the potential of reused water for potable purposes to become a feasible source of water supply for domestic use.

### **Process Intensification By Using Hybrid Integrated Fixed Film - Membrane Bio Reactor (IF-MBR) For Treatment And Reuse Of Refinery Wastewater**

G. Wu, KP. Chiu, K. Khoo, SK. Chee, C. Koh, HQ. Li, SK. Woon. AECOM (Singapore)

Refinery wastewaters can be difficult to treat due to the inherent variability of the inlet streams which contain difficult to treat compounds. The conventional processes typically require a large footprint and suffer from operational problems leading to environmental non-compliances. The Hybrid Integrated Fixed Film Membrane Bio Reactor (IF-MBR) combines the benefits of both IFAS and MBR into a more compact and robust treatment process. The IF-MBR process can achieve a high resistance to organic and hydraulic shock loadings due to the fixed film process and provides process flexibility with total solids retention with the membrane system, all within a much smaller footprint than a standalone MBR or IFAS-Clarifier process. A pilot plant is currently being operated to validate the concept using actual wastewater from the refinery. The results are expected to validate the main design parameters of the IF-MBR system.

### **Project Implementation And Strategies For Design, Procurement And Implementation For Upgrading Of Online Large Scale Water Treatment Plants Development Projects**

R. Salenga, N. Lethan, S. Moore. Maynilad Water Services Inc (Philippines)

This work focuses on development of project management strategies, methods, and tools to be applied for rehabilitation, retrofitting and process improvement of large scale water treatment plants. We emphasize on the application and implementation of asset management approach in examining the plant's condition and performance and development of risk management tool to monitor risks in all project's phases. We define the entire project duration into three phases: Engineering Phase is the phase when conditional assessment of plant's assets is conducted that serves as input for generating conceptual reference design; Procurement Phase is duration of tendering and selection of prospective bidders; Construction Phase is phase when detailed design work done by the selected Contractor shall be realized and subsequently put into physical installation and construction works.

### **Rethinking Urban Resilience: The Impact Of The COVID-19 Pandemic On Urban Water Resilience**

P. Dircke, D. de Weerd. Arcadis (Netherlands)

COVID-19 has brought into sharp focus how unprepared cities around the world were for the impact of a pandemic. There currently is a window of opportunity to use the COVID-19 pandemic experiences to rethink urban resilience. To maximize this opportunity this paper depends on a throughout literature review and the expertise and experiences of Arcadis consultants from around the world. From this various important new and reaffirmed insights can be gained with regards to urban resilience in general and urban water resilience. While in recent years water resilient cities approaches and water sensitive design (both climate resilience related) have already gained momentum both in academia and in practice, the pandemic reaffirms their importance. The pandemic has highlighted the importance ensuring urban water resilience through appropriate sensitive urban design to prevent crisis-on-crisis situations, provide public shared blue-green space, and to bring back the balance between natural and engineered processes.

### **Soft Sensing Of Water Depth In Combined Sewers Using LSTM Neural Networks**

R. Palmitessa, M. Borup, PS. Mikkelsen, WKA. Law. Nanyang Technological University (Singapore)

We investigate the efficacy of LSTM neural networks as a soft sensing tool to perform gap filling in scenarios of missing or limited antecedent observations. Particularly, we compare the prediction accuracy of different LSTM networks: i) without knowing the antecedent water depth, ii) with different gaps in the antecedent observations and iii) with different amounts of training data. We present and discuss results obtained from a large set of real observations from a combined sewer in Copenhagen, Denmark. The results showed that the prediction error significantly decreased when the antecedent observations of water depth were used as input. For gaps longer than 30 min, the LSTM neural network was capable of exploiting the rainfall data to generate a better prediction than a naïve model. When the model relied solely on the rainfall data, longer learning periods improved the prediction accuracy.

### **Start-up Of SIX®, ILCA® And CeraMac® At Mayflower WTW**

G. Milton, M. Welling, B. Uekoetter, M. Sijm. PWNT (Netherlands)

This paper describes the start-up of a new state-of-the-art water treatment works of capacity 90 MI/d in Plymouth, UK, employing (amongst others) an ion exchange process for the removal of DOC from the water and ceramic membrane filtration. The paper describes initial plant performance both during start-up and for the first few months' operation. The design and commissioning activities are reviewed and summarised to provide insight into the start-up procedures that are used for these process technologies. As these are innovative technologies, the procedures differ from those of conventional treatment, and this will be of interest to the water industry. A discussion of membrane loading into the CeraMac® vessels will also be included, as this is a unique procedure which has been specifically developed for this configuration.

### **Water Network Management Through Centralized Control Room Operation**

AK. Ayco, RK. Ramos, D. Gonzales, G. Andres, ME. Rodil. Maynilad Water Services, Inc. (Philippines)

Maynilad Water Services, Inc. (MWSI) is the water and wastewater solutions provider in the West Zone concession of the Metropolitan Manila area. With over 9 million customers, the company must ensure that there is a 24-hour water supply at a minimum pressure of 7 psi (pounds per square inch) at the entire West concession. With the recent challenges, MWSI has established the Central Control Room (CCR), taking advantage of the technologies used in automation of monitoring, analysis and control for centralized water network management. Essentially, it integrates multiple data sources in real-time. Data are presented and displayed 24/7, and the operators can quickly recognize the network issues and respond with them quickly. The establishment of the CCR has optimized the operational management of Maynilad's facilities through remote control and automation systems.

### **Wet Chemical Analyzer With Minimum Reagent Consumption**

F. Honold, M. Rosenauer, P. Rauch, R. Schuhmacher, U. Franke, N. Leiprecht. Xylem Analytics Germany GmbH (Germany)

Sensors and analyzers are essential for providing information on monitoring and treatment of water. Devices like optical oxygen sensors do not consume reagents. But there are parameters like phosphate and others, which require a wet chemical analyzer in order to convert the interesting molecules into a detectable measurand. So far bigger and unwieldy amounts of chemicals were needed to operate such instruments. A new type of analyzer has been developed which reduces the reagent volume down to 5 µL and daily consumption to less than 1 mL. Additionally lifetime of reagents could be improved up to two years simplifying the handling for users distinctly. Also the amount of waste is minimized and its collection and orderly disposal is possible now. Small bags enable harmless handling of reagents.

**29 June 2021 (Tuesday)**

**6.00pm-6.30pm (SGT) (GMT +8)**

**Poster Session 5**

### **A Comparison Of Real World And Modeled Performance For An Osmotic Brine Concentration System -- Defining The Process Window**

J. Tracy, E. Beaudry, M. Schutter. Fluid Technology Solutions (FTS) (United States)

A novel, membrane based water treatment process has been developed and deployed in pilot and commercial projects, based on the principals of osmotically assisted reverse osmosis (OARO). The economics of this process, defined as the combination of process flow capital cost and process flow operating cost, are such that a higher level of water recovery, beyond that of reverse osmosis stages alone, can be justified in many more cases. This paper will study the economics of several operating cases, and offer guidance on the process window within which the technology offers strong value for providing higher levels of fresh water recovery from industrial effluent streams.

### **Accurate Inspections. Information And Concise Data In Help Of Asset Management**

T. Lampola, S. Pietila, O. Sorvari. WSP Finland Oy (Finland)

Commonly used CCTV method is quite slow, e.g., due to the requirement of pre-cleaning (or -washing) of the pipelines. The process of choosing the parts of the water supply network for the inspection process is often also very vague and is made with too little information of the network. Pre-screening and analysis is often neglected or done only partly, which gives also too few data for proper and accurate process of pipeline inspections. The publication of inspection methods for sewer pipes was published in Finnish on Dec. 11th 2018 and in English on Sept. 26th 2019. The manual presents the condition assessment and inspection methods used globally. This information will increase both the amount and variability of inspection methods for water utilities, thus, improving the means for asset management.

### **Challenges & Performance Of Polymeric MBR In Treatment Of Mixed Industrial Wastewater**

A. Motorwala, N. Hu, L. Zsoldos. SUEZ Water Technologies & Solutions (Singapore)

Polymeric MBR technology has made it economically viable to produce reclaimed water alleviating stress on fresh water reserves. However, varying characteristic & mix composition (COD, Solvents, hydrocarbons etc) typical in industrial wastewater raises concerns of irreversible fouling and overall reliability of polymeric MBRs. To evaluate the feasibility of using polymeric MBR, a pilot plant was set up at Jurong WRP, SG, treating mixed industrial wastewater. Turbidity & Permeability were monitored continuously as a measure of membrane performance. COD, TOC, TSS, TDS, etc were analyzed to check treatment efficiency. A stable permeability (@20°C) of 400 LMH/bar was observed during first 6 months before experiencing a steep decline of permeability > 50% prompting recovery cleaning (RC). During 2nd phase of increased flux, a noticeable decline in permeability of >40% prompted a second RC. Both the RC restored the permeability ~ 90% of the original values indicating reversible nature of fouling. The average permeate turbidity over the 1-year period was 0.06 NTU. Restoration of permeability through chemical cleaning and stable turbidity demonstrates reliability of using polymeric MBR



## **Clean Water And Sanitation: Laguna Water's Experience In Ensuring Safe And Reliable Water To 500,000 People In Laguna**

V. Rivera, M. Alcasid. Manila Water Company (Philippines)

Eighty percent of World mega cities in Asia are highly dependent on groundwater. In the Philippines, groundwater resources supply the water needs for most households, agricultural activities, and industrial processes, among others. However, even with the abundance of the country's groundwater source, different raw water quality issues still exist. Considering the dependence of most households on groundwater for drinking water, protecting its quality is critical to ensure safe and reliable water supply. In exerting all its effort to provide safe and potable water to almost 500,000 residents of Laguna, Laguna Water, being the largest groundwater service provider in the Philippines, faced various challenges to address raw water quality issues of groundwater sources. This paper focuses on the raw water quality concerns encountered in Prima Casa, Binan and Victoria, both located in Laguna. This also aims to discuss subsequent strategies and technologies including Catalytic Water Filtration and Nanofiltration used by Laguna Water to address these challenges which could help other countries in Asia in coming up with sustainable solutions in the use of groundwater sources.

## **DeCalon™ Ultimate Solutions For Cooling Water Management**

BK. Ng, Innovative Polymers P|L (Singapore)

DeCalon™ (DCI) is a revolutionary approach to eliminating scale, controlling corrosion and bio-fouling in cooling water systems. Through applied electro-chemistry and a patented intelligent controller, DCI removes water hardness from cooling systems without the need for hazardous chemicals. The innovation provides a green solution to scaling and corrosion in HVAC systems and industrial chiller. The DCI system removes existing scale and prevents further scale formation.  $\text{SiO}_2$  is also removed along with the hardness. The system ensures heat transfer efficiency is maintained at all times and the requirement for routine shut downs and chemical descaling is no longer required. Water blow-down quantities are also substantially reduced. In addition, Legionella and heterotrophic bacteria counts of less than 10 and 100,000 CFU/ml respectively will be maintained at all times and corrosion for copper of less than 1 mpy (mil per year) and carbon steel of less than 3 mpy can be well controlled.

## **Demineralization-Remineralization Dynamics In Water**

SY. Chew. Pro-health Water Technologies Pte Ltd (Singapore)

Mineralization is a dynamic, complex, lifelong process to control precipitations of inorganic nanocrystals within organic matrices to form unique hybrid structures, for example, hydrogen atoms, oxygen atoms and water molecules. Understanding the process of mineral deposition is important for the developments of treatments for mineralization of water and also for the innovation and development of water. This review provides an overview of the possible mechanisms and the factors implicated as agonists and antagonists of mineralization. Then, the role of calcium, magnesium, potassium, sodium and sulphate ions in the maintenance of health and well-being is described. The new technologies of reversing through demineralization and boosting remineralization in water are discussed. Turning these new technologies to products and practices would improve health care and well-being worldwide.



## **Disruptive Quantum Water Filtration Technology "QTI"**

P. Marconi. Wiracocha (China)

Qti is a new quantum technology of water filtration. No loss of water, no plastic waste, keeps mineral salts, reduces salt and the main pollutants: bacteria, pesticides, endocrin disruptor, heavy metals, arsenic 3 & arsenic 5, antibiotic, tritium and uranium. The refills consist of carbon tube; fill with different component, which are returned to the laboratory for analysis and recycling. See video: Leautus Home tap water testing <https://www.youtube.com/watch?v=fkwTodtOeKw> Global warming and melting glaciers will cause rising waters and submergence of coastlines and infrastructure. The technology is ready to remove salt from water. This technology can be implemented in different portable or fixed machines, it does not require a connection to the network. It is a mini autonomous filtration station.

## **Effect Of The Home Improvement Programme On Residential Water Consumption In Singapore**

M. Fan, S. Agarwal, E. Araral, Y. Qin, H. Zheng. Lee Kuan Yew School of Public Policy, National University of Singapore (Singapore)

Water efficient appliances play an important role in water conservation in Singapore and worldwide. To evaluate the effectiveness of these appliances, water utilities and researchers alike have mostly relied on small-scale randomized control trials with uncertain external validity. In this paper, we evaluate a nationwide program, the Home Improvement Programme (HIP) with an optional upgrade of toilets and water taps, to provide insights on the effect of the installation of more efficient appliances on residential water consumption.

In Singapore, close to 80% of the population lives in public housing developed and managed by the Housing and Development Board (HDB). There are more than one million HDB flats, some of them built in as early as 1960s. HIP is an upgrading program, introduced in 2007, to resolve common maintenance problems of aging HDB flats. As of December 2019, 55% of all HDB blocks were eligible for HIP, out of which 56% had been or were being upgraded. Using monthly water billing data for all households residing in HDB flats from 2011 to 2019, we will employ a staggered difference-in-difference regression approach to evaluate the average treatment effect of HIP by comparing the monthly water consumption by flats that completed HIP before and after the upgrades with the consumption by flats that are not being upgraded. We will further study the evolution of the treatment effect over time and the heterogeneous effect on housing characteristics and consumption quintiles. Last but not least, we will investigate how the effect of water efficient appliances interacts with climate change and extreme weather events.

## **Enabling Operational Efficiencies Through Decision Intelligence In The Water Supply Network Of Singapore**

M. Iqbal, A. Preis, KC. Lai, SF. Hew, JK. Pang, N. Lim. Xylem (Singapore)

This paper describes how the smart water system has evolved to support two main applications: (i) online management of response to incidents in the pipe network and (2) planning dashboard to assess performance of the network for targeted management. The enabling technology for these two applications is the digital twin of PUB's pipe network. The digital twin incorporates an online calibrated nationwide hydraulic model that allows accurate simulations of operational scenarios (e.g., valve closure, hydrant flushing, and demand change), water age/TRC prediction, water quality source tracing and a framework that assesses the performance of the network from various singular or composite perspectives such as material, age, customer complaints, pipe fatigue due to surges, thereby allowing targeted rectification for day-to-day operations as well as long-term planning.

### **Field Experiment On SMS And Household Water Conservation**

M. Nakajima. Lee Kuan Yew School of Public Policy, National University of Singapore (Singapore)

Information campaigns have long been adopted as a tool to promote water conservation in many countries. Short Message Service (SMS) is a recently emerged tool used in information campaigns which can reach a broad target at a low cost. This study conducts a field experiment to investigate the effect of messages delivered via SMS about one's weekly water use on household's water conservation behavior. By combining the weekly water consumption data with household level data, the analysis can identify how household characteristics affect water conservation through the weekly SMS about water use. The findings from this study can provide valuable insights into the expected effect of information campaigns through mediums like SMS in the field of resource conservation.

### **Financial District And Seaport Climate Resilience Master Plan: Building A Comprehensive Resilience Strategy For Lower Manhattan**

R. Deitz, E. Hutchinson. Arcadis (United States)

In October 2012, Hurricane Sandy hit New York City and exposed Lower Manhattan's vulnerabilities to climate change. To reduce flood risk to the Financial District and Seaport, NYC Economic Development Corporation retained the Arcadis-led consultant Team to study climate adaptation strategies for both neighborhoods. This work is part of the City's broader strategy to invest over \$500 million in capital projects in Lower Manhattan beginning in 2021. Given the unique convergence of climate risk and physical constraints, it is critical to examine both on-land and in-water solutions (i.e., extending the shoreline of Lower Manhattan) to implement a comprehensive resilience strategy. Our presentation will explore (1) the process to develop project alternatives to reduce flood risk -- including sea level rise, coastal storms, and precipitation; (2) key project challenges and solutions, including siting blue-green drainage infrastructure, complex transportation and maritime infrastructure; and, (3) funding and financing strategies, including phasing and governance.

### **Fluorescence Analysis Of Methanogenic Biomass In Anaerobic Waste Treatment**

J. Dolfing, B. Shamurad, N. Gray. Newcastle University (United Kingdom)

Coenzyme F420 levels are significantly higher in hydrogenotrophic than in acetoclastic methanogens. We therefore hypothesized that F420 analysis can be used to discern the dominant methanogenic pathway in a given environment. We tested this hypothesis in a series of bioreactors fed different ratios of wheat straw (WS) and synthetic organic waste (SOW). Metagenomics revealed that *Methanosarcina* was prevalent in most of these systems, but given the ability of *Methanosarcina* to use both acetate and hydrogen it was not immediately clear which methanogenic pathway prevailed. Measurements of methane production rates and fluorescence at 420 nm over time then allowed us to conclude that *Methanosarcina* performed hydrogenotrophic methanogenesis at low WS levels, versus acetoclastic methanogenesis at higher WS levels. This example illustrates that F420 analysis is a welcome addition to our ecophysiological toolkit for AD.

### **Fully Automated Rapid Microbiology - Basic Considerations Regarding Different Measurement Approaches And Evaluation Of The Enzymatic Measurement Approach.**

W. Vogl, J. Koschelnik, I. Dubek. VWMS GmbH (Austria)

A safe and efficient water cycle requires efficient processes and therefore sufficient process control and monitoring. Water quality monitoring is therefore a crucial task throughout the complete water cycle, to effectively control treatment processes and safeguard the water quality throughout the distribution network. The physical and chemical quality of water, unlike the microbiological quality, is automatically monitored by various sensors. While microbiological quality is still being determined by manual, culture-based lab procedures. These evaluations take 24 hours or longer to deliver a result and are therefore not suitable for process control or short-term decision making. Basic considerations regarding possible approaches of rapid microbiological measurements are being presented. One rapid measurement approach, based on direct measurement of enzymatic activity of target organisms, is being evaluated in detail. Effects of different types of disinfection in parallel test series with traditional methods are presented to evaluate advantages and limitations of the enzymatic measurement approach.

### **IIOT Thermodynamic Pump Condition Monitoring System For Maintenance & Performance Management**

MA. Samadi, SC. Cheung, Y. Qin, S. Barrett, R. Hale, T. Lam. Public Utilities Board (Singapore)

Real-time pump condition monitoring together with a Decision Support Interface can guide operations personnel to ensure the most efficient pump operations. Real-time monitoring of pump operational parameters such as Pump Head, Input Power, Hydraulic Efficiency, and Flow Rate provide insight to pump performance. Pump with higher hydraulic efficiency can be favored to run more often and remedial action can be taken on pumps with lower hydraulic efficiency. The FREEFLOW system also compares between single pump pumping against parallel pumping (concurrent running of two pumps) to increase pump station efficiency. The system allows monitoring of performance with different pump combinations. Moving forward, data and insights from this project will be used to optimise our pumping station operational and maintenance efficiency

### **Improved Management Of *Legionella* Risks Using Rapid On-Site Testing**

G. Rankin, M. Connolly. Hydrosense Ltd (United Kingdom)

The widely performed laboratory culture testing method for legionella lacks the required accuracy and speed to properly manage legionnaires' disease risk in the built environment. Factors such as transportation time, lack of biocide neutralisation, exposure to variable temperature and presence of background flora can affect the performance of lab culture results. This research examines the effect of biocide exposure and sample transport time/temperature, on the accuracy of the lab culture method and offers an effective complimentary legionella testing solution which can be used in conjunction with the lab culture method to improve water system management and public safety.

### **Improved Transparency With Digital Twins Of Urban Drainage Systems**

AN. Pedersen, M. Borup, A. Brink-Kjær, LE. Christiansen, PS. Mikkelsen. VCS Denmark (Denmark)

VCS Denmark is currently reconstructing its digital twin (DT) to include new and more optimized features. A DT can provide increased transparency throughout the entire utility thereby improving the support of employees for taking better actions. The utility's primary needs are within better models for planning and design as well as improving operational tasks, all with help from the DT environment. Features that need upgrading are identified and replaced with better and more flexible solutions. In the future error diagnostics will be a part of the DT toolbox, in order to reduce model uncertainty and the risk of operational errors. The DT is expected to reduce the environmental impacts from the urban drainage system and to support smarter investments.

### **Integrated Water Resource Management In Upper Godavari Basin Using ESource Model As DSS**

J. Hire, D. Tawar, S. Nagargoje. Water Resources Department, Govt. of Maharashtra (India)

The Godavari River basin is the second largest river basin in India and is a key area for irrigated agriculture in Maharashtra. Most of the regions in India, the river systems are dominated by the kharif/monsoon rains (July to October). Due to urbanization, the rapid growth of industrialization, recent water shortage in the Upper Godavari basin increased pressure on the sharing of water between the upstream water users and downstream water users. The distress in water availability during deficit period shall be shared equitably amongst different sectors of water use and also amongst upstream and downstream users. In this perspective to develop a modelling system in Upper Godavari sub-basin. The aim of the modelling system is to assess reservoir operating rules for equitable distribution amongst the Upper Godavari basin. eSource forecast models for UGB will help as a decision support system to access the equitable distribution of water in the Upper Godavari basin. eSource Management and Forecast Model are more appropriate in terms of prediction, computational and sustainable water management and DSS.

### **Keppel Marina East Desalination Plant (KMEDP) Design Approach To Energy And Water Sustainability**

EK. Goh, PT. Tay, TM. Leong, KP. Chiu, KS. Goh. AECOM (Singapore)

Desalination and water reuse provide circular economy solutions for water-scarce environments. However, seawater desalination draws general concerns on energy consumption and sustainability. Keppel Marina East Desalination Plant (KMEDP) addresses these through a dual-mode solution and other designs. KMEDP is located in Singapore Marina East, near an urban catchment reservoir and the sea, allowing the Plant to feature dual intake from both sources. In dry season, when the water level in the reservoir is low, seawater is desalinated to produce drinking water. In rainy season, the Plant draws water from Marina Reservoir instead, which requires less energy and fewer treatment process steps compared to desalination. Other than the dual mode, KMEDP implements a direct coupling design which significantly reduces the energy consumption. Besides the innovative technologies and process design, the architectural design incorporates environmental friendly elements into its landscaping such as collecting rainwater for irrigating the green roof, supporting the facility's water features and landscaping needs. Its design enhances the overall water and energy consumption efficiency of the plant.

### **Leveraging Dual Polarimetric X-band Radar Rainfall And Nowcast For Urban Flood Management In Singapore**

M. Keem, A. Goedbloed, M. Vierstra. Hydroinformatics Institute (Singapore)

To improve the performance of the X-band radar system nowcasting model operated by PUB, we evaluated new nowcasting models using various distributed advection vectors with the semi-Lagrangian persistence-based extrapolation scheme. The optical flow model shows the best skill scores in predicting rainy area with the lowest computational load. The numerical diffusion and the Lagrangian persistence model without the growth and decay cause the deficiency in accurate rain rate predictions, which will be investigated as a part of this project in the future.

### **Managing A Structural Improvement Project -- Marrying Structural And Project Management Principle Into Action Plan (Water Treatment Facilities Upgrading Project)**

R. Salenga, E. Malahito, MS. Orticio. Maynilad Water Services Inc (Philippines)

Retrofitting works for structures of existing industrial plants are challenging and have tendency to cause major negative impacts on Revenue, Reputation, and Regulatory (the 3 Rs) for stakeholders. For instance, an existing large scale water treatment plant, serving millions city-dwellers, cannot partially or totally shutdown as the shutdown might cause extreme negative impacts such as Revenue (e.g. owner of the plant cannot sell water, resulting loss in revenue); Reputation (e.g. the reputation of the owner decreases as he cannot meet the demand of water daily); Regulatory (e.g. the owner might face business penalty and loose business chance when not meeting the requirement from the regulatory authority).

### **Investigating adsorption of natural organic matter by HAOPs via molecular dynamics simulation**

Y. Ma, S. Velioğlu, MB. Tanis-Kanbur, R. Wang, JW. Chew. Nanyang Technological University (Singapore)

Heated aluminum oxide particles (HAOPs) have been used as dynamic membranes pre-deposited onto the primary membrane to effectively remove natural organic matter (NOM) and thereby significantly diminish the fouling potential. Molecular dynamics (MD) simulations were conducted to compare the performance of HAOPs with the conventional powdered activated carbon (PAC) adsorbent. Results indicate that the mechanisms underlying the effective removal of high molecular weight (HMW) NOM by HAOPs include: (1) higher foulant-HAOPs interaction energy; (2) greater hydration of the HMW NOM; and (3) diminished mobility of the foulant once adsorbed, which deters desorption.

## Performance Evaluation And Kinetic Studies On A Membrane Bioreactor For Treating Biodegradable Industrial Waste Streams

R. Natarajamani, B. Subramanian. Annamalai University (India)

Membrane Bio Reactors (MBR), as it was evaluated for its history of development and its suitability for treating high COD waste streams, is found as a fast developing technology for biodegradable industrial waste water treatment. The lesser foot print of MBR plants is an attractive feature of the technology and the waste-specific feasibility studies on MBR is under investigation around the world. The present study was envisaged with an experimental model on MBR and as case studies, for treating synthetic waste streams of Sugar and Dairy. The MBR model, of effective size of 108 litres, was designed using empirical approach and used in the study. The characterization of Sugar and Dairy effluent concluded that both streams are biodegradable with BOD/COD ratio of 0.59 and 0.62 respectively. The biodegradation of the effluent streams with respective nutrients for Sugar and Dairy were assessed term of COD: N: P as 100:0.5:0.7 and 100:0.7:0.8 respectively. In case of Sugar effluent treatment, the maximum COD reduction was observed for 96% and minimum being 69%. The maximum COD reduction was observed for organic loading Rate of 0.12 Kg COD/m<sup>2</sup>.day and hydraulic Retention Time of 36 hrs. In case of Dairy effluent treatment, the maximum COD reduction was observed for 96% and minimum being 15%. The maximum COD reduction was observed for organic loading rate of 0.03 kg COD/m<sup>2</sup>.day and hydraulic retention time of 20 hrs. The trend of the results for the operated influent COD and OLR showed the effectiveness of MBR in treating high COD waste streams. Perhaps, the operating conditions Vs. COD reduction proved that still more organic loads, can be proceed in the MBR without compromising on the COD removal efficiency. If the Ultra filtration Membranes (UF) membranes were used in place of Micro filter (MF) cartridge, the results could have been be still better as Suspended Solids (SS) removal will eventually result in higher COD removal. The replacement of MF cartridge during the conductance of experiment warrants further study in respect of membrane behaviours like Trans Membrane Pressure (TMP), Clogging etc., As the flux of membrane will be critical in ensuring the operating efficiency, experiment are required to be conducting using UF membranes for application of MBR with UF packages for the treatment of Sugar and Dairy effluent streams. The bio kinetics found using Michelin Menton equation proved the veracity of biomass accumulation and activity in the effective utilization of substrate. In the case of Sugar effluent, the  $K_s$ ,  $K_d$ ,  $Y$  and  $K_d$  values are 0.44, 86, 0.53 and 0.043 respectively. In the case of Dairy effluent, the  $K_s$ ,  $K_d$ ,  $Y$  and  $K_d$  values are 0.62, 104, 0.61 and 0.051 respectively. The study established through continued experiments on the model of MBR for its feasibility for treating high COD, industrial, biodegradable waste stream.

## Pilot Gravity-driven Membrane (GDM) Reactor For Seawater Reverse Osmosis Desalination Pretreatment

B. Wu, S. Lee, TH. Chong. University of Iceland (Iceland)

Seawater pretreatment by a pilot gravity-driven membrane (GDM) filtration system (operated over 500 days) was investigated. This study aims to (1) examine the effects of membrane module and system configurations on the GDM permeate flux and permeate water quality; (2) compare the performances of reverse osmosis (RO) membranes fed with the pilot GDM reactor permeates and full-scale ultrafiltration (UF) permeate. The results indicated that (1) the gravity-driven flat sheet membrane module achieved higher permeate flux than hollow fibre; (2) the GDM reactor produced superior permeate quality than the UF pretreatment, leading to less RO membrane fouling; (3) Integration of a biofiltration process with the GDM system further improved subsequent RO membrane performance.

### **Portable Rapid Bacteria Detector**

L. Lei, CM. Yeo, Z. Wang. Zweec Analytics Pte Ltd (Singapore)

Globally, regulators are increasingly paying attention to the biosafety of the drinking water especially in a pandemic. Real time and direct detection of biological suspensions with high sensitivity and accuracy remains an extremely difficult task in the water monitoring industry. In this work, we developed a revolutionary enzyme-assay based bacteria detection system that can realize rapid bacteria detection with high sensitivity and specificity, and low cost. The innovation is expected to exceed the current detection limit and be able to build up a new water monitoring standard.

### **Removal Of Organic Micropollutants From Wastewater By Ozone-Activated Carbon Filtration And Porous Cyclodextrin Polymers Adsorption: A Laboratory Batch Study**

JP. van der Hoek, C. de Jong, TK. Liu, T. Spit, H. Schijfsma. Delft Univesrity of Technology (Netherlands)

Wastewater treatment effluent contains organic micropollutants. The removal requires advanced treatment technologies. The removal efficiency of ozonation-granular activated carbon (O3-GAC) and porous cyclodextrin polymers (P-CDP) was investigated in laboratory batch experiments. O3-GAC and GAC as single process were very effective, while adsorption by P-CDP lagged behind. However, fast kinetics, selectivity and easy on-site regeneration of P-CDP may make this process potentially more competitive and attractive.

### **Smart Water Model - A Case Study At Anderson Road Quarry Site Development, Hong Kong**

HS. Tsang. Government of Hong Kong Special Administrative Region (China)

Like many water utilities around the world, the Water Supplies Department ("WSD") of the Hong Kong Special Administrative Region Government has been facing challenges which include rising water demand due to continuous population and economic growth, diminishing water resource due to impact of climate change, and increasing water loss due to aging of water supply network, etc. WSD has found that use of advanced technologies is a sustainable mean to cope with the challenges and has therefore recently implemented many smart water initiatives such as Grey Water Recycling and Water Intelligent Network ("WIN"). While the application of these smart water initiatives could be constrained by the developed environment of Hong Kong, WSD takes the opportunity of the new Anderson Road Quarry Site Development ("ARQD") and plans to implement various smart water initiatives therein with a view to formulating a Smart Water Model to facilitate the formation of a Smart City.



## **Short-Term Water Quality Prediction Using Tree-Based Classification For Coagulation Control In Drinking Water Treatment Plant To Improve Waterworks Operation Efficiency And Event Detection**

V. Sim, P. Cai. Surbana Jurong Consultants Pte Ltd (Singapore)

The SJ Solution harnesses the power of Data Science & Analytics, and Machine Learning/Artificial Intelligence to help water treatment plants maximize efficiency and reduce manpower reliance. The machine learning models perform fault identification via root cause analysis and prediction of anomalies before they happen. This data modelling has set as a precedence to other processes and create a value chain optimization for the future. The solution makes the currently reactive SCADA system more intelligent through descriptive and predictive analytics. Operators will reap the benefits of AI-assisted models that comes with an interactive dashboard and improve the efficiency of operations through diagnostic troubleshooting and assisted decision-making.

## **The Importance Of Designing For The Real-world And Not Just To Meet The Specification**

D. Nicklin, L. Rusiecki. Xylem (United Kingdom)

Standards are acknowledged as being beneficial for manufacturers and users alike. They provide a minimum level of performance and conditions a meter must meet in order to become certified as compliant to the standard. However, meeting a specification under controlled test bench conditions may not be the best measure of performance in real-world field deployments. For example, the OIML test designed to examine whether a meter can work within defined error limits should there be upstream and downstream pipe bends and valves, only applies across a very short part of the range -- from 0.9Q3 -- Q3. A meter can easily meet the error bands for that short section to claim compliance but fall rapidly outside the bands for large parts of the range, making it totally inaccurate for a real-world installation. In addition, specifications initially developed to test mechanical metrology do not necessarily provide the best basis for qualifying new solid state meter technologies. Utilities should be sure to consider other factors that are not covered in the standard tests and evaluate whether these may be significant to the how the meter may perform in their network.



**30 June 2021 (Wednesday)**

**6.00pm-6.30pm (SGT) (GMT +8)**

**Poster Session 6**

### **Beyond The Urban Limits: A RURBAN Platform To Strengthen Water Governance In India**

G. Sandal, ICLEI Local Governments for Sustainability (India)

A RURBAN platform is formulated to bring rural and urban authorities and stakeholders together at common platform to make climate informed decisions guided by Integrated Urban Water Management (IUWM) and Integrated Water Resource Management (IWRM) principles to mainstream current water management practices at Micro catchment level. The approach is being tested in two Indian cities (Solapur in Maharashtra a drought prone region in western India and Vijayawada in Andhra Pradesh prone to urban flooding in southern region of India. An Integrated Micro Catchment Management Plan (ICMP) is developed as a result of collaborative decision making for the micro catchments. The ICMP supports a shift towards catchment based approaches to water management with greater acceptance towards principles of IUWM by decision makers and practitioners. Strategies are formulated to reduce conflicts across upstream and downstream users and enhance climate readiness in critical zones that are considered to develop more effective and localized action plans. This initiative is a part of IAdapt project funded by IDRC and is being implemented by ICLEI SA in partnerships with Athena, IITM and IWMI Srilanka.

### **Connecting The Poor For SDG 6 And Good Business**

L. Pories, A. Surianingrat. Water.org (United States)

In pursuit of SDG 6, the water sector is striving to increase the number of low-income households that are connected to safely-managed water and sanitation services. One major constraint for this segment is the up-front connection cost, which can be overcome when utilities offer instalment plans that embed the connection fee in its monthly fees. However, utilities are typically skeptical of serving this group. This case study challenges that reluctance by assessing the experience of four urban water utilities in Indonesia that have been serving poor households for three years and seen corresponding revenue increases of 20% and above.

### **Degradation Of Carbamazepine By UVA-LED/WO<sub>3</sub>/peroxydisulfate Process: Effects Of Light Wavelength And Water Matrix**

J. Hu, D. Han. National University of Singapore (Singapore)

Carbamazepine (CBZ), a widely used prescription drug for seizure treatment, has been frequently detected in effluents from wastewater treatment plants due to its high recalcitrance to conventional wastewater treatment processes. In this study, an advanced oxidation process -- UVA-LED/WO<sub>3</sub>/peroxydisulfate process -- was applied to degrade CBZ. The effects of light wavelength and water matrix on CBZ degradation was investigated. The results of this study indicated that UVA-LED/WO<sub>3</sub>/PDS process was a powerful and promising process for CBZ degradation.

### **Design Features And Initiatives At Tuas Water Reclamation Plant**

ZE. Lim. Public Utilities Board (Singapore)

The Tuas Water Reclamation Plant (WRP) will be the largest Membrane Bioreactor (MBR) treatment facility in the world, treating up to 800,000m<sup>3</sup>/day of used water with a 30% more compact footprint compared to conventional WRPs. Domestic and Industrial used water will be treated in two separate liquids treatment modules and further purified to NEWater and Industrial Water respectively. Sludge produced will be treated in a common Biosolids treatment facility. With the adoption of MBR technology, higher treated effluent quality can be produced and discharged via near shore outfall in a responsible manner. The Tuas WRP will be co-located with the National Environment Agency's Integrated Waste Management Facility (IWMF) to harness potential synergies in the water-energy-waste nexus. This paper focuses on highlighting the Tuas WRP Process Design and its co-location synergies along with the SMART initiatives which leverage on technology enabling tools to improve performance of used water treatment.

### **Design Methodology for Next-Generation Smart Water Quality Analyser System in Water Supply Network**

D. Yong, MH. Teh, KK. Toh, CW. Lim, ZY. Ye. PUB (Singapore)

Water quality, pressure and flow monitoring has historically been conducted by constructing permanent sensor installations. There is a need for mobile instrumentation units to support transient, short-term operations and monitoring purposes for the Water Supply Network island-wide. This will drive agnostic decision support capabilities. PUB and Flotech Controls have entered a joint collaboration to develop a comprehensive island-wide mobile instrumentation scheme covering a suite of monitoring capabilities integrated with the smart water grid. The mobile instrument station was designed to overcome operational challenges by addressing design objectives on reliability, mobility and application. Experimental results show that key design considerations in sensor selection, station configuration and panel design allow for a robust integration of the mobile stations to the smart water grid. A successful program for storage, deployment and sustainable use in the field has allowed PUB to conduct real-time ad-hoc monitoring of water quality across the entire Water Supply Network.

### **Developing A Novel Non-Invasive Method For Imaging Of Flow Profile Using Ultrasonic Flowmeters**

Q. Yi, MH. Teh, RA. Ooi, MR. Mohd Akip. PUB (Singapore)

Ensuring good flowmeter accuracy is an important tenet in PUB Water Supply (Network)'s Non-Revenue Water (NRW) management strategy to allow for accurate accounting and for mass balance. Two important factors to ensure flowmeter performance are its site installation conditions and a well-developed ideal flow profile similar to that encountered in the calibration test-rig. This project has developed a novel non-invasive method of investigating and classifying flow profile characteristics within the pipeline which can be used to determine impacts on flowmeter accuracy. Using multi-path data from clamp-on ultrasonic flowmeters (USFM), mathematical algorithms were designed to determine the type of flow profile within a pipeline. An application was then developed using these algorithms to allow the user to obtain important flow characteristics and visualise possible flow profiles.

### **Development Of 3D Visualization Platform For Compound Flooding and Transport Resiliency In Coastal Cities**

AW. Law, F. Zhu, P. Yang, H. Ho, VST. Sim, X. Wu, Y. Liang, JH. Loh, H. Chan, D. Chitwatkulsiri, KN. Irvine. Nanyang Technological University (Singapore)

Coastal cities around the world are increasingly facing the threats of compound flooding, caused by intense rainfall events due to global climate changes coupling with extreme storm surges and sea level rise. Direct visualization of the predicted impacts due to compound flooding can provide useful insights to effective flood resiliency solutions for city planners and government officers. In this project, a 3D visualization platform is developed which integrates the layers of assessment data, including coastal storm surges and sea level fluctuations, inland flood simulations and transportation processes in order to assist non-experts with an authentic view of the urban infrastructure alternatives and enable real-time operational decision-making and evacuation activation with flood control strategies. The usefulness of the platform is demonstrated in two ASEAN study sites, the first in the province of Samut Prakan, Thailand and the second at Vung Tau, Vietnam.

### **Direct-coupling UF-RO Desalination Plant; A Keppel Marina East Desalination Plant Perspective**

AL. Lim, F. Knops, PT. Tay, EK. Goh, YX. Chua, CL. Lee. Pentair Water Asia Pacific Pte Ltd (Singapore)

The Keppel Marina East Desalination Plant (KMEDP) is the first desalination plant in Singapore to adopt direct-coupling UF-RO (DC-UF/RO) design. While DC-UF/RO plants have existed in plants in Europe, Middle-east and Australia, it is uncommon for East and Southeast Asia. This poster aims to provide a comparison of DC-UF/RO desalination against conventional UF/RO desalination plant design from the perspectives of KMEDP. It will compare the pros and cons of DC-UF/RO in general; and the decision of adopting DC-UF/RO design at KMEDP. The startup and operational challenges of DC-UF/RO coupled to the dual feed source operations at KMEDP is discussed. Lastly, recommendations are made on the use of DC-UF/RO design for future plants based on the KMEDP experience.

### **Employing Technology For Faster, Safer And More Cost-Effective Asset Condition Assessments**

B. Eaton, L. McMillan, J. Inglis, A. Adis. Cardno (New Zealand)

The Kapiti Coast District Council (KCDC), a government agency responsible for the management of the Paraparaumu WWTP (Kapiti Coast, New Zealand), sought assistance to carry out a condition assessment of the bridge, internals as well as the tank of one of the clarifiers on the plant. Cardno utilized the services of a multidisciplinary team using a drone and laser scanning to carry out the condition assessment of a clarifier. This innovative approach reduced the safety risk of working in confined spaces and heights, in a contaminated area, while ensuring the task was completed faster and more accurately. The project is also a testament to Cardno's Safety core value and Zero Harm program. This paper aims to highlight the advantages of utilizing technology such as drones and laser scanning to minimize safety risks while still delivering quality condition assessments cost effectively.

### **Fouling-resistant, Highly Permeable Reverse Osmosis Membranes Via Green Synthesis**

Y. Zhang, S. Zhang. National University of Singapore (Singapore)

Here we report a fast, cost-effective and environmental-friendly method to engineer the membrane structure, and simultaneously enhance the permeance and fouling resistance in RO. By free radical polymerization in water, copolymers containing fouling-resistant zwitterionic and hydroxyl-based anchoring groups are synthesized and quickly bonded to the polyamide membrane surface. The copolymer also functions as the molecular engine to reduce the thickness of the polyamide layer and drill nanopores, thereby re-shaping its 3D structure for higher permeability. It is revealed that by design of the size and functionality of the copolymer, the water permeability and salt rejection may be simultaneously increased. Our membrane demonstrates a pure water permeability of 10.5 L m<sup>-2</sup> h<sup>-1</sup> bar<sup>-1</sup>, NaCl rejection of 98.1%, and superior fouling resistance towards various foulants and realistic feed. This paper provides a new perspective for the development of highly permeable, fouling-resistance membranes not only for RO, but also nanofiltration

### **Impact Of Floating Solar Panels On Surface Water Quality For Drinking Water Production**

E. Prest, B. Martijn, A. Waagenvoort. PWNT (Netherlands)

Drinking water utilities in the Netherlands intend to install floating solar panels on open reservoirs for surface water storage before treatment. However, floating solar panels may impact the quality of water used for drinking water production. Here we studied the impact of reduced light input into the water on water quality. The study was performed using an aquarium set-up under controlled conditions. The absence of light significantly reduced phytoplankton growth in the water. As a result, the low biopolymers production by phytoplankton caused a lower dissolved organic carbon concentration. In contrast, the inorganic matter concentrations (nitrate, phosphate, silicate, bicarbonate) were higher in the absence of light, as nutrients are not utilized by phytoplankton activity. This preliminary study shows that floating solar panels can have both a positive and negative impact on water quality used for drinking water production. Careful monitoring before and after installation of solar panels is required.

### **Influence Of Cleantech Interventions On Wastewater Chain And The City Of Amsterdam: Towards A Resilient System For Phosphorus Recovery & Valorisation**

M. Amosov, JP. van der Hoek. Organic Village (Netherlands)

The wastewater chain in Amsterdam offers an opportunity to recover up to 100% of phosphorus (P) per year, versus 47% currently recovered. For water boards, like Waternet, it is difficult to scale-up centralised, decentralised or hybrid P-recovery solutions. Because widely-used methods like Total Cost of Ownership, Mass Flow and Life-Cycle Analysis are limited in providing systemic assessment of risks and propagation among linked stakeholders e.g. municipalities, customers. The Multi-Domain Mapping Model was applied to evaluate risks propagated by four scales of P-recovery solutions - city, block, house, hybrid - onto infrastructure, stakeholders and resources in the region. Change Propagation Indicator showed that centralised solution creates a system where Waternet is the Top-Absorber of risks/costs; and customers are Multipliers. Scenario with house-scale solution shifted risks from Waternet, indicating potential value models with other actors e.g. utilities, biotech startups, citizens, business. Scenario comparison allowed deriving system-wide patterns and change management strategies for identified actors. The developed toolkit allows integration - analysis of new data.

### **Integrated Anaerobic Fixed-Film MBR-Reverse Osmosis-Chlorination Process: An Environmentally Sustainable Approach For Reclamation Of Municipal Used Water**

Y. Liu, S. Wang, H. Liu, J. Gu, M. Zhang. Nanyang Technological University (Singapore)

Nowadays, the reclamation of municipal used water to high-grade water (e.g. NEWater) has been widely accepted as a feasible alternative to achieve water sustainability. However, there may be some room to further improve the current NEWater production line in terms of energy consumption and excess sludge production. To address these emerging issues, an integrated anaerobic fixed-film MBR (AnfMBR), reverse osmosis (RO) and chlorination process was developed for producing high-grade product water from municipal used water. It turned out that the product water could meet typical NEWater quality in terms of TOC, ammonium, phosphorous, chlorine and other major ions, with net energy consumption estimated to be 0.30 kWh per m<sup>3</sup> product water. Consequently, this study may open a new window for reclamation of municipal used water to high-grade product water with reduced energy consumption and negligible excess sludge production.

## **Integrating MBR Systems To Potable Reuse Treatment Schemes And Associated Pathogen Removal Capabilities**

Z. Erdal, U. Erdal. Binnies (United States)

Although a limited number of MBR systems coupled with RO exist in potable reuse projects (e.g.; Gippsland, Australia), indirect potable reuse (IPR) via ground water injection in California, USA has been established relying on "full advanced treatment" that requires MF/UF, RO and UV advanced oxidation (AOP) to meet pathogen, TOC, N and other requirements specified in the recharge regulations. The main functions of MF/UF in the process train are to greatly reduce solids and pathogen and provide pretreatment for downstream RO process. In drinking water and potable reuse, California Division of Drinking Water awards up to 4-log credit for *Cryptosporidium* and *Giardia* for MF/UF systems by passing a daily direct integrity test. For IPR via groundwater recharge, a total of 12, 10 and 10-log removal values (LRV) is needed for viruses, *Cryptosporidium* and *Giardia*. Despite various benefits and increased interest toward replacing MF/UF systems with MBR, historically MBR systems have not been given LRV credits. Results of this study showed complete rejection of pathogens and MS-2 phage by the tested MBR membranes. Permeate turbidity values correlated well with rejection and membrane integrity.

## **Intensified Wastewater Sludge Treatment And Resources Recovery Using Thermophilic Pretreatment And Liquid Separation**

Y. Hirmiz, A. Elsayed, S. Fernandes, H. Guo, N. Piccolo, Y. Hong, Y. Kim. McMaster University (Canada)

Anaerobic digestion (AD) is an essential process in wastewater treatment to reduce and stabilize waste sludge. However, the rate of sludge digestion is slow and as a result AD usually requires a long retention time. Thermophilic pretreatment can accelerate sludge digestion, in particular, hydrolysis of particulate biosolids. Enhanced hydrolysis rapidly releases soluble organics and ammonia, resulting in substantial inhibition effects on the following methanogenesis reactions. In this study, we investigated kinetics of hydrolysis reactions and inhibition effects under thermophilic conditions based on lab-scale experiments and model simulations (as described in this abstract). We also looked into new technologies to recover ammonia from liquid digestate after thermophilic pretreatment. Separation of liquid digestate also reduces ammonia and volatile fatty acids in the digestate that can be reliably treated in mesophilic digesters. In the presentation, more details on the kinetics of hydrolysis and inhibition as well as ammonia recovery will be discussed.

### **Macro-patterning Of Micro-crumpled Nanofiltration Membranes By Spacer Imprinting For Low-scaling Desalination**

C. Shang, S. Zhang. National University of Singapore (Singapore)

Surface patterns provide a chemical-free approach to reduce fouling by mimicking nature, and are yet limited by their complicated fabrication procedures. Here we develop readily scalable methods to create sub-micrometer- and millimeter-scale patterns on membrane surfaces for low-scaling desalination, with a focus on the anti-scaling mechanism. Specifically, a robust polyethylene (PE) lithium battery separator prepared from melt casting and stretching has been used as the support for nanofiltration (NF), giving micrometer-scale crumples on the surface. Then the PENF membrane is imprinted by permeate spacer during tests, leading to millimeter-scale patterns. A comparison of the impact of different feature sizes on scaling, ranging from smooth-, nm-,  $\mu\text{m}$ - and mm-levels, was given through no-stirring dead-end and crossflow tests. Results indicate that  $\mu\text{m}$ -scale patterns are resistant to scaling through both spatial and hydrodynamic effects, and mm-scale patterns are also effective in reducing scaling solely due to hydrodynamic effects.

### **Maximizing RO Recovery At The World's Largest Potable Reuse Plant**

M. Boyd, M. Plumlee, H. Gu, J. Lozier, M. Hwang. Desalitech (United States)

The Orange County Water District (OCWD) Groundwater Replenishment System (GWRS) is the world's largest potable reuse plant, treating secondary effluent to produce purified water for groundwater recharge as a drinking water supply augmentation and for injection into coastal wells that form a barrier to prevent seawater intrusion. Currently the GWRS has a production capacity of 100 million gallons per day (MGD), with the existing three-stage, 85% recovery reverse osmosis (RO) system generating 18 MGD of RO concentrate that is discharged to the ocean. Upon completion of the final GWRS plant expansion in 2023, full production capacity will increase to 130 MGD while the RO concentrate flows will increase to 23 MGD. To further increase GWRS purified water production, OCWD has been pilot testing CCRO for two years to recover additional water from the RO concentrate and generate a new water supply for the region. This paper summarizes the long-term results.

### **Optimization Of Residual Polymer Measurement In Dewatering Filtrate Using In-line UV-Vis Spectrometer**

Y. Yang, SZ. Abdullah, R. Mallampati, A. Andaya, F. Kassim. TÜV SÜD PSB (Singapore)

A pilot system is used to assess the UV spectrometers performance in detecting and monitoring the residual polymer concentration in the filtrate of the sludge dewatering process to select the optimal polymer dose. It can effectively optimize the dewatering performance and reduce polymer consumption. When monitoring the residual polymer concentration with optimum UV wavelength and optimum dilution ratio, the optimum polymer dose can be determined by finding the polymer dose presenting minimum UV absorbance value. The resulting data has shown the optimum UV wavelength is in the range of 190 -- 193 nm, which has the most sensitive response to polymer concentration variation. This UV system consisting of spectrometer and probe can be utilized for real-time monitoring of polymer dose in the wastewater treatment plant. This would potentially save cost and increase sludge dewatering efficiency.



### **Pilot-scale Operation Of A Gas-sparged Staged Anaerobic Fluidized Bed Membrane Bioreactor: Treatment Performance, Air-stripping Of Dissolved Methane And New Insights Into COD Removal Mechanisms**

S. Tilmans, C. Shin, S. Galdi, R. Luthy, P. McCarty, C. Criddle. Stanford University Codiga Resource Recovery Center (United States)

The Staged Anaerobic Fluidized Bed Membrane Bioreactor (SAF-MBR) couples an anaerobic fluidized bed reactor with ultrafiltration for efficient anaerobic secondary treatment of domestic wastewater, reduced energy demand, and decreased biosolids production compared to aerobic treatment. This study, funded by Singapore PUB, describes process performance of a novel configuration using biogas sparging for membrane fouling control to avoid membrane damage experienced in previous tests. Additional challenges for anaerobic MBRs are management of effluent dissolved methane and modeling of system kinetics. Dissolved methane was efficiently removed using an air stripper, and equations and parameters needed for modeling of system performance are defined.

### **Polyamide Thin Film On PTFE Hollow Fibres For Nanofiltration**

JY. Chong, G. Yang, H. Yi, L. Du, R. Wang. Nanyang Technological University (Singapore)

Polytetrafluoroethylene (PTFE) is an excellent material for membrane applications due to its highly inert property. However, it is still challenging to produce PTFE membranes with small pore size (<1 nm) for nanofiltration. In this study, nanofiltration PTFE hollow fibres were successfully synthesized by coating a polyamide thin film layer on the inner surface. Surface modification was first carried out to improve the hydrophilicity of the PTFE substrates, followed by the synthesis of polyamide through interfacial polymerization. This simple coating method can effectively transform commercially available microfiltration PTFE substrates to high value nanofiltration membranes. The prepared polyamide-PTFE composite membranes showed good permeability for both water and organic solvents, and had a small MWCO of ~350 Da in water. This highly stable membrane can potentially be used in applications involving harsh conditions such as organic waste treatment and organic solvent nanofiltration.

### **Process Performance And Energy Production Potential In A High Rate A-stage System Without Aeration**

S. Cao, G. Tao, KM. Phua, Y. Zhou. Nanyang Technological University (Singapore)

High rate activated sludge (HRAS) process operated with aeration can capture organics from wastewater with energy recovery, while it still causes a certain amount of carbon loss due to the mineralization. In this study, the feasibility of operating a HRAS process without aeration was carried out in a demo-scale plant, it was demonstrated to be more effective for organics recovery than that with aeration (53.82% versus 40.94% COD harvesting from raw wastewater). Mass balance analysis indicated minor organics (1.75% of incoming COD) was lost during operation compared to with aeration (23.86%). Moreover, biochemical methane potential (BMP) tests showed that the produced sludge had higher degradability, methane yield is 8.2% greater than that with aeration (388.9 versus 359.4 mL CH<sub>4</sub>/g VS). Overall, this study documented the feasibility of HRAS without aeration, and acted as a guide in achieving the goal of energy neutrality or even energy-positive wastewater treatment.



### **Regional Water Security Study (RWSS): Defining No-regret Measures And Investments To Sustainably Improve Water Security In The Short And Medium Term In The Yangon Region In Myanmar**

T. Huizer, R. Steijn, J. de Groot, D. Spaans, H. Nandar Aye. Arcadis (Netherlands)

Yangon Region, the former capital and fast-growing economic engine of Myanmar is facing various water related challenges. Coastal and riverine flooding, saltwater intrusion and insufficient water supply for public, commercial, industrial, and agricultural use jeopardize sustainable future growth of the area. As part of the Regional Water Security Study (RWSS), three interlinked investment programs were developed that aim to secure the future water security in the Greater Yangon Region. The regional water system was analyzed with the use of a specially developed hydrodynamical model (Delft3D FM), which also served to study the cumulative impact of proposed or new measures. The programs with measures are focusing on Weakest Link Strengthening (hotspots for embankment improvements and flood protection), Freshwater Supply in the rural areas and Drainage System Improvement.

### **Sludge Dewatering In A Novel Two Steps Process Combining Mechanical Dewatering And Electro-osmosis**

N. Boelee, CY. Jen, A. Hamhuis. Nijhuis Industries (Netherlands)

The transport and incineration of large amounts of watery sludge is costly and has a high environmental impact. Sludge can be dewatered to high dry matter contents by combining mechanical dewatering and electro-osmosis. Sludge was dewatered to 14 - 35% dry matter by mechanical dewatering, depending on the type of sludge. By applying electro-osmosis the sludge can be further dewatered up to 50% dry matter reducing the transport costs significantly. Furthermore, the produced cake has a high energy content, which requires less incineration energy. Therefore this two-step sludge dewatering reduces both the economic and environmental impact of sludge.

### **The Use Of Deliberative Community Engagement When Planning The Removal Of Wet Weather Sewage Overflows From A SE Queensland Suburban Creek**

I. Jennison, S. Scott, S. Taylor. Queensland Urban Utilities (Australia)

Cannery Creek is a small canalized, tidal waterway in suburban Brisbane, SE Queensland, formed during the 1940's. The Creek receives stormwater and wet weather sewage overflows. A solution is required to the increasing frequency of wet weather overflows. Two options are available to sewerage provider, Queensland Urban Utilities; either construct a large diameter trunk sewer conveying flows to a sewage treatment plant. High flows bypass that plant discharging into Moreton Bay; or screen locally and discharge to a neighbouring waterway that flows to Moreton Bay. Stormwater would be treated in a dedicated wetland offsetting nutrient in sewage discharges. Extensive community engagement described benefits and impacts, such as flooding, waterway and ecological health. The outcome was community approval of the nature-based option. The community also proposed designs to address concerns for the Creek beyond the service provider's remit. This paper discusses the issues, options, community engagement process and outcomes.

### **Towards An Integrated Flood Resilience Strategy For Yangon**

T. Nauta. Deltares (Netherlands)

Yangon's flood hazard profile is influenced by flood drivers related to the regional river system of the Ayeyarwady Delta, the urban drainage system and local topography and the interaction between them. The 2020 World Bank financed flood resilience strategy, as currently developed together with Yangon City Development Committee for Yangon City for the period 2020 -- 2040, includes a package of structural and non-structural measures that aim at decreasing fluvial, coastal and pluvial flood risks coupled with a strong disaster response and recovery program. Structural green and grey measures aim to reduce flood hazard by keeping floods away from people and assets, while non-structural measures aim to keep people safe from flooding through better planning and management of flood prone areas.

### **Understanding The Temporal Variability Of Influent Wastewater And Microbial Activity With Bio-electrochemical Sensors**

R. Cusick, A. Emaminejad, C. Ragush, J. Ambler, G. Wells, P. Kiely. University of Illinois at Urbana-Champaign (United States)

Bio-electrochemical sensors (BES) provide a novel opportunity for continuous monitoring of wastewater characteristics and microbial activity. The Microbial Electron Transfer (MET) signal obtained from a BES installed in the influent channel of an activated sludge treatment battery of a large wastewater facility in Midwestern United States, indicated variable water quality conditions that signify unstable biological response at the influent, suggesting high potential for biological treatment disruptions. MET typically responded strongly to changes in COD & VFAs in the summer and into the fall, but less so in the winter. Further analysis suggested a change in the nature of the influent, highlighting the seasonality of wastewater treatment. Microbial activity changes in the influent align with change in other process parameters and effluent water quality. Rain events proved to have a significant impact on BES response, suggesting that large rain events result in large fluctuations in microbial activity and require operational attention.

### **WOW! - A New Business Approach For Resource Recovery From Sewage**

J. de Best, G. Kolisch, A. Christen, S. Venditti, J. Hansen, K. Bijl. Regional Water Authority Vallei en Veluwe (Netherlands)

Did you know that even used toilet paper can get a second life? Sewage contains valuable substances that could be used as circular raw materials for biobased products. The WOW! project aims to capitalise on these opportunities and work towards a more circular approach. We do this by a) demonstrating the technical feasibility for recovery & upcycling techniques for cellulose, lipids and PHA from sewage, b) Investigating the market potential and creating five high potential value chains for raw materials and c) addressing policy barriers for the circular uptake of raw materials from sewage. Preliminary results are promising. So far we successfully produced biobased products from sewage and are currently upscaling the pilots. Furthermore, current market potential shows that the markets for biobased alternatives for conventional products are increasing. Current national and European legislation however doesn't always permit the reuse of raw materials from sewage.



## SINGAPORE INTERNATIONAL WATER WEEK 2021

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

SIWW2021 SPOTLIGHT

21 June 2021

SIWW2021 ONLINE

21 June – 2 July 2021

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*\*Denotes free-to-air sessions*

## **TW.1 Water Resilient Cities – Lessons from Recent Extreme Events**

22 June 2021 (Tuesday), 4.00pm-5.30pm SGT (GMT+8)

Co-organiser: Water Convention Programme Committee

The threats posed to water security and the liveability of our cities have been on the rise. Climate change has led to an increasing frequency of extreme weather events across the world. The Covid-19 pandemic has shifted preconceived notions of normalcy in almost every facet of life. Moreover, the challenge of overcoming these threats are compounded by longstanding legacy issues in urban planning. In this webinar, experts across globe will share their experiences, solutions and shortfalls in the responses to recent extreme events. The lessons learnt, solutions and broad principles of practice for building resilience in our cities and people.

<b>Welcome Remarks</b> <i>Mark Fletcher, Global Water Business Leader, Arup (UK)</i>
<b>Building a Water Resilient Future: From Diagnosis to Delivery</b> <i>Louise Ellis, Associate, Arup (UK)</i>
<b>A Case Study from Hong Kong on Pluvial Flooding and High Intensity Storms</b> <i>Ho Yiu Kwong, Assistant Director Operations and Maintenance, Drainage Services Department (Hong Kong)</i>
<b>COVID-19 Pandemic Impacts on The Water Sector</b> <i>Geoffrey Wilson, Senior Water Resources Specialist, Asian Development Bank (Philippines)</i>
<b>Overcoming Legacy Issues</b> <i>Suresh Rohilla, Senior Director, Centre for Science and the Environment, New Delhi (India)</i>
<b>Panel Discussion</b> <i>Henk Ovink, Special Envoy to UN (the Netherlands)</i> <i>Louise Ellis, Associate, Arup (UK)</i> <i>Ho Yiu Kwong, Assistant Director Operations and Maintenance, Drainage Services Department (Hong Kong)</i> <i>Geoffrey Wilson, Senior Water Resources Specialist, Asian Development Bank (Philippines)</i> <i>Suresh Rohilla, Senior Director, Centre for Science and the Environment, New Delhi (India)</i> <i>Mark Fletcher, Global Water Business Leader, Arup (UK) – Moderator</i>
<b>Insights from Panel Discussion</b> <i>Henk Ovink, Special Envoy to UN (the Netherlands)</i>
<b>Closing Remarks</b> <i>Mark Fletcher, Global Water Business Leader, Arup (UK)</i>

## **TW.2 Lee Kuan Yew Water Prize Laureates Roundtable: “Game-changing Technologies for a Sustainable Water Future”**

22 June 2021 (Wednesday), 9.00pm-10.30pm SGT (GMT+8)

Co-organiser: PUB, Singapore’s National Water Agency

The Lee Kuan Yew Water Prize was established in 2008 to honour the best minds in water solutions. To-date, eight Laureates have been awarded this prestigious Prize to recognize their contributions towards solving the world’s water challenges by developing or applying innovative technologies, policies or programmes which benefit humanity.

This roundtable brings our past Laureates together for the first time in a special webinar. In this session, our esteemed speakers will share their insights on the global trends and advances in science and innovation, and changes in approaches in technology development and implementation that would be necessary to tackle emerging urban water challenges and meet the SDGs.

### **Speakers:**

- Professor Rita R. Cowell, 2018 Laureate
- Professor John Anthony Cherry, 2016 Laureate
- Mike Markus, Orange County Water District, 2014 Laureate
- Professor Mark van Loosdrecht, 2012 Laureate
- Dr James Barnard, 2011 Laureate
- Dr Andrew Benedek, 2008 Laureate

**Moderator:** Prof Shane Snyder, Executive Director, Nanyang Environment and Water Research Institute

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### **TW.3 Digital Water Hackathon – DemoDay@SIWW**

23 June 2021 (Wednesday), 2.00pm-3.30pm SGT (GMT+8)

Co-organisers: Ripple2Wave Incubator and Singapore University of Social Science (SUSS)

The Digital Water Hackathon is organised by Ripple2Wave Incubator (R2WI) and Singapore University of Social Sciences (SUSS), and supported by A\*START Central, Enterprise Singapore (ESG), Infocomm Media Development Authority (IMDA) and PUB, Singapore's National Water Agency.

Selected applicants go through a week of bootcamp workshop and pitched to get shortlisted into the "3 months Deep Mentoring Phase". These finalists are now ready to present their solution in addressing the respective Digital Water Problem Statements to a panel of esteemed judges.

Listen to the different teams' presentations. Understand how the Singapore Ecosystem came together to support Entrepreneurship and Innovation in the Water Industry.

<b>Opening Address</b> <i>Dr Helge Daebel, Managing Director, Ripple2wave</i>
<b>Welcome Address</b> <i>Professor Cheah Horn Mun, Assistant Provost and Dean (College of Lifelong &amp; Experiential Learning), SUSS</i>
<b>Pitching Presentations and Q&amp;A</b> <i>Tan Jiale, Co-Founder, Majid-JT</i> <i>Kenny Wong, Co-Founder, Neptune – WaterFutureTech</i> <i>Alex Wong, Co-Founder, Groundup.ai</i> <i>Clement Collignon, Fieldbox.ai</i> <i>Sumanta Bose, Datakrew</i> <i>Wong Liang Jie, Teredo Analytics</i> <i>Tyler Huang, Memsing</i>
<b>Hackathon Highlights</b>
<b>Prize Ceremony and Closing Speech</b> <i>Dr Helge Daebel, Managing Director, Ripple2wave</i>

## **TW.4 Empowering Women in Water**

23 June 2021 (Wednesday), 2.00pm-3.30pm SGT (GMT+8)

Co-organiser: Jacobs

## **TW.5 Business of Water**

23 June 2021 (Wednesday), 4.00pm-5.30pm SGT (GMT+8)



## **TW.6 Utilities of the Future – Is Smarter Water Better Water? (Session 1)**

23 June 2021 (Wednesday), 8.00pm-9.30pm SGT (GMT+8)

Co-organiser: Water Convention Programme Committee

Digitalisation offers opportunities for utilities to redefine existing business processes. It allows for the optimisation of internal processes, improved service and value for customers and better environmental outcomes at a lower cost. However, there remains significant risks and impediments to its widescale adoption which include cybersecurity, keeping up with new developments, and optimising deployment. This two-part webinar aims to assess what problems are best addressed through digitisation and where they may not have a place.

This session will cover the lessons learnt from early adopters of “smart water” and take stock of the past decade of “smart water” innovation.

<b>Welcome Remarks</b> <i>Adam Lovell, Executive Director, Water Services Association of Australia (Australia)</i>
<b>Overview Presentation</b> <i>Dragan Savic, Chief Executive Officer, KWR Water Research Institute (the Netherlands)</i>
<b>Smart Water: A Decade in Review of Technology, Strategy and Culture by Early Adopters</b> <i>William Yeo, Chief Information Officer, PUB (Singapore)</i> <i>Louise Dudley, Chief Executive Officer, Queensland Urban Utilities (Australia)</i> <i>Kishia Powell, Chief Operating Officer and Executive Vice President, DC Water (USA)</i>
<b>Panel Discussion</b> <i>Dragan Savic, Chief Executive Officer, KWR Water Research Institute (the Netherlands)</i> <i>William Yeo, Chief Informations Officer, PUB (Singapore)</i> <i>Louise Dudley, Chief Executive Officer, Queensland Urban Utilities (Australia)</i> <i>Kishia Powell, Chief Operating Officer and Executive Vice President, DC Water (USA)</i> <i>Adam Lovell, Executive Director, Water Services Association of Australia (Australia) – Moderator</i>
<b>Summary</b> <i>Adam Lovell, Executive Director, Water Services Association of Australia (Australia)</i>

**\*TW.7 A Career in the Water Profession**

24 June 2021 (Thursday), 2.00pm-3.30pm SGT (GMT+8)

Co-organiser: Environmental Engineering Society of Singapore (EESS), National University of Singapore

This session welcomes youths and students interested in pursuing a career in the water sector to join us. Find out about the exciting developments in the water industry and hear from a panel of successful young water professionals from the government, industry and academia who will share with you their career journey. Don't miss this opportunity to meet and interact (virtually) with these water professionals and be inspired to embark your own journey in the water sector!

## **TW.8 Utilities of the Future – Is Smarter Water Better Water? (Session 2)**

24 June 2021 (Thursday), 8.00pm-9.30pm SGT (GMT+8)

Co-organiser: Water Convention Programme Committee

Digitalisation offers opportunities for utilities to redefine existing business processes. It allows for the optimisation of internal processes, improved service and value for customers and better environmental outcomes at a lower cost. However, there remains significant risks and impediments to its widescale adoption which include cybersecurity, keeping up with new developments, and optimising deployment. This two-part webinar aims to assess what problems are best addressed through digitisation and where they may not have a place.

Following yesterday's webinar, this session will discuss the unanswered questions and unsolved problems with "smart water" implementation in utilities and provide an outlook for the future.

<b>Welcome Remarks</b> <i>Albert Cho, Senior Vice President, Chief Strategy and Digital Officer, Xylem Inc (USA)</i>
<b>Overcoming Obstacles in Smart Water Implementation: Cybersecurity</b> <i>Mekorot (Israel)</i> <i>Judith Germano, Distinguished Fellow, New York University (USA)</i>
<b>Overcoming Obstacles in Smart Water Implementation: Integration and Interoperability</b> <i>Melvin Koh, Director, Joint Operations, PUB (Singapore)</i> <i>George Hawkins, Founder and Executive Director, Moonshot Missions (USA)</i>
<b>Overcoming Obstacles in Smart Water Implementation: People and Change Management</b> <i>Roch Cheroux, Managing Director, Sydney Water (Australia)</i> <i>Joone Kim-Lopez, General Manager, Moulton Niguel Water District (USA)</i>
<b>Panel Discussion</b> <i>Mekorot (Israel)</i> <i>Judith Germano, Distinguished Fellow, New York University (USA)</i> <i>Melvin Koh, Director, Joint Operations, PUB (Singapore)</i> <i>George Hawkins, Founder and Executive Director, Moonshot Missions (USA)</i> <i>Roch Cheroux, Managing Director, Sydney Water (Australia)</i> <i>Joone Kim-Lopez, General Manager, Moulton Niguel Water District (USA)</i> <i>Albert Cho, Senior Vice President, Chief Strategy and Digital Officer, Xylem Inc (USA) - Moderator</i>
<b>Summary</b> <i>Albert Cho, Senior Vice President, Chief Strategy and Digital Officer, Xylem Inc (USA)</i>

## **GREEN TALKS – Virtual Denmark-Singapore dialogue on Water Resource Recovery**

25 June 2021 (Friday), 2.00pm – 3.30pm SGT (GMT+8)

Organisers: State of Green

Denmark and Singapore have been collaborating in the water space for the past many years, with the most recent five-year environmental collaboration agreement (MoU) between Singapore and Denmark, including water, signed in February 2020.

Join us, as we dive into Singaporean and Danish collaboration during Singapore International Water Week. We have secured keynote speakers and are pleased to announce that H.E Ms. Grace Fu, Minister for Sustainability and the Environment Singapore and H.E Ms. Lea Wermelin, The Minister for Environment of Denmark will speak live at the event. The keynotes are followed by moderated fireside CEO-chat by three of the leading water utilities in Denmark.

Do not miss your chance to ask questions on all things water resource recovery related as the event splits into dual panel debates with leading professionals from both Singapore and Denmark.

Panel track #1 focuses on business opportunities and operation models within Resource Recovery. Panel track#2 will focus on collaborations with focus on new R&D and innovation on the horizon within resource recovery.

The event will be of interest to wastewater/resource recovery professionals from utilities, universities and private businesses from both Denmark, Singapore and the overall international water community.

Registration link:

<https://stateofgreen.com/en/events/virtual-denmark-singapore-dialogue-on-water-resource-recovery/>

**\*TW.10 Dealing with the Deep Uncertainty of Sea Level Rise**

*Organised as part of the Urban Sustainability R&D e-Symposia*

28 June 2021 (Monday), 7.00pm-8.30pm SGT (GMT+8)

Co-organiser: PUB, Singapore's National Water Agency

There are different types of uncertainties – unpredictability (e.g. global emission scenarios and changing climate conditions, urbanisation), incomplete knowledge (e.g. lack of knowledge, limited data availability) and ambiguity (e.g. differing stakeholders' perspectives/values). Not considering these uncertainties in decision making may result in future options becoming constrained by earlier decisions, or situations where assets are obsolete before end of design life. To manage uncertainties while ensuring adequate system performance, adaptive planning is necessary to safeguard the future and interests of Singapore. This thematic webinar invites you to catch a glimpse of some of the uncertainties associated with sea level rise, decision making tools and building with nature as a future proof strategy.

## **TW.11 Resource Recovery – From Policy to Practice (Session 1)**

28 June 2021 (Monday), 9.00pm-10.30pm SGT (GMT+8)

Co-organiser: Water Convention Programme Committee

Conventional waste streams, such as sewage sludge, water treatment sludge and brine streams, contain valuable resources like nutrients, heavy metals and inorganic minerals that can be extracted for reuse. With a growing demand for our limited supply of natural resources, resource recovery is necessary to close the gaps in the water, carbon and energy cycles to ensure environmental sustainability.

This session, the first of two, will discuss the broader principles, challenges and economics of resource recovery and explore its application through the Tuas Nexus Integrated Waste and Water Treatment Facility case study.

<b>Welcome Remarks</b> <i>Andrew Shaw, Associate Vice President, Black &amp; Veatch (USA)</i>
<b>Overview Presentation: Grand Challenges in Eliminating Waste</b> <i>Kartik Chandran, Professor, Columbia University (USA)</i>
<b>Circular Economics in Resource Recovery</b> <i>George Tchobanoglous, Professor Emeritus, University of California, Davis (USA)</i>
<b>Policy and Agency Barriers</b> <i>Arne Panesar, Head of Program, giz (Germany)</i>
<b>Case Study: Tuas Nexus</b> <i>Bettina Kamuk, Global Market Director Waste to Energy, Ramboll Group (Denmark)</i>
<b>Panel Discussion</b> <i>Andrew Shaw, Associate Vice President, Black &amp; Veatch (USA) – Moderator</i> <i>Kartik Chandran, Professor, Columbia University (USA)</i> <i>George Tchobanoglous, Professor Emeritus, University of California, Davis (USA)</i> <i>Aarne Panesar, Head of Program, giz (Germany)</i> <i>Bettina Kamuk, Global Market Director Waste to Energy, Ramboll Group (Denmark)</i>
<b>Summary</b> <i>Andrew Shaw, Associate Vice President, Black &amp; Veatch (USA)</i>

## **TW.12 Climate Change, Water Quality and Health**

29 June 2021 (Tuesday), 7.00pm-8.30pm SGT (GMT+8)

Co-organiser: Water Convention Programme Committee

Climate change poses an array of uncertainties that threaten water quality which, if not addressed, could ultimately lead to a deterioration of public health. This webinar discusses these uncertainties and explores adaptation strategies such as the diversification and conservation of water supplies, resilient infrastructure and public health preparedness.

<b>Welcome Remarks by the Moderator</b> <i>Tom Panella, Director, Environment, Natural Resources, Agriculture Division, East Asia Department, Asian Development Board (Philippines)</i>
<b>The Uncertainties Introduced by Climate Change</b> <i>Bruce Gordon, Coordinator of WASH, World Health Organisation (Switzerland)</i>
<b>Diversification and Conservation of Water Supplies</b> <i>Monica Emelko, Professor, University of Waterloo, (Canada)</i>
<b>Resilient WASH Infrastructure</b> <i>Guy Howard, Professor, University of Bristol, (United Kingdom)</i>
<b>Post-COVID-19 Water Management in Urban Areas in the Anthropocene</b> <i>Kensuke Fukushi, Professor, University of Tokyo, (Japan)</i>
<b>Panel Discussion</b> <i>Lim Mong Hoo, Senior Consultant, Water Quality Department, PUB (Singapore)</i> <i>Raya Muttarak, Program Director, Population and Just Societies Program, International Institute for Applied Systems Analysis, Wittgenstein Centre (Austria)</i> <i>Robin Price, Managing Director, Water Resources East (United Kingdom)</i> <i>Paul Hunter, Professor, University of East Anglia (United Kingdom)</i> <i>Tom Panella, Director, Environment, Natural Resources, Agriculture Division, East Asia Department, Asian Development Board (Philippines) - Moderator</i>
<b>Wrap-up and Summary</b> <i>Tom Panella, Director, Environment, Natural Resources, Agriculture Division, East Asia Department, Asian Development Board (Philippines)</i>

## **TW.13 Resource Recovery – from Policy to Practice (Session 2)**

29 June 2021 (Tuesday), 9.00pm-10.30pm SGT (GMT+8)

Co-organiser: Water Convention Programme Committee

Conventional waste streams, such as sewage sludge, water treatment sludge and brine streams, contain valuable resources like nutrients, heavy metals and inorganic minerals that can be extracted for reuse. With a growing demand for our limited supply of natural resources, resource recovery is necessary to close the gaps in the water, carbon and energy cycles to ensure environmental sustainability.

This session will look more closely at advances in various resource recovery technologies and the applications of the recovered resources.

<b>Welcome Remarks</b> <i>Kartik Chandran, Professor, Columbia University (USA)</i>
<b>Resource Recovery and Reuse from a Water Perspective</b> <i>Peter Fiske, Executive Director, National Alliance for Water Innovation, University of California, Berkeley (USA)</i>
<b>Mineral Recovery from Brine</b> <i>Nikolay Voutchkov, President, Water Globe Consultants (USA)</i>
<b>Carbon and Hydrogen Recovery</b> <i>Luc Kox, Commercial Manager, Hazer Group (Australia)</i>
<b>From Dissipation to Capture: Upgrading Mineral Nutrients from Waters via Aerobic Fermentation</b> <i>Willy Verstraete, Professor, Ghent University (Belgium)</i>
<b>Panel Discussion</b> <i>Kartik Chandran, Professor, Columbia University (USA) – Moderator</i> <i>Peter Fiske, Executive Director, National Alliance for Water Innovation, University of California, Berkeley (USA)</i> <i>Nikolay Voutchkov, President, Water Globe Consultants (USA)</i> <i>Luc Kox, Commercial Manager, Hazer Group (Australia)</i> <i>Willy Verstraete, Professor, Ghent University (Belgium)</i>
<b>Summary</b> <i>Kartik Chandran, Professor, Columbia University (USA)</i>



## **TW.14 Singapore Water Exchange (SgWX) Water Utilities Series: Uncovering Water Opportunities in Bangladesh**

30 June 2021 (Tuesday), 2.00pm-3.30pm SGT (GMT+8)

Co-organiser: Singapore Water Association (SWA) and PUB, Singapore's National Water Agency

Bangladesh is an extremely densely populated country with 168 million people. Around 121 million people take their water from tube wells, around 47 million people have access to water through piped water systems or other sources. Millions of people in Bangladesh are navigating the COVID-19 pandemic with the added challenge of living without access to safe water. Now more than ever access to safe water is critical to the health of families in Bangladesh. The Government of Bangladesh aims to limit COVID-19 transmission through safe water, sanitation & hygiene (WASH) services, practices and behaviours, and focus on ensuring continuity and expanded accessibility of WASH services, which have proven to protect human health. The World Bank and its partners support such initiative and provide funding and analyses to promote regional collaboration in managing water resources in Bangladesh.

This webinar presents the water challenges faces by Bangladesh and explore how investment in infrastructure improvements and technologies can tackle these challenges.

## **TW.15 Water Industry Transformation to Achieve SDG2030 – Overcoming Bottlenecks**

30 June 2021 (Wednesday), 4.00pm-5.30pm SGT (GMT+8)

Co-organiser: Water Convention Programme Committee

With 2030 closely approaching, the concern for the global community to achieve the Sustainable Development Goals (SDG) is rising. The reality is clear – if governments and industry continue business-as-usual, achieving SDG2030 is unattainable. This workshop will discuss how SDG 6, Water and Sanitation, interlinks with the other goals and identify the barriers, bottlenecks and low-hanging fruit in policy, technology and implementation. The main outcome of the workshop is to develop a list of possible actions for water utilities to lead the water industry transformation to overcome the bottlenecks in achieving SDG2030.

<b>Welcome Remarks</b> <i>Tony Wong, Chair, CRC for Water Sensitive Cities (Australia)</i>
<b>Overview Presentation</b> <i>Federico Properzi, Chief Technical Adviser, UN Water (Switzerland)</i>
<b>Policy Approaches</b> <i>Adam Lovell, Executive Director, Water Services Association of Australia (Australia)</i>
<b>Technologies to Ensure Access to Water and Sanitation for All</b> <i>Bertrand Garnier, Applications and Solutions Leader, Technology, Suez (France)</i>
<b>Implementing Policy and Technology</b> <i>Chong Mien Ling, Director, Policy and Planning, PUB (Singapore)</i>
<b>Break-out Session</b>
<b>Formulating Possible Actions to Achieve SDG2030 and Closing Remarks</b> <i>Tony Wong, Chair, CRC for Water Sensitive Cities (Australia)</i>

## **TW.16 Reinventing Membranes – Present to Future**

30 June 2021 (Wednesday), 8.00pm-9.45pm SGT (GMT+8)

Co-organiser: Water Convention Programme Committee

This webinar will provide an overview of present membrane technologies, their evolution and the new challenges they aim to address today. Experts from across the globe will discuss the latest in polymeric membranes, ceramic membranes, biomimetic membranes and what the future has in store.

<b>Welcome and Introduction - Evolution of Membranes</b> <i>Gary Amy, Professor, Clemson University (USA)</i>
<b>Polymeric Membranes</b> <i>Craig Bartels, VP Technology, Hydranautics (USA)</i>
<b>Ceramic Membranes</b> <i>Holly Shorney-Darby, Senior Project Manager, PWNT (the Netherlands)</i>
<b>Future of Membranes – Biomimetics: Quo Vadis?</b> <i>Claus Helix-nielsen, Professor, Technical University of Denmark (Denmark)</i>
<b>What does the Future Look Like for Water Treatment Membranes?</b> <i>Eric Hoek, Professor, University of California, Los Angeles (USA)</i>
<b>Panel Discussion</b> <i>Seungkwan Hong, Professor, Korea University (South Korea) – Moderator</i> <i>Wang Rong, Professor, Nanyang Technological University (Singapore)</i> <i>Nikolay Voutchkov, President, Water Globe Consultants LLC (USA)</i> <i>Jonathan Clement, Global Technology Officer, Nanostone Water, (the Netherlands)</i>
<b>Summary</b> <i>Seungkwan Hong, Professor, Korea University (South Korea)</i>

## **\*TW.17 ABC Waters - Embracing Sustainable Blue-Green Solutions for Urban Cities**

*Organised as part of the Urban Sustainability R&D e-Symposia*

July 2021 (Thursday), 7.00pm-9.00pm SGT (GMT+8)

Co-organisers: Institution of Engineers Singapore and PUB, Singapore's National Water Agency

Join us in this seminar as we discuss how Active, Beautiful and Clean Waters (ABC Waters) Design concepts are brought to life from design to construction. Awardees of the ABC Waters Gold certificate will also be sharing on how they have managed to successfully integrate the blue and the green into their urban designs.

<b>Opening Address</b>
<b>Announcement of ABC Waters Certified projects (Gold)</b>
<b>Adoption of ABC Water Design Features for enhancement of sustainability of heritage site</b> <i>Alfred Lee, Director and Landscape Architect, STX Landscape Architects</i> <i>Mr Sherman Stave, Principal and Landscape Architect, STX Landscape Architects</i>
<b>Integrating Blue with Green in Heartland Living</b> <i>Hoo Xin Yu, Deputy Director (Landscape Implementation), Housing &amp; Development Board</i>
<b>Announcement of ABC Waters Certified projects</b>
<b>Green, Blue and Desalination Too – Keppel Marina East Desalination Plant</b> <i>Mr Goh Eng Kwang, Executive Director (Project Management &amp; Water Services), Keppel Infrastructure</i> <i>Mr. Leong Tatt Man, Director of Projects, Tierra Design Studio Pte Ltd</i>
<b>Moderated Panel Discussion and Q&amp;A</b> <i>Alfred Lee, Director and Landscape Architect, STX Landscape Architects</i> <i>Mr Sherman Stave, Principal and Landscape Architect, STX Landscape Architects</i> <i>Hoo Xin Yu, Deputy Director (Landscape Implementation), Housing &amp; Development Board</i> <i>Mr Goh Eng Kwang, Executive Director (Project Management &amp; Water Services), Keppel Infrastructure</i> <i>Mr. Leong Tatt Man, Director of Projects, Tierra Design Studio Pte Ltd</i> <i>Mr Damian Tang, Senior Director, Park Management &amp; Lifestyle Cluster, National Parks Board – Moderator</i>

Singapore International Water Week 2021 Online  
Programme at a Glance (21 June 2021 - 2 July 2021)



Refer to pages 2-6 for details

Time (GMT+8)	21st June 2021 (Monday)				22nd June 2021 (Tuesday)				23rd June 2021 (Wednesday)				24th June 2021 (Thursday)				25th June 2021 (Friday)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
9:00 - 10:00 AM	<b>SIWW2021 Spotlight</b> <b>Opening Address by Minister for Sustainability and the Environment Ms Grace Fu</b> <b>Plenary 1: “Fostering Innovation and Collaboration: Overcoming Challenges for Water Sustainability”</b>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
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12:00 - 12:30 PM	<b>SIWW2021 Spotlight</b> <b>Plenary 2: “Riding the Wave: Ensuring Security Against Climate Uncertainties”</b>				<b>*PS1</b> Advancing Water Sustainability with Innovations				<b>*PS2</b>				<b>*PS3</b>				<b>TW.3</b> Digital Water Hackathon – DemoDay@SIWW				<b>TW.4</b> Empowering Women in Water				<b>*PS7</b>				<b>*PS8</b> Addressing Industrial Water Challenges with Aquaporin Inside* Forward Osmosis Technology				<b>*TW.7</b> A Career in the Water Profession				<b>*PS11</b> Sustainable Water Solutions: Performance Achieved Across Industries				<b>*PS12</b> Invest in Future-proof and Proven Water Treatment Innovations: PIMT Presents its Core Technologies Offering Sustainability, Long-term Reliability and Low Life-cycle Costs				<b>*PS13</b>				<b>TW.19</b>				<b>12P.6</b> Imagine H2O Asia Startups in Action: Case Studies from Singapore, Vietnam & Cambodia				<b>*PS14</b> New Viable Telemetry Revolutionises Remote Water Data Collection for Environmental and Process Applications				<b>*PS15</b>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
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3:00 - 3:30 PM	<b>SIWW2021 Spotlight</b> <b>In Conversation with Deputy Prime Minister of Singapore Mr Heng Swee Keat</b>				<b>TW.1</b> Water Resilient Cities: Lessons from Recent Extreme Events				<b>WC3.1</b> Decentralised Water Treatment				<b>WC2.1</b> Improving Water Treatment				<b>WC3.2</b> Resource Efficient Treatment I				<b>TW.5</b> Business of Water				<b>WC4.1</b> Water Circular Economy in Cities of the Future I				<b>WC2.2</b> Innovation is Desalination				<b>WC3.4</b> Intensification of Anaerobic Digestion				<b>12P.4</b> Planning Blue and Green Cities				<b>WC4.2</b> Water Circular Economy in Cities of the Future II				<b>WC2.3</b> Membranes- Fast Forward				<b>WC3.6</b> Membrane Bioreactor Processes				<b>12P.7</b> Sembcorp Innovation to Market Programme – SWING				<b>WC4.3</b> Hybrid Blue/ Green/ Grey Infrastructure				<b>WC2.4</b> Expanding Ceramic Membrane Applications				<b>WC3.8</b> Process Intensification: Integrated Approaches																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
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6:00 - 6:30 PM					<b>12P.1</b> The Journey of Innovation Implementation: Ceramic membrane microfiltration for surface water treatment												<b>12P.3</b> Building Water Resilience with Membrane Technology – Urban and Industrial Applications				<b>WCP.1</b> Poster Q&A Session				<b>12P.5</b> Breaking Boundaries in Digital Delivery				<b>WCP.2</b> Poster Q&A Session								<b>WCP.3</b> Poster Q&A Session																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
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9:00 - 9:30 PM					<b>*12P.2</b> Digital Blueprint for Water Utility Companies – Data Driven Decision Making				<b>WC1.1</b> Network Planning for Resilience				<b>WC5.1</b> Systems Approaches and Enabling Environment				<b>WC3.3</b> Resource Efficient Treatment II								<b>WC1.2</b> Optimising Network Operations				<b>WC5.2</b> Source Tracking				<b>WC3.5</b> Advancement in Solids Treatment				<b>TW. 8</b> Utilities of the Future – Is Smarter Water Better Water? II								<b>WC1.3</b> Water Conservation and Efficiency Measures				<b>WC3.7</b> Nutrient Removal				<b>*12P.8</b> Increased Efficiency using Digital Water Solutions for Water Utilities				<b>WC1.4</b> Non-revenue Water				<b>WC5.3</b> Wastewater Monitoring and Management				<b>WC3.9</b> Biofilm Processes																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
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## Session Listing

*As of 20 May 2021  
\*denotes free-to-air content*

### Thematic Webinars (TW)

Date	Day	Time (GMT+8)	Session Title	Co-organiser(s)
22 June 2021	Tuesday	4.00pm - 5.30pm	TW.1 Water Resilient Cities: Lessons from Recent Extreme Events	Water Convention Programme Committee
22 June 2021	Tuesday	9.00pm - 10.30pm	TW.2 Lee Kuan Yew Water Prize Laureates Roundtable: "Game-changing Technologies for a Sustainable Water Future"	PUB, Singapore's National Water Agency
23 June 2021	Wednesday	2.00pm - 3.30pm	TW.3 Digital Water Hackathon – DemoDay@SIWW	Ripple2Wave Incubator and Singapore University of Social Science
23 June 2021	Wednesday	2.00pm - 3.30pm	TW.4 Empowering Women in Water	Jacobs
23 June 2021	Wednesday	4.00pm - 5.30pm	TW.5 Business of Water	
23 June 2021	Wednesday	8.00pm - 9.30pm	TW.6 Utilities of the Future – Is Smarter Water Better Water? I	Water Convention Programme Committee
24 June 2021	Thursday	2.00pm - 3.30pm	*TW.7 A Career in the Water Profession	Environmental Engineering Society of Singapore (EESS), National University of Singapore
24 June 2021	Thursday	8.00pm - 9.30pm	TW.8 Utilities of the Future – Is Smarter Water Better Water? II	Water Convention Programme Committee
28 June 2021	Monday	7.00pm - 8.30pm	*TW.10 Dealing with the deep uncertainty of sea level rise	PUB, Singapore's National Water Agency
28 June 2021	Monday	9.00pm - 10.30pm	TW.11 Resource Recovery – From Policy to Practice I	Water Convention Programme Committee
29 June 2021	Tuesday	7.00pm - 8.30pm	TW.12 Climate Change, Water Quality and Health	Water Convention Programme Committee
29 June 2021	Tuesday	9.00pm - 10.30pm	TW.13 Resource Recovery – From Policy to Practice II	Water Convention Programme Committee
30 June 2021	Wednesday	2.00pm - 3.30pm	TW.14 Singapore Water Exchange (SgWX) Water Utilities Series: Uncovering Water Opportunities in Bangladesh	PUB, Singapore's National Water Agency
30 June 2021	Wednesday	4.00pm - 5.30pm	TW.15 Water Industry Transformation to Achieve SDG2030 – Overcoming Bottlenecks	Water Convention Programme Committee
30 June 2021	Wednesday	8.00pm - 9.45pm	TW.16 Reinventing Membranes – Present to Future	Water Convention Programme Committee
1 July 2021	Thursday	7.00pm - 9.00pm	*TW.17 ABC Waters - Embracing Sustainable Blue-Green Solutions for Urban Cities	PUB, Singapore's National Water Agency

**Innovation to Practice Series (I2P)**

Date	Day	Time (GMT+8)	Session Title	Co-organiser(s)
22 June 2021	Tuesday	6.00pm - 7.00pm	I2P.1 The Journey of Innovation Implementation: Ceramic membrane microfiltration for surface water treatment	PWNT
22 June 2021	Tuesday	7.30pm - 8.30pm	I2P.2 Digital Blueprint for Water Utility Companies – Data Driven Decision Making	Binnies
23 June 2021	Wednesday	6.00pm - 7.00pm	I2P.3 Building Water Resilience with Membrane Technology – Urban and Industrial Applications	Memstar
24 June 2021	Thursday	4.00pm - 5.00pm	I2P.4 Planning Blue and Green Cities	Arup
24 June 2021	Thursday	5.30pm - 6.30pm	I2P.5 Breaking Boundaries in Digital Delivery	Mott Macdonald
25 June 2021	Friday	1.00pm - 2.00pm	I2P.6 Imagine H2O Asia Startups in Action: Case Studies from Singapore, Vietnam & Cambodia	Imagine H2O Asia
25 June 2021	Friday	4.00pm - 5.30pm	I2P.7 Sembcorp Innovation to Market Programme – SWING	Sembcorp
25 June 2021	Friday	8.00pm - 9.00pm	*I2P.8 Increased Efficiency using Digital Water Solutions for Water Utilities	Netherlands Water Partnership and Embassy of the Kingdom of the Netherlands
28 June 2021	Monday	4.00pm - 5.00pm	I2P.9 Phnom Penh Water Story	
28 June 2021	Monday	5.30pm - 6.30pm	I2P.10: Achieving Carbon Net Zero Utilities	Isle Utilities
28 June 2021	Monday	9.00pm - 10.00pm	I2P.11 Discover Novel Ceramic Filtration Technology	Nanostone
29 June 2021	Tuesday	2.30pm - 3.30pm	I2P.12 Innovative Tools for City-level Sanitation	Asian Development Bank
29 June 2021	Tuesday	4.00pm - 5.00pm	I2P.13 Advancing water sustainability with innovations- learnings from municipal	DuPont
29 June 2021	Tuesday	5.45pm - 6.45pm	I2P.14 Delivering Vibrant and Climate-Resilient Coastal Communities	Jacobs
30 June 2021	Wednesday	4.00pm - 5.30pm	I2P.15 Resource Circularity through Digital Solutions	Witteveen+Bos
30 June 2021	Wednesday	7.00pm - 8.00pm	I2P.22 Technological Solutions for Early Warning of Water Quality	Binnies
30 June 2021	Wednesday	9.00pm - 10.00pm	*I2P.17 Adaptation in South East Asian Cities: Solutions for Heat Stress, Flooding & Planning an Integrated Vision for the Future	Netherlands Water Partnership and Embassy of the Kingdom of the Netherlands
1 July 2021	Thursday	4.00pm - 5.30pm	*I2P.19 ReCirc - Towards integrated zero waste solutions for a circular economy	Netherlands Water Partnership and Embassy of the Kingdom of the Netherlands
1 July 2021	Thursday	4.00pm - 5.00pm	I2P.20 Beyond the Buzz: Demystifying Smart Water	SWAN
2 July 2021	Friday	2.30pm - 3.30pm	I2P.21 Smart Water Safety Technologies for Augmented Capabilities and Performance: Case Studies from Singapore and China	ZWEEC

**Water Convention (WC)**

Date	Day	Time (GMT+8)	Session Title	Co-organiser(s)
22 June 2021	Tuesday	4.00pm - 5.30pm	WC2.1 Improving Water Treatment	Water Convention Programme Committee
22 June 2021	Tuesday	4.00pm - 5.30pm	WC3.1 Decentralised Water Treatment	Water Convention Programme Committee
22 June 2021	Tuesday	4.00pm - 5.30pm	WC3.2 Resource Efficient Treatment I	Water Convention Programme Committee
22 June 2021	Tuesday	7.00pm - 8.30pm	WC1.1 Network Planning for Resilience	Water Convention Programme Committee
22 June 2021	Tuesday	7.00pm - 8.30pm	WC3.3 Resource Efficient Treatment II	Water Convention Programme Committee
22 June 2021	Tuesday	7.00pm - 8.30pm	WC5.1 Systems Approaches and Enabling Environment	Water Convention Programme Committee
23 June 2021	Wednesday	4.00pm - 5.30pm	WC2.2 Innovation is Desalination	Water Convention Programme Committee
23 June 2021	Wednesday	4.00pm - 5.30pm	WC3.4 Intensification of Anaerobic Digestion	Water Convention Programme Committee
23 June 2021	Wednesday	4.00pm - 5.30pm	WC4.1 Water Circular Economy in Cities of the Future I	Water Convention Programme Committee
23 June 2021	Wednesday	7.00pm - 8.30pm	WC1.2 Optimising Network Operations	Water Convention Programme Committee
23 June 2021	Wednesday	7.00pm - 8.30pm	WC3.5 Advancement in Solids Treatment	Water Convention Programme Committee
23 June 2021	Wednesday	7.00pm - 8.30pm	WC5.2 Source Tracking	Water Convention Programme Committee
24 June 2021	Thursday	4.00pm - 5.30pm	WC2.3 Membranes - Fast Forward	Water Convention Programme Committee
24 June 2021	Thursday	4.00pm - 5.30pm	WC3.6 Membrane Bioreactor Processes	Water Convention Programme Committee
24 June 2021	Thursday	4.00pm - 5.30pm	WC4.2 Water Circular Economy in Cities of the Future II	Water Convention Programme Committee
24 June 2021	Thursday	7.00pm - 8.30pm	WC1.3 Water Conservation and Efficiency Measures	Water Convention Programme Committee
24 June 2021	Thursday	7.00pm - 8.30pm	WC3.7 Nutrient Removal	Water Convention Programme Committee
25 June 2021	Friday	4.00pm - 5.30pm	WC2.4 Expanding Ceramic Membrane Applications	Water Convention Programme Committee
25 June 2021	Friday	4.00pm - 5.30pm	WC3.8 Process Intensification: Integrated Approaches	Water Convention Programme Committee
25 June 2021	Friday	4.00pm - 5.30pm	WC4.3 Hybrid Blue/Green/Grey Infrastructure	Water Convention Programme Committee
25 June 2021	Friday	7.00pm - 8.30pm	WC1.4 Non-revenue Water	Water Convention Programme Committee
25 June 2021	Friday	7.00pm - 8.30pm	WC3.9 Biofilm Processes	Water Convention Programme Committee
25 June 2021	Friday	7.00pm - 8.30pm	WC5.3 Wastewater Monitoring and Management	Water Convention Programme Committee
28 June 2021	Monday	4.00pm - 5.30pm	WC.1.5 Smart Water Grid	Water Convention Programme Committee
28 June 2021	Monday	4.00pm - 5.30pm	WC3.10 Advanced Modelling, Sensing & Control I - Outside the Fence	Water Convention Programme Committee
28 June 2021	Monday	4.00pm - 5.30pm	WC4.4 Water for Liveability	Water Convention Programme Committee
28 June 2021	Monday	7.00pm - 8.30pm	WC2.5 Emerging Contaminants - Practice and Science	Water Convention Programme Committee
28 June 2021	Monday	7.00pm - 8.30pm	WC3.11 Advanced Modelling, Sensing & Control II - Inside the Fence	Water Convention Programme Committee
28 June 2021	Monday	7.00pm - 8.30pm	WC5.4 Water Resources in Catchments/ Reservoirs	Water Convention Programme Committee
29 June 2021	Tuesday	4.00pm - 5.30pm	WC1.6 Smart Metering	Water Convention Programme Committee



29 June 2021	Tuesday	4.00pm - 5.30pm	WC3.12 Used Water Asset Management	Water Convention Programme Committee
29 June 2021	Tuesday	4.00pm - 5.30pm	WC4.5 Basin Connected Cities	Water Convention Programme Committee
29 June 2021	Tuesday	7.00pm - 8.30pm	WC2.6 Integrated Water Reuse	Water Convention Programme Committee
29 June 2021	Tuesday	7.00pm - 8.30pm	WC3.13 Microbial Ecology	Water Convention Programme Committee
30 June 2021	Wednesday	4.00pm - 5.30pm	WC1.7 Asset Management for the Distribution Networks	Water Convention Programme Committee
30 June 2021	Wednesday	4.00pm - 5.30pm	WC3.14 Industrial Wastewater Treatment and Reuse	Water Convention Programme Committee
30 June 2021	Wednesday	7.00pm - 8.30pm	WC2.7 Intelligent Plant of the Future	Water Convention Programme Committee
30 June 2021	Wednesday	7.00pm - 8.30pm	WC5.5 Water Quality in Distribution Systems and Buildings	Water Convention Programme Committee
1 July 2021	Thursday	4.00pm - 5.30pm	WC4.6 Social resilience of communities to climate extremes	Water Convention Programme Committee
1 July 2021	Thursday	7.00pm - 8.30pm	WC2.8 Source Control in Advanced Reuse Applications	Water Convention Programme Committee
1 July 2021	Thursday	7.00pm - 8.30pm	WC3.15 Wastewater Treatment for Developing Countries	Water Convention Programme Committee
1 July 2021	Thursday	7.00pm - 8.30pm	WC5.6 Bio-sensing	Water Convention Programme Committee

**Product/ Technology Showcase (PS)**

Date	Day	Time	Session Title	Co-organiser(s)
22 June 2021	Tuesday	2.30pm - 3.30pm	*PS1 Advancing Water Sustainability with Innovations	DuPont
22 June 2021	Tuesday	9.00pm - 10.00pm	*PS4 One Size Does Not Fit All: Balancing Membrane Life and Cost with the Right Hollow Fiber Technology	Memstar
22 June 2021	Tuesday	9.00pm - 10.00pm	*PS5 Ecosystem Efficiencies – Delivering Value by Digitising the Water Utility	Binnies
23 June 2021	Wednesday	2.30pm - 3.30pm	*PS8 Addressing Industrial Water Challenges with Aquaporin Inside® Forward Osmosis Technology	Aquaporin
24 June 2021	Thursday	2.30pm - 3.30pm	*PS11 Sustainable Water Solutions: Performance Achieved Across Industries	Sembcorp and Singapore Water Association
24 June 2021	Thursday	2.30pm - 3.30pm	*PS12 Invest in Future-proof and Proven Water Treatment Innovations: PWNT Presents its Core Technologies Offering Sustainability, Long-term Reliability and Low Life-cycle Costs	PWNT-Metawater
25 June 2021	Friday	1.00pm - 2.00pm	*PS14 How VuLink Telemetry Revolutionises Remote Water Data Collection for Environmental and Process Applications	In-Situ
25 June 2021	Friday	2.30pm - 3.30pm	*PS16 Centrifuge Decanter Aldec G3 Vecflow for Sludge Thickening & Dewatering	Alfa Laval
28 June 2021	Monday	2.30pm - 3.30pm	*PS18 Cambi Thermal Hydrolysis: Recent Developments in the APAC Market	Cambi Group
28 June 2021	Monday	2.30pm - 3.30pm	*PS20 Sustainable (Ground)water Management: Challenges and Solutions Using Integrated Modelling Approaches	Deltares/NUSDeltares
29 June 2021	Tuesday	2.30pm - 3.30pm	*PS23 De Nora Cechlo-Ms 200 on-Site 12% Sodium Hypochlorite Generation System	De Nora
29 June 2021	Tuesday	2.30pm - 3.30pm	*PS24 Imagine H2O Asia: New Products Showcase	Imagine H2O Asia
1 July 2021	Thursday	1.00pm - 2.00pm	*PS33 Next Generation Water Security Technologies: Efficient and Robust Water Safety	Zweec Analytics
1 July 2021	Thursday	1.00pm - 2.00pm	*PS34 Dropwise Condensation Technology - Enhanced Condensation for Improving Energy Efficiency and Productivity	Kurita
1 July 2021	Thursday	1.00pm - 2.00pm	*PS37 PUB x 500 Startups - Commercialisation Programme Demo Day	500 Startups and PUB, Singapore's National Water Agency

**Up Close and Personal (UCP) Series**

Date	Day	Time (GMT+8)	Session Title	Co-organiser(s)
25 June 2021	Friday	2.30pm - 3.00pm	*UCP The Water Technology Access Partnership (WTAP): Unlocking Water Innovation for Emerging Asia with the World Bank	Imagine H2O Asia

**Training (TRG)**

Date	Day	Time (GMT+8)	Session Title	Co-organiser(s)
1 July 2021	Thursday	1.00pm - 5.30pm	Studies and Overcoming Challenges	Singapore Water Association
2 July 2021	Friday	1.00pm - 5.30pm	Studies and Overcoming Challenges	Singapore Water Association