MESSAGES BY CO-CHAIRS

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Singapore International Water Week 2022 returns as an in-person event from 17 to 21 April 2022 at the Sands Expo & Convention Centre in Singapore, along with a virtual on-demand component for participants who are unable to travel to Singapore.

On behalf of the Programme Committee, we extend a warm invitation to you to join us at the Water Convention, one of the flagship programmes of SIWW2022.

In response to the Call for Papers, we received over 350 high quality papers from 42 countries in the short span of 12 weeks. We are grateful by the strong show of support from the international water community to the Call, despite the uncertainties and challenges posed by the on-gong pandemic. Many papers of exceptional quality were received and after a careful review of all the papers, the Programme Committee has put together a quality Water Convention programme, which we believe is the very best yet.

To ensure the knowledge presented at the Water Convention keep abreast with the latest challenges and trends facing the urban water profession, we have included a new theme on Nexus and Circularity in this year's Water Convention, alongside other traditional themes in water distribution, water treatment, wastewater management, water quality and health, and cities of the future. We hope this theme will add a new dimension to the discussions, as the water sector places increasing emphasis on circular resource management and sustainability.

Besides the technical oral and poster sessions, delegates to the Water Convention can look forward to the popular Hot Issues Workshops, where we hope to stimulate open discussion on hot issues, such as digital transformation of the water sector, future of seawater desalination, sustainable wastewater management, coastal revitalisation, consumer aspects in reuse and recycling of domestic water and carbon circularity.

As the Water Convention enters its 9th edition, we remain confident that it continues to serve as one of the leading platforms for the open sharing of technology, innovation, and best practices in urban water management. We wish to thank the continued support of the International Water Association as the co-organiser, as well as the many water experts who have contributed their time as Programme Committee members, abstract reviewers, session co-chairs and invited speakers.

We look forward to seeing you in Singapore as a delegate. Should you be unable to travel to Singapore due to travel restrictions, do consider joining us as a virtual participant to get the opportunity to catch the Convention workshops and sessions on-demand.

Together, let us work towards our shared goal of building a better water future for all.

SINGAPORE INTERNATIONAL WATER WEEK

The Singapore International Water Week (SIWW) is a global premier platform to share and co-create innovative water solutions. The biennial event gathers stakeholders from the global water industry to share best practices, showcase the latest technologies and tap business opportunities. SIWW is part of the strategic programme of the Singapore Government to grow the water industry and develop water technologies.

In 2018, the SIWW celebrated 10 years of water excellence and ended on a high note with more than 24,000 participants from across the world and S$23 billion in total value for announcements on projects awarded, tenders, investments and MOUs, underscoring its role in driving industry growth. The 8th edition of the Singapore International Water Week (SIWW) was held alongside the World Cities Summit (WCS) and CleanEnviro Summit Singapore (CESG).

Singapore International Water Week (SIWW) 2022 returns as a physical event from 17 to 21 April at the Sands Expo & Convention Centre, Marina Bay Sands, Singapore.

As one of the leading international water events in Asia, SIWW brings thought leaders, experts and practitioners from governments, utilities, academia and industry together to share and co-create innovative solutions to meet with pressing urban water challenges globally.

Organised by PUB, Singapore's national water agency, SIWW will cover all aspects of the urban water cycle reflective of current trends and issues in and around the water sector. Critical to shaping the future of water, emerging themes such as digital water, resource recovery and climate resilience will continue to be featured at SIWW.

PROGRAMME AT A GLANCE

<table>
<tr><th>DATE</th><th colspan="4">AM</th><th colspan="2">PM</th><th>EVENING</th></tr>
<tr><td rowspan="4">17 April (Sun)</td><td colspan="6">Technical Site Visits [0800 – 1400]</td><td rowspan="4">Jurong Island Desalination Plant Opening (by-invitation)</td></tr>
<tr><td colspan="6">SWA Golf @SIWW2022 [0700 – 1500]</td></tr>
<tr><td colspan="6">TechXchange (L3) [0930 – 1700]</td></tr>
<tr><td colspan="6">Hot Issues Workshops (L3) [1000 – 1700]</td></tr>
<tr><td rowspan="2">18 April (Mon)</td><td rowspan="2">Joint Opening (L4) [0900 – 0930]</td><td>Environment & Water Leaders Forum (L4) [0945 – 1145]</td><td rowspan="2">GOH Expo tour [1245 – 1345]</td><td rowspan="2">Lee Kuan Yew Water Prize Lecture (L5) [1415 - 1515]</td><td>WC Poster Presentation (L3) [1545 – 1745]</td><td rowspan="2">Lee Kuan Yew Water Prize Award Ceremony & Banquet [1830 – 2100]</td></tr>
<tr><td>Water Convention (WC) Opening Plenary (L5) [1000 – 1200]</td><td>Forums (L5|B2) [1545 – 1815]</td></tr>
<tr><td colspan="6">Expo [0900 – 1800]</td></tr>
<tr><td rowspan="4">19 April (Tue)</td><td colspan="2">Water Leaders Summit (WLS) Plenary 1 (L4) [0930 – 1100]</td><td colspan="2">WLS Plenary 2 (L4) [1130 – 1300]</td><td>WLS Plenary 3 (L4) [1400 – 1530]</td><td>WLS Plenary 4 (L4) [1600 – 1730]</td><td rowspan="2">Utility Leaders Networking Reception (B2) [1730 – 1830]</td></tr>
<tr><td colspan="2">WC Parallel Session 1 (L3) [0900 – 1030]</td><td colspan="2">WC Parallel Session 2 (L3) [1100 – 1230]</td><td>WC Parallel Session 3 (L3) [1400 – 1530]</td><td>WC Parallel Session 4 (L3) [1600 – 1730]</td></tr>
<tr><td colspan="2">Forums (B2|L3) [B2: 1000 – 1200 L3: 0930 – 1100]</td><td colspan="2">Forums (L3) [1130 – 1300]</td><td>Forums (B2|L3) [B2: 1300 – 1500 L3: 1330 – 1500]</td><td>Forums (L3) [L3: 1530 - 1700]</td><td rowspan="2">Industry Night @ Water Expo [1730 – 2000]</td></tr>
<tr><td colspan="6">Expo [0900 – 2000]</td></tr>
<tr><td rowspan="4">20 April (Wed)</td><td colspan="2">WC Parallel Session 5 (L3) [0900 – 1030]</td><td colspan="2">WC Parallel Session 6 (L3) [1100 – 1230]</td><td>WC Parallel Session 7 (L3) [1400 – 1530]</td><td>WC Closing Plenary (L3) [1600 – 1730]</td><td rowspan="3"></td></tr>
<tr><td colspan="2">Forums (B2|L3) [B2: 1000-1200 L3: 0930 – 1100]</td><td colspan="2">Forums (L3) [1130-1300]</td><td>Forums (B2|L3) [B2: 1300 – 1500 L3: 1330 – 1500]</td><td>Forums (L3) [1530 – 1700]</td></tr>
<tr><td colspan="6">Co-located Events (L3) [0900-1700]</td></tr>
<tr><td colspan="6">Expo [0900 – 1500]</td></tr>
<tr><td>21 April (Thurs)</td><td colspan="6">Technical Site Visits [0800 – 1400]</td><td></td></tr>
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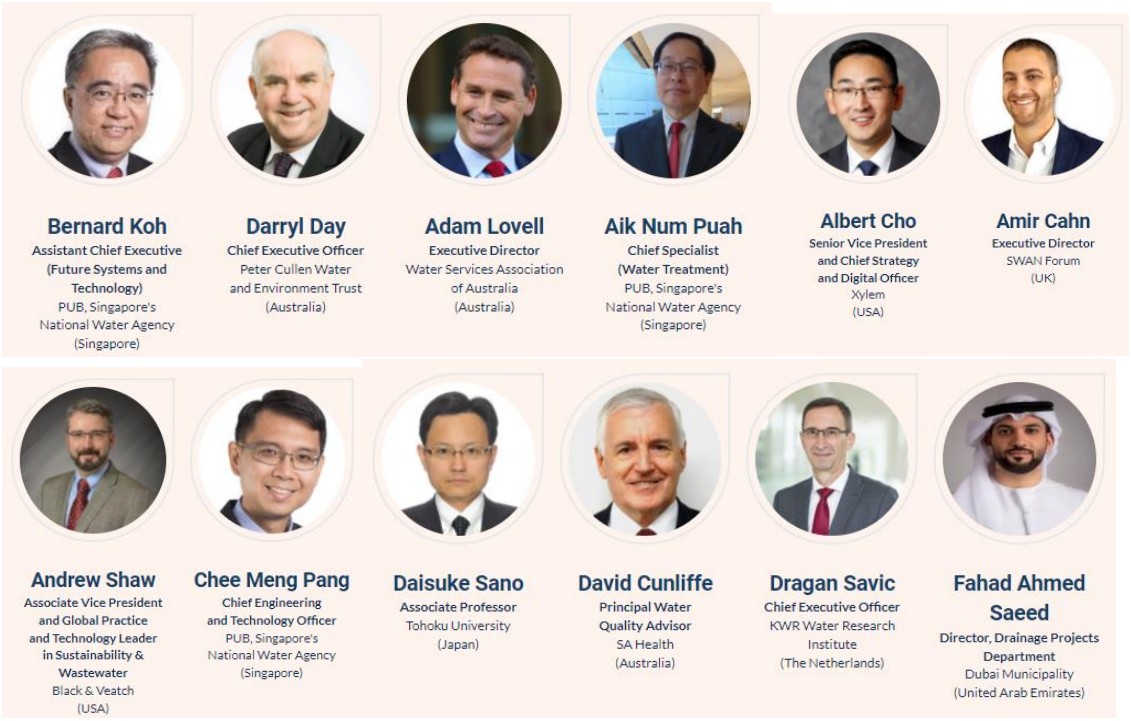
PROGRAMME COMMITTEE

Please follow the list from here: https://www.siww.com.sg/home/programme/water-convention/overview

To be listed in the same format as what's shown in the website. Refer below for an extracted example



WATER CONVENTION 2022

The Water Convention is a platform for gathering professionals and technology providers from around the world to share their knowledge, practical experiences and novel technologies to address the current and emerging water challenges under the following themes:

- Delivering Water from Source to Tap (Network)
- Delivering Water from Source to Tap (Treatment)
- Effective and Efficient Wastewater Management (Treatment & Conveyance)
- Cities of the Future
- Water Quality and Health
- Nexus and Circularity

The Water Convention technical programme focuses on spurring knowledge sharing, fruitful discussions and engaging debates among water leaders and practitioners through high quality presentations on technological innovations, management strategies and best practices.

WATER CONVENTION PROGRAMME 2022

Sessions	Theme 1: Delivering Water from Source to Tap – Network	Theme 2: Delivering Water from Source to Tap – Treatment	Theme 3: Effective and Efficient Wastewater Management – Treatment & Conveyance		Theme 4: Cities of the Future	Theme 5: Water Quality & Health	Theme 6: Nexus & Circularity
17 April 2022 (Sun)	Water Convention Hot Issue Workshops						
18 April 2022 (Mon)	Joint Opening						
	Water Convention Opening Plenary						
	Lee Kuan Yew Water Prize Lecture						
	Water Convention Poster Presentation						
19 April 2022 (Tue)	Planning, Design and Implementation	Advanced Oxidation Process	Membrane Technologies for Reuse	Conveyance – Modelling and Digital Solutions	Digital Technology for Remote Sensing and Real-Time Control	WQ Assessment and Management for Health – Treatment and Management	Policy and Planning (I)
	Efficiency of Operations – Tools for Overall Efficiency Optimisation	Innovative Technologies to Tackle Emerging Contaminants	Membrane Bioreactor (MBR)	Corrosion in Conveyance Systems	Digital Twins for Water Quality Management	WQ Assessment and Management for Health – Real-Time Sensors and Standards	Policy and Planning (II)
	Asset Management and Network Renewal	Advances in Membrane Technologies and Applications	Membrane Aerated Biofilm Reactor (MABR)	Overflows, Tunneling and Climate Change	City Water Resilience	Wastewater-Based Epidemiology (I)	Stakeholder Engagement and Cross-Sectoral Collaboration – Circular

							Water Economy
	Water Conservation and Efficiency Measures	Innovations in Desalination – Pre-Treatment	Advances in Anaerobic Digestion (I)	Non-Municipal Wastewater Reuse	Urban Adaptation Strategies	Wastewater-Based Epidemiology (II)	System of Systems for a Circular Economy
20 April 2022 (Wed)	Digital Twin	Innovations in Desalination – Energy Saving Technologies	Advances in Anaerobic Digestion (II)	Resource Recovery	Water Master-Planning for Cities	WQ Assessment and Management for Health – Risk Assessment	Resource Circularity
	Smart Sensors for Network Monitoring	Resource Recovery from Brine	Process Intensification through Novel Nitrogen Pathways	Climate Change and Carbon Footprint Reduction	Economic Valuation of Hybrid Infrastructure	Systems Approaches to Service Delivery	Carbon Circularity
	Augmenting Water Supply by Water Reuse	Digitalization of Water Treatment Plants	Phosphorus Removal	Next Generation of Intelligent Plant	Flood Resilience for Cities of the Future	Water Quality/Food Safety Nexus (organised with FAO)	Integrated Approach in Removing Emerging Contaminants
	Water Convention Closing Plenary and Best Poster Awards Presentation						

WATER CONVENTION 2022 HOT ISSUE WORKSHOPS

The Water Convention 2022 Hot Issues Workshops will take place on Sunday, 17th April 2022 where emerging topics such as digital transformation of the water sector, future of seawater desalination, sustainable wastewater management, coastal revitalisation, consumer's inclusivity in reuse and recycling of domestic water and carbon circularity will be featured. These workshops will run on a highly interactive, panel discussion-based format, providing a focused platform to stimulate more open engagement between experts and delegates on 'hot' or emerging issues facing the water industry today. This will serve as the perfect opening to the technical sessions on 19th – 20th April 2022.

HOT ISSUE WORKSHOPS PROGRAMME 2022

The details of the six workshops are as follows:

DATE	TIME	WORKSHOP TOPICS
17 April 2022 (Sun)	MORNING 10.00 – 13.00	**Workshop 1** Digital Transformation of the Water Sector and Role of Digital Twins - Part 1 (Co-organized with SWAN Asia-Pacific Alliance)
		Workshop 2 The Future of Seawater Desalination: Innovations in Desalting and Brine Management - Part 1 (Co-organized with Gary Amy and Jonathan Clement)
		Workshop 3 Sustainable Wastewater Management in Developing Countries: An Innovative Indian Approach in River Rejuvenation
		Workshop 4 Coastal Revitalisation - Emerging Lessons from Singapore for Small Island States
	AFTERNOON 14.00 – 17.00	**Workshop 1 (cont'd)** Digital Transformation of the Water Sector and Role of Digital Twins - Part 2 (Co-organized with SWAN Asia-Pacific Alliance)
		Workshop 2 (cont'd) The Future of Seawater Desalination: Innovations in Desalting and Brine Management - Part 2 (Co-organized with Gary Amy and Jonathan Clement)
		Workshop 5 Reduction, Reuse and Recycling of Domestic Water – Benefits, Health risks, and Consumers' Inclusivity
		Workshop 6 Water Sector Decarbonisation and Carbon Circularity

WORKSHOP SYNOPSIS

Workshop 1: Digital Transformation of the Water Sector and Role of Digital Twins - Part 1

(Co-organized with SWAN Asia-Pacific Alliance)

The pace of digital transformation has been accelerated by the COVID-19 pandemic which drove the need for working remotely. While digitalisation has improved operations, maintenance and customer service, concerns and issues remain in the implementation of digital solutions in the water sector. In the first part of the workshop, utilities will share the needs and challenges of the water sector today as they embark on their digital transformation journey. A panel of utilities, consultants and solution providers will then discuss on the solutions to overcome some of the challenges and what to expect in the road ahead. The second part of the workshop will focus on digital twins and their applications in different parts of the urban water cycle, from water treatment, distribution, used water collection, treatment, recycling and receiving waters. The workshop will end with a panel discussion on challenges and benefits of an integrated digital twin solution across the entire water loop.

Workshop 2: The Future of Seawater Desalination: Innovations in Desalting and Brine Management - Part 1

(Co-organized with Gary Amy and Jonathan Clement)

The current state-of-the-art in seawater desalination is standard pre-treatment, single-stage seawater reverse osmosis (SWRO) with a recovery of about 50 %, and brine disposal by an outfall diffuser, with challenges identified in the operation of conventional SWRO. High energy consumption by SWRO has led to innovations in membrane materials and process configurations. In addition, there is increasing interest in valorisation of SWRO brines and concomitant recovery of valuable materials to contribute to the circular economy. In this workshop, high level speakers from industry and academic researchers will share their expertise on SWRO pre-treatment innovations, SWRO materials and processes innovations, and valorisation of SWRO brines and valuable materials recovery. Selected industry panellists will then share their innovations in desalination membrane and processes followed by panel discussion on the future of seawater desalination.

Workshop 3: Sustainable Wastewater Management in Developing Countries: An Innovative Indian Approach in River Rejuvenation

Developing countries have enormous challenges yet with increasing role in Global Leadership, India is committed towards meeting UN's SDGs particularly SDG 6 in all respect. It is with this focussed approach, the first Governance challenge was met when Govt. of India in 2014-2015 launched 'Namami Gange' (Clean Ganga), a flagship programme under Ministry of Jal Shakti, (erstwhile Ministry of Water Resources) for protection, conservation, and rejuvenation of River Ganga and its tributaries. The dedicated efforts of NMCG, Government of India and active stakeholder engagement has led to the identification of governance issues and technological challenges which hindered the Indian wastewater sector. Subsequently, innovative methods were developed which not only mitigated the problem of pollution created through domestic sewage and industrial effluents but also ushered in a paradigm shift in the water sector. NMCG also extensively worked on other components such as, solid and liquid waste management, restoring biodiversity, afforestation, wetland conservation, river and people connect etc. to holistically rejuvenate the entire riverine

ecosystem. In this workshop, speaker presentations from NMCG, GoI and allied partners will share experiences on effective and efficient wastewater management in Indian context. The panellists from other developed and developing countries will share their viewpoint on the Indian experience and through this discussion, various other countries may also derive inspiration from the work and models adopted by India.

Workshop 4: Coastal Revitalisation - Emerging Lessons from Singapore for Small Island States

In the first part of this workshop, PUB will provide an overview of the coastal protection strategy in Singapore followed by presentations from Singapore-based researchers on innovative solutions for coastal protection. In the second part of this workshop, consortium of representatives from small island states will be invited to deliver case study presentations followed by a presentation from Deltares to provide insights on transferrable lessons from Singapore to small island states. This workshop will then be concluded by a brainstorming session to identify future challenges and risks to small island states and potential solutions to overcome some of the challenges.

Workshop 5: Reduction, Reuse and Recycling of Domestic Water – Benefits, Health Risks, and Consumers' Inclusivity

Across the world, consumers demand 24/7 access to safe, wholesome and aesthetically pleasing water. However, behavioural changes to become "greener", population growth, climate change, emergence of new chemicals and increasing scarcity of quality water sources have led to adaptations made to the water distribution infrastructure and management, including of internal and community water systems. Ideas that were once "on the fringe" (e.g. rainwater harvesting) have become mainstream options. The awareness required of consumers and practitioners in this evolving context, to ensure public health is not adversely impacted, has not kept pace with the changes in the way water in homes, communities and public buildings is delivered. The end users/consumers seem least represented in conversations about water and yet they must be included if they are to become aware of the impacts of their water use behaviours. Public confidence in water supplies is essential and access to safe water is a fundamental human right. However, it is consumed with little awareness and consideration of the health risks and benefits. This workshop will discuss the health dimensions of reducing domestic water use and re-using and recycling water for safe consumptions, the evolution of standards and good practice in plumbing to protect health and the importance of consumer inclusivity in balancing risks and benefits in the water sector's efforts to achieve universal access against the backdrop of growing constraints.

Workshop 6: Water Sector Decarbonisation and Carbon Circularity

While the water sector has gone through different stages of revolution, from reclaiming used water to recovering resources, there remains a leap for the next step of achieving carbon neutrality or negative emission. This workshop will provide an overview of the challenges and strategies of the water sector's pathway to net zero emissions, developments in the green energy sector, process innovations in desalination and wastewater treatment to reduce carbon emission and implementations of late-stage research technology. A panel of utilities, companies and associations from developed and developing countries will then discuss on challenges and key strategies to net zero.

LIST OF ORAL PRESENTERS

Theme 1: Delivering Water from Source to Tap – Network

Session 1.1 - Planning, Design And Implementation
19 April 2022 (Tuesday)
0900 – 1030 hours

Session Co-Chairs: Hamanth Kasan, IWA (South Africa), Mark Wilton, Aurecon (Australia)

Overview on network planning
Cindy Wallis-Lager. Black & Veatch (USA)

Presenter is an invited speaker. No executive summary is available

Optimising Pipeline Planning and Design enhanced with Artificial Intelligence in England
Jon Tang. Mott Macdonald (Singapore)

This abstract provides the journey and lessons learnt in semi-automated pipeline design using the latest developments in technology and availability of structured data to improve engineering design and reduce whole-life cost of assets for resilient networks whilst minimising impacts on the environment. Pipeline design is one of the largest technical practice communities in Mott MacDonald with over 1000 staff members across the world and hundreds of pipeline design projects delivered every year. Over the past five years, our multi-disciplinary team has taken the initial idea through stages of experimentation and trialling on demonstration projects, through to full-scale commercial deployment. Our working hypothesis was that regional pipeline network design can be significantly improved using new digital technologies. Relatively recent advancement in Geographic Information Systems (GIS) computing power and algorithm development techniques presented an opportunity to rapidly calculate design solutions and present the optimum from a wider range of options more quickly.

SPOT 2023TM: Performance And Operational Transformation For Effective Network Management
Jonathan Piveteau, Guillaume Rondot, Diego Tobar, Philippe Mappa, Dr. Joshua Cantone, Thomas Van Becelaere. Suez (France)

In the management of drinking water networks, operational costs generally play second fiddle to capital investment costs, because their optimization strategies are often distinct. However, to effectively reduce real water losses and pipe bursts, these actions need to be considered holistically to find the balance between CAPEX and OPEX. As part of Suez SPOT (SUEZ Performance and Operational Transformation) 2023 strategy to minimize bursts and physical losses, Suez and Optimatics have partnered to develop an integrated approach. The result is a framework that has allowed three of Suez French operations to identify strategies for pipe renewal and pressure management that minimize OPEX and CAPEX.

Adaptive Planning Tools In A Deeply Uncertain And Complex Future
Apra Boyle-Gotla. Watercare (New Zealand)

Watercare has adopted dynamic adaptive policy pathways (DAPP) to address emergent challenges and deep uncertainty. Here, we describe an integrated planning exercise that utilizes DAPP to optimize our upgrade plans. This exercise yielded upgrade pathways that are resilient to growth and climate uncertainties and produce opportunities for resource recovery.

Through this exercise, DAPP has enabled holistic and integrated planning that not only increases our adaptive capacity but enables us to shape our future by creating pathways that reframe challenges as opportunities. By enabling a holistic view and visualization of alternative pathways and how they integrate, we can more easily select upgrade pathways that lend themselves to greater flexibility and resilience.

Strategic planning for integrated network management

Mark Wilton. Aurecon (Australia)

Presenter is an invited speaker. No executive summary is available

Session 1.2 - Efficiency Of Operations – Tools For Overall Efficiency Optimisation
19 April 2022 (Tuesday)
1100 – 1230 hours

Session Co-Chairs: Raziyeh Farmani, University of Exeter (United Kingdom), Doeke Schippers, Vitens (Netherlands)

Overview On Tools For Network Optimisation
Ir. Abas Abdullah. Air Selangor (Malaysia)

Presenter is an invited speaker. No executive summary is available

Model Predictive Control In Water Distribution: Operations, Workflow & Experiences
Lars Drejer, Sten Linberg. DHI (Denmark)

A three-year research project on smart control and monitoring in water distribution was recently concluded. The test site is a single pressure zone (located in Aarhus, Denmark), which is operated by the utility company Aarhus Vand. Water demand forecasts and model predictive control (MPC) have been developed and implemented in a cohesive software system called RTC robot. The demand forecasts are based on the gradient boosting method. The predictive controller is a quadratic program based on a linear first-principles model of the system dynamics. The RTC robot is deployed to an operational system and configured to update with latest measurements each hour. At the time of writing, it has been running for over three months in an extended test.

Using Edge Analytics And Digital Twin Technology To Optimize Pump System Performance & Asset Management
Matt Rolls. Specific Energy (United Kingdom)

Proper application of edge analytics can be used to optimize and protect pumping systems, and reduce the total cost of ownership by extending the operating life of pumps and reducing the associated energy costs. This digital twin technology predicts, tracks and reacts to changes in both the performance of the pumps and in the hydraulics of the upstream and downstream piping networks, and uses this real-time data to ensure the pump system operates at optimum efficiency. This same data is used automatically generate monthly performance reports for pump stations and each individual pump within, using financial metrics for net present value analysis of repair activities. Allowing utilities to make informed decisions on their asset management and capital planning programs. This presentation will show how this tool is being used as a total asset management solution for utilities to better engineer, operate and manage their pumping systems.

Real-Time Software For Distribution System Operations: An Operator-Focused Design Approach
Ashley Ng, Xylem (Singapore)

MWS partnered with Xylem to develop a decision support solution for MWS's real-time hydraulic and water quality distribution network. The solution, Xylem's Water Network Optimization (WNO), provided the means to optimize water distribution operations by employing a flexible and configurable "live" water modeling solution tailored to Nashville's infrastructure. WNO enabled finding root-causes for network pressure issues as well as correlating water age at specific network locations to the originating treatment plant.

Session 1.3 - Asset Management And Network Renewal
19 April 2022 (Tuesday)
1400 – 1530 hours

Session Co-Chairs: Zdravka Do Quang, SUEZ (France), Iman Jafari, NUS (Singapore)

Testing A Novel Leak Detection Method At DMA Level

Martijn Deenan, Daniel Woodworth, Nicole Friedrich Neumann, Sian Evens.
Royal Haskoningdhv (Netherlands)

The UK based water company SES Water aims to reduce leakage by limiting the time between the start and the repair of leaks and bursts. Therefore, SES trials a novel leak localization method at 10 DMAs. The 10 DMAs were selected from 50 DMAs after running a newly developed quick scan that determines the suitability of a DMA for leak localization. High, medium, and low scoring DMAs were selected to trial the method. Next, additional pressure sensors were installed, and the localization method was implemented. Shortly, some 60 leak tests will be performed for an extended performance evaluation of the novel method.

CALM NETWORK: Reduction Of Impact Due To Transients In Macao Water Networks

Zhao Yu ,Pierre Bonardet, Jacky Lei, Satish Vegi, Andrea Rossi, Huan Yin, Guillaume Cussonneau, Robert Wright. Suez (France)

SUEZ has been working since 2016 on a solution bringing together a unique combination of hydraulic expertise, Data analytics & Algorithms and continuous monitoring & alerting, for an integrated dedicated performance-based management system known as "Calm Network", with the objective of understanding the dynamic of a water network in order to achieve high precision pressure management and mitigate related risks. With the project broad premises introduced in the last SIWW, we hereby propose a presentation of the solution deployment in Macao's water network.

Development Of A High-Resolution Non-Invasive System To Assess The Condition Of Buried Pipeline Infrastructure

Joseph Butterfield, Valentin Burtea, Bruce Robertson, Ghim Chew Yong, Meng Kin Wong.
Mueller Water Products (United Kingdom)

Through the transport of drinking water, buried pipelines provide an essential service to society. Besides supply disruption and water loss, water-main breaks may cause significant economic losses and catastrophic failures. Therefore, pipelines require continued maintenance and renewal in order to mitigate these risks. To efficiently replace pipelines, the most deteriorated and 'at risk' pipelines need to be identified. Acoustic condition assessment represents an important tool in addressing this problem. This paper presents a new method to identify structural defects on ductile iron pipes at higher resolution compared to existing non-invasive methods. A large-scale validation study was performed whereby the acoustic measurements are compared to ground truth data. The findings show that the high-resolution acoustic assessment measured pipeline condition with an error of less than 10% with a confidence of over 80%. The proposed method represents an important tool for water utilities to proactively develop an effective asset management strategy.

Leak Localization And Benchmarking NRW Via Daily Model Calibration With Continuously Monitoring Data

Zheng Yi Wu, Alvin Chew, Meng Xue, Jianping Cai, Jocelyn Pok, Rony Kalfarisi, Kah Chong Lai, Sock Fang Hew, Jia Jie Wong. Bentley Systems Incorporated (United States)

Calibrated hydraulic models, via traditional approaches, are usually unable to adequately represent the true hydraulics in real-world water distribution networks (WDNs) where non-revenue water (NRW) is definitively to exist but not well calibrated. In this paper, we propose a generic daily model calibration approach using continuously monitoring data capable of estimating and localizing water losses in WDN systems. The approach conducts a series of systematic analyses daily, namely: (1) estimating the daily NRW volume and time-series; (2) calibrate net flow balance; (3) identifying and correcting pressure offset(s); (4) performing anomaly localization analysis; and (5) calibrate other physical properties for energy balance. The validity of the proposed approach is confirmed with a real-world WDN system in Singapore by achieving a mean absolute percentage error (MAPE) score of < 0.1% and 2% for the flow (with NRW) and average pressure agreement in the system using data from a historical week of 30 Nov 2019.

Reducing Water Loss from Early Leak Detection on Large Diameter Pipelines

Naama Zeldis, Aquarius-Spectrum (Isreal)

Leaks on water pipes leads to increase in operational costs from leak repair, pipe replacement, water loss and energy waste. Proactive leak detection of leaks on water mains have huge operational benefits. Repairing small developing leaks are easier and cheaper to repair; and can be scheduled in with proper planning, minimising impact to the network and customer supply. Larger leaks are much more expensive to fix and tend to be disruptive.

Permanent monitoring of trunk mains, that transport large volumes of water, allows for proactive monitoring of the network on a daily basis, detecting leaks when they are small and pinpointing the leak to within a few metres, allowing for efficient repairs. Water utilities are able to reduce their non-revenue water (NRW), maintenance and operational costs as well as improve network efficiency by using highly sensitive sensors, management software and a mobile application.

Session 1.4 – Water Conservation And Efficiency Measures
19 April 2022 (Tuesday)
1600 – 1730 hours

Session Co-Chairs: Ridzuan Ismail, Public Utilities Board (Singapore), Michael John Webster, City of Cape Town (South Africa)

Overview On Water Conservation And Efficiency Measures

David Johnson. South Nevada Water Authority (United States)

Presenter is an invited speaker. No executive summary is available

An Exploration Of Water Use Intensity In The Non-Domestic Sector In Singapore

Joost Buurman, Lingjie Wang. Institute of Water Policy, Lkyspp, NUS (Singapore)

There are large differences in the amount of water used for a dollar of output in Singapore. 'Accommodation and food service activities' are the least efficient in water usage in terms of dollars of GDP per m3. This sector needs more than twice the amount of water than 'Manufacturing', the second-most intensive sector. The services sectors and retail and trade need much less water. An analysis using the Divisia index shows a shift towards less water intensive sectors between 2011 and 2019, yet a large part of reduction in water use intensity from 2016 onwards comes from water savings by existing users, indicating a possible positive impact of the water utility's efforts for water conservation measures.

Making 50 Liters Of Daily Water Use Per Person A Reality

Braulio Eduardo Morera. 50L Home Coalition (Switzerland)

Presenter is an invited speaker. No executive summary is available

Policy for sound water stewardship

Sarah Porter. Kyl Center for Water Policy at Morrison Institute, Arizona State University (Switzerland)

Presenter is an invited speaker. No executive summary is available

Session 1.5 – Digital Twin
20 April 2022 (Wednesday)
0900 – 1030 hours

Session Co-Chairs: Albert Cho, Xylem (United States), David Johnson, South Nevada Water Authority (United States)

Dynamic Digital Twins - The Past, Present And Future State Of Networks With Data Driven And Physics Based Models

Patrick Bonk, Eland Afuang, Mike Pennell. Innovyze (Australia)

The past, the present and future conditions at the level of the asset can now be applied with digital twins to solve key problems and meet objectives for water networks. A digital twin of a water network or plant, in short is a virtual replica of a physical asset, updated in real-time via two-way data connection to represent the live characteristics of a network or plant. Trust in these systems has reached a point where predictive alerts actively support predictive responses to planned and emerging incidents with “What-if” scenarios, informing the operation of networks with real-time AI recommendations.

The technological focus of this paper will be around the emergence of digital twin use cases where combinations of data driven and physics-based models are being used within cohesive workflows that have been enabled through advancements in the respective platforms via cloud computing for increased scalability, deploying against previously unavailable computing resources.

- The past, the present and future conditions at the level of the asset.
- Trusted predictive decisions for incident management, water loss & energy reduction.
- Combinations of data driven and physics-based models within cohesive workflows.
- Mitigating trade-offs between model types via platform enabling scalability and compute power.

Building A Business Case For Intelligent Water: Applications Of AI And Digital Twins

James Cooper. Arcadis (United States)

Most utilities today are facing the decision to take further steps toward implementing digital and intelligent water. Nearly all aspects of utilities from watershed and supply, treatment, and conveyance, as well as nearly all aspects of workforce including front-line operators, utility management, and engineers are being presented with opportunities to improve or optimize their systems through use of advanced analytic techniques such as Digital Twins, Predictive Analytics and Artificial Intelligence (AI). Are these opportunities worth the investment? What is the business case for making these changes? This presentation will summarize a year-long research effort to identify business cases for applying intelligent water.

Four types of digital twins will be discussed, including a maturity matrix consisting of four levels of digital twins: Digital Twin Ready, Informational Twins, Operational Twins, and Connected Twins. Details for each type and level of digital twin maturity will be presented, including business value, technical requirements, workforce requirements, and governance requirements. Multiple case studies will be shared demonstrating the various types and levels of twins as well.

Policy for sound water stewardship

Doeke Schippers. Manager, Extraction & Treatment, Vitens (The Netherlands)

Presenter is an invited speaker. No executive summary is available

Establishing A Distribution System Digital Twin For Real-Time Water Quality And Energy Management At Hillsborough County Public Utilities

James Uber, John McCary, Sam Hatchett, Ernesto Arandia. Xylem, Inc (United States)

Hillsborough County Public Utilities (HCPU) is implementing a digital twin to predict and forecast system-wide hydraulics (flows, velocities, pressures, tank levels), water quality (water age and total chlorine residual), and energy inputs/losses. The key objective of is achieving broad operational efficiencies through situational awareness, and optimization of pump and valve operations. The digital twin technologies integrate network hydraulic and quality models with SCADA and billing data, producing a continuously calibrated operational simulator (mean absolute error over 16-week evaluation: flows, 285 GPM; pressures, < 2 PSI). Current work is designing customized and intuitive web-based information displays - brought on-line in Spring 2020 - that deliver KPIs and strategic options to operational staff.

Session 1.6 – Smart Sensors For Network Monitoring
20 April 2022 (Wednesday)
1100 – 1230 hours

Session Co-Chairs: Amir Cahn, SWAN (Israel), Martijn Deenen, Royal Haskoningdhv (The Netherlands)

Smart Technology For Network Monitoring

Dammika Vintanage. Sydney Water (Australia)

Presenter is an invited speaker. No executive summary is available

Power Of Low-Resolution Pressure Data

James Smith. Xylem (United States) Jihane Kalloul

Historically Pressure Monitoring has been synonymous with High Resolution Sample Rates needed to monitor Pressure Transients in a limited number of sample locations. Due to new technology, there is a revolution of Low-Resolution data in hundreds and thousands of distributed sampling locations which are arming Water Utilities with the data they need to better understand Pressure throughout the entire water distribution system.

This lecture will present the data science comparing sensitivity and correlation of high- & low-resolution sensors at the same location, as well as findings from (2) water utilities which deployed low resolution monitoring of system pressure to better understand pressure behaviour and the types of asset & system incidents able to be detected and prevented with low resolution data.

NB-Iot Coverage Study For Smart Metering In Singapore

Wee Beng Lim, Zuoyuan Wang. Public Utilities Board (Singapore)

Narrowband Internet of Things (NB-IoT) is a Low Power Wide Area (LPWAN) communication technology developed by 3GPP offered by telcos that has potential for smart water metering. Although utilities can reduce upfront capital costs by tapping on telcos networks for NB-IoT, utilities and meter vendors are concerned that telcos networks may have insufficient coverage at water meter positions, and thus reduce battery lives. This study collects coverage measurements of the 3 major telcos at identified water meter locations across Singapore, through a combination of static and drive tests. It was found that NB-IoT services are generally well deployed for all locations measured and can reach water meter positions in various scenarios such as high-rise housings, commercial buildings and industrial areas which are representative of most meter positions and environment. It was also observed that in high-rise buildings, mid-levels (between 6 to 25 floors) appear to have most ideal coverage performance.

Monitoring Of Water Quality Changes Due To Rising Temperatures During Production, Storage And Distribution

Christopher Wagner. S::can Gmbh (Austria)

We combined an online water quality monitoring system with online flow cytometry and deployed it at various sites throughout Austria to survey different parts of the distribution systems as well as raw water sources with the aim to better understand the effects of climate change on the systems.

Thames Water AMI Programme

Andrew Tucker. Thames Water (United Kingdom)

Presenter is an invited speaker. No executive summary is available

Theme 2: Delivering Water from Source to Tap – Treatment

Session 2.1 – Advanced Oxidation Process
19 April 2022 (Tuesday)
0900 – 1030 hours

Session Co-Chairs: Min Yang, Chinese Academy of Sciences (China), Jaehong Kim, Yale University (United States)

Membrane-Confined Heterogeneous Advanced Oxidation

Jaehong Kim. Yale University (United States)

This talk summarizes a few different ultrafiltration membrane-based AOPs platforms that we have been developing for organic pollutant degradation in complex water scenarios.

World's First Sequential Advanced Oxidation Process Installation For Efficient And Safe Drinking Water Production

Steffen Rueting. Xylem Inc (Germany)

The presentation will describe the exciting journey from bench scale testing via piloting to full-scale implementation and successful operation of a first of its kind novel advanced oxidation process at the drinking water pre-treatment plant of DUNEA, in Bergambacht NL. The developed treatment train utilizes hydrogen peroxide, ozone, low pressure UV system and downstream GAC contactor for efficient treatment of micropollutants with minimized by-product formation at low energy demand in a compact arrangement.

Bromate Formation And Mitigation In Low Bromide Water From Ozone Upgrading

Fong Eddy. Binnies Singapore (Singapore)

PUB has been recently upgraded its waterwork's treatment process with post-ozonation and biological activated carbon (BAC) contactors to achieve reduction in disinfection by-product (DBP) precursor removal, reduction of taste and odor causing compound such as MIB/Geosmin and 1-log inactivation of Cryptosporidium and Giardia. The raw water entering the waterworks has moderate levels of bromide and upgrading of the plant to include ozonation presented concerns on bromate formation. Before the commencement of design, bench scale testing was conducted to study the bromate formation potential. Bench scale testing confirmed the formation of bromate at ozone doses above 2.5 mg/L. Bromate mitigation involving chlorine-ammonia addition to feed water before ozonation was included in the design of plant to enable plant to adopt higher ozone doses (which may be required at times to deal with adverse raw water quality conditions). During testing and commissioning of constructed facilities, bromate formation was observed at low levels of bromide (even less than 50 ug/L) and low ozone doses (1-1.5 mg/L) and chlorine ammonia addition provided bromate mitigation enabling addition of required ozone dose for treatment.

Enhanced Solar Light-Driven Photocatalytic Ppcps Degradation By Chlorine Activation For Drinking Water Treatment

Cheuk Wai Lung. The Hong Kong University of Science And Technology (Hong Kong SAR)

The extensively used of Pharmaceuticals and personal care products has drawn increasing concerns to drinking water treatment techniques due to their poor removal efficiency in conventional water treatment processes. Photocatalysis is a promising approach for PPCPs degradation, but the recombination of photoinduced charge pairs is of great concern on its degradation performance. In this study, free chlorine is proposed to be used as an electron acceptor to improve the photocatalytic PPCPs degradation efficiency. The results showed that the addition of 100 μM chlorine into the solar/TiO2 system significantly enhanced the photocatalytic PPCPs degradation efficiency with the pseudo-first-order carbamazepine (CBZ) degradation rate constant increased by 2.68 times. In addition, the solar/TiO2/chlorine process exhibited satisfactory CBZ degradation efficiency at various pH levels and in the presence of various common anions while maintained excellent E. coli disinfection ability. This study provides a novel and cost-effective strategy for PPCPs degradation in drinking water treatment.

Session 2.2 – Innovative Technologies To Tackle Emerging Contaminants
19 April 2022 (Tuesday)
1100 – 1230 hours

Session Co-Chairs: Hadas Manane, Tel Aviv University (Israel), Shane Snyder, Nanyang Technological University, Nanyang Environment And Water Research Institute (Singapore)

Electrochemical Mineralization Of A Concentrated Antibiotic Stream And Toxicity Assessment Of Its By-Products

Orlando Garcia Rodriguez, Zong Han Goh, Kai Shing Yeo, Jiang Huan, Riccardo Muzzi, Olivier Lefebvre. National University of Singapore (Singapore)

Despite numerous efforts to treat wastewater with pharmaceuticals, their full mineralization is rarely achieved, which sometimes results in the generation of degradation intermediates more toxic than the parent compound. In this study, 63% mineralization of Cloxacillin – a common pharmaceutical compound – was achieved following 180 min of electrochemical oxidation, the second highest available in the literature. Furthermore, toxicity evaluation confirmed the elimination of hazardous by-products with higher toxicity. In conclusion, electro-Fenton (EF) combined with anodic oxidation (AO-EF) appears as a promising alternative for antibiotic wastewater treatment enabling high mineralization efficiency and toxicity abatement with reasonable energy consumption of 18 kWh/m3 (approx. SGD$3.5/m3), the lowest obtained when compared with the literature.

PFAS Challenges And The Emerging Technologies: An Utility Point Of View

Morez Jafari. PWNT (Netherlands)

Poly- and perfluoroalkyl substances (PFAS) are a large family of anthropogenic organic compounds which have attracted significant attentions due to their resistance to natural degradations. PFAS compounds are reported recently to be present, more than expected, in drinking water sources in The Netherlands. PWN technologies is evaluating several emerging technologies as potential options for drinking water production and PFAS removal capability of these technologies is one their main performance criteria. The PFAS removal of the three selected emerging technologies (suspended ion exchange resin, hollow-fibre nanofiltration and vacuum UV) under elevated concentration were determined. The results show that the selected technologies are effective in removal of a certain PFAS species up to 90%. However, PFAS removal of all the selected technologies are significantly dependent on the operating conditions or PFAS species structure.

Pilot Study Of An Ion Exchange Resin Regenerated With Alternative Bicarbonate Counter Ion For The Removal Of Natural Organic Matter

Elisabeth Vaudevire. PWNT (Netherlands)

This research addresses the feasibility of operating an ion exchange resin for the purpose of natural organic matter (NOM) removal with bicarbonate as alternative counter ion to minimize the release of chloride ions in the drinking water. After promising kinetics studies of bench scale confirming the selectivity of the resin for DOC, this investigation was conducted on pilot scale with 15mL/L of Lewatit S-5128 resin in a bicarbonate form. It provides the proof of principle of the stable adsorption of 55% of DOC and >95% of sulphate from Ijssel Lake water, sustained after several cycles of regeneration. As a consequence of using bicarbonate as counter ion, the chloride level in the effluent water was reduced below 79 mg/l achieving up to 33% removal but the bicarbonate concentration increases up to 300 mg/L (+100%). Additionally the use of bicarbonate reduced the corrosion potential of the spent brine.

Impact Of Reduced Regeneration Frequency On The Ion Exchange

Lucie Pidoux, P. Jarvis, I. Carra. Cranfield University (United Kingdom)

Suspended ion exchange (IEX) processes are efficient methods for natural organic matter (NOM) removal. However, the treated water's corrosivity generates potential issues with lead and discolouration due to the release of chloride during operation. The disposal of the chloride brine used to regenerate the exchanger poses an additional problem. Previous research has shown promising results when using bicarbonate as an alternative regenerant. Therefore, the impact of reduced regeneration frequency on the IEX equilibrium has been evaluated with both regenerants. After investigating the IEX mechanisms and using jar tests results, a model has been developed in MATLAB which enables the prediction of consecutive IEX equilibria. This work revealed that similar levels of NOM removal were achieved with both regenerants at reduced regeneration frequency, that two mechanisms take place for NOM removal and that suspended IEX processes can be optimised by using bicarbonate at a regeneration frequency comprised between 2 and 5.

Session 2.3 – Advances In Membrane Technologies And Applications
19 April 2022 (Tuesday)
1400 – 1530 hours

Session Co-Chairs: Seung Kwan Hong, Korea University (South Korea), Wang Rong, Nanyang Technological University (Singapore)

Development Of Pilot-Scale High-Performance Bio-Programmable Membranes For Water Reclamation Process

Rong Wang, Yunfeng Chen, Wai Ren Keng, Lizhi Zhang, Ye Li, Yining Wang, Rajeshkanna Velayutham, Clover Lim. National Technological University (Singapore)

In this study, a highly water permeable thin film composite (TFC) membrane is developed by introducing one type of biomolecules during the formation of the selective layer via interfacial polymerization. The addition of the biomolecules to the polyamide layer makes the membrane more water permeable, while high salt rejection can be maintained or further improved. Thus the resultant membranes are named as bio-programmable membranes (BPMs).The tradeoff between the water permeability and solute rejection is often a concern for the fabrication of thin film composite membranes used for reverse osmosis (RO) process, i.e., increasing membrane water permeability is often accompanied by the decreased solute rejection. However, the BPMs can have both increased water permeability (5-8 LMH/bar) and solute rejection (>96%) as compared with that of the control membrane. The fabrication method was further developed to produce pilot-scale modules for batch testing (2 months) and on-site testing (3 months) using real membrane bioreactor (MBR) permeate from the water reclamation plant. Long term testing data have demonstrated the pilot-scale modules can save up to 40-50% of the pumping energy by operating at almost half of the normal operating pressure (8-10 bars) for water reclamation.

Innovative Chloramine Free Water Reuse Technology, 85% Recovery, 28 Lmh, Single Stage, 100% Uvt, Water Cost Saving 20%

Boris Liberman, Lior Eshed, Gal Greenberg. IDE Water 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 an 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 the 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. The operation was conducted at 86% recovery in a single RO stage. No chloramine was dosed, thus no NDMA components were developed. Chloramine-free the operation generates permeate with a UVT value of about 100%, thereby saving 30-40% on CAPEX and OPEX in the final UV/AOP stage.

DuPont™ B-Free™ – The Biofouling Prevention Technology

Guillem Gilabert-oriol, Gerard Massons, Marc Slagt, Eduard Gasia-Bruch. Dupont Water Solutions (Spain)

Biological fouling remains one of the top unsolved problem in the water treatment industry using reverse osmosis (RO) and nanofiltration (NF) membranes. Biofouling occurs when bacteria adheres on the membrane and feed spacer. This leads to an increase in feed pressure, which is addressed through chemical cleanings (CIP). Eventually affects membrane lifetime, reducing plant availability and leading to a cost of water increase up to 6%. The DuPont™ B-Free™ pre-treatment is a novel vessel-based media technology that efficiently mitigates the effects of biofouling. It works under three main mechanisms, combined to provide a biostatic environment. The first relies on providing phosphate reduction, then it uses a chemical barrier polisher as safeguard, and finally it retains particles and bacteria to ensure no particle migration. Field validation equipped with a B-Free column demonstrated that biofouling is prevented in RO during a 35 days test and 8 replacements were avoided.

Investigation And Optimization Of The Ozone-Ceramic Membrane Process

Moses Shijie Leow, Aron Shu Tien Loh, Babu Narayanswamy, Teik Thye Lim, Isaac Ng, Jonathan Clement, Gilbert Galjaard, Shane A. Snyder. Nanyang Technological University (Singapore)

PUB is operating the world's first large-scale ozone-ceramic membrane plant at Choa Chu Kang Waterworks (CCKWW) at a capacity of 180,000 m^3/day. This study explores the use of ozone with ceramic membranes for treatment of surface waters at CCKWW to develop an understanding of the mechanisms related to fouling, cleaning, and permeability during ozonation-filtration. From bench-scale tests it can be concluded that coagulation with $FeCl_3$ leads to the highest DOC removal for the reservoirs tested. Results indicate that the phenomena of increased initial permeability often witnessed when ozone is applied for the first time to ceramic membranes, is possibly caused by foulants being present on the membrane due to post-manufacturing checks, given that release of DOC from the membrane is witnessed after applying the ozone in DI water. Preliminary results also indicate that most likely no hydroxyl radicals are being formed during contact of the ozone with the membrane.

Session 2.4 – Innovations In Desalination - Pre-Treatment
19 April 2022 (Tuesday)
1600 – 1730 hours

Session Co-Chairs: Puah Aik Num, Public Utilities Board (Singapore), Gary Amy, Clemson University (United States)

Innovative Highly Resource Efficient Configuration For Seawater Desalination

Olga Ferrer, Jorge J. Malfeito, Carlos Bayona, Daniel García-Huertas, Zulema Borjas, Andrea Picazo, Nil Llopart, Raquel Escorihuela, Leticia López, Joana Carvalho, Bart Nelemans. ACCIONA (Spain)

An innovative concept aiming at increasing the sustainability of seawater reverse osmosis (SWRO) desalination systems has been demonstrated at pilot scale, proving the concept. This approach mainly relies on i) an increase of the process recovery, which in turn leads to a lower waste stream generation; ii) a decrease in the external use of chemicals and iii) the recovery of resources generated within the desalination scheme that are not currently being used. After the optimization carried out of each technology and of the overall process, up to 80% conversion has been achieved, with a significant reduction in the volume of brines generated, and chemicals used. The processes tested do not present significant additional energy requirements, enabling a diminished specific energy consumption due to the greater overall recovery. The Life Cycle Analysis (LCA) carried out has shown that the envisaged scheme presents a reduction in 15% approximately of the potential environmental impacts from different categories from a conventional SWRO.

Evaluation Of A Ceramic Membrane For Improved Pre-Treatment Of Desalination

Isaac Ng, Jonathan Clement, Gilbert Galjaard. Nanostone (The Netherlands)

Pilot testing was conducted at Singapore's TUAS desalination test bedding facility to determine the feasibility of pressurized ceramic membrane filtration for pre-treatment for desalination. A pilot unit consisting of a full-scale ceramic membrane module was evaluated over a 10 month period. The results showed stability at high fluxes (250 lmh) through periods of elevated algae.

Results and conclusions

- 'Enhanced' coagulation at a pH=5 led to a higher DOC removal rate (>79%) than 'sweep' coagulation at a pH=7 (30-70%).
- Permeability, TMP and flux so far seems to indicate that a flux equal or above 250 lmh is feasible at pH=7 with filtration cycles of 90 min.
- Based on the long-term operation results and fouling rate, the CIP frequency could be more than 107 days.
- Filtrate water qualities were excellent with majority filtrate SDI15 were below 2 and the filtrate UVT were around 98%.
- During increased algae concentrations going from <2 ppb to 40-60 ppb chlorophyll-a, TMP increased but seem to auto recover well by CEB with NaOCl. This proves that Nanostone ceramic membrane can sustain the increased algae concentrations without DAF.

High Efficiency Cross-Flow Microsand Filtration As Pretreatment In Desalination Applications

Kris Lim, Xiangyi Qiao, Henry Lim, Romulo Conde, Reashika Das, Alain Silverwood. Evoqua Water Technologies (Singapore)

Evoqua Water Technologies is developing an alternative solution to the conventional desalination pretreatment process. The pretreatment stage of the conventional process utilizes MMF or ultrafiltration (UF) system to remove suspended solids before the reverse osmosis process. As an alternative, Evoqua Water Technologies has studied pretreatment performance with Vortisand® high efficiency cross-flow microsand filtration system. Results have demonstrated that the new pretreatment system has superior efficiency at reducing suspended solids and Silt Density Index (SDI) from seawater. It also reduced energy cost for the pretreatment stage of the desalination process in comparison to the conventional UF system. Moreover, the chemicals required for the operation of the pretreatment process is minimised with the new system.

Breakthrough Dry-Tested Seawater Reverse Osmosis Elements

Santhosh Ramalingam. Dupont (Singapore)

Water scarcity is one key challenge mankind is facing. Seawater reverse osmosis desalination is a promising technology to solve it. However, further innovation to go beyond product specifications is needed to decrease the total cost of water while at the same time, improving sustainability footprint. This paper describes a breakthrough step-change in innovation within the desalination industry: transitioning from Wet-test SWRO elements to Dry-test SWRO elements. This new concept has been achieved by DuPont thanks to continuous advancements in membrane chemistry, automated precision manufacturing, a robust quality control, and enhancements in testing methods.

Dry-test SWRO elements offer significant advantages over wet-test elements. Dry-tested membranes enable longer storage times, lower labor costs and easier warehouse planning. Dry-test membranes are safer to install due to lower weight and easier to handle. The dry-test SW concept also brings plenty of sustainability benefits in eliminating fresh-water consumption for testing, eliminating wastewater generated during testing, reducing energy consumption in wet testing which can be translated to 20% lower CO2 emission per element. The lower weight for shipping will also significantly decrease the environmental footprint of these elements.

Additionally, dry-test SWRO elements offer the same water productivity and permeate quality as wet-test elements, once stabilized.

Session 2.5 – Innovations In Desalination - Energy Saving Technologies
20 April 2022 (Wednesday)
0900 – 1030 hours

Session Co-Chairs: Seung Kwan Hong, Korea University (Korea), Co-Chair 2 TBC

Novel PRO Membranes For Salinity Gradient Energy Harvesting: Towards Scale Up And Pilot Validation Of 4 Inch And 8inch Modules

Chakravarthy Gudipati, Junyou Zhang, Jiun Hui Low, Aunt Thet Paing, Karikalan Mottaiyan, Chunfeng Wan, Tianshi Yang, Adil Dhalla, Tai-Shung, Neal Chung. Nanyang Technological University (Singapore)

The current work highlights the translation of the novel membranes developed for Pressure Retarded Osmosis (PRO) with a specific target of harvesting the salinity gradient energy arising out of mixing wastewater brine (Newater RO retentate) with seawater RO brine. The novel membranes were developed in Prof. Chung's group at NUS, while the scale up of chemistry, process, module fabrication and testing were carried out at the START facility. The membrane fabrication process was successfully scaled up from 1.5 kg batches in the NUS lab to 20 kg batches in the START centre, with consistent replication of membrane characteristics, such as the pure water permeability (2-3 LMH/bar), salt rejection (> 99%), and power density (≥5 W/m2). The scaled-up membranes were then assembled into modules of 1-inch, 2-inch, 4-inch, and 8-inch diameter with varying lengths from 30 cm to 50 cm. The 4-inch and the 8-inch modules were tested in a 25 m3/day pilot system using Newater brine feed and a synthetic SWRO brine draw solution. The results from the lab study as well as the field testing will be discussed in the presentation along with challenges in sustaining the membrane performance over a period of time.

Filmtec™ NF270-440 – Energy Savings In Nanofiltration By New Module Design

Guillem Gilabert-oriol, Claudia Niewersch, Xueyi Liao, Jon Johnson, Russ Swerdfeger, Javier Suárez. Dupont Water Solutions (Spain)

This extended abstract shows the results of an experimental study about a new module design for nanofiltration elements. The new element type FilmTecTM NF270-440 was compared in parallel operation with standard nanofiltration elements. It was demonstrated that the improved module design leads to lower feed-concentrate pressure drop as function of the average feed-concentrate flow. At typical flows, it allows 48% less pressure drop. In continuous operation with River Ebro water 13% energy reduction and 23% reduction of number of CIPs was shown.

Electrically Assisted Reverse Osmosis For Enhancing Boron Removal In One-Pass SWRO Desalination

Qianhong She. Nanyang Technological University (Singapore)

Insufficient boron removal efficiency of reverse osmosis (RO) membranes poses critical challenges in seawater desalination process. Herein, we report a novel electrically assisted reverse osmosis (EARO) process which integrates an electrochemical process with the conventional RO process by employing an external porous carbon cloth as cathode on the seawater RO (SWRO) membrane surface. The SWRO membrane in the EARO process exhibited a significantly enhanced boron rejection of 93.8% under the applied voltage of 4 V compared with the conventional RO process (~75.0%). On the other hand, the variation of salt ion rejection was marginal with increasing the applied voltages in EARO. This study demonstrates that the EARO has a great potential to achieve low-chemical and low-cost boron removal in one-pass RO seawater desalination.

Enhanced Operation Of Capacitive Deionization Using A Novel Biochar Integrated Flow-Electrode

Jihun Lim, Yong-Uk Shin, Seungkwan Hong. Korea University (Korea Rep.)

This work investigated the performance of a capacitive deionization system using flow-electrode (FCDI) consisting of a novel biochar prepared via pyrolysis under 700 °C. Comparison of flow-electrode prepared with activated carbon alone and in mixture with the synthesized biochar under a wide pH range revealed superior enhancement for the novel biochar integrated flow-electrode. Significance was further evaluated by investigating the following in the study: 1) characterization of the physicochemical and electrical properties of the materials, 2) comparative evaluation on the mass loading of the materials, 3) feasibility for heavy metal removal via lead assessment, and 4) comprehensive ion electro-adsorption efficiency. Through the optimum operational conditions and flow-electrode composition, the FCDI process achieved outstanding performance for desalination and further removal of heavy metal lead ion. To the best of our knowledge, this work is the first to apply the novel biochar as a flow-electrode material in the FCDI system.

Session 2.6 – Resource Recovery From Brine
20 April 2022 (Wednesday)
1100 – 1230 hours

Session Co-Chairs: Nicolay Voutchkov, Water Globe Consultants (United States), Christos Charisiadis, Lenntech Water Treatment Solutions (Netherlands)

Brine Concentration And Mining - The Path Forward

Nikolay Voutchkov. Water Globe Consultants (United States)

Presenter is an invited speaker. No executive summary is available

8 Months Of Successful Pilot Operation For Highly Purified And Concentrated Nacl Brine Production

Seungwon Ihm, Eslam S. B. Al-Waznani, A. Mohammed Farooque, Nikolay Voutchkov, Ahmed S. Al-Amoudi. Saline Water Conversion Corproation (Saudi Arabia)

A dual brine concentration pilot plant had been operated for 8 months to produce a purified NaCl brine targeting the concentration level of 170,000 mg/L in Jubail, Saudi Arabia. Divalent ions such as Ca, Mg and SO4 are effectively removed to increase the purity of the monovalent ions-enriched stream by a NF system. After a high-recovery two-stage RO system, a two-stage membrane brine concentration (BC) system is installed to concentrate the RO brine further. The NF-RO-BC pilot plant, which utilizes commercial-size membranes, successfully demonstrated its long-term stable operational performance.

Lithium Extraction From Hypersaline Brine With Nanofiltration

ZiHao Foo, Andrew Bouma, John Lienhard. Massachusetts Institute Of Technology (United States)

The feasibility of employing membrane-based separation technologies for lithium extraction from hypersaline brines is investigated. Nanofiltration experiments with commercially available monovalent selective membranes are conducted, using synthetic brines based on actual feed composition from continental salt-lake in Chile. The effects of total dissolved solids (TDS) level and kinetic coupling between ions on the monovalent perm-selectivity are evaluated. Our preliminary experiments demonstrate a Li+/Mg2+ selectivity of 6.15, reducing the Mg2+ concentration by up to 85 % while retaining up to 95 % of Li+ in the monovalent-rich stream.

Zero-Liquid Discharge Made Affordable with Minimal Liquid Discharge Technology and a Circular Economy Mindset

Lewis Liu, Tina Arrowood. Dupont Water Solutions (Singapore)

Water scarcity and increasing operational costs related to brine management and tightened environmental regulation motivate the industrial water consumer to maximize the reuse and recycling of water and reduce the effluent flow, in some cases up to zero liquid discharge. When facing this challenge, standard RO systems are limited by the water's chemistry and quality, which may cause scaling and fouling on the RO membranes. The MAXH2O Desalter overcomes these limitations by implementing a unique process that integrates an RO membrane with an integrated salt precipitation unit.

Session 2.7 – Digitalization Of Water Treatment Plants
20 April 2022 (Wednesday)
1330 – 1500 hours

Session Co-Chairs: Bram Martijn, PWNT (Netherlands), Wim Audernaert, AM-Team (Belgium)

Water digitalisation and lessons learned from experiences of automation pioneers

Dragan Savic. KWR Water Research Institute (Netherlands)

Presenter is an invited speaker. No executive summary is available

PUB's Experiences In Application Of AR & MR Technologies For Training In Water Facilities

Desmond Tan. Public Utilities Board (Singapore)

Augmented Reality and Mixed Reality (AR and MR) technologies have the potential to support decision making in the field by providing holographic representations of pipes, cables and other assets, and offering immersive scenario-based training for employees. Recognizing this potential, PUB embarked on a journey since 2017 to use these technologies for training our employees in water facilities. A pilot project was done to use AR for site training at Kallang River. PUB had extended the use of AR for more site trainings in water works, water reclamation plants and reservoirs, and MR for pumps and electrical switchgear training. This paper shares PUB experiences in applying AR and MR for training in water facilities. It discusses benefits, limitations and future opportunities of using these technologies for training in water facilities.

Real-Time Digital Twin Based Process Monitoring Of Drinking Water Treatment Plants;

Abel Heinsbroek, Nico Wolthek, Rein Wuestman, Christiaan Slippens. Vitens NV (Netherlands)

Accurate and real-time prediction of water quantity and quality inside drinking water treatment plants is paramount to a more efficient and stable operation. In conventional operation, the quality of produced drinking water is monitored by laboratory analysis. From sampling to analysis results takes a minimum of one day, which, coupled with a comparatively low sampling rate, renders this data unfit for real-time monitoring of treatment plants. Vitens has developed a data and analysis platform that combines lab-analyses and online quality and process sensors with digital twins of complete treatment plants to allow for real-time monitoring of treatment plant performance. The system is fully operational and embedded into daily operations, with more than thirty digital twins currently running in parallel with reality. The validity of the digital twins is continuously evaluated by parallel validation processes.

Advancing Digital Design To Digital Twin

James Leverton, Claire Penny. AECOM (United Kingdom)

Following the successful stage 2 BIM delivery of the design & construction phases of the Durleigh Water Treatment Centre (WTC) located in Somerset, UK, the client tasked AECOM to investigate and create a Proof of Concept (PoC) demonstrating how the data rich models generated could be leveraged to create a Digital Twin. The Digital Twin had to provide the client Operations and Asset Management team with a current, accurate, inventory of assets and associated documentation whilst having the ability to visualize live operational data from SCADA systems.

The POC results clearly demonstrated that when good quality, classified data is delivered during the BIM process it can be utilized to generate a Digital Twin for use in the operations phase of a system. Geometry and data generated during the capital project were integrated with third party data & information to not only deliver a digital building manual for use in operations, but also deliver operational excellence through the curation of dynamic data and automated analytics.

Session 2.8 – Augmenting Water Supply By Water Reuse
20 April 2022 (Wednesday)
1330 – 1500 hours

Session Co-Chairs: Puah Aik Num, Public Utilities Board (Singapore), Ong Say Leong, National University of Singapore (Singapore)

Potable Reuse – A Secure And Safe Water Supply Option
Ian Law. IBL Solutions (Australia)

Presenter is an invited speaker. No executive summary is available

Joint Desalination and Reuse – A New Trend Towards Integrated Water Management
Nikolay Voutchkov. Saline Water Conversion Corproation (Saudi Arabia)

Potable Reuse From A Water/Wastewater Plant Operator's Perspective
Vijay Sundaram. AECOM (United States)

Potable reuse is becoming an attractive option for incorporating circular economy, resiliency, and the One Water approaches. As regulations for potable reuse get promulgated and projects get implemented globally, water and wastewater operators are being introduced to newer topics, such as the use of adenovirus as one of the indicator organisms; the requirement to demonstrate multiple treatment barriers; removal and management of Per- and polyfluoroalkyl substances (PFAS); and management of nitrogen-based disinfection byproducts (DBPs) such as NDMA. Because purified water becomes raw water or finished water for a drinking water system during the implementation of a potable reuse project, it connects and forges collaboration between wastewater and drinking water operators. Case studies from California, Nevada, Virginia, and the Caribbean involving membrane-based and carbon-based AWT solutions will be discussed. The elements of potable reuse projects from a plant operator's perspective will be highlighted.

Wastewater Recycling In Singapore By EDR
Neil Moe. Suez Water Technologies & Solutions (United States)

Wastewater recycling has always been an integral part of Singapore's plan to achieve water independence. Every drop of recycled water can displace a corresponding amount of imported or desalinated water. SUEZ WTS has recently completed pilot studies in Singapore targeting recycling a) municipal wastewater (MWW), and b) industrial wastewater (IWW). The process flow scheme for a) was MBR-RO1-EDR-RO2, where RO1 concentrate was desalinated by EDR, EDR product was fed to RO2, and RO2 concentrate was directed to EDR concentrate makeup for 93% overall recovery. The process flow scheme for b) was MBR-EDR, operating at 80% recovery. The EDR product flow rate in each case was around 50 m3/d. Both plants achieved the desired water quality and operational stability over several thousand operating hours. We present normalized operating data and some important lessons learned during operations.

Theme 3: Effective and Efficient Wastewater Management – Treatment & Conveyance

Session 3.1 – Membrane Technologies For Reuse
19 April 2022 (Tuesday)
0900 – 1030 hours

Session Co-Chairs: Sandeep Sathyamoorthy, Black & Veatch (United States), Liu Yu, National University of Singapore (Singapore)

Best Management Practice For Wastewater Reuse

Yountae Seo. SUEZ WTS (Singapore)

In Singapore, around 11% of NPW (Non-Potable Water) is consumed by Local Scrubber Make-up in semiconductor sector. By increasing internal recovery rate of LSR (Local Scrubber Reclamation) from 70% to 85%, the annual water saving of 650,000m3 (equivalent to 1.3M USD saving per year) is achievable. However, there are a couple of challenges in terms of waste water characteristics and space. Many different types of system configuration have been reviewed to meet the sustainable > 85% recovery objective, dealing with the restriction. As a result of the comprehensive studies, EDR (Electro Dialysis Reversal) and UF (Ultrafiltration) with RO (Reverse Osmosis) were selected as the best solution for Main Stream and for Reject Recovery Stream, respectively. The system was installed in one of semiconductor sector in Singapore and has been running for nine (9) months since July 2019, delivering sustainable and reliable > 85% overall LSR recovery rate and completely meeting water specification.

Ceramic Membrane Filtration Flux Enhancement By Ozonation And Coagulation Pretreatment For WWTP Effluent Reuse

Martin Spruijt, Marvin Ouma, Maaike Hoekstra, Joop Kruithof. PWNT (Netherlands)

In this research effort, CMF flux enhancement by ozonation and coagulation pretreatment to establish high quality WWTP effluent for reuse applications is pursued. In pilot experiments, CMF flux enhancement by single ozonation and coagulation and by a combination of ozonation and coagulation pretreatment was pursued. Compared to untreated WWTP effluent, applying coagulation pretreatment with 10 mg/L Fe3+ at pH 6.8 caused a sustainable flux increase from 100 to 200 Lmh, while applying an ozone dose of 1.9/1 g/g O3/DOC (O3-residual 0.6 mg/L), caused a sustainable flux increase to 227 Lmh. Ozonation (1.9/1 g/g O3/DOC) followed by coagulation (10 mg/L Fe3+, pH 6.8) resulted in an even higher sustainable flux of 250 Lmh. Under these conditions, %UVT254 increased from 52% to 89% and the average pharmaceutical degradation was >99%. These promising results have provided starting conditions for an O3/CMF pilot demonstration plant currently under construction.

Validation of High Recovery Water Treatment for Non Potable Reuse using an Integration of Ion Exchange and Reverse Osmosis

Iswaran Sivan,. Clean TeQ Water (Australia)

Water scarcity due to population growth, water pollution, and climate change is a growing global issue, and society depends on a continuous supply of clean water and water supply is vital for people, industries, and economies. Companies and Municipalities are pursing non-potable reuse more than ever to substitute precious potable water resources. Large brine volumes when

desalinating brackish and saline feeds is a common issue, with evaporation ponds, brine pipelines, sending brine to sewer, and trucking brine offsite common disposal methods used. Precious water that is often lost with the brine from low recoveries is a wasted resource. This paper presents the results of recent piloting in Australia, new projects, and desktop studies of a high recovery water treatment solution which has proven recoveries >92-95% are possible for tertiary effluent wastewater, mine wastewater, industrial process water, and in the oil and gas industry, greatly reducing the volume of brine produced. The reduction in brine volume achieved provides a minimum liquid discharge solution for non-potable reuse, making non-potable reuse a viable option for constrained sites, reducing the cost of brine management, and providing higher volumes of treated water for reuse.

Implementing Desalitec SOAR CCRO To Increase Efficiency And Reliability In Wastewater Reuse

Santhosh Ramalingam, Michael Boyd, Javier Suarez Martin. Dupont (Singapore)

Municipal wastewater represents a reliable feed source for potable reuse and industrial process water in Singapore. However, operating at RO recovery rates greater than 90% increases the risk of fouling/scaling due to the variable nature of secondary and/or tertiary effluent. The current paper demonstrates how multiple utilities in California have increased RO recovery over 90% without sacrificing reliability using CCRO's adaptive control strategies.

Session 3.2 – Membrane Bioreactor (MBR)
19 April 2022 (Tuesday)
1100 – 1230 hours

Session Co-Chairs: Andrew Shaw, Black & Veatch (United States), Koh Sock Hoon, Binnies (Singapore)

A Practitioner's Perspective On The Design Of Large Membrane Bioreactor Facilities

Tim Constantine, Scott Levesque. Jacobs (Canada)

Since the first full-scale municipal membrane bioreactor (MBR) plant commissioned in 1999, the number and capacity of MBR facilities worldwide has steadily increased. There are now more than 8000 MBR plants, the largest of which is 800 million liters per day. Design of large MBR plants has several special considerations that are discussed in this paper. These considerations include designing for energy efficiency, designing for good mixed liquor filterability, achieving even flow split to membrane tanks, handling peak flows economically, and meeting intense aeration requirements. The authors have been involved in the design of 5 of the largest MBR facilities in North America, as well as the groundbreaking designs at the Changi WRP and Tuas WRP in Singapore and they will share their lessons learned and best practices.

Comparison Of Removal Performance Of SARS-Cov-2 In Wastewater By Membrane Bioreactor And Conventional Activated Sludge Processes

Rong Xuan Wang, MD Alamin, Shohei Tsuji, Hiroe Hara Yamamura, Akihiko Hata, Masaru Ihara, Hiroaki Tanaka, Ryo Honda. Kanazawa University (Japan)

The potential risk of SARS-CoV-2 in treated effluent from wastewater treatment plant (WWTP) is concerned during COVID-19 outbreak. However, removal of SARS-CoV-2 in WWTP is virtually unknown. The objective of this study is to clarify removal performance of SARS-CoV-2 in a WWTP and superiority of membrane bioreactor (MBR) process in SARS-CoV-2 reduction. Influent wastewater, secondary treatment effluent, and final effluent after chlorination were collected from a WWTP in Japan during the second wave of COVID-19 outbreak in Japan from May 28 to September 24, 2020. The target WWTP had MBR and conventional activated sludge (CAS) processes. As a result, SARS-CoV-2 RNA was detected 3.7-6.0 log10 copies/L in influent. Log removal value (LRV) of MBR was 3.36 ± 0.65 log, while LRV of CAS process was 2.95 ± 1.10 log. The total LRV by the target WWTP was estimated over 3.22 log after chlorination. Consequently, removal performance of SARS-CoV-2 in a WWTP were better than typical reduction of other enteric viruses. A MBR process has more stable reduction than CAS process.

Optimisation Of Membrane Bioreactor Air Scouring: Effect Air Scouring On MBR Long Term Hydraulic Performance

Kaushalya Wijekoon, Steven Cao. Dupont Water Solutions Windsor Nsw (Australia)

Membrane fouling and high energy demand are still the major obstacles restricting membrane bioreactor (MBR) technology in wide applications. Air scouring has proved to be the most efficient technique to reduce membrane fouling in MBR operations, however, air scouring contributes to more than 60% of MBR's mean energy demand [1]. Improving the efficiency of air scouring can potentially reduce the capital and operating costs of a MBR plant significantly. This research focused on the optimisation of scouring air consumption of Memcor Dupont Water Solutions MemPulse® aeration system at a range of process conditions. Pilot and full-scale trials were carried out using standard Memcor® B40N modules with MemPulse® aeration device. Results showed up to 55% air scouring reduction for average fluxes (<25 LMH) and 15% reduction for flux greater than >30 LMH at 8000 -10000 mg/L MLSS concentrations.

Results from pilot trials and full-scale demonstration suggest that significant savings in scouring air consumption can be achieved by revising airflows and fine tuning the correspondent operating fluxes. Full-scale validation of average flux concluded that proposed lower airflows can be successfully applied in full scale MBR systems.

Long-Term Operation Of Pilot NF-MBR System For High Recovery In Water Reclamation

Tzyy Haur Chong, Huijuan Xu, Seonki Lee, Xin Li, Emile R. Cornelissen, Bing Wu. Nanyang Technological University (Singapore)

A pilot NF-MBR system was developed to achieve high recovery in water reclamation. The results showed that the pilot NF-MBR achieved excellent treatment efficiency and good stability for a long-term operation (~192 days). The pilot NF-MBR achieved superior permeate quality with TOC < 2 mg/L due to good rejection properties of the scaled up 4" NF membrane modules. And the salt accumulation observed in the NF-MBR did not have negative impact on the biological removal efficiency. Furthermore, operating conditions were optimized to increase NF recovery rate and mitigate membrane fouling. It was found that long-term stable operation of the pilot NF-MBR could be achieved at CFV ~0.04 m/s, over 40% NF recovery rate. Periodic backwash was helpful to control NF membrane fouling. However, the irreversible fouling would increase gradually, which mainly caused by organic cake layer and calcium phosphate on NF membrane surface.

Session 3.3 – Membrane Aerated Biofilm Reactor (MABR)
19 April 2022 (Tuesday)
1400 – 1530 hours

Session Co-Chairs: Andrew Shaw, Black & Veatch (United States), Ng Wun Jern, Nanyang Technological University (Singapore)

Overview On Membrane Aerated Biofilm Reactor (MABR)

Robert Nerenberg. University of Notre Dame (United States)

Presenter is an invited speaker. No executive summary is available

Three Years Of MABR Operation At The Ejby Mølle WRRF

Nerea Uri Carreno, Per H. Nielsen, Tim Constantine. VCS Denmark (Denmark)

Two MABR tanks with one MABR unit each have been operated at the Ejby Mølle WRRF for three years. The MABRs are fed with mixed liquor from the anaerobic zones of the EBPR-based bioreactor and are operated as CSTRs. The reactors were able to perform simultaneous nitrification-denitrification throughout the whole study period, achieving NOx concentrations of < 3 g N m-3. Out the outset of the trials, the highly reduced conditions of the anaerobic zone feed, as evidenced by very low ORPs) negatively impacted nitrification performance, but modifications allowing for increased ORPs in the MABR tanks resulted in increased nitrification rates to an average of 1 g N m-2 d-1. The increased oxygen transfer efficiency obtained resulted in potential energy savings of up to 75% compared to the existing aeration at the Ejby Mølle WRRF.

High-Rate Ammonia Removal Using A Full-Scale Spirally Wound MABR

Lotan Dagai, Yuval Nevo, Ronen Shechter, Neri Nathan, Lotan Dagai. Fluence (Israel)

A full scale MABR unit was installed in a wastewater treatment plant to treat part of the centrate coming from its thermophilic anaerobic sludge digesters. The goal of the treatment was to remove more than 90% of the ammonia load in the centrate stream, which accounts for about 20% of the ammonia load in the biological process. Results from first three months of operation show exceptionally high ammonia removal rates (ARR), partly attributed to shortcut nitrogen removal. Molecular microbiology analyses show an abundance in AOBs and scarcity in NOBs, indicating that shortcut nitrogen removal is taking place.

Accelerated Startup Of PN/A Biofilm In Zeenammoxtm Without Anammox Inoculation

Han Zhuang, Neil Hu. Suez Water Technologies & Solutions (Singapore)

ZeeNAMMOX forms a single partial nitritation and anammox (PN/A) biofilm on the platform of ZeeLung membrane aerated biofilm reactor (MABR), and has demonstrated high and stable deammonification rate at minimal energy cost. Data from pilots shows that ZeeNAMMOX can also be started in around 50 to 80 days without anommox inoculum and that the oxygen supply rate in the inlet air to ZeeNAMMOX is the key parameter that determines the startup period. Simulations suggests that the maximum specific growth rate of anammox is one of the most sensitive parameters for the simulation of the startup period. It should be noted that the maximum specific growth rate of anammox should be treated as a lumped growth rate under the pilot conditions. Since the maximum specific growth rate of anammox was reduced in order to match the startup period (by around 75% in Reactor 2), this might indicate that the growth conditions were still not ideal for the accumulation of anammox in the biofilm. Therefore, it can be concluded that the startup of ZeeNAMMOX can be accelerated by optimizing the growth conditions for anammox. Anammox bacteria is ubiquitous, including in the centrate from anaerobic digestion, which should be sufficient as the seed.

Session 3.4 – Advances In Anaerobic Digestion (I)
19 April 2022 (Tuesday)
1600 – 1730 hours

Session Co-Chairs: Katrik Chandran, Columbia University (United States), Tao Guihe, Public Utilities Board (Singapore)

From Digestion To Ultra-Digestion: A Screening Of All The Possibilities To Reach The Limits Of Sludge Carbon Conversion To Biogas

Matthieu Haddad, Huges Vanden Bossche. Suez (France)

Biogas production through sludge anaerobic digestion is the core process of the WWTP to produce energy and tend towards the overall net energy production of the plant. The ultra-digestion concept lies in implementing an ultra-treatment downstream conventional digestion to convert hardly biodegradable carbon into easily biodegradable for a second step of digestion. Pushing the biogas production from sludge to its limits, in other words, converting as much carbon from sludge into methane is the challenge of the ultra-digestion concept. From an extensive literature review to laboratory trials, several processes prove significant performances, up to 50% increase in biogas production, from CAPEX solutions such as thermal treatment and OPEX solution with enzyme addition.

Predictive Management Of Codigestion Using A Novel Bioelectrochemical Sensor

Sandeep Sathyamoorthy. Black And Veatch (United States)

Utilities are implementing co-digestion projects driven by the benefits associated with increased biogas production. However, there are challenges associated with managing feedstock composition variability, changing nutrient requirements, and complex feeding strategies. Our research evaluates a novel bioelectrochemical sensor to predict the performance of a codigestion system. Results suggest that a multivariate predictive regression model can be used to predict codigestion performance.

Effect Of Stepwise Reduction Of Solids Retention Time On The Microbial Community And Functional Pathways In Mesophilic Anaerobic Digestion Of Sludge

Angel Anika Cokro, Albert Ng, Soheil Ashgarineshat, Ezequiel Santillan, Krithika Arumugam, Rohan Williams, Stefan Wuertz. Singapore Center For Life Sciences Engineering (Singapore)

We investigated the effect of stepwise solids retention time (SRT) reduction from 30 and 25 d to 15 d on process performance, relative abundance, and potential functional pathways in four mesophilic anaerobic digesters treating wastewater sludge. Four reactors were divided into Groups 1 and 2 (n = 2 for each group) with an initial SRT of 30 and 25 d, respectively. Several archaeal taxa contained genes that were involved in pathways identified in KEGG as methanogenesis from precursors such as acetate and CO2. Reduction in the SRT had no effect on the relative abundances of archaea and bacteria in our samples, thus it was deduced that these pathways were not affected by the reduction. The observed average volatile solids (VS) removal in Cluster 1 was 46 ± 13 %, 52 ± 6 %, and 45 ± 6 %, while the average methane yield was 602 ± 212, 474 ± 137, and 502 ± 100 mL CH4/g-VS when the SRT was 30, 25, and 15 d, respectively. Hence, SRT reduction in the range used in this study did not negatively affect the digestion of sludge, nor was it a driver of community structure and functional potential using the assays chosen here.

Modelling Of Co-Digestion

Damien Batstone. University of Queensland (Australia)

Presenter is an invited speaker. No executive summary is available

Session 3.5 – Advances In Anaerobic Digestion (II)
20 April 2022 (Wednesday)
0900 – 1030 hours

Session Co-Chairs: Nerea Uri Carreno, VCS Denmark (Denmark), Hong Pei Ying, KAUST (Saudi Arabia)

Synergistic Enhancement Of Recalcitrant Organic Degradation By P. Chrysosporium And Fenton Reaction As A Pretreatment For Biogas Generation

Julian Van Der Made. Columbia University (United States)

The production of biogas from excess sludge is limited by the presence of lignin, which encases cellulose and hemicellulose making them unavailable for anaerobic digestion.In natural environments, white-rot fungi degrade lignin through enzymatic modification while leaving large portions of cellulose for downstream biogas production. However, traditional biological wastewater treatment relies on bacterial metabolism, largely overlooking the metabolic capabilities of fungi. In addition to their lignin-degrading capacity, these fungal enzymes are inherently non-specific and can be leveraged to degrade diverse persistent organic contaminants. To date, difficulties in maintaining fungal biomass and lignolytic enzyme production have hampered widespread adoption and integration of fungal metabolism in wastewater treatment systems. In this study we show that introducing Fenton chemistry into a system with white rot fungi enhances the degradation of organic compounds that are recalcitrant to bacterial transformation. Further, the Fenton-fungal process may also improve the stability of white-rot fungi in bioreactors through selective disinfection of competitive bacterial species.

Advanced Anaerobic Digestion With Thermal Hydrolysis Process In Xiaohongmen Water Reclamation Plant – Experience From Planning To Execution

Julien Chauzy, Zuliang Liao, Qiuyin Cheng, Yun Zhang, Di Deng, Chao Guo, Bao Zou, Tiejun Zhang. Cambi As (France)

Xiaohongmen Water Reclamation Plant (XHM) was upgraded and expanded for sludge treatment by Advanced Anaerobic Digestion (AAD) with Thermal Hydrolysis Process (THP). From planning and designing in 2010-2014, to installing and commissioning in 2015-2016 and operating since 2016, the XHM project has exemplified the procedure of how THP was integrated in an existing plant for improving both capacity and performance of sludge anaerobic digestion. The operating performances were deeply analyzed. The AAD with THP has contributed to the carbon footprint reduction in line with Carbon Neutrality Plan in Beijing Drainage Group. Further optimization is also indicated.

Mitigation Of Inhibitory Effect Of THP-AD Centrate On Partial Nitrification And Anammox: Insights Into Ozone Pretreatment

Yan Zhou. Nanyang Technological University (Singapore)

The anaerobic digestion centrate produced from thermal hydrolysis pretreated sludge (THP-AD centrate) has serious inhibitory effect on ammonium oxidizing bacteria (AOB) and anammox bacteria. This imposes a huge challenge to employ partial nitrification/anammox (PN/A) process to treat THP-AD centrate. This study, for the first time, presented an effective strategy, ozone pretreatment, to alleviate such inhibitory effect. The activities of AOB and anammox bacteria increased with the increased ozone dosage, and the color intensity of the effluent was reduced by 90% at 5.52 g O3/g COD. Long-term operation of a PN/A system further demonstrated the improved performance in term of nitrogen removal, organics degradation as well as sludge settleability and effluent solids content. The nitrogen removal rate (NRR) of 0.64 Kg N/m3/d was achieved in treating ozone pretreated THP-AD centrate (1.38 g O3/ g COD), which was 42.2% higher compared to treating untreated THP-AD centrate. Overall, this study provides a promising method to improve the PN/A performance and final effluent quality when treating organic-rich THP-AD centrate.

Beyond Heat Exchangers: A Novel Approach To Cooling And Heat Recovery

Mathieu Haddad, Troels Hilstrom, Valéry Geaugey, Adrien Belacel. Suez Treatment Infrastructure (France)

An innovative approach to sludge cooling and heat-recovery is presented and aims at erasing limitations inherent to the use of conventional Heat Exchangers. The innovation mainly targets thermophilic digestion, temperature-phased anaerobic digestion, either continuous (TPAD) or batch (2PAD), or anaerobic digestion placed downstream a pasteurisation unit. Cooling of sludge downstream the biological hydrolysis (BH) step is performed using a vacuum cooling (VC) step. Preheating of the raw sludge fed to the BH step is carried out by direct condensation of the steam produced in the VC step. Feasibility of the vacuum cooling step was demonstrated on a pilot unit installed at the Evry WWTP (France). Results demonstrated stable operation over the course of 4 months. Thermodynamic modelling of the heat recovery process was carried out using Aspen HYSYS® Dynamics. The process was modelled and fitted with the pilot plant data, which allowed predicting the performances of the industrial unit to be installed on the Okhla WWTP (New Delhi, India).

Session 3.6 – Process Intensification Through Novel Nitrogen Pathways
20 April 2022 (Wednesday)
1100 – 1230 hours

Session Co-Chairs: Ong Say Leong, National University of Singapore (Singapore), Zhou Yan, Nanyang Technological University (Singapore)

Overview On Shortcut Nitrogen Pathways

Kartik Chandran. Columbia University (Unites States)

Presenter is an invited speaker. No executive summary is available

Microbial Advanced Oxidation – Intensifying SND Using H2O2 As Oxidating Agent

Liron Friedman. Columbia University (United States)

Soil infiltration is a common practice to reclaim treated wastewater for reuse. Nevertheless, infiltration is limited by large area and oxygen availability. Intensification of the removal of organic matter in soil systems was previously presented using H2O2 as an oxygen vector.

This study characterizes the intensification of the removal of contaminants from secondary effluent by H2O2 addition. Chemical and microbial analysis along the depth of soil columns and measurements of oxygen uptake (OUR) and introduction rates allowed to evaluate the bio-kinetics of the process. After 10 cm, higher removal of COD (23±0.25%), ammonia (31±3%), nitrogen (13±0.1%) and Sulfate (17±0.5%) was obtained H2O2.

reflecting a competition for oxygen and NOx within the microbial community. For the whole process, was obtained when H2O2 was added, indicating simultaneous intensification and denitrification and sulfur reduction.

Phosphorus Footprinting

Andrew Shaw. Black & Veatch (United States)

Presenter is an invited speaker. No executive summary is available

Full Scale Optimization of a Side Stream Enhanced Biological Phosphorus Removal System

Keith Sears, Beverley Stinson, Gerry Stevens. Aecom (United States)

In 2019, the Water Research Foundation (WRF) published the report "Optimization and Design of a Side-Stream EBPR (S2EPR) Process as a Sustainable Approach for Achieving Stable and Efficient Phosphorus Removal U1RI3/4869." This paper builds on the recommendations of the WRF study, and presents findings from a 12-month optimization study of a full-scale Westbank process located in British Columbia, Canada. The findings present a theory for building and maintaining a significant population of Tetrasphaera, a key microbe needed for stable phosphorus removal.

Enhanced Biological Phosphorus Removal

Guihe Tao. Public Utilities Board (Singapore)

Presenter is an invited speaker. No executive summary is available

Session 3.7 – Phosphorous Removal
20 April 2022 (Wednesday)
1330 – 1500 hours

Session Co-Chairs: Kartik Chandran, Columbia University (United States) Jason Ren, Princeton University (United States)

Electroreforming of Waste Activated Sludge with Green Hydrogen Generation

Hu Zhao, Chenchen Li, Li Quan Lee, Dan Lu, Hong Li, Yan Zhou. Nanyang Technological University (Singapore)

Huge amount of waste activated sludge (WAS) is generated in wastewater treatment plants nowadays. Conventional anaerobic digestion process is time-consuming due to the complicated microbial structure, with nonnegligible waste residue and emission of green hydrogen gases. As an alternative, a novel hybrid electrochemical method was developed herein to valorize WAS to value-added chemicals with simultaneous green hydrogen generation. Specifically, polysaccharides and humic substances were thoroughly decomposed and selectively converted into small organic acids (dominantly acetic acid), while protein matters and nutrient components (i.e., nitrogen and phosphorus) were retained and recovered. Importantly, the heavy metals were almost completely removed. Importantly, the developed electroreforming method can be directly driven by renewable energy, such as solar energy, due to the great suppression of oxygen evolution. Our work paves a sustainable way for WAS upcycling and green hydrogen generation.

Energy and carbon offsetting through ammonium recovery: an essential step towards carbon neutral municipal wastewater reclamation

Xiaoyuan Zhang, Yu Liu. Nanyang Technological University (Singapore)

Recently with the fast evolving global climate change, carbon-neutral municipal wastewater reclamation has been put on an urgent agenda in more and more counties. This article argues that energy and carbon offsetting through ammonium recovery will be a game changer towards the carbon neutral municipal wastewater reclamation, according to which an innovative anaerobic membrane bioreactor (AnMBR)-biochar adsorption-RO process was further developed. It was shown that direct energy recovery from municipal wastewater (i.e. 0.36 kWh/m3) could be realized in AnMBR without the generation of waste sludge, but it was not sufficient to cover the total energy consumption associated with AnMBR and RO. However, in the proposed process, the ammonium in AnMBR permeate could be totally recovered through biochar adsorption, while offsetting 0.503 kWh/m3 of electricity originally required for chemical synthesis of ammonium via the Haber-Bosch method. Moreover, after removal of major divalent ions by biochar, the RO-associated energy consumption would also be reduced accordingly. With the energy and carbon offsetting through ammonia recovery, a net carbon emission in the proposed process was estimated as -4 g CO_2e/m3. Consequently, it appears that energy and carbon offsetting via ammonium recovery was a game-changer towards the carbon-neutral operation.

Sterling Natural Resource Center: Making Every Source a Resource

John Mura, Jeff L. Noelte, Kelly Malloy, Andrew Benedek, Peter Tymkiw, Ashok Dhingra. East Valley Water District (United States)

In 2019, the Water Research Foundation (WRF) published the report “Optimization and Design of a Side-Stream EBPR (S2EPR) Process as a Sustainable Approach for Achieving Stable and Efficient Phosphorus Removal U1RI3/4869.” This paper builds on the recommendations of the WRF study, and presents findings from a 12-month optimization study of a full-scale Westbank process located in British Columbia, Canada. The findings present a theory for building and maintaining a significant population of Tetrasphaera, a key microbe needed for stable phosphorus removal.

Enhanced Biological Phosphorus Removal

Guihe Tao. Public Utilities Board (Singapore)

Presenter is an invited speaker. No executive summary is available

Session 3.8 – Conveyance - Modelling And Digital Solutions
19 April 2022 (Tuesday)
0900 – 1030 hours

Session Co-Chairs: Susan Moisio, Jacobs (United States), Fahad Ahmed Al Awadhi, Dubai Municipality (UAE)

Future City Flow – Online Value-Based Decision Support For Optimized Real Time Forecast And Control Of Sewerage Systems.

Dennis Jursic Wanninger. DHI Sverige AB (Sweden)

The emerging challenges facing the local municipality – City of Gold Coast (CoGG) – include the impacts of a variable climate, rapid growth and urbanization, the provision of infrastructure, some of which is approaching the end of its serviceable life and changing community values and customer expectations. The challenges facing Water and Waste include the expansion of services to support rapid growth, the ability to be 'on the front foot' with community expectations for the uninterrupted provision of services and the prevention of environmental harm to natural landscape, waterways and beaches. Future City Flow provides an opportunity to address many of the challenges in terms of improved sewerage real-time performance and predictability in the face of storms, improved digital-twin visualization of the networks for operators, greater responsiveness to the customer interface in the event of any atypical and non-conforming system performances and contributing to the breaking-down of organizational silos.

Effect Of Rainfall Characteristics On The Sewer Sediment, Hydrograph And Pollutant Discharge Of Combined Sewer Overflow

Dawei Yu, Yonglong Hai, Mark Randall, Yuansong Wei. Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences (China)

Significant management needs raised in urban sewer system to facilitate urban resilience to rainstorm. The work investigated the effects of temporal evolution of rainfall on hydrograph and pollutant discharge of CSO over an intensive observation period of 12 months, with special attention to differences in temporal scale for supporting management decision making. The characteristics of rainfall in different temporal scales helped overflow-risk identification and assessment. Prolonged dry seasons over 112 days in the CSO monitored year 2018 increased the sediment buildup in the pipes. The accumulated sediment was flushed out to overflow (and the treatment facility) by one rainfall event during 47 hours. Following CSO hydraulics and pollutant discharge follow peak-sustain patterns that are similar to short-duration heavy rainfalls and could lasted 12 hours more. Results of Redundancy analysis and network analysis showed that the combined effects of rainfall, urbanization, and sediments as "CSO troika" are the driving forces for CSO pollutants in the long-term. The improved characterization of CSO events and the associated pollutants has refined our understanding of how overflow hydrograph and pollutant discharge responds to rainfall temporally, which methodology supported decision making in the combining source/process control with terminal management for facilizing urban resilience.

Smart Monitoring And Communications Using Wastewater And Storm Water Infrastructure For Cities Of The Future

Samuel Shelley, Paul Dickenson, Louise Keogh, Simon Tait, Kirill Horoshenkov. NURON LIMITED (United Kingdom)

Continuous fiber monitoring systems provide an efficient and effective method for monitoring the entirety of the wastewater network while deploying additional fiber for communications. The acquisition of real time dense data allows for the creation of a real time digital twin enabling proactive management of wastewater and stormwater networks. This unlocks the full potential of smart cities. Results are shown for the measured flow rate from a sensor installed in a live sewer over the course of a day. Normal flow can be seen during the day followed by a heavy rainfall event. Such a system can also be used to monitor blockage formation, infiltration and security events.

Session 3.9 – Corrosion In Conveyance Systems
19 April 2022 (Tuesday)
1100 – 1230 hours

Session Co-Chairs: Richard Lewis, Tideway (United Kingdom), Co-Chair 2 TBC

Comparison Of Corrosion Resistance Of One-Part Geopolymer And Calcium Aluminate Cement Mortar Exposed To Live Aggressive Sewer Environment

Marjorie Valix. School of Chemical and Biomolecular Engineering, The University of Sydney (Australia)

The corrosive impact of sewer microbiome in concrete sewer infrastructure are mitigated by protective coatings. This study compared and evaluated the corrosion-resistance performance of three OGPm (one-part geopolymer mortar) with a 100% CACm (calcium aluminate mortar) in a highly aggressive live sewer (129 ppm H2S) for up to 359 days. The performance was established from the depth of corrosion and residual compressive strength. Microstructural analyses of the corroded mortars were performed using FTIR, TGA, and Xray-microanalysis by SEM-EDS. Mortar corrosion resistance was found to depend on the cement microstructure (composition and types of hydrates), alkalinity and exposure conditions. The OGPm performance was found to be specifically impacted by the quantity of C-S-H and Al substituted C-S-H hydrates in the cement paste. CACm overall perform better compared to OGPm, however OGPm with controlled C-(N),(A)-S-H hydrates concentration could provide comparable performance to CACm within the 359 days study.

H2S Corrosion Protection Of Wastewater Concrete Assets: Technical Performance And Environmental Benefits Of A Thin Calcium Aluminate Mineral Solution

Francois Saucier. Imerys (France)

H2S Biogenic Corrosion of wastewater assets is a growing concern for Wastewater Authorities around the world. While Ordinary Portland Cement concrete is an unescapable choice to build wastewater assets, it can be rapidly corroded by the bacterial activity transforming H2S into sulfuric acid. The use of polymer protection linings – like epoxy resin lining – is too often failing prematurely, driving owners to seek for more durable solutions. A thin mineral lining based on calcium aluminate has been evaluated from 2 angles: 1) its H2S corrosion resistance, through accelerated biogenic corrosion tests; 2) its environmental performance, through a complete life-cycle-analysis comparing the overall environmental footprint of a thin mineral protection liner to a classical epoxy protection liner. The results are showing that not only calcium aluminates provide a very durable protection but it do so with a lower impact for the environment over the life of a wastewater asset.

Evaluation Of Adhesion Of Cement Based Protective Mortars Overlayed On Corroded Concrete Host

Ye Jun In, Cherdphong Seedao, James Gardner, Marjorie Valix. The University of Sydney (Australia)

Adhesion in addition to the corrosion resistance are features of protective coatings that have a significant bearing on the overall durability of the protective system. Practical guidelines to promote the adhesion of cement-based coating on corroded host structures is currently scarce. To address this gap this study examined the bond strength of calcium aluminate and geopolymers based mortars and surface repair materials on corroded concrete host. This was undertaken through a series of laboratory and field tests to evaluate the effect of surface preparation of various host that have been in service for 18-81 years under various corrosivity (1.6-155 ppm H_2S) and the microstructure of the host on the bond strength. Results show that adequate bond strength can be attained by overlaying cement mortars on corroded host, however suitable surface preparation can lead to premature failure of the coating through loss of adhesion.

Session 3.10 – Overflows, Tunneling And Climate Change
19 April 2022 (Tuesday)
1400 – 1530 hours

Session Co-Chairs: Ganeshan Vallipuram, AECOM (Singapore), Co-Chair 2 TBC

Overflows And Impact Of Climate Change
Susan Moisio. Jacobs (United States)

Presenter is an invited speaker. No executive summary is available

Case Study On DTSS And Smart Sewer
Wong Kin Wee. Public Utilities Board (Singapore)

Presenter is an invited speaker. No executive summary is available

Case Study On DTSS And Smart Sewer
Veradej Phipatanasuphorn. DHI (Singapore)

Presenter is an invited speaker. No executive summary is available

Case Study On Tideway
Richard Lewis. Tideway (United Kingdom)

Presenter is an invited speaker. No executive summary is available

Cincinnati - a case study
Reese Johnson. MSDGC (United States)

Presenter is an invited speaker. No executive summary is available

Session 3.11 – Non-Municipal Wastewater Reuse
19 April 2022 (Tuesday)
1600 – 1730 hours

Session Co-Chairs: Nupur Bahadur, The Energy and Resources Institute (TERI), New Delhi (India), Kiran Kekre, Public Utilities Board (Singapore)

Advanced Treatment At The WWTP Wervershoof (NL): Pilot- And Demonstration-Scale Testing Combined With Digital Twins For Real-Time Prediction Of Key Variables, Including Micropollutants

Giacomo Bellandi, Roberta Muoio, Maaike Hoekstra, Miguel Daza, SImon Duchi, Martin Spruijt, Jeremy Versteegh, Usman Rehman, Wim Audenaert. AM-TEAM (Belgium)

This paper presents the first results of a digital twin for advanced wastewater treatment currently being established in the province of North-Holland in the Netherlands. The local water authority HHNK and drinking water company PWN work closely together to tackle the challenges of increasing water scarcity and trace organic contaminants (TrOCs). Using an integrated approach, experiences in wastewater treatment and with drinking water production are combined with today's digital opportunities. The ultimate goal is a digital twin that runs in real-time with four onsite advanced treatment trains for advanced monitoring and improved decision making. TrOCs, bromate formation and other key variables will be predicted in real-time. First model calibration and validation results based on bench-scale data look promising, showing the capabilities of the model to predict TrOC removal based on literature rate constants. More extensive model calibration and advanced 3D plant modelling are currently ongoing.

Wastewater Reuse For Agriculture – Smart Control Concepts

Achim Ried. Xylem Services Gmbh (Germany)

Water scarcity drives the need to rethink water management concepts. Because of climate change more and more regions worldwide do not have enough water available to fulfill the needs for agriculture. Therefor Germany set up a government funded program to develop flexible and sustainable concepts for water reuse in 2019. The project "FlexTreat" (BMBF funded) started in Feb 2021. The goal of the project is the development and demonstration of processes to fulfill the requirements in innovative water management concepts in agriculture.

Work package "Digital Green Tech" investigates in advanced monitoring and control concepts of the treatment train "Ozonation + Biological Filtration + UV". This includes the development of a digital twin of the real plant and the use of neural networks (AI). The development of smart "dashboards" will support the plant managers in operation and maintenance. In addition, the outcomes from the Artificial Intelligence will be used to generate so called "Virtual Sensors" for information which can´t be measured on-line directly.

The project will run over 3 years till Jan 2024. The installation of the real pilot treatment train was accomplished in September 2021. Till spring 2022 the project will deliver the first results of operation and digital twin.

Total Water Reuse For Industrial Food Plant And Increased Output Due To Operational Excellence

Rodrigo Haro. Nijhuis Saur Industries (Netherlands)

Installing water reuse technologies is a more and more accepted tool to increase the water life time at production sites and reduce the risk and impact of the upcoming water crisis. Utilising/valorising the maximal capacity of installed assets requires a next level of operational excellence by learning the interactions of different installed processes, associated data trending and actions to be taken. A latest project example of an advanced water reuse plant is in operation at a leading European meat processor. The wastewater treatment plant (WWTP) was gradually expanded with WWTP and anaerobic digestion (AD) technologies utilizing to the capacity expansion. Their challenges are increasing draught periods stressing the quality and quantity of their boreholes resulting in forced reducing in slaughterhouse capacity. To anticipate on this thread, they implemented a Sewage Treatment Effluent Reuse Facility of 4000 m3 per day of certified drinking water quality for process applications, all recovered from their industrial wastewater.

Validation Of High Recovery Water Treatment For Non-Potable Reuse Using An Integration Of Ion Exchange And Reverse Osmosis

Iswaran Sivan. Clean TeQ Water (Australia)

Water scarcity due to population growth, water pollution, and climate change is a growing global issue, and society depends on a continuous supply of clean water and water supply is vital for people, industries, and economies. Companies and Municipalities are pursing non-potable reuse more than ever to substitute precious potable water resources. Large brine volumes when desalinating brackish and saline feeds is a common issue, with evaporation ponds, brine pipelines, sending brine to sewer, and trucking brine offsite common disposal methods used. Precious water that is often lost with the brine from low recoveries is a wasted resource. This paper presents the results of recent piloting in Australia, new projects, and desktop studies of a high recovery water treatment solution which has proven recoveries >92-95% are possible for tertiary effluent wastewater, mine wastewater, industrial process water, and in the oil and gas industry, greatly reducing the volume of brine produced. The reduction in brine volume achieved provides a minimum liquid discharge solution for non-potable reuse, making non-potable reuse a viable option for constrained sites, reducing the cost of brine management, and providing higher volumes of treated water for reuse.

Session 3.12 – Resource Recovery
20 April 2022 (Wednesday)
0900 – 1030 hours

Session Co-Chairs: Kartik Chandran, Columbia University (United States), Jason Ren, Princeton University (United States)

Electroreforming Of Waste Activated Sludge With Green Hydrogen Generation

Hu Zhao, Hong Li, Chenchen Li, Li Quan Lee, Dan Lu, Yan Zhou, Nanyong Technological University (Singapore)

Huge amount of waste activated sludge (WAS) is generated in wastewater treatment plants nowadays. Conventional anaerobic digestion process is time-consuming due to the complicated microbial structure, with nonnegligible waste residue and emission of green hydrogen gases. As an alternative, a novel hybrid electrochemical method was developed herein to valorize WAS to value-added chemicals with simultaneous green hydrogen generation. Specifically, polysaccharides and humic substances were thoroughly decomposed and selectively converted into small organic acids (dominantly acetic acid), while protein matters and nutrient components (i.e., nitrogen and phosphorus) were retained and recovered. Importantly, the heavy metals were almost completely removed. Importantly, the developed electroreforming method can be directly driven by renewable energy, such as solar energy, due to the great suppression of oxygen evolution. Our work paves a sustainable way for WAS upcycling and green hydrogen generation.

Energy And Carbon Offsetting Through Ammonium Recovery: An Essential Step Towards Carbon Neutral Municipal Wastewater Reclamation

Xiaoyuan Zhang, Yu Liu, Nanyang Technological University (Singapore)

Recently with the fast evolving global climate change, carbon-neutral municipal wastewater reclamation has been put on an urgent agenda in more and more counties. This article argues that energy and carbon offsetting through ammonium recovery will be a game changer towards the carbon neutral municipal wastewater reclamation, according to which an innovative anaerobic membrane bioreactor (AnMBR)-biochar adsorption-RO process was further developed. It was shown that direct energy recovery from municipal wastewater (i.e. 0.36 kWh/m3) could be realized in AnMBR without the generation of waste sludge, but it was not sufficient to cover the total energy consumption associated with AnMBR and RO. However, in the proposed process, the ammonium in AnMBR permeate could be totally recovered through biochar adsorption, while offsetting 0.503 kWh/m3 of electricity originally required for chemical synthesis of ammonium via the Haber-Bosch method. Moreover, after removal of major divalent ions by biochar, the RO-associated energy consumption would also be reduced accordingly. With the energy and carbon offsetting through ammonia recovery, a net carbon emission in the proposed process was estimated as -4 g CO_2e/m3. Consequently, it appears that energy and carbon offsetting via ammonium recovery was a game-changer towards the carbon-neutral operation.

Sterling Natural Resource Center: Making Every Source A Resource

John Mura, Jeff L. Noelte, Kelly Malloy, Andrew Benedek, Peter Tymkiw, Ashok Dhingra, East Valley Water District (United States)

East Valley Water District's Sterling Natural Resource Center (SNRC) demonstrates that sustainable wastewater treatment facilities can serve as a nexus for making every source a resource. Traditionally, wastewater treatment providers have operated with a clear focus on a strict organizational mission. As the SNRC proves, they can serve as the link for water, energy, waste, economic development, and community fostering. The SNRC effluent is used to recharge the local groundwater aquifer where it can be stored for use in dry years. Furthermore, this advanced facility includes high strength anaerobic digesters to produce electricity from biosolids and local food waste. The electricity generated will be transferred to the community, benefitting the stressed statewide energy grid. The digested biosolids will be converted to compost to benefit agricultural soil management programs. The SNRC's unique vision encompasses creating a public center to benefit local residents by providing educational opportunities, community spaces, and neighborhood improvements. To establish a direct pathway to inspire future industry professional, the District established a partnership with local educational institutions. The District has embraced an innovative mindset resulting in measurable results that can be modeled, scaled and replicated by other organizations.

Advanced organic recovery from municipal wastewater with an enhanced magnetic separation (EMS) system: Pilot-scale verification

Conghui He, Kuo Fang, Kaijun Wang. Tsinghua University (China)

We proposed a pilot-scale enhanced magnetic separation (EMS) system as an up-concentration step to maximize energy recovery from municipal wastewater. The design of EMS was based on the hypothesis that magnetic-driven separation could be a breakthrough in separation speed, and adsorption could further enhance the separation efficiency by capturing soluble substances. Over one-year operation of a 300 m3/d EMS equipment provided optimum operation strategies and evidence of system effectiveness. More than 80% of particulate organics and 60% of soluble organics were removed within 10 minutes. The anaerobic experiments demonstrated the potential value of the concentrated products. The developed EMS system exhibited significant advantages in time consumption and space occupation.

Session 3.13 – Climate Change And Carbon Footprint Reduction
20 April 2022 (Wednesday)
1100 – 1230 hours

Session Co-Chairs: Kalanithy Vairavamoorthy, IWA (United Kingdom), Ng How Yong, National University of Singapore (Singapore)

Pathways to Water Sector Decarbonisation, Carbon Capture and Utilisation

Jason Ren. Princeton University (United States)

Presenter is an invited speaker. No executive summary is available

Coping With Climate Change At A Wastewater Treatment Works

Tony Koodie, Andy Shaw, Tak Chan, Sock-Hoon Koh, Sandeep Sathyamoorthy. Binnies (United Kingdom)

Rapid population growth in our cities and changing weather patterns because of climate change are placing increasing pressures on many urban wastewater treatment facilities globally while at the same time, we strive to meet tighter environmental standards. These changing dimensions are also challenging the traditional design approaches previously adopted for the design of new and upgrade of existing treatment facilities. The aim of this presentation will be to provide an appreciation of the impact that climate change has had on the design of wastewater treatment plants citing examples across the UK, USA, Australia and Asia. In addition, the presentation will highlight the potential risks and opportunities when designing wastewater treatment plants to accommodate the impact of climate change.

Advances In GHG Monitoring And Mitigation At The Ejby Mølle WRRF: Trace Gas Quantification, CH4 Capturing, And N2O Mitigation

Per H Nielsen, Nerea Uri Carreño, Nina Almind- Jørgensen. VCS Denmark (Denmark)

Many utilities worldwide aim to reduce their carbon footprint as governments and economies transition into de-carbonization. Greenhouse gases produced and emitted during the conveyance of wastewater in sewers and its posterior treatment at WRRFs are a threat to utilities' ambitions of carbon neutrality. Most of these emissions are in the form of methane and nitrous oxide. Some of the magnitude and mechanisms behind these emissions are becoming well understood, while some remain largely unknown. VCS Denmark, together with other leading utilities in Denmark, SDU, and DTU, is working towards better monitoring and mitigation of these emissions. The main current efforts include: whole-plant monitoring of GHG, including emissions from sewers, degassing of digested sludge and energy production with the captured CH4, and N2O mitigation strategies, including emissions from nitrifying trickling filters.

Precise And Energy Efficient Aeration Control – Reduction Of Carbon Footprint And Cost Saving Using Load-Depending Process Control

Heiko Hermann, Kristina Becker, Robert Binder. Binder Gmbh (Germany)

In a wastewater treatment plant, aeration process is the largest energy consumer, greatest energy saving opportunities arise in this area. A load-dependent DO-control in combination with a sliding pressure control can be achieved with an intelligent advanced aeration controller only, to ensure that this can be done without endangering the biological process. Years of field studies and installations have shown that even minimal reductions in pressure and oxygen save enormous amounts of air and thus energy. Beside this, due to improved denitrification less chemicals must be used. This leads to high savings in OPEX, an improved energy efficiency of operation and reduced CO2 emissions.

Session 3.14 – Next Generation Of Intelligent Plant
20 April 2022 (Wednesday)
1330 – 1500 hours

Session Co-Chairs: Mads Leth, VCS Denmark (Denmark), Kelvin Koh, Public Utilities Board (Singapore)

International Advanced Analytics Research Collaborative – Operating a Full Advanced Treatment Demonstration Project Using AI

Kevin Hardy. National Water Research Institute (United States)

Presenter is an invited speaker. No executive summary is available

Digital Twin For Advanced Process Control And Analytics At PUB IVP

Otto Loke, Liyun Tai, Daniel Marten van Es, Emma Weisbord, Kian Ming Phua, Jiawei Ng, Kelvin Koh, Wei Jun Chang, Guihe Tao. Royal HaskoningDHV (Netherlands)

The water sector is facing compounding and growing challenges in combination with increasingly complex infrastructure and higher effluent quality requirements. Simultaneous digital transformation provides opportunities and technologies to deal with these key challenges. One example is the application of a data-driven predictive digital twin including artificial intelligence techniques. Such a digital twin has been developed and piloted for the Integrated Validation Plant (IVP) of PUB, Singapore's National Water Agency. The digital twin consists of an on-premise predictive control solution and a cloud-based advanced analytics environment. The predictive control applies self-learning forecast algorithms and machine learning relationships to determine setpoints. Operational results show stable operation and effluent quality and that an aeration reduction up to ≈15% can be achieved. The advanced analytics applies artificial neural network modelling (ANN) for early detection of different anomalies. Preliminary results show the ability of early autodetection of process, instrument, and equipment events.

Digital Twin Development Implementation, And Results For The Changi WRP, Singapore

Bruce Johnson, Raja Kadiyala, Garrett Owens, Colin Newbery, Aayush Saxena, Jack Greene. Jacobs (United States)

The whole plant digital twin of the Changi WRP is currently envisioned as an advisory tool without direct control capabilities, that can grow into control functions as staff gains confidence in the tool. It has automated data inputs directly from both the SCADA system and the laboratory information management (LIMs) system. There are three primary functionalities of the digital twin. First, comparison between model predictions and measured data can be used to highlight areas which require particular attention by operators and maintenance staff, thus minimizing their efforts. The second use of the calibrated model includes automated evaluation of various operational scenarios, both operator defined, and fixed. Lastly, the auto-calibrated model can be used to predict the likelihood of future events at the wastewater facility up to 5 days in the future that operations can use to help proactively operate the facility.

Digital Twin Of Water Resource Recovery Facilities – From Concept To Implementation

Fabio Polesel, Remigi Ulisse Remigi, Mads Hoffmann Bech Merrild, Lars Haslev Drejer, Henrik Sørensen, Trine Dalkvist, Jiandong Liu. Dhi A/s (Denmark)

Traditional modelling of biological, chemical and physical processes in Water Resources Recovery Facilities are now being combined with on-line sensor data, automated data validation and process

modelling hence transforming traditional modelling into a real-time operational decision support context. This abstract presents a concept for real-time decision support including a Digital Twin which is currently being implemented and tested on a facility driven by Aarhus Water, Denmark. Real Time decision support systems embedding Digital Twins have large potential and can often contribute significantly to reduction of operational costs, energy neutrality, carbon footprint while maintaining regulatory effluent requirements.

Session 3.15 – Integrated Approach In Removing Emerging Contaminants
20 April 2022 (Wednesday)
1330 – 1500 hours

Session Co-Chairs: He Jianzhong, National University of Singapore (Singapore), Co-Chair 2 TBC

Integration Of TADOX® Technology For Enhancing Water Reuse And Augmenting Capacity Of Stps – Case Study From India

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

This pilot study aims at treating wastewater from Sewage Treatment Plant (STP) in two ways using TERI Advanced Oxidation Technology called TADOX®; (I) Outlet (STP-OUT) i.e. current biologically treated water is further treated using TADOX® (II) Inlet (STP-IN) i.e. inlet is directly treated using TADOX®, bypassing any kind of bioremediation. %Change in color, BOD, COD, NO3-N, PO3-P, Total coliform bacteria and E. Coli (in MPN/ 100ml) in STP-OUT were 4.5, 70, 67, 22.5, 70, 406 and 206; whereas in STP-IN, were 88, 97, 94, 89, 80, 6 and 3, respectively. % Removal of Micro-pollutants like Diazinon, Caffeine, Acetaminophen, Ibuprofen, Diclofenac, and Naproxen in STP-OUT were 55.5, 49, 20, 29, 83, 55; whereas in STP-IN, 87, 100, 93, 60, 100, 40, respectively. Thus TADOX® treatment led to high quality water for reuse. Bypassing biological treatment and reducing HRT to 3-5 h could enhance treatment capacity and augment existing infrastructure in developing countries.

Integrated Approach For The Treatment Of Pharmaceutical Industry Wastewater

Pankaj Patil, SVN Vamsi, Monica Sharma, Nivarutti Patil. SUEZ Water Technologies & Solutions (India)

The pharmaceutical industry has been growing rapidly in recent decades resulting in large volumes of wastewater being generated. Concerning the method of production/formulation, characteristics of wastewater vary significantly. The generalized treatment method cannot be applicable for all kinds of effluents due to the variation in quality. This brings the necessity of evaluating the best possible treatment flowsheet for the typical effluent. The present paper focuses on providing an integrated approach for the treatment solution to overcome the challenges in these types of wastewaters. Treatment methods like physio chemical (coagulants/flocculants), advanced oxidation processes (Fenton, ozone, hydrogen peroxide), biological oxidation, membrane filtration and the minimal/zero-liquid discharge (MLD/ZLD) studies are done on the different types of effluents received from pharmaceutical industries across Asia Pacific regions. Depending upon the effluent characteristics, experiments were performed to get the best possible solution in order to meet the target treated water quality.

Removing Pharmaceutical Compounds At The Source And Centralised To Reuse Wastewater Effluent For Irrigation Purposes

Yue Mei He, Eddie Broeders, Nadine Boelee, Annemarie Kramer-Hoenderbroom, Kaspar Groot Kormelinck, Clare Thege. Nijhuis Saur Industries (Netherlands)

Water security and resilience are becoming more challenging with climate change and population growth. Water reuse is becoming an important need to existing water supplies. Besides the additional need for water quality improvement, the reuse of wastewater effluent is required more often. While most of the domestic WWTP's can effectively remove nutrients, no disinfection takes place and most pharmaceutical compounds are not degraded. In this research a system was first tested as decentralised pre-treatment to remove pharmaceuticals in two process steps; a filtration step and an advanced oxidation process (AOP) consisting of ozonation and UV. The pilot treating 0.5 – 1 m3/h was tested at the Streekziekenhuis Koningin Beatrix (SKB) hospital in Winterswijk, the Netherlands. For the second part, the pilot was tested as an centralised effluent polishing technology at the municipal wastewater treatment plant (WWTP) Winterswijk, the Netherlands. The removal of 59 pharmaceuticals and the disinfection of E.coli were determined.

Photoelectrochemical Activation Of Chloride In Sewage To Simultaneously Degrade Ppcps, Disinfect E. Coli, And Produce H2 By A Mos2@BL-Bivo4 Photoanode

Zexiao Zheng. The Hong Kong University of Science and Technology (Hong Kong SAR)

Pharmaceuticals and personal care products (PPCPs) and escherichia coli (E. coli) are ubiquitous in sewage posing adverse threats on ecosystems and human health. Herein, we have developed a multifunctional photoelectrochemical (PEC) system for simultaneous PPCPs degradation, E. coli disinfection, and H2 evolution via in situ activation of chloride ions in sewage. To this end, we have synthesized MoS2@BL-BiVO4 photoanode with high PEC performance via strategies of reducing bulk and surface recombination. 2 ppm benzophenone-3 and the E. coli in real sewage can be completely removed by the PEC system using MoS2@BL-BiVO4 photoanode in 30 minutes at 1.0 V vs. Ag/AgCl under visible light illumination, simultaneously, 89.32 μmol H2 was produced as the by-product. The mechanism study revealed that chloride ions in sewage were activated to be chloride-based radicals (•Cl, •ClO) for sewage treatment. This study provides a novel strategy for sewage treatment coupled with renewable energy generation.

Theme 4: Cities of the Future

Session 4.1 – Digital Technology For Remote Sensing And Real Time Control
19 April 2022 (Tuesday)
0900 – 1030 hours

Session Co-Chairs: Xavier Litrico, SUEZ (France), Tony Wong, CRC for Water Sensitive Cities, Monash University (Australia)

Presentation Title To Be Confirmed

Samuel Loyson. Suez (France)

Presenter is an invited speaker. No executive summary is available

Water Monitoring For Climate Resiliency - City of Miami Beach, Florida, USA Case Study

Adam Hobson. In-Situ (United States)

The City of Miami Beach, Florida, USA, is built on a barrier island and is therefore increasingly vulnerable to coastal inundation from high-tide flooding, storm surges, and heavy rainfall induced by sea level rise and extreme weather. In response, the city is building resiliency and reducing the risk of impacts from flooding using a variety of methods including improvements to infrastructure based on continuous data collection. The city is assessing flooding hazard through telemetry-enabled water quality and level instrumentation installed in over 42 stations to monitor changing groundwater levels, saltwater intrusion, and coastal water quality. Access to near-real time data allows the City to efficiently make decisions regarding building requirements and infrastructure needs, alert citizens to hazardous conditions, and study long-term trends without the demands and risks of manual data collection and visualization.

Real-Time Flood Forecasting System For Stormwater Management

Tatsuya Tobe, Masanobu Tominaga, Takashi Miyabe, Yuji Asada, Sune Lee. Nihon Suido Consultants Co., Ltd. (Singapore)

The Real-time Flood Forecasting System enables a preventive stormwater management in urban area through the weather radar, IoT monitoring system and AI based model (Deep Learning). The rainfall is monitored and forecasted with high accuracy and resolution by the X-band Multi Parameter (X-band MP) weather radar. The water level is monitored through the Smart Manhole Cover integrated with a water level sensor, battery and IoT gateway installed inside drainage manholes. The AI based model is applied to forecast the water level and flooded area in a real-time using forecasted rainfall data. The system can inform a flood risk in advance to local government officials involved in disaster response and make flood control activities more effective and preventive.

Delivering Smart Flood Management In Bangkok

Sharla McGavock, Fiona Barbour, Ismail Weiliang Osman. Mott Macdonald (Singapore)

Mott MacDonald has developed a pilot Flood Management Decision Support System (DSS) in Bangkok. The DSS improves Bangkok Metropolitan Administration's (BMA's) capacity to manage and respond to stormwater flooding through asset optimisation and digital innovation. The DSS integrates world-class rainfall estimates, gauge data, and rainfall and flooding predictions supporting effective stormwater flood management. Rainfall radar observations significantly improved through installation of new masts, facilitating automatic generation of accurate near real-time rainfall maps and operational rainfall forecasting. Machine learning is applied to a hydraulic flood model to

produce a ground-breaking stormwater flood forecasting system which converts rainfall forecasts to flood maps in seconds. Stormwater flood forecasting was successfully demonstrated in a tropical climate, where intense convective rainfall presents significant prediction challenges. The DSS is delivered in Mott MacDonald's digital twin platform, Moata Smart Water, providing a central, easily accessible, and visual platform with in-built early warning alarms to inform operational response.

Session 4.2 – Digital Twins For Water Quality Management
19 April 2022 (Tuesday)
1100 – 1230 hours

Session Co-Chairs: Xavier Litrico, SUEZ (France), Co-Chair 2 TBC

Development Of An Online Receiving Environment Digital Twin To Enhance Liveability Outcomes

Justin Hanson. DHI (Australia)

Urban Utilities and DHI are developing a "Receiving Environment Digital Twin (REDiT)" of waterways in South-east Queensland to support investment decisions to improve environmental condition and associated liveability outcomes for local communities. REDiT is an online environmental Decision Support System that assists Urban Utilities and their stakeholders with effects-based planning to accurately determine environmental footprints, collaboratively assess the impact of urban development/infrastructure planning scenarios and forecast water quality in the receiving environment and associated risks. The interactive and data rich visualisation and analysis of model results provided by the system facilitates in decision making and communication with regulators and community stakeholders.

Digital Solutions, Empowered With Machine Learning Methods, To Optimize Water Quality Management In Singapore Catchments

Cui Chun. Suez (Singapore)

In Singapore, reservoirs essentially serve as raw water sources for drinking water. To monitor the water quality of reservoirs, PUB has deployed online sensors at various strategic locations besides traditional method of grab sampling. Furthermore, PUB engaged Suez in developing an integrated real-time monitoring and decision support system, Catchment and Waterways Operations System (CWOS) to utilize the collected data more efficiently. CWOS has multiple critical data processing capabilities, such as data cleaning, data visualization and real-time alert of data against guidelines. On top of that, the system has been built with the aim of enabling operations team to trace and identify potential pollution sources. To maximize system capability, PUB developed an enhancement plan utilizing machine learning technique. With this enhancement, the system would be able to forecast water quality events and generate early warnings

Spatial Analysis And Planning System To Determine The Impact Of Urbanisation On Freshwater Quality

Kalyan Chakravarthy. DHI Water & Environment (New Zealand)

Development of effective plans for stormwater quality management to mitigate the degradation of freshwater quality in urban catchments demands an explicit understanding of the catchment both spatially and temporally. This includes "identification" of critical source areas for pollutant load reduction, "prioritization" based on contaminant influence on in-stream ecological health, and "mitigation" through optimal measures. To address these three major aspects of stormwater quality management, we developed an online geospatial decision support system called "MEDUSA Online: Contaminant Loading On Demand". The integrated system enables the identification and prioritization of critical source areas for pollutant reduction, and facilitates mitigation measures for optimal siting of LID measures in urban catchments. The web-based system is accessible to a wide range of users – including Regional Council, City Council, District Council, Consultants, Infrastructure developers, and Property owners.

Smart Monitoring Of Surface Water Quality Using Internet-Of-Things At Sembakkam Lake, Chennai

Nisha Priya Mani, Kamal Das, Michael Jacobs, Ajay Ratnakar, Alpana Jain, Indumathi Manivannan Nambi, Jayshree Vencatesan, Emmanuel Varghese, Sagar R Mysorekar. The Nature Conservancy – India (India)

Urban wetlands provide multiple eco-system services including drought and flood mitigation benefits, that are crucial in times of present climate uncertainties. Conservation efforts in these wetlands including holistic restoration, regular monitoring and maintenance assume prime importance in long term management of these threatened natural resources aka green/ blue infrastructure. Technological advancements in earth observation and Internet of Things (IoT) offer a giant leap forward in real time monitoring and providing reliable actionable information to conservation planners. The current work at Sembakkam lake, in Chennai, India, attempts to generate evidence-based solutions for smart monitoring of water quality as a part of its restoration efforts and serve as a replicable model. Geospatial and earth observation data and tools were used to delineate the watershed and monitor the water quality for important water quality indicators such as cyanobacteria, turbidity and coloured dissolved organic matter. The work also involves the use of IoT based water quality sensors for real time monitoring of the wetland.

Session 4.3 – City Water Resilience
19 April 2022 (Tuesday)
1400 – 1530 hours

Session Co-Chairs: Mark Fletcher, Arup (United Kingdom), Katrin Bruebach, Resilient Cities Network (Germany)

The Emergency Actions For Centurial Drought In Taiwan

Wen Wen Liao, Chien-Hsin Lai, Chia-Heng Wu. Water Resources Agency, Ministry Of Economic Affairs (Taiwan)

From the second half of 2020 to the first half of 2021, it had suffered from a centurial severe drought in Taiwan. The challenge of water supply was the greatest in history. In order to reduce the impact on people's lives, Water Resources Agency (WRA) used multiple adjustment actions to enhance water resilience capabilities. Those actions include advance deployment through cross-domain organization division of labor, multiple dialogues and communication to establish social drought resistance awareness, strengthening economic resilience to reduce the impact of drought, and central and local governments' cooperation to improve water supply resilience. The contingency actions, e.g. detailed reservoir operating, daily water condition monitoring, cross-regional water supply dispatching, water-saving of agricultural and industrial uses, artificial rainfall enhancing, tap water decompression, and diversely developing emergency water sources those reached 1.66 million tons per day, had also been implemented to reduce the water supply from reservoirs effectively.

Urban Floods And Human Health Impacts

Ira Wardani, Bastien van Veen, Gertjan Geerling. Deltares / Radboud University (Netherlands)

The non-lethal health effects after (yearly) floods are manifold and have a high burden on the affected population. In this study we listed the kind of health effects occurring after floods in Indonesia, and secondly, we statistically confirmed relations between reported floods and reported cases of dengue haemorrhagic fever, diarrhoea, and leptospirosis and reported floods for sub-districts in Jakarta. The advice is to integrate health impacts and health related measures in flood management planning, effectively co-manage floods and health. Which calls for more understanding and cooperation between health oriented and water management-oriented stakeholders.

Building A Climate Resilience Strategy For Lower Manhattan: Extending The Shoreline

Roni M Deitz, Elijah Hutchinson, John Batten. Arcadis (United States)

For over 400 years, the historic identity of New York City has been rooted in Lower Manhattan. In October 2012, Hurricane Sandy hit New York City and exposed Lower Manhattan's vulnerabilities to climate change.

To reduce both acute and chronic 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. 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 via land reclamation) to implement a comprehensive flood risk reduction strategy while maintaining public access to the waterfront and critical maritime functions that serve the region. Our presentation will explore:

- The process to develop a set of project alternatives to reduce flood risk – including sea level rise, coastal storms, and precipitation;
- Key project challenges and solutions, including siting coastal defense and blue-green drainage infrastructure, as well as protecting complex transportation and low-lying maritime infrastructure all while providing waterfront access and egress; and,
- The shift in project vision and reconceptualizing the urban waterfront and landscape for a resilient Lower Manhattan.

Session 4.4 – Urban Adaptation Strategies
19 April 2022 (Tuesday)
1600 – 1730 hours

Session Co-Chairs: Piet Dircke, Arcadis (Netherlands), Co-Chair 2 TBC

Presentation Title To be Confirmed

Tony Wang. Monash University (Australia)

Presenter is an invited speaker. No executive summary is available

Developing Flood Resilience Investment Strategies Through Global Flood Risk Tool

Matthijs Bos, Michael Van De Watering, Wouter de Hamer, Chi Bui. Royal Haskoningdhv (Netherlands)

Together with CPG Consultants, Royal HaskoningDHV is developing the flood resilience investment strategies for the climate change adaptation project southeastern coastline of Singapore. A risk-based approach is commonly used for the development of flood resilience investment strategies for coastal cities (Hallegatte, 2013). Royal HaskoningDHV has developed the Global Flood Risk Tool (GFRT) as a cloud-based platform (Bos, 2002), which will be used for "Site Specific Study for Climate Adaptation Measures for the Southeast Coast". The GFRT delivers fast and accurate flood risk analysis to, allowing for a more comprehensive way to review the various climate adaptive pathways (Haasnoot, et al., 2013) within the Singapore context, and create a safe and resilient environment.

Adapting To The Uncertain: A Different Climate Strategy

Fiona Barbour, Kiki Pattenden, Ismail Weiliang Osman. Mott Macdonald (Singapore)

Through the use of case studies from Singapore and Ireland this paper demonstrates the process to develop an adaptive strategy for climate change. It also outlines ther work of the private sector led Coalition for Climate Resilient Investment (CCRI), which will help bring down barriers to achieving transformational change in resilience.

From City To Block: A Multi-Scale Analysis To Improve Outdoor Space

Mariana Pereira Guimaraes, Valentina Dessì, Luc Cartigny. Politecnico Di Milano (Netherlands)

The present paper highlights preliminary steps of an ongoing doctoral thesis, developed in the context of a European Commission's Horizon 2020 innovation program conducted in partnership with the industry, which aims to define strategic urban water use guidelines that can help alleviate the heat stress in neighborhoods located in different European climate regions. The Cool district in the central area of Rotterdam was selected as a pilot to test a multi-scale analysis to evaluate adaptation strategies targeted at relieving extreme heat and cope with excess stormwater on a local scale. The analysis follows a tri-part methodology of (I) hotspot mapping, (II) sustainable stormwater solutions aptness of the site, and (III) thermal comfort improvement before and after solutions. The methodology and results are presented for each step. Ultimately, only a network of systems involving pathways and "microclimatic cool niches" guarantees the efficient and effective functioning of the proposed strategies.

Session 4.5 – Water Master-Planning For Cities
20 April 2022 (Wednesday)
0900 – 1030 hours

Session Co-Chairs: Robert Nicholls, Tyndall Centre for Climate Change Research (United Kingdom), Mark Fletcher, Arup (United Kingdom)

Water In Circular Economy And Resilience (WICER) Framework

Anna Delgado, Diego J. Rodriguez, Carlo A. Amadei, Midori Makino. World Bank (Netherlands)

Circular Economy has emerged as a response to the unsustainable linear model of "take, make, consume, and waste". Yet so far, the water sector has not been systematically included in high-level circular economy strategy discussions and has not fully reaped the potential benefits. Circular economy principles offer an opportunity to recognize and capture the full value of water – as a service, an input to processes, a source of energy and a carrier of materials. This paper presents the Water in Circular Economy and Resilience (WICER) Framework to establish a common understanding of circular economy and resilience in the urban water sector. The Framework grew out of a literature review and was informed by lessons learned from global case studies. It aims to guide practitioners who are incorporating the principles in policies and strategies, planning, investment prioritization, and design and operations of water infrastructure and water service delivery.

The Integration Of Infrastructure Hardening And Equitable Transformational Resilience Strategies In The New York City Region Post Sandy And Post Ida

Edgar Westerhof, Alan Blumberg. Arcadis (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. While different in nature, both hurricane Sandy in 2012 and hurricane Ida in 2021 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 progressive future risk standards for Sea Level Rise and extreme precipitation and approaches to harden their critical assets, in conjunction with longer term planning efforts with several billion dollars in capital expenses. Early warning systems, 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.

Session 4.6 – Economic Valuation Of Hybrid Infrastructure
20 April 2022 (Wednesday)
1100 – 1230 hours

Session Co-Chairs: Tony Wong, CRC for Water Sensitive Cities, Monash University (Australia), Piet Dircke, Arcadis (Netherlands)

World Bank Economic Valuation Model

Marcus Wishart. World Bank (China)

Presenter is an invited speaker. No executive summary is available

Valuing The Invaluable – A Framework For Valuing The Economic, Social & Environmental Benefits Of Blue, Green & Grey Infrastructure

Alexandra Cifuentes Humphrey Cifuentes, Ehson Shirazi. Frontier Economics (Australia)

Integrated planning and delivery of blue, green and grey infrastructure is critical to supporting resilient and liveable cities and environments. However, the benefits of blue-green infrastructure have historically not been well established or quantified, and therefore not integrated into decision-making. As part of work for a range of utilities and government agencies across Australia, Frontier Economics developed an economic evaluation framework to robustly identify, quantify and value costs and benefits of blue-green infrastructure, ensuring these broader impacts can be incorporated into decision-making. Application of this framework in one major urban greenfield development showed that the benefits of integrating blue-green infrastructure to the community was valued at over $6.5 billion. Our work led to Infrastructure Australia accepting blue-green infrastructure in the Western Parkland City as a national priority initiative. Other key decision-makers across Australia have also recognized the need for holistic investment in blue, green and grey infrastructure.

Evidencing The Benefit-Cost Value Of Blue-Green Infrastructure Retrofit Across London To Catalyse Greater Investment In Sustainable Drainage

Simon Ainley. Arcadis Consulting (UK) Ltd (United Kingdom)

This project procured to demonstrate that the strategic long-term delivery of small-scale retrofit SuDS features across London is a robust, investable and, sustainable approach to mitigate current and future flooding.

Extensive hydraulic modelling and evaluations were undertaken to identify the most optimal locations and strategies, focusing on returning the highest cost-benefit.

The work demonstrating the value of hydraulic modelling in targetting investment, plus the opportunity that large scale, long-term SUDS retrofit has to manage flooding.

Plan For Liveability And The Unexpected: A Socio-Economic Approach To Account For Stakeholder Priorities And Future Uncertainty

Julie Skrydstrup, Ida Linde Hansen, Stine Dybkjær, Roland Löwe, Nena Kroghsbo, Ida Bülow Gregersen, Karsten Arnbjerg-Nielsen. Ramboll A/s (Denmark)

Uncertainties caused by long planning horizons and stakeholders with different priorities increase the planning complexity of nature-based solutions in urban areas. We developed a socio-economic approach that assess NBS ability to achieve stakeholders' planning objective(s), and the robustness of the NBS performance by including future uncertainty and different stakeholder priorities. The framework was tested and exemplified through a Danish case study. We introduced the term "Decision lens" that illustrates different ways of considering NBS performance depending on the decisions different stakeholder can make. Overall, the inclusion of planning objectives, future scenarios of climate change and urban development, and decision lenses clearly impacted the performance of NBS. Thus, suggesting the need for considering multiple stakeholder perspectives and scenario analysis.

Session 4.7 – Flood Resilience For Cities Of The Future
20 April 2022 (Wednesday)
1330 – 1500 hours

Session Co-Chairs: Suresh Rohilla, Centre for Science and Environment, New Delhi (India), Co-Chair 2 TBC

Lessons Learned From The European Floods In July 2021: Climate Adaptation Measures And Emergency Response In Cities Along The Meuse River

Piet Dircke, Tabea Mueller. Arcadis (Netherlands)

Due to climate change, extreme weather events are expected to occur more frequently, and precipitation patterns are expected to change. Particularly cities in coastal areas, deltas and along large rivers are vulnerable to flooding events induced by extreme weather events, resulting in storm surges or high river discharges. The recent July 2021 European flood event was used in this research to evaluate the impact of climate adaptation measures on emergency preparedness and urban resilience as a result of two implemented programs along the Meuse. Municipalities and governments can use such insights from successful case studies to better adapt to the increasing future risks posed by climate change. Findings showed that the two programs used to protect cities along the Meuse river from extreme weather events had a positive effect on damage reduction compared to cities that did not implement climate adaptation measures as well as compared to previous flood events in 1993 and 1995 during which climate adaptation measures were not yet implemented. Findings also show that, to reduce the level of emergency measures, cities need to become more robust for impacts that might occur

The Next Wave Of Risk Reduction: Fostering Urban Flood Resilience In Rapidly Urbanizing Mid-Tier Cities

Travis Bunt. One Architecture (United States)

Throughout the developing world, rapid urbanization and climate change, combined with natural geography and hydrology, have increased the vulnerability of population centers to natural hazards including floods, earthquakes, landslides, and stronger storms and storm surges. Though much emphasis and capital is generally put upon the biggest metro areas, flood risk in quickly-growing second and third tier cities is also increasing, and there is opportunity to reduce the risk concurrent with urban growth, before flood issues are further exacerbated. These accelerating conditions necessitate change and provide opportunities for innovation in processes and practice. Key to meeting these needs is to integrate an interdisciplinary team and workflow from project inception, a strategy which we have deployed across four regional hubs in Indonesia: Semarang, Manado, Pontianak, and Bima. By de-siloing project disciplines and implementing a multipronged approach to resilient design, teams of engineers, architects, urban designers, economists, government experts, and NGOs, can work collaboratively to develop holistic approaches to multifaceted challenges.

Flood Resilience For Cities Of The Future – The Hong Kong Experience

Sueann Sheung Yan Lee, Joy Ching Man Lee, Raymond Leung Him Woon, Richard Wah Ming Leung. Government Of Hong Kong Special Administrative Region Of The People's Republic Of China (Hong Kong SAR)

Hong Kong Special Administrative Region of the People's Republic of China is a dense coastal city facing the threats of extreme rainfall and coastal flood risk from typhoons. With the increasing threats from climate change, HKSAR has developed a comprehensive flood resilience strategy in multiple dimensions, with drainage infrastructure such as drainage tunnels and storage tanks for flood prevention, sustainable drainage systems, multi-functional assets such as flood lake, non-structural measures and a smart drainage system. The need for adaptive management is highlighted for a smart, green and resilient city.

Integrated Flood Resilience Strategy For Yangon, Myanmar

Tjitte Nauta. Deltares (Netherlands)

Myanmar's city of Yangon is the largest financial and commercial centre. It accounts for about 50% of the country's industrial capacity, and is the seat of education, art, culture, healthcare, tourism, research and development. Population growth and rapid urbanisation are putting pressure on infrastructure, natural resources and the environment. Furthermore, the impacts of natural hazards, especially recurrent pluvial (rainfall related), fluvial (river related and most problematic during the monsoon season) and coastal flooding (caused by high tides, and periodic storm surges), are expected to be exacerbated by climate change and sea level rise.

Flooding is associated with damage to properties and assets, disruption of economic activity and causes health problems. The proposed Integrated Flood Resilience Strategy (IFRS) for Yangon provides a conceptual framework for identification of priority flood resilience investments in response to the challenges the city is facing with regards to the frequent flooding of parts of the city.

Theme 5: Water Quality & Health

Session 5.1 – Water Quality Assessment And Management For Health Across The Full Water Spectrum: Treatment And Management
19 April 2022 (Tuesday)
0900 – 1030 hours

Session Co-Chairs: Ana Maria de Roda Husman, RIVM (Netherlands), Daisuke Sano, Tohoku University (Japan)

Reuse Of Municipal Reclaimed Water And Treated Greywater: Implications For Crop Irrigation And Human Health
Silvia Monteiro. Universidade Lisboa, Tecnico Lisbon (Portugal)

Water scarcity is a worldwide problem with agriculture consuming high loads of potable water. To overcome this problem, several types of water have been proposed: disinfected wastewater, greywater, and rainwater. Most studies addressing the microbial safety of these waters are performed in laboratory-controlled environment, looking mainly at one class of pathogen. It is important, therefore, to conduct studies in real life situation. The objective of the present study was to fill in these gaps in the knowledge. Tomato, lettuce, and carrot seeds were irrigated with three types of water: treated and disinfected wastewater and treated greywater. The fresh produce was grown in a greenhouse and subjected to environmental factors and tested after growth to different bacteria, enteric viruses, and protozoa. Results have shown internalisation of specific viruses in each produce using wastewater whereas no internalisation was found with greywater. This highlights the potential health risks when using wastewater for agricultural purposes.

Short-Term Assessment Of Chlorine Losses In Water Distribution Networks With Downstream Tanks
Adichai Pornprommin, Natchapol Charuwimolkul. Faculty Of Engineering, Kasetsart University (Thailand)

Recently, a chlorine mass balance to assess chlorine losses in networks was proposed. We extend the concept to possibly assess chlorine mass losses in water distribution networks with downstream tanks on the short term. Applying the concept to a simple network example, we simulate the network and evaluates the results on an hourly time scale. The hourly chlorine mass losses in pipes and a downstream tank can be quantified as well as the hourly changes of chlorine masses in the pipes and the tank. Thus, our concept opens a way to assess chlorine losses in the finest detail.

Effect Of Intermittent And Continuous Flow Regimes On The Microbial Water Quality And Microbiomes In A Pilot-Scale Drinking Water Test Bed
Mats Leifels, Dan Cheng, Sophia Wu, Nasha Nadhirah, Jiawei Cai, Eric Hill, Nico Boon, Jorien Favere, Stefan Wuertz, Andrew Whittle. Nanyang Technological University (Singapore)

We established an above-ground testbed to conduct a side-by-side comparison of conditions typical of an intermittent water supply (IWS) and continuous water supply (CWS). The flow rate was either slow or fast in the CWS setup and the IWS was either stagnant or operated at a fast flow rate. Both flow cytometry-based fingerprinting and 16S rRNA gene metabarcoding were used to understand community changes over time under different hydraulic operating conditions. We found significant increases in the concentrations of total and live cells in the outflowing water during the first 60 s over periods of up to 720 s after initiating the flushing process. Changes in monochloramine concentrations (residual disinfectant) and other nitrate species occurred during the initial phase of

flushing in the IWS system (Δt ≤ 60 s). Both systems had higher alpha diversity during this initial flushing phase, but only the IWS system showed notable changes in beta diversity as well as the number of total and live bacteria between initial flushing and longer-term flow conditions.

Effect Of Swabbing Cleaning Method On Biofilm Communities Of A Drinking Water Distribution System In Madrid (Spain)

Carolina Calero Preciado, Manuel José Arias Guedón. Canal De Isabel Ii (Spain)

The implementation of biofilm control strategies is vital to guarantee the supply of good-quality drinking water. Alternative pipe cleaning tools to flushing are increasing, but there is a lack in the knowledge about their effectiveness or influence on microbial dynamics. This study aimed to investigate the effect of swabbing method in the biofilm communities of a real system in Spain. Biofilm samples were taken before and after the swabbing. Then, the biofilm re-growth over a two-years after the cleaning was evaluated thanks to a coupon device. Biofilm was characterised by metal screening, total cell counts and the 16s-rRNA bacterial gene sequencing. Results showed a reduced number of total cells after the swabbing, but two years later similar values were reached. Moreover, this cleaning method affected bacterial communities, changing their structure and composition over time, and thus it can be an effective tool to control problems related to the microbial presence.

Session 5.2 – Water Quality Assessment And Management For Health Across The Full Water Spectrum: Real-Time Sensors And Standards
19 April 2022 (Tuesday)
1100 – 1230 hours

Session Co-Chairs: Annalisa Contos, Atom Consulting (Australia), Robert Bos, IWA (Switzerland)

Development Of Rapid Detection Methods To Enumerate Bacteria In Water Systems

Peiying Hong. King Abdullah University of Science And Technology (Saudi Arabia)

Extended stagnation is known to cause deterioration of drinking water quality and has affected public buildings during lockdowns in the current COVID-19 pandemic. The impact of biofilm on the bulk water due to extended stagnation from national or regional lockdown remains unknow. The aim of this study is to understand how extended stagnation in the absence of monochloramine influences potable water quality, to assess the changes in biomass (detached biofilm) with resuming operations, and also to determine how long the bulk water microbiome takes to regain its equilibrium. Here we use an above-ground testbed to simulate stagnation of drinking water distribution systems (DWDS) in five replicate pipes and over nine weeks. Extended stagnation in the absence of the disinfectant monochloramine coincided with a significant increase in total bacterial cell counts and augmented the fraction of viable cells from 0.2 to 0.6 as shown by flow cytometry. A subsequent flushing experiment revealed rapid detachment of biofilm in the first 60 s, which affected the bacterial concentration and community composition in the outflowing bulk water. We propose conductivity as a potential water quality indicator in DWDS, as it correlated strongly with the more expensive flow cytometry and 16S rRNA gene metabarcoding methods.

Method Development And Analysis Of Disinfectants In A University Campus During Covid19 Pandemic

Sanjeeb Mohapatra, Lin Yutao, You Luhua, Ngoc Han Tran, Karina Yew-Hoong Gin. National University of Singapore (Singapore)

This study aims to demonstrate the proof-of-concept for two approaches that can lead to smart water quality assessment systems for the future. The first is a neural network estimation model that can utilize in-situ measurements derived from sensors already available in WWTP to estimate the bacterial cell densities present in wastewater samples. The second is a microfluidic device that can rapidly determine for the presence of E. coli in a flow through system without having to perform culture-based analysis.

Quick And Easy Characterization Of Microplastics In Surface Water And Treated Effluent

Danence Lee. Public Utilities Board (Singapore)

Microplastics is a Contaminant of Emerging Concern (CEC). Conventional analysis for microplastics in complex water matrices generally involves laborious sample preparation and incurs long man-hours during analysis. Presented herein is a simple approach to isolating microplastics from complex water matrices like surface water and treated effluent, and identifying them using a Laser Direct Infrared (LDIR) Chemical Imaging System. Using this approach, low counts of microplastics ranging in size from 20 to 200 µm were easily detected and calculated in the surface water and treated effluent from wastewater reclamation plant. Good particle isolation efficiency (73% recovery) and reproducibility (<10% RSD) of the procedure were verified using DI water samples spiked with known numbers of 80 µm polystyrene beads. Overall, a promising sample preparation and analysis method for microplastics in complex water matrices is being presented.

Colorectal Cancer And Nitrates: Implications For Health And The Economy

Marion Savill, Alistair Humphrey, Dan Deere. Affordable Water (New Zealand)

There is increasing evidence that there is a relationship between increasing levels of nitrate in drinking water and cancer, particularly colorectal cancer (CRC). Studies carried out in Spain/Italy, USA, Denmark and NZ have all identified this association.

Most of seven large epidemiological studies investigating this have found that the risk of CRC from nitrates in drinking water begins below the current MAV of 50 mg/L- some have suggested that carcinogenesis begins well below this level.

There are two main difficulties with studying this relationship. First, there is a long lag time between exposure and the development of cancer, and increasingly mobile populations may consume water from many different sources during this time. Secondly, although the pathogenesis is understood to progress via nitrites to N-nitroso compounds (ultimate carcinogen), there are confounders on this pathway, including nitroso containing diets, such as processed meats. Moreover, the conversion of nitrates (which are also found in many vegetables) to nitroso-compounds is inhibited by antioxidants, also found in fruit and vegetables.

To answer the question of what level of nitrate in drinking water causes cancer, drinking water and cancer datasets going back many decades will need to be linked in large case-control or retrospective cohort studies.

Session 5.3 – Wastewater-Based Epidemiology (I)
19 April 2022 (Tuesday)
1400 – 1530 hours

Session Co-Chairs: Karina Gin, National University of Singapore (Singapore), Regina Sommer, Medical University of Vienna (Australia)

WSPHERE: Global Data Network On Sewage Surveillance As Public Health Tool

Gertjan Medema, Colleen Naughton, Panagis Katsivelis, Vajra Allan, Joan Rose. KWR Water (Netherlands)

Currently, over 2600+ sites across the world are monitoring wastewater for SARS-CoV-2 or have communicated that they will be setting up for monitoring soon. Using COVIDPoops19 as a starting point, our interdisciplinary team has developed a global database for environmental surveillance data of SARS-CoV-2. Working with dashboards, utilities, scientists and laboratories from around the globe, sewage surveillance data, methods, quality assurance are collated and transferred into the W-SPHERE datasets, along with their metadata, contextual information and data dictionaries. The WSPHERE data are open for access and sharing across the world in a number of reusable formats.

The data are visualized on dynamic/updated maps on a global and country scale with options to zoom in regionally at a spatial level to enable examination of the spatial and temporal trends of SARS-CoV-2.

In addition to the data, WSPHERE showcases good examples of the added value of wastewater surveillance and how wastewater data have been used to guide public health decision-making on different levels (national, regional, local, building-level) and in sewered and non-sewered settings in high-, middle- and low-income countries. The first use cases will show how wastewater data provide: 1) early warning, 2) confirmation of absence, 3) underreporting, 4) objective surveillance.

A Wastewater-Based Epidemiology Tool For COVID-19 Surveillance In Portugal

Silvia Monterio, Daniela Rente, Monica V. Cunha, Manuel Carmo Gomes, Tiago A. Marques, Artur Lourenço, Eugénia Cardoso, Pedro Álvaro, Marco Silva, Norberta Coelho, João Vilaça, Fatima Meireles, Nuno Brôco, Marta Carvalho, Ricardo Santos. Universidade (Portugal)

The presence of SARS-CoV-2 in wastewater produced interest in its use for sentinel surveillance. With this work, we set the foundations for WBE in Portugal by monitoring the trends of SARS-CoV-2 RNA circulation. SARS-CoV-2 was monitored, from April to December 2020, at the inlet of five WWTP, serving more than two million people. Raw wastewater from three COVID-19 hospitals was also analyzed during this period. Initially, detection of SARS-CoV-2 RNA was sporadic and prevalence increased by the end of May into late June, mainly in Lisboa e Vale do Tejo region (LVT), during the reopening phase. After the summer, with partial reopening of the country, a pronounced increase of SARS-CoV-2 RNA in wastewater was detected. In the LVT area, SARS-CoV-2 RNA load agreed with epidemiological stage of the region. Synchrony between trends of SARS-CoV-2 RNA in raw wastewater and daily COVID-19 cases highlights the value of

WBE. This is the first study crossing several epidemiological stages highlighting the long-term use of WBE for SARS-CoV-2.

Developing A Global Wastewater Epidemiology Service That Delivers Public Health Benefits And Manages Current And Future Outbreaks

Olivia Bailey, Joe Shuttleworth, Olivier Perkins, Vikki Williams. Ove Arup & Partners (United Kingdom)

Wastewater-based epidemiology (WBE) has proven an invaluable tool in the fight against COVID-19 in the UK and several other developed nations. Arup has been at the forefront of this effort in the UK, as well as developing a strategic programme for the monitoring of wastewater beyond the COVID-19 pandemic. This work continues to explore the future of WBE as a global health monitoring system and aims to unlock it's potential for transforming global health and development policy. This paper presents demonstrates the use of InfoWorks® ICM to model the movement of SARS-COV-2 through several UK sewer systems. The trials conducted in parallel to the modelling confirmed that the T90 decay rate for SARS-COV-2 in sewers was between 10-14hours. As this work continues to develop, we explore how WBE could be utilised globally in developing and developed nations and identify key changes that would be required to make this a reality.

High Level Guidance Document Of Sewage Surveillance Research Of COVID-19

Stephanie Rinck Pfeiffer. Global Water Research Coalition (Australia)

The Global Water Research Coalition (GWRC) together with "The European Commission' Science Services and key experts will be collaborating in the drafting of a "High level overview and best practice guide to undertake Sewage Surveillance of COVID-19", a guide to be used by Operators and Practitioners in the context of the Commission recommendation".

Session 5.4 – Wastewater-Based Epidemiology (II)
19 April 2022 (Wednesday)
1600 – 1730 hours

Session Co-Chairs: Hiroyuki Katayama, University of Tokyo (Japan), David Cunlife, SA Health (Australia)

The Role Of Drainage Air Leaks In Transmission Of COVID-19 In High-Rise Housing

Kenneth Leung. Hong Kong SAR (Hong Kong SAR)

More than 10 high-rise housing outbreaks of COVID-19 have been observed in Hong Kong, in which a vertical distribution of infected flats linked by the same vertical drainage stacks was found. The role of leaking stack aerosols into the bathrooms where the secondary infected lived, has been suspected. We performed tracer gas dispersion tests in five infected high-rise buildings, immediately after each outbreak. The distribution of the leaked tracer gas concentration in the bathrooms are consistent with the observed infection pattern, suggesting a possible role of the vertical spread of virus-laden aerosols into the infected flats via these stacks and vents. We concluded that the stack aerosols were probably transported by upward flows in the drainage stack, mainly driven by the chimney effect during non-flushing calm period.

Understanding COVID-19 Spread In A College Community Via Wastewater Based Epidemiology

Nishita D'Souza, Matthew Flood, Rebecca Ives, Ryan Julien, Jade Mitchell, Samantha Carbonell, Joan Rose. Michigan State (United States)

The COVID-19 pandemic brought unprecedented changes which caused a profound impact on life in East Lansing. The executive order restrictions caused the community to face unique challenges, including monitoring the prevalence of the SARS CoV-2 virus in the population. Wastewater based epidemiology was assessed for its potential to monitor trends of the virus presence in the college community. Over three semesters the approach, interpretation and value were realized. Eleven sites on and around campus were sampled May'20-May'21 (n=390). SARS CoV-2 virus was concentrated from wastewater using polyethylene glycol and target genes N1 and N2 quantified using droplet digital PCR. The SARS virus signal was quantified in 57.18% (223/390) of samples present at concentrations of 2.62x102- 8.35x105 gene copies/100mL.Targeted mutation detections of the Alpha variant were tracked in the community during Spring 2021 and detected at 7 locations. N501Y/del69-70 mutations were quantified in 25.94% (55/212) at concentrations of 5.82x102-1.42x105 gene copies/100mL.

Combating COVID-19 With A Systematic Sewage Surveillance Strategy For Megacities: A Successful Large-Scale Implementation In Hong Kong

Tong Zhang, Yu Deng, Gabriel Leung, Xiaoqing Xu, Xiawan Zheng, Ho Kwong Chui, Sussana Wai Kwan Lai, Lit Man Leo Poon, Hein Min Tun, Che Kong Chen, Shing Cheong Lau, Yiu Hon Chan, Rong Yang, Kenneth Chan, King To, Tat Kwong Lau, Wing Cheong Fung. The University of Hong Kong (Hong Kong SAR)

COVID-19 sewage surveillance is an emerging and evolving science. Under certain circumstance it can help contribute to the control of the pandemic. But until now, no studies have provided practical data to show the mechanism in practical application and the effectiveness of this surveillance tool for public health interventions. Here we present the ongoing large-scale implementation trial of COVID-19 sewage surveillance in Hong Kong SAR of China, which provided great contribution to the goal of achieving zero local infection. Our practice-based evidence provides aspects of guidelines for plan formulating, sample processing and public health responding that can serve as reference for

other regions and countries to explore. A sewage surveillance system has been well established in Hong Kong, and now serves as a powerful management tool to fight COVID-19 by providing early warning signals of silent virus transmission with over 200 samples collected every week from 112 stationary monitoring sites that cover 5.3 million people living in the city.

Panel Discussion

Panellists: Joan Rose. Michigan State (United States)
Gertjan Medema. KWR Watercycle (Netherlands)
Shane Snyder. National Technological University (Singapore)

Panel session to discuss further research needs to enhance the role of wastewater surveillance in covid prevention and control, what capacity strengthening is needed to optimize the role of wastewater epidemiology, how the role of utilities can be expanded and what the options are to use COVID as an exemplar for wastewater-based epidemiology for other health related water microbiology challenges.

Session 5.5 – Water Quality Assessment And Management For Health Across The Full Water Spectrum: Risk Assessment
20 April 2022 (Tuesday)
0900 – 1030 hours

Session Co-Chairs: Joan Rose, Michigan State University (United States), Fiona Waller, Affinity Water (United Kingdom)

Overall Developments On Legionella

Ana Maria de Roda Husman. RIVM (Netherlands)

Presenter is an invited speaker. No executive summary is available

Regularized Regression Modeling Of Rotavirus Disinfection In Wastewater For Predictive Environmental Microbiology In Sanitation Safety Planning

Youhei Miura, Daisuke Sano, Atsuhiro Ishii, Syunsuke Kadoya. Tohoku University (Japan)

Under the framework of HACCP-based Sanitation Safety Planning using Predictive Environmental Microbiology and multiple-barrier in the wastewater reclamation, it is necessary to monitor the removal efficiency (= log reduction value: LRV) of pathogens for checking the fulfilment of target LRV at each process of wastewater treatment. In this study, we developed an LRV prediction model of rotavirus using water quality information and disinfection conditions as explanatory variables, and established a framework to derive appropriate critical limit values at critical control points. Data on inactivation efficiency, water quality, and disinfection parameters were collected from past literatures, and various regularized regression algorithms (Ridge regression, Lasso regression, Elastic net regression, Bayesian ridge, and automatic relevance determination (ARD)) were applied to select relevant variables. The results showed that ARD with interaction terms had the highest prediction accuracy, and the LRV prediction model for rotavirus in treated wastewater by free chlorine disinfection was successfully constructed.

Resistance Of Mycobacterium In Water Treatment Processes

Ricardo Santos, Silvia Monteiro, Catarina Martins. Instituto Superior (Portugal)

Mycobacterium species are distributed in a wide variety of natural and man-made reservoirs, namely lakes, soil, water distribution systems, among others. The present study focused in the behavior of these microorganisms when faced with adverse conditions, particularly some to which they are subjected in water distribution systems. Isolated species of nontuberculous mycobacteria were tested for their resistance to temperature, pH, chlorine and nutrient starvation. It was observed that most of the studied species were able to survive to extreme adverse conditions, growing between temperature ranges of 8-60 ºC, pH between 0-14 and chlorine concentration of 1-10 ppm. In addition, under nutrient starvation the cells entered a latent state characterized by non-morphological changes. The obtained results demonstrate a high resistance of the isolated species to these stress parameters, indicating the remarkable adaptation strategies of Mycobacterium. This adaptation justifies, in part, the maintenance and persistence of these species in water distribution systems.

Measuring Impact Of Systematic Risk Assessment And Risk Management Of Piped Water Supplies

Alauddin Ahemd. ITN-BUET (Bangladesh)

The risk assessment and risk management approach of water safety plan focuses on ensuring quality of water from source to pint of consumption through process monitoring to achieve health-based targets. The study attempted to assess the impact of water safety plan after four years of implementation in two municipal piped water supplies of Bangladesh through indicator-based analysis. O&M practices and associated score for that in Chandpur municipality water supply increased three times. The percentage of samples compliant with microbial water quality targets increased to 90 and diarrheal incidence rate decreased by10 percent. In Chapi-Nawabganj municipality water supply O&M practice score increased to 17 from 8. The diarrheal incidence rate has also gone down from 37 percent to 29 percent. The results indicate that the measurable impacts of water safety plans are easy to understand and continued risk assessment and management processes are effective to ensure water quality and community health.

Regularized Regression Modeling of Rotavirus Disinfection in Wastewater for Predictive Environmental Microbiology in Sanitation Safety Planning

Daisuke Sano. Tohoku University (Japan)

Presenter is an invited speaker. No executive summary is available

Session 5.6 – Systems Approaches To Service Delivery
20 April 2022 (Wednesday)
1100 – 1230 hours

Session Co-Chairs: Sasha Koo-Oshima, FAO (Italy), Bruce Gordon/ Jennifer de France, WHO (Switzerland)

ADB's Policies And Programmes To Promote Sustainable And Resilient WASH In The Asia Pacific Region

Neeta Pokhrel. Asian Development Bank (Manila)

Presenter is an invited speaker. No executive summary is available

WHO study on sanitation and wastewater regulations

Kate Medlicott. WHO (New Zealand)

Presenter is an invited speaker. No executive summary is available

Utility-Managed Rural Water Services: Models, Pathways, Performance And Enabling Environment

Patrick Moriarty. IRC (Netherlands)

Rural water services are increasingly being provided by utilities that, in turn, require a strong enabling environment of policies, institutional, planning, monitoring, capacity, regulatory and financial frameworks. 40 cases of utility managed rural water supply were mapped in 30 countries in Europe, the Americas, Asia and Africa. This paper provides insight into the different pathways under which "utilitisation" of rural water supply has taken place and the factors that drive these processes. Highly performing utilities operate in a strong enabling environment. These primarily include the well-established models or utilities in high income countries, but also models applied at national level in lower middle-income countries. Examples include the expansion of national urban utilities into rural areas (Burkina Faso Uganda, and Vietnam). Utilities under these models have proven well positioned to expand their services into rural areas and present useful cases for improving the professionalization of services provided in rural areas.

Urban Utilities Don't Operate In A Vacuum: Assessment And Strengthening Of The Enabling Environment

Patrick Moriarty. IRC (Netherlands)

In many places, efforts are underway to strengthen the performance of utilities in water supply services provision. Ideally, those are accompanied by efforts to strengthen the enabling environment for utility water service provision is threefold. Reasons for that are threefold: 1) external factors are important to initiate and sustain the results of utility performance improvement, 2) it is crucial for scaling up experience of supporting one or a few utilities to the entire utility sector, and 3) a strong enabling environment is needed to attract public and private financers to the sector and to the utilities. This paper describes an assessment methodology that allows for the identification of actions to strengthen the enabling environment. The paper presents the findings from applying the methodology in 6 countries (Colombia, Ethiopia, Kenya, Mozambique, Rwanda and Vietnam).

Urban Utilities And The Need To Raise Additional Finance: The Role Of National Public Development Banks

Patrick Moriarty. IRC (Netherlands)

Public development banks are banks located within the public sphere by mandate, ownership or governance. PDBs have a specific mandate to deliver on public policy objectives that support the economic and social development. Technical assistance to local governments and utilities is an added value of PDBs, as are the conditions for loan repayment. One of the most relevant aspects to the water sector is that PDBs are instrumental in implementing multi-sector projects that are cross-subsidising in nature. This allows for the mutualisation of risk between lower (i.e. larger utilities) and higher credit risk borrowers (i.e. smaller municipalities) and lower and higher risk sectors, enabling smaller borrowers to access more favourable conditions. This paper is based on desk review and interviews with 29 of the largest PDBs working in the water sector. It describes their bottlenecks to be involved in the water sector and how to overcome them.

Session 5.7 – Water Quality/Food Safety Nexus: From Safely Managed Drinking Water Through WSP To HACCP For Food Safety (Organised With FAO)
20 April 2022 (Wednesday)
1330 – 1500 hours

Session Co-Chairs: Sasha Koo-Oshima, FAO (Italy), Robert Bos, IWA (Switzerland)

Programme To Be Confirmed

Theme 6: Nexus & Circularity

Session 6.1 – Policy And Planning (I)
19 April 2022 (Tuesday)
0900 – 1030 hours

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

Presentation Title To Be Confirmed

Janez Susnik. IHE Delft Institute for Water Education (United States)

Presenter is an invited speaker. No executive summary is available

Circular Water 2050 For Future Proof Cities - Impact And Opportunities For The Urban Water Cycle Of The 'Fully Circular In 2050' Target Of The Netherlands In A Changing World

Kees Roest, Aalke de Jong, Henk-Jan van Alphen, Andrew Segrave. KWR Water (Netherlands)

A vision and roadmap for the water sector was developed, with a view to the national 'A Circular Economy in the Netherlands by 2050' program. This involved the raw material efficiency in the urban water cycle, including the extraction and reuse of raw materials. An overview of possible conceptual and technological innovations that can be relevant for the water cycle in 2050, including an inspirational illustration, has been produced. Also a tool with 16 characteristics to monitor and evaluate circularity has been developed. 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. Via back casting the steps and open questions to reach circularity in 2050 have been defined. Cross-sectoral collaboration is really needed for a sustainable circular economy. Integration of water, waste and climate adaptation with other aspects in a city will make cities a more attractive place to live and save money too.

Development Of National Water Security Framework: A Cultural Revolution Of Water Consumption In The Household Sector

Franklin Retes, Alan Alejandrino. Digos Water District (Philippines)

Big cities are experiencing their worst bouts of water shortages in recent years. Lake Mead has dropped to historically low, putting pressure in the region's water supply. Seventeen major river basins in the Philippines will experience shortages by 2025. In the center of these realities are household consumers. In connection, this study employed concurrent mixed method research design with the aim to determine the water consumption of the future and how it is influenced by the cultural dimensions of the household sector. The findings showed that the future of water consumption will be shaped by information campaign, policing, seasonal variability, environment, economic status, and hygiene. In addition, the cultural dimensions of water consumption in the household sector focused on transformative innovation, policy convergence, adaptive behavior, water demand, and social cooperation. Thus, the enactment of the Philippines' National Water Security Framework is imperative, towards sustaining water security into the future.

Principal Component Analysis: A Tool To Establish The Typology Of Drivers Of Water Policy Options: Solar Powered Irrigation System As A Nexus Example

Nisreen Lahham, Hammou Laamrani. International Water Management Institute (iwmi) (Egypt, Arab Rep.)

Middle East and North Africa is facing growing water scarcity that requires adequate policies, strong institutions and investments. Technologies are part of the solutions for a more water secure future. However, adoption and scaling up of technological solutions are not advancing as fast as they should be. The purpose of this study is to analyze the key determinants of such progress. Using the solar powered irrigation systems as an example, the study looks into the key drivers that make a policy option fail or succeed. Principal Component Analysis (PCA) in three countries surveyed (Morocco, Tunisia and Egypt) show that subsidy schemes have better weight than regulation and extension services for small farmers. Supply companies' marketing and access to credit are the strongest variables for farmers holding more than 5Ha farm size. These and other key lessons stakeholders inform policies promoting water technologies penetration to achieve water security in the region.

Principal Component Analysis: A Tool To Establish The Typology Of Drivers Of Water Policy Options: Solar Powered Irrigation System As A Nexus Example

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Session 6.2 – Policy And Planning (II)
19 April 2022 (Tuesday)
1100 – 1230 hours

Session Co-Chairs: Pang Chee Meng, Public Utilities Board (Singapore), Co-Chair 2 TBC

Approach To Sustainability In PUB, Singapore's National Water Agency

Mien Ling Chong, Elaine Puay Hoon Quek, Lennis Kiat Hui Seow, Pearlene Xin Lin Then. Public Utilities Board (Singapore)

Since the formation of PUB in the 1960s, every one of PUB's milestones has served to strengthen Singapore's water security and sustainability. Over the years, PUB has successfully built up and diversified our water resources, engaged with new and smarter technologies, and faced new challenges, including rising water demand, increasing cost of treatment, and the threat of rising seas due to climate change. This abstract outline PUB's approach to sustainability, explores PUB's overall decarbonisation plan, and highlights PUB's deployment of floating solar photovoltaic (PV) systems on our reservoirs as a key case study in our efforts towards sustainability.

Reclaimed Water Policy In Taiwan

Chien-Hsin Lai, Yu-jen Chin. Water Resources Agency (Taiwan)

Due to the climate change impacts, the challenges of water resources management are increasing. In 2021 Taiwan suffered the most severe drought since 1947, and eventually survived the crisis because of the implementation of multiple water resources policy. In the policy, the reclaimed water is one of the vital items. The Taiwan government has been demanding the enterprises to apply the reclaimed water through a serious of regulations, such as the "Reclaimed Water Resources Development Act" promulgated in 2015, "Regulations for the Review and Management of Proposal of Water Usage" in 2018 and the "Environmental Impact Assessment Act". The government has planned 11 reclaimed water plants and will be constructed step by step. In the future, the government will continue to search new suitable sites and resolve the issues of price difference between tap and reclaimed water and strengthen the incentives. The target is consuming 1.32 million CMD of reclaimed water in 2031 and reaching the goal of building a circular resilient country.

Digitalisation For Low-Carbon Thinking In New Zealand

Jonny Breen, Atisha Daya, Ismail Weiliang Osman. Mott Macdonald (Singapore)

In New Zealand (NZ), the Climate Change Response (Zero Carbon) Amendment Act 2019 commits us to net-zero carbon emissions by 2050. The water sector has a significant role to play in achieving this target, requiring a step-change in how we design, build, and manage our assets. The most significant strides are being realised by organisations that embrace and embed "low-carbon thinking" in their people and processes and employ digital solutions that support this new way of working. Progress is being made across the NZ water sector in terms of measuring, understanding, and reducing embodied, operational and user carbon. This is unique as embodied carbon is addressed unlike most water utilities which only focus on operational carbon. This low-carbon thinking is implemented across the design and delivery of more than NZ$15bn of water projects in the UK and NZ through Mott MacDonald's carbon monitoring digital solution, Moata Carbon Portal.

Impact Of Floating Solar Panels On Drinking Water Reservoir Water Quality

Bram Martjin, Arco Wagenvoort, Emmanuelle Prest. PWNT (Netherlands)

In the context of transition towards CO2 neutral water production, PWN has initiated the installation of solar panels at various production locations. The location with the largest potential for energy production is located in Andijk, where floating photovoltaic (FPV) structures are installed on the water reservoir (50 ha) of wtp WPJ. The first data after the installation of the first three FPV-installations (coverage of approximately 9%) are available. The following observations were done: In the first half year, the water quality of the effluent did not changed compared to the last two previous years. However, additional measurement in the water column under the FPV-installation at a shallow part of the reservoir, made clear that the development and composition of phytoplankton deviate from the phytoplankton in the deep and well mixed part of the reservoir, indicating slower transition processes. It should be realized that the structures of the FPV-installations create a new habitat. This habitat could lead to the mass settling of nuisance organisms (like Dreissena mussels), which can have a substantial impact on the availability and maintenance of the plant.

Session 6.3 – Stakeholder Engagement And Cross-Sectoral Collaboration In The Circular Water Economy
19 April 2022 (Tuesday)
1400 – 1530 hours

Session Co-Chairs: Adam Lovell, WSAA (Australia), Chong Mien Ling, Public Utilities Board (Singapore)

Stakeholder Engagement In The Circular Water Economy

Jos Frijns, Dimitrios Bouziotas, Lovisa Bengtsson, Ewa Lind, Kate Baker, Mehdi Khoury, Barry Evans, Tina Katika, Dimitra Tsiakou, Lydia Vamvakeridou-Lyroudia. KWR Water Research Institute (Netherlands)

The transition to a circular water economy requires the active engagement from relevant stakeholders. This engagement can be organised through Communities of Practice in which the circular water solutions are discussed in their institutional context. These communities extend beyond the exchange of information to actual consultations, making it possible to co-design the technologies and fit the innovations to the local needs and settings. This paper presents how Communities of Practice can be organised to ensure meaningful consultations through social learning, drawing from lessons learnt from ten large-scale demonstration sites across Europe. Within these demonstration sites, the engagement of the general public is organised through public outreach activities. Further opportunities for citizen engagement through an Augmented Reality app and Serious Game are presented as well in this paper. Preliminary results of these virtual visualisation platforms, that benefit people to experience circular water solutions, show the high potential of increasing public understanding and acceptance.

Linking Stakeholder Engagement To Capital Planning And Decision Making

Boudewijn Neijens. Copperleaf (Canada)

Capital intensive organizations such as water utilities need to consider the interests and inputs of multiple stakeholders in their decision making. The current emergence of Environmental, Social and Governance (ESG) reporting requirements is a good illustration of the growing complexity and diversity of the factors that organizations need to consider in their decision-making. This complexity calls for more rigor and specialized processes in capital planning. Research shows that adopting multi-criteria decision analysis techniques can yield significant returns for organizations interested in optimizing the use of their scarce resources and having to honor multiple internal and external constraints.

Community-Led Approach To Collect National Sanitation Infrastructure Data In The United States

Brandon Hunter, Catherine Flowers, Taylor Hutt, Alastair Gee, Kartik Chandran. Columbia University (United States)

The Center for Rural Enterprise & Environmental Justice (CREEJ), Columbia University, and The Guardian media outlet developed a first-of-its-kind national initiative to establish a centralized database from which national environmental justice initiatives could be implemented regarding access to sanitation throughout the United States. Across California, Alabama, Illinois, Georgia, Louisiana, Maryland, North Carolina, and New York, grassroots, community-driven methods were used to assess sanitation access qualitatively and quantitatively, to develop the capacity of communities, and to compile infrastructure data to influence state- and federal-level policy and decision making. This community-based approach proved to be effective at procuring essential data to inform action-based policy- and decision-making at the state and federal level. Learnings from this collaborative initiative resulted in the documentation of sometimes missing or inconsistent infrastructure data between county- and state-level entities and identified where investments should be made to fill in gaps. Based on our findings, more investments should be made into identifying where there are gaps in infrastructure data are to mitigate disproportional burdens of marginalized communities which lack access to safe, affordable, and equitable water and sanitation.

Reaping The Benefits Of Public-Private Partnerships To Attain Circularity In Wastewater: A Case Of Two Indian Cities

Avinandan Taron, Josiane Nikiema. International Water Management Institute (Sri Lanka)

Indian cities generate 38,254 million liters of sewage every day of which 11,787 MLD is treated and the rest flows into surface water bodies. In contrast, peri-urban areas face steep demand from industry and agriculture which are met using freshwater. Recently, government, private players, donors, and expert groups are exploring alternative water supply in the form of recycled wastewater to meet the demand. Most of the wastewater generated is treated up to the secondary level as Urban Local Bodies (ULBs) are financially constrained and are not mandated by regulations. The partially treated wastewater is not suitable for industries or agricultural purposes and requires additional treatment. The government is planning to manage financial distress and increase efficiency by introducing options like Public-Private Partnerships (PPPs). This study explores the opportunity of wastewater reuse via PPPs to tackle water quality and adequate tariffs to make it financially sustainable.

Session 6.4 – System Of Systems For Circular Economy
19 April 2022 (Tuesday)
1600 – 1730 hours

Session Co-Chairs: Inga Jacobs-Mata, International Water Management Institute (South Africa), Janez Susnik, IHE Delft Institude for Water Education (Netherlands)

Advanced Anaerobic Digestion Helps Achieve Asset Optimization, Sustainable & Circular Economy For Effective Biosolids Management

Julien Chauzy, William Barber, Dawn Taylor, Ashish Sahu. Cambi As (France)

The Kenneth W. Hotz wastewater treatment plant (wwtp), OH, USA under design-build and energy performance contract installed disruptive technologies such as thermal hydrolysis process (THP), struvite recovery and energy recovery systems to attain a circular and sustainable economy, with a long term biosolids management strategy in mind. The $35 million assets upgrade resulted in $1.7 million operational expenditure savings per year. The energy intensive Zimpro process was replaced by THP. Installing THP enabled the digesters to be smaller and therefore affordable. Higher loadings to the digesters up to 60% more with imported sludge and food waste was achieved. Higher biogas generation on co-digestion helped offset the energy prices while reducing the overall energy costs by 38%. The biosolids generated were Class A and are land applied. THP resulted in lower operating costs and gas requirements than the previous Zimpro process. The KWH wwtp achieved assets optimization, resource recovery thus building on the circular economy model.

A System Dynamics Modeling Approach TO Integrate Management OF Municipal Drinking Water AND Wastewater Services.

Matthew Griffey, Andy Gibson, Devan Thomas. AECOM (United Kingdom)

The work to be presented will outline the development of a decision support tool that simulates, utility scale provision of drinking water and wastewater services, across a 30-year time horizon, within a monthly temporal resolution. The development of the tool utilizes system dynamics 93odelling and integrates data from multiple sources. The tool is intended to support a municipal water/wastewater service provider to investigate:

supply/demand balance, CAPEX/OPEX minimization, impacts of and responses to; changing regulatory policies, population growth, customer behavior, affordability and climate change.

Water-Energy-Environment Nexus Modelling For Optimizing Water Loss Control Strategy And Interventions

Eunher Shin, Seo Hyung Choi, Bongwoo Shin. Unesco I-wssm (Korea Rep)

Due to the increasing water-related challenges, water loss management has been given high priority by governments, water utilities, and other stakeholders in the water sector. General water loss management strategy, programs, and interventions are established by water utilities only considering outputs in the water sector. To overcome limitations, we developed the urban water Nexus model to assess and evaluate the synergies and trade-offs in the water, energy, and environment sectors. System dynamics modelling, a top-down modelling method based on causal mechanisms among the elements within a specific system, is adopted for the comprehensive analysis of multi-sectoral systems at a macro level. Based on the multi-scenario and multi-attribute analysis, the Nexus model can offer optimal water loss management interventions and provide the scientific basis for decision-making. Therefore, sustainable and systematic water loss management is possible through the generalized and holistic urban water-energy-environmental Nexus model.

Session 6.5 – Resource Circularity
20 April 2022 (Wednesday)
0900 – 1030 hours

Session Co-Chairs: Gary Gu, DuPont Water Solutions (United States), Zhou Yan, Nanyang Technological University (Singapore)

Presentation Title To Be Confirmed

Tina Arrowood. DuPont Water (United States)

Presenter is an invited speaker. No executive summary is available

A New Paradigm For The Mining Industry: Recovery Of Valuable Metals From Saline Aqueous Sources

Gary Amy. Clemson University (United States)

Given the water-related and other environmental impacts associated with conventional surface and subsurface mining, we propose a new paradigm of aqueous-phase mining of various saline water sources and brines. Of particular interest is extraction and recovery of valuable dissolved metals occurring in a readily accessible dissolved form. The challenge is their extraction from a complex water quality matrix containing competing/interfering ions, indicating the need for selective extraction technologies. The most opportune saline aqueous sources are seawater and desalination brines, oil-and-gas produced waters, geothermal aquifers and brines, and acid mine drainage. The highest market opportunity resides with various rare earth elements, platinum group metals, and lithium. In addition to recovery of valuable metals, there is an opportunity for the concomitant recovery of other important resources including desalinated water and embedded energy. A comparative life-cycle economic assessment requires consideration of the environmental costs of conventional mining.

Beyond Value Creation: (Financial) Impact With Resource Recovery

Martijn Olde Weghuis. Vitens (Netherlands)

The abstract presented will focus on the positive environmental impact but also provides a unique insight in the financial projections within a water utility showing the economic potential of waste streams within Vitens.

Towards Zero Waste Through Co-Gasification Of Sludge And Municipal Solid Waste And Generation Of Waste-Derived Slag As Newsand

Xiaoxu Fu, Wei Ping Chan, Yinn Zhao Boon, Vernette Chin, Andrei Veksha, Liya Ge, Yan Zhou, Shane Snyder, Grzegorz Lisak. Nanyang Technological University (Singapore)

In this study, a comprehensive analysis of the co-gasification of municipal solid waste (MSW), sludge and incineration ash at the Waste-to-Energy Research Facility (WTERF) by employing high-temperature slagging gasifier has been performed. Sewage sludge from the Water Reclamation Plants (WRPs), waterworks sludge from water treatment facilities and ash from the sewage sludge incineration facilities (IFs) were tested, concurrently with MSW. Stable and satisfactory operation of the gasifier is achieved with the input of diverse streams of sludge and ash. Leaching behaviour, geotechnical properties, and structural performance of the different types of waste-derived slag generated demonstrated the great potentials for their re-utilization as green construction materials and the mortar specimens derived from slag were produced. Gasification has been proven to be able to reduce approximately 82% of the sludge and ash residues by mass, compared to the conventional

incineration processes. In gasification process, these waste materials were converted into recyclable metals and slag that can be used as NEWSand.

Session 6.6 – Carbon Circularity
20 April 2022 (Wednesday)
1100 – 1230 hours

Session Co-Chairs: Tao Li, IWA (China), Tina Arrowood, DuPont Water Solutions (United States)

Hydrogen Circular Economy: Viability, Scalability, And Risk For Water Industry

Arash Zamyadi. Water Research Australia (Australia)

Integration of sustainable hydrogen (H2) and hydrogen peroxide (H2O2) production into wastewater treatment plant (WWTP) processes may facilitate water industry contributions to an emerging circular economy. Recycled wastewater (RWW) produced at WWTPs may provide an alternative feedstock to the already scarce freshwater resources conventionally used for this process. Energy efficiency opportunities also reside in excess renewable energy utilisation. Australian water utilities have however raised key concerns regarding scalability, technological/economic viability, and risks associated with incorporating hydrogen production into WWTPs. A state-of-knowledge is therefore required to address these concerns and provide site-specific guidance to prospective utilities.

Smart Thermal Grid With The Integration Of Aquifer Thermal Energy Storage And Surface Water To Decarbonize The Buildings Heating And Cooling Systems, Floriade 2022 Case Study, Netherlands

Saleh Mohammadi, Jair Smits, Taco Postma. Witteveen+Bos N.V. (Netherlands)

The world horticultural exhibition Floriade 2022 will be held in the Dutch municipality of Almere. In addition to showcasing the latest technology in horticulture, energy transition towards the gas-free neighborhood is one of the Expo's main objectives. Therefore, an innovative energy system is applied to mitigate the CO2 emission by utilizing Aquifer Thermal Energy Storage (ATES) and surface water for heating and cooling to decarbonize the building environment. A collective energy system based on the Smart Thermal Grid (STG) with a temperature of about 12 °C has been designed which consists of collective ATES, thermal energy exchange with surface water and heat pumps (HPs). ATES systems as a sustainable thermal energy storage method reuse and recycle heating and cooling across seasons. To balance the heating and cooling of the ATES system, thermal energy from the surface water was recovered from the nearby lake. The STG as a backbone connects the main system components to the apartments and utility buildings and regulates temperature and flows throughout the system across the seasons. Our study shows that the proposed system of ATES, surface water and STG can play a major role in mitigating carbon emissions compared to conventional natural gas systems and aircon.

Techno-Economic Analysis Of Electrochemical CO2 Reduction For Biogas Upgrading To Ethanol Or Pure Methane.

Huan Jiang, Olivier Lefebvre. National University of Singapore (Singapore)

Biogas generated during anaerobic digestion shows great potential as a renewable source of energy, but the large CO2 content (40-45%) [1] reduces the heat value of biogas and may corrode pipelines, on top of being a greenhouse gas. In this context, we evaluate the techno-economic feasibility of electro-converting CO2 in biogas into valuable products (C2H5OH or CH4). After setting up realistic target conditions achievable in the short term, we show that electro-conversion of CO2 to C2H5OH would generate an economic gain > 180 USD/tonne. In the long term, three cost reduction strategies are proposed to lower the cost of CH4 production to < 400 USD/tonne. In addition, as a fossil fuel, the market price of CH4 is expected to increase in the future, suggesting the significance of producing CH4 as a final product in the future. In conclusion, both options (C2H5OH and CH4) are interesting to study though their timelines to application are different.

Climate Mitigation In The Water-Cycle: The Greenhouse Gas Abatement Selection Procedure

Thomas De Groot. Arcadis (Netherlands)

The Paris agreement pushes organisations to come-up with a planned approach to reduce their carbon emissions. Specifically, water companies have a strong societal push to fulfil these obligations due to their exemplary function. Many of these companies struggle with the second step: from strategy to implementation. Arcadis has developed a (GRASP-GReenhouse gas Abatement Selection Process) model to support the management decision process to come to a transparent and well substantiated/informed action plan to reduce the company's carbon footprint. GRASP helps them to map, select, prioritize, and plan the carbon reduction opportunities in future. The model consists of a multi-criteria analysis of identified carbon reduction measures, factsheets per identified measure with quantitative and qualitative indicators, a roadmap feature where opportunities can be plotted over time, estimations of the expected effect of identified measures on the carbon emissions over a pre-defined implementation period, and other indicators of relevance for the drinking water and wastewater sector.

LIST OF POSTER PRESENTERS

Theme 1: Delivering Water from Source to Tap – Network

Analyzing Pipe-End Pressure To Investigate Pump Base Pressure

Shin Tanaka, Yuichiro Tsuyuki, Daisuke Ikada. Yokohama Waterworks Bureau (Japan)

The goals of the long-term vision and the mid-term management plan of the Yokohama Waterworks Bureau (YWWB) include calls for environmentally friendly waterworks and measures for further power saving.

To achieve sustainable waterworks, a new initiative geared to reducing power consumption and CO2 in its facilities, including pumping stations, was undertaken aiming at lowering environmental load. It involved measuring pipe-end pressure, finding optimum discharge pressures of pumps and investigating base pressure. YWWB sets a target value of 0.25MPa for water supply pressure in order for supply water to reach up to 4th floors of buildings. And, the studies on the targeted distribution pumping station (Kawai Station), confirmed operation at target value and normal function. Based on the current reduction in water demand and the need to downsize, we have studied a case where the target value is lowered to 0.20MPa. And, results suggest that pump discharge pressure can be lowered.

Research On A System To Streamline Construction Management

Hiroshi Motojima, Tomomi Murakami, Yusako Shibata. Yokohama Waterworks Bureau (Japan)

The Yokohama Waterworks Bureau replaces around 110 km of pipelines annually, facing challenges such as concentration of workload in a particular period and extension of construction periods.

For that reason, in 2018 we engaged in joint research with a private company in the form of a system (hereafter, “Construction Information System”) that could track the progress of daily construction work based on using tablets positioned at water pipeline construction sites to send information such as pipe attributes and connection checklist items to a cloud server and automatically generating construction management documents, pipeline diagrams and other materials in real time.

Anti-Seismic Measures Of Water Supply Utility In Taipei City

Yung Ming Wang. Taipei City Government (Taiwan)

This paper presents the measures of emergency water supply against earthquakes in Taipei metropolitan area. Taipei city is the capital of Taiwan, one of the areas where earthquakes happen most frequently. After the devastating Chi Chi earthquake, many of water supply systems in central Taiwan were heavily damaged; the water department of Taipei city government attends austerely to the risk of water supply damages in great earthquakes. The water department has three anti-seismic measures nowadays: water supply system strengthening plans, emergency recovery measures, and emergency water supply measures. The emergency water supply countermeasures include emergency water tanks, emergency underground water supply plans, water supply trucks, and so on. We hope that with the introduction of this paper and through its discussion will lead to continuous collection of better advices to improve the department’s measures of anti-seismic.

Water Pipes' Corrosion Inspection In Xinbeitou Hot Spring Area

Yung Ming Wang. Taipei City Government (Taiwan)

Xinbeitou hot spring area is a famous tour spot in Taiwan and its tape water supply infrastructure has been existed for more than one hundred years.Water distribution pipes in this area were made of Cast Iron Pipe before and most of them are replaced by Ductile Iron Pipe material now. Since the soil acid degree in some parts of this area pH is low to 1.5, some metal pipes have been corroded heavily. Consequently, pipes leakage situation is also more serious than neighborhood. This paper will investigate into the water pipes corrosion situation in Xinbeitou hot spring area and submit the proposal for improvement the corrosion and leakage of water pipes in this area.

TWINET Deployment In Milano Water Network

François Figueres, Andrea Rossi, Olivier Knapen. Suez (France)

Hydraulic models are a must have for any top-class water utility. Nevertheless, they are often only used for design studies and their calibration in not sufficiently accurate so that they could be trusted for operational diagnosis. After having been working in the coupling of hydraulic models with operational data Suez has developped since several years a digital twin approach called Twinet.

A premiere of that approach of virtual sectorization is implemented in Milano city in Italy, on the distribution network operated by Metropolitana Milanese.

Memosens 2.0 – Simple, Safe And Connected The Next Evolution Of Liquid Analysis Sensor Digitalization

Michael Tan, Oliver Durm. Endress+hauser (s.e.a.) Pte. Ltd (Singapore)

Measurement of liquid analysis process variables (eg. pH, ORP, Conductivity, DO, Disinfection) with analog instrument sensors often encounter issues with electrical cabling and connections due to moisture ingress, cable properties, EMC interferences that can distort true measurement values. To address these concerns, Endress + Hauser pioneered Memosens technology in 2004. Analog sensors were redesigned from ground up with “non-contact” connectors, digitalized and embedded with memory and sensor intelligence to monitor and record process and sensor information. To date, over one million Memosens sensors are used in the Chemical, Life sciences, Food, Water & Wastewater industries. To address the challenges and applications of Industry 4.0, Memosens 2.0 was evolved with new and updated hardware and software whilst maintaining all the well-established benefits.

World’s First, Full Bore Zero Inlet/Outlet DN Electromagnetic Flowmeter Independent Of Flow Profile

Michael Tan. Endress+hauser (s.e.a.) Pte. Ltd (Singapore)

In flow measurement, the location of the flowmeter in a pipe layout is of great importance. Insufficient straight inlet & outlet pipe runs from pipe obstructions often result in an inaccurate flow measurement. Typically for optimum flow profile, standard electromagnetic flow meters require 5xDN and 2xDN straight inlet & outlet pipe runs respectively. This means long straight pipes must be installed before and after the flowmeter. This increases the cost of investment and higher pumping costs.

To overcome this limitation, the flowmeter inner diameter is reduced to condition the flow profile without inlet and outlet straight pipe run. However, the inner diameter reduction causes pressure losses requiring more pumping energy. Also, this constraint is not optimal for hygienic applications such as drinking water networks.

For sustainable energy efficiency and hygienic compliance, Endress + Hauser invented the world's first Promag W 0 x DN full bore Electromagnetic flowmeter.

Heartbeat Technology – State-Of-The Art Flowmeter Verification For The Water And Wastewater Industry

Michael Tan. Endress+hauser (s.e.a.) Pte. Ltd (Singapore)

In the water industry today, it is critical to ensure high levels of process reliability, consistent quality and accurate billing of water. There is also an increasing need to prove that operations are economically and environmentally sustainable. It is common practice to conduct periodic traceable verification and calibration of critical measurement points. State-of-the-art measuring technology is the key to ensuring these values, since it is well-known for ensuring highly stable measurement results over a long period of time. Endress + Hauser addresses this through its innovative Heartbeat Technology with integrated intelligence for self-diagnostics, verification and monitoring. This means sensors comes with continual self-check and with its embedded reference no longer requires external verification and interruption to the process. Verification provides confidence in measurement reliability and calibration extension. Sensor monitoring of the process eg. build-up, reference potential etc. provides advanced information to the operator for maintenance planning.

Understanding Water Demand Survey As A Strategy For Water Security In Metro Manila

David Andrew Fernandez, Romalyn Malsi. Maynilad Water Services, Inc. (Phillipines)

This paper gives an overview of the water demand survey which provides a better understanding of commercial establishments' water consumption, usage patterns and its characteristics. The gathered data during the water survey will also assist in creating a benchmark for various customer segments and for future planning of strategies and policy-making. The results of the water survey will give the management a definite understanding of where the water is used as well as water efficiency opportunities, including achieving water savings from detected leaks. Water survey is a great opportunity to encourage and teach the staff on the efficient water use behavior. The actual survey is a chance to customize the recommendations to each consumer and allows a person-to-person discussion of water use, potential savings and recommendations.

District Metered Area (DMA) Automation: How Maynilad Manages Its NRW Operations During The Pandemic?

Rafaelle Posadas, Romalyn Malsi, Abe Longued. Maynilad Water Services, Inc. (Phillipines)

Supply measurement is essential in determining the NRW level of an area. Without it, one cannot proceed with its diagnostic activities. Before automation, reading of meters at supply points poses a great challenge to Maynilad. Some chambers are either full of trash and/or full of water. These scenarios are most common in coastal areas like Malabon and Navotas due to frequent high tide. Daily operations like accessing of manholes cause obstruction to traffic and risk the safety of personnel especially in highly congested locations. Traffic congestion can also slow down the productivity of NRW teams in terms of reaction time.

Using Machine Learning And Absorbance-Transmittance And Excitation-Emission Matrix (A-TEEM) Spectroscopy For Water Soluble Fraction (WSF) Contaminant Early Warning Detection In Source Water

Linxi Chen, Adam Gilmore, Joseph Mockus, Adam Eyring. Horiba Scientific (United States)

This study presents using the combination of a patented A-TEEM spectroscopy instrument and multivariate analysis techniques, including machine learning approaches, for identification and quantification of fluorescence markers of the water-soluble fractions (WSF) petroleum and oil contaminants in raw water. This method can be used to identify the type of oil contamination in raw water with a model and to quantify the target contamination components, such as aromatic compounds from the BTEX (benzene, toluene, ethylbenzene, and xylenes) family and naphthalene from the polycyclic aromatic hydrocarbon (PAH) family (combined as BTEXN), to provide a threshold-based alert signal. Identification and quantification of targeted BTEXN contaminants is made by multivariate data analysis involving Extreme Gradient Boosted Tree Discrimination Analysis (XGBDA) classification and Extreme Gradient Boosted Tree Regression (XGBR) techniques. This method can be used by drinking water treatment plant operators and technicians as a first line of defense for detecting petroleum product spills in source water to prevent their withdrawal into, and contamination of, the processed water and treatment infrastructure.

OPTI REVENUE: From Apparent “Commercial” Losses Identification, Quantification And Decrease Strategy To Improved Revenue Management

Alexandre Gil, François Figueres, F Timoner, Asier Arrizabalaga. Suez (France)

This abstract introduces SUEZ's innovative and integrated offer, OPTI REVENUE (OR) which includes a preliminary assessment, the design of a NRW baseline using component analysis method, a NRW action plan definition and quantification, and Solutions and services implementation to decrease apparent losses and improve fair water tariff collection.

AI Application For Dam Safety Monitoring

Jordi Cros. Adasa (Spain)

Use of AI and machine learning method can help to improve decision making in dam safety, where the operation requires using several data provided in general in manual form, that is stored and analysed separately in different tools.

DAM360, validated in a real pilot, integrates information from different sources and used different techniques to predict evolution of control parameters, comparing this to real evolution to identify anomalous behaviour.

Use Of Spatial Failure Clustering Analysis To Target Deployment Of Noise Loggers

Milna Mandusic. Municipality Of Oslo – The water and sewerage department (Norway)

Oslo Municipality Water Works (VAV) commenced intensified work on leakage reduction in DMA Lambertseter, due to rising Water Loss in March 2021. Methods used was the recommended ALC methodology from IWA. Also failure clustering analysis provided guides to deployment of leakage noise loggers, which is considered a success factor in this project. To obtain correct time synchronization, an FM-antenna was commissioned, so VAV had their own frequency, because Norway switched from FM to DAB. Leakage detection and localization were completed, as well as confirmational steps to ensure the quality of leak localisation. After repairs, water loss was reduced from 100 L/s to 20 L/s, reducing the ILI factor from 17,89 to 3,57. Conclusions from this study, ending in May 2021, was that use of failure clusters are very effective in targeting areas that have a higher

probability for failures for deploying leakage technology. Also the methodology from IWA was proved very effective in VAVs case, which VAV will continue to develop, including a ALC strategy and technology strategy.

Pipe Jointing Technology – Delivering Water From Source To Tap

John Wilson. Teekay Couplings Ltd (United Kingdom)

A look into the jointing of Pipework systems to suit a changing market place, to ensure that they do exactly what they need to do, whilst beings strong, light weight, and have health and safety benefits to those that use and install them and provide the correct performances to ensure that the water quality for drinking is preserved and not degraded.

The Pipe Couplings should be able to give a trouble-free performance as expected. Whilst giving the flexibility that is required by today's designers, installers and the client.

Model Based Exploration Of Optimal Asset Management Strategies To Minimize Leakages In Water Distribution Networks

Harsha Abeykoon, Assela Pathirana. National Water Supply And Drainage Board (Sri Lanka)

Water loss is a worldwide problem that the water utility companies are suffering at this moment. The optimal asset management strategies to minimize the physical leakages in an urban water distribution system in Sri Lanka (with pipe lengths of about 600 km serving 69,000 connections) was investigated using a pressure driven demand (PDD) hydraulic model. Pressure management and pipe replacement were the key leakage reduction strategies considered. Pressure management could reduce the leakage by 15% to 25% with minimal impact on water supply (0.3% to 1.75% customers adversely affected). Hydraulic analysis together with limited available field measurements were used to identify leakage hotspots. Pipes in those areas were proposed to be rehabilitated. Pipe rehabilitation in suspected leakage hotspot area could result in reduction of leakage by about 90%, but at a high cost.

Impact Of Domestic Water Storage Tanks On Equity And Performance Of Water Supply Under Rationing Scenarios

Randunu Pathirannehelage Aruna Shantha, Assela Pathirana. National Water Supply And Drainage Board (Sri Lanka)

Many of the water supply schemes were functioning at the limit of their water supply as the capacity of the primary water sources was getting endangered by drying up due to a severe drought in Sri Lanka in 2016 and 2017. Water rationing was initiated by interrupting the continuous supply for a few hours per day based on the cycle time and water storage, and it was extended to a few days per week in the Kakkapalliya, a water supply scheme of NWSDB. It was observed that domestic water tanks affect highly the outcome of water rationing. Consumers and launched massive protest campaigns were questioning the water rationing strategies. Therefore, we analyzed the influence on the consumers due to domestic storage tanks and cycle time during the water rationing using the Gini-Index and Available Demand Fraction (ADF) in an idealized Model. The results show that extended cycle time can increase the equity under intermittent water supply with less impact on the system.

National Digital Communications Policy’s 2018 India Mission And Accomplishing It With Ensuring Environmental Sustainability By Leveraging Emerging Digital Technologies AI/5G/Iot In Water Sector

Sanjay Sohani, Parvati Sohni, Rohit Sohni. BSNL (India)

Since time immemorial, deployment of evolving and emerging technologies for conserving precious natural resources like water hitherto heralded a boon for emergence of new business cases because emerging technologies like AI, 5G and IoT offers immense timely inputs for analysing, planning and managing natural resources. To analyse a particular area and its associated trends in terms of water leakages, increase in Non-revenue water, increase in water contaminants etc. numerous use cases can be developed by employing emerging technologies like AI,5G and IoT Sensors/Actuators which can be analysed with the help of Machine and deep learning algorithms.

- Managing the water distribution network with a Smart Water Grid
- Smart Water Grid system will ensure supply good water 24/7 to its customers. With sensors and analytic tools deployed through 5G/IoT area wise may provide a real-time monitoring and decision support system thus enabling water supply network to curb and prevent leakage by timely intervention.

*New Pipe Design Methodology For Pressure Loss Reduction Of Pipe Elements And Pipe Networks

Gábor Gönczi. Budapest Waterworks (Hungary)

A theoretical research was conducted from 2016 to 2018 which aimed to reduce the head loss of pipe networks in the pump stations. The results were promising and predicted an average of head loss reduction by 30%. Afterwards physical experiments were carried out to test the effectiveness of the new pipe designs. Two new prototype pipe sections were installed into one of our pump stations. The experiment was successful as two unique pipe section installed in the discharge section reduced the head loss of the pump station by 25-26%. According to these results we can set a target value of 30% head loss reduction at full pump station pipe reconstruction.

*Reducing Water Loss From Early Leak Detection On Large Diameter Pipelines

Oded Fruchtman, Yan Ming, Waseem Akram, Harry Low. Aquarius-Spectrum (Israel)

Leaks on water pipes leads to increase in operational costs from leak repair, pipe replacement, water loss and energy waste. Proactive leak detection of leaks on water mains have huge operational benefits. Repairing small developing leaks are easier and cheaper to repair; and can be scheduled in with proper planning, minimising impact to the network and customer supply. Larger leaks are much more expensive to fix and tend to be disruptive.

Permanent monitoring of trunk mains, that transport large volumes of water, allows for proactive monitoring of the network on a daily basis, detecting leaks when they are small and pinpointing the leak to within a few metres, allowing for efficient repairs. Water utilities are able to reduce their non-revenue water (NRW), maintenance and operational costs as well as improve network efficiency by using highly sensitive sensors, management software and a mobile application.

*Using Satellite Remote Sensing Scanning In Water Pipeline Condition Assessment Program: A Case At Piave Servizi

Cristina Scarpel, Jonathan Jacobi. Asterra (technology By Utilis) (Israel)

ASTERRA has a solution to help monitor and assess underground pipes called MasterPlan. Using their Utilis technology, MasterPlan helps evaluate water systems for pipe replacement or multi-year planning activities.

Theme 2: Delivering Water from Source to Tap – Treatment

~~**Water Quality Safety Monitoring And Application Of Construction Site Groundwater For Drought Resilience In Taiwan**~~

~~Tsung-Yu Wu, Nan-Tzer Hu, Cheng-Long Lin, Wen-Yi Diao, Kuo-Ching Lin. Taiwan Water Corporation (Taiwan)~~

~~This year (2021) Taiwan faces its most drought in more than 50 years, especially in the central of Taiwan, Taichung. The water storage capacity of two large reservoirs in Taichung area are less than1% in May. Taichung area daily water demand exceeds one million tons. Taiwan Water Cooperation (TWC) was facing rationing and reducing pressure of water supply. TWC actively developed new water sources, especial construction site groundwater. For the drinking water safety, in addition to several times of raw water quality examination, internal discussions by TWC, Taiwan EPA, experts, scholars evaluate the water quality of 72 construction sites. Finally, 10 temporary water treatment facilities have been completed in construction sites, total daily water supply is 100,000 tons. Each temporary water treatment facility is equipped with water quality monitoring station, including 24-hour automatic water quality monitoring, biological fish surveillance and daily manual inspection.~~

Investigation Of Surfactant–Membrane Interaction Using Molecular Dynamics Simulation With Umbrella Sampling

Yunqiao Ma, Sadiye Velioğlu, Thien An Trinh, Rong Wang, Jia Wei Chew. Nanyang Technological University (Singapore)

Nanoscale characteristics of the polyamide layer are key towards the high desalination performance of thin-film composite reverse osmosis (TFC-RO) membranes. Herein, we discuss the properties of polyamide layers formed using identical IP conditions over support membranes of different polymers and chemistries (polyethersulfone, polyetherimide and polysulfone) under fairly similar surface pore properties. The characteristics of the polyamide layers formed thereon displayed different physicochemical properties. It is postulated that the support membrane chemistry actually affects the IP reaction and polyamide formation by controlling the amine diffusion speed as well as the breadth of the IP reaction zone. The mechanistic insights from this study are expected to provide more understanding towards a better control over the fabrication of polyamide layers for TFC membranes. The findings in this work are also expected to facilitate tailoring polyamide layers for specific osmotically driven processes.

Unraveling The Role Of Support Membrane Chemistry And Pore Properties On The Formation Of Thin-Film Composite Polyamide Membranes

Yu Jie Lim. Nanyang Technological University (Singapore)

Membranes are effective for removing oil emulsions in oily wastewater treatments, which is important for environmental remediation as well as recovery of oil for economic benefits. Surfactants play a critical role in stabilizing the oil emulsions, but their effects on the inevitable membrane fouling phenomena remain poorly understood. The focus here is the interesting flux enhancement relative to water conferred by the cationic CTAB surfactant. Molecular dynamics simulations were performed to understand the interactions between three different surfactants and a hydrophilic PVDF surface. Unbiased MD simulations quantify the surfactant–water, surfactant–membrane, and water–membrane interactions, but none appears well-correlated to the relative flux trends due to the interplay of all three interactions. To account for all interactions concurrently, umbrella sampling was performed to obtain the PMF curves. The adsorption of all three surfactants

is driven by enthalpy (rather than entropy), and CTAB was found to have the most attractive binding free energy, smallest equilibrium distance, and looser water network near the PVDF surface, which are tied to the experimental observation of flux enhancement and highest retention. The Angstrom-scale results here reveal the need to consider all the interactions simultaneously rather than separately to fully account for mechanisms underlying membrane fouling by surfactants.

Predicting Reverse Osmosis Membrane Cleaning Times Using Machine Learning

Mike Dixon, Nick Herold, Katie Higgins, Joelyn Tan, Xiao Qiang King. Synauta Inc. (Canada)

Timing membrane clean-in-place (CIP) activities is a critical action necessary in a reverse osmosis (RO) membrane-based plant. However, making manual calculations and estimates can be extremely difficult and with multiple trains of membranes it becomes very difficult for humans. Synauta applied their patent pending machine learning software to the problem to predict the optimal time to undertake clean-in-place activities. The study's objective was to demonstrate the use of machine learning to predict the optimum time to clean RO membranes at the Bedok NEWater Factory (BNF), a water reuse plant owned and operated by PUB Singapore. Synauta used their standard machine learning for RO deployment method, whereby BNF Phase 1's data is reviewed and algorithms applied. In the initial results that analyzed historic membrane data, as much as 0.67bar savings were observed when cleaning at a more optimal time, with an average of 0.18bar savings. This is now being demonstrated at the plant over 18months and updated results will be ready for the full paper.

Using Co2 For Acidification And Process Improvement In A Seawater Ro Plant

Ratul Das, Thomas Altmann, Shinsuke Hirata, Nobuyuki Masumoto. ACWA Power (Saudi Arabia)

We present an enhanced RO desalination system that improves the efficiency of the coagulation system and helps to maintain (or even increase) RO first-pass recovery ratio, while simultaneously reducing the need for industrial acids, and antiscalants in the second-pass that can potentially cause biofouling. This improvement project aims to eliminate the use of industrial acids for acidification of feed water for the RO process; we instead inject carbon dioxide gas (CO2) in seawater after capturing it from the flue gas exhaust of the fossil-fuel power plant at. The injection of CO2 into raw seawater prior to pretreatment and membrane separation process, essentially reduces the carbon footprint of the process. CO2 addition will reduce scaling potential and allow a high recovery operation, it will also make expensive industrial acid and antiscalant dosing obsolete.

Enhancing Municipal Desalination Performance

Santhosh Ramalingam, Javier Suarez. Dupont (Singapore)

Desalination is an important source of fresh water for Singapore. However, desalination process is often expensive and unreliable due to sensitivities of the membrane-based technology, namely reverse osmosis and ultrafiltration. The current paper demonstrates how novel innovations in membrane-based technology can improve robustness of desalination operation, eventually resulting in energy savings and better reliability.

3D-Printing Of Anti-Fouling Nanocellulose Desalination Membrane

Liang Ying Ee. National University of Singapore (Singapore)

A novel fabrication approach of brackish water desalination membrane employing 3D electrohydrodynamic spray printing has been successfully demonstrated and shows promising desalination performance of more than 65%. The proprietary print ink enables further modification of the 10% cellulose acetate/polyethylene glycol-based membrane with anti-fouling capability for longer lifetime.

Dechlorination Control In Reverse Osmosis Membrane Applications

Vadim Malkov. Hach (United States)

For efficient Reverse Osmosis (RO) membrane operations, it is important to accurately monitor and control residual chlorine in the feedwater and, sometimes, permeate. Currently, such monitoring and proportional addition of dechlorinating agents to feedwater is mostly done with either grab sample analysis, or in combination with continuous ORP measurement, which is not ideal. Other employed methods are also not efficient given the current state of technology. An online analyzer, accurately detecting ultra-low concentrations of chlorine and quantifying it above 8 ppb, hence allowing better control, was developed and successfully tested in various RO applications.

Analysis And Prediction Of Ultrafiltration Membrane Fouling Resistance In Water Treatment Using Artificial Intelligence

Mahdi Faramarzi, Kaushik Ghosh, Gokula Krishnan Sivaprakasam, Matsui Yasuhiro. Yokogawa Engineering Asia Pte. Ltd. (Singapore)

Ultrafiltration membranes which is widely used in water treatment plants are exposed to membrane fouling, where frequent cleaning procedure are inevitable to restore the membrane permeability. Various cleaning methods have been practiced including backwash and chemical cleaning to prevent irreversible membrane fouling. In this study, (1) the impact of backwash and chemical cleaning at different flux level have been investigated. (2) membrane resistance during production mode and after chemical cleaning have been modelled using artificial intelligence and (3) The developed models have been used to predict the future fouling resistance for production mode and after chemical cleaning. The proposed method was applied to 1-year data collected from low-pressure ultrafiltration membrane. The experimental and the analytical results showed that the flux can be maintained by controlling the membrane fouling using a sequence of filtration, backwash, and chemical cleaning. Artificial Intelligence Models have shown high potential to predict membrane fouling resistance.

Sustainable Urban Water Management – A Triumph On The Supply Of Recycled Water In Hong Kong

C.K. Lee, T.T. Lin, S. Shou, C. Chan, H. Lee, T.S. Yu. The Government of the Hong Kong Special Administrative Region (Hong Kong SAR)

As pledged in its Policy Agenda 2017 and 2018, the Government of the Hong Kong SAR set the goal to reduce the average fresh water per capita consumption by 10% by 2030 the earliest, using 2016 as the base year. To achieve this, the Water Supplies Department (WSD) has been taking forward a host of demand management measures, including expanding the use of lower grade water (i.e. seawater and recycled water) for non-potable uses, further promoting water conservation and managing water loss. The two ongoing WSD projects discussed in this paper, one recycling grey water collected from a new development area while the other generating reclaimed water through extra processing of treated sewage effluent (TSE) from sewage treatment works for non-potable uses, form the cornerstones and authenticate the feasibility and potentials of adopting public large-scale supply of treated grey water and reclaimed water in Hong Kong.

Removals Of Methicillin-Resistant Staphylococcus Aureus And Its Methicillin-Resistant Meca Genes By LED-UV And LED-UV-Based Advanced Oxidation Processes

YW Chen, S Ghosh, L Wang, Jiangyong Hu. National University of Singapore (Singapore)

To control the spread of antibiotic resistance in drinking water, LED-UV and LED-UV-based advanced oxidation processes (AOPs) were adopted to remove the model bacteria, methicillin-resistant Staphylococcus aureus (MRSA), and its methicillin-resistant genes mecA. The results showed that LED-UV inactivated MRSA similarly to the low-pressure mercury UV (LP-UV) did at fluences lower than 40 mJ/cm2. However, LED-UV outperformed LP-UV in the removal of mecA by 1-log at 600 and 900 mJ/cm2. Two AOPs, LED-UV/Cl2 and LED-UV/NH2Cl, showed positive synergetic effects in the inactivation of MRSA. For the removal of mecA, the efficiencies of AOPs were lower than those of LED-UV alone. It implies the unimportant roles of Cl2/NH2Cl and the radicals in the mecA removal. This study reveals that LED-UV was more advantageous than LP-UV in the removal of mecA, and the adoption of LED-UV or its derived AOPs depends on the specific target to achieve.

The Beneficial Impacts Of Ozonated Microfiltration On Water Quality And Ceramic Membrane Performance

Holly Shorney-Darby, Jumeng Zheng. PWNT (Netherlands)

This paper will present the water quality and operational benefits of ozone oxidation on ceramic membranes. This include water quality benefits, such as taste and odor, disinfection byproducts, and organics oxidation, as well as the impacts on downstream disinfection, membrane cleaning intervals, and process efficiencies for downstream processes like granular activated carbon and UV light irradiation. Membrane performance is also enhanced with ozone. Surface water plants having ozone residual on the ceramic membrane operate at lower transmembrane pressures and with less cleaning chemicals.

Soil Contamination Due To Reuse Of Zno Nanoparticles Contaminated Wastewater Effluent

Radhika Sharma, Toru Watanabe, Arun Kumar. Indian Institute Of Technology Delhi (India)

Reuse of wastewater effluent for non-potable uses presents an interesting opportunity for areas or countries without abundance of freshwater or for smart cities looking for integrated water management approach. However, this should be cautiously approached in the context of how the pollutants remaining in the wastewater effluent may affect the environment if used for purposes like irrigation. The presence of nanoparticles in the environment presents no surprise, with their wide-ranging application today. This theoretical study conducted an ecological risk assessment for soil due to non-potable urban reuse of nanoparticle contaminated treated wastewater for irrigation of Spinach. Literature was thoroughly searched to gather data relevant to this work. Lognormal distribution of collected ZnO nanoparticles concentration in wastewater effluent was made as part of Monte Carlo analysis. Plant uptake models based on existing data were derived to compute uptake of Zn in the plant. Simple mass balance was used to find soil contamination. Contamination Factor, Potential Ecological Risk Factor, and Geo-accumulation index were found to be well within their respective contamination limits. This study found no risk to soil in such a hypothetical scenario. The framework demonstrated here could be well utilized again to find risks for such reuse.

Resource Recovery From The Greenhouse Water Cycle: Characterizing Selectivity Using Multicomponent Transport Models

Danyal Rehman, John Lienhard. Massachusetts Institute Of Technology (MIT) (United States)

Anthropogenic eutrophication can severely disrupt the natural ecosystem by degrading freshwater quality. One of the leading causes of eutrophication is greenhouse effluent. This effluent is usually

comprised of nutrients that include nitrates, phosphates, calcium, magnesium, and sulphates. In addition, the effluent also has high concentrations of sodium and chloride – ions that are detrimental to crops. These harmful ions serve as the primary barrier to water reuse and zero liquid discharge (ZLD). Monovalent selective electrodialysis (MSED), a selective electrochemical desalination method, has proven effective at treating brackish sourcewater and preferentially removing multivalent ions relative to monovalent ions. Although experimental studies have indicated MSED's ability to treat greenhouse wastewater, a high-fidelity model characterizing MSED's selectivity with greenhouse effluent as the feed solution, is unavailable in the literature. This paper quantitatively asserts MSED's ability to remove harmful ions and retain beneficial ones from various greenhouse effluents using computational models.

Biological Treatment In Drinking Water? Treating Potable Water With Advanced Biofiltration To Reduce Disinfection Byproducts

Stanley Shmia, Alex Bettinardi. De Nora Water Technologies (United States)

In the past, when natural water supplies were more plentiful and pristine, conventional water treatment involved conventional sedimentation, and disinfection with chlorine. Today, due to global warming, population expansion, and new contaminants entering the environment, drinking water sources have become harder to treat with conventional water treatment trains.

Combing ozone with a biologically active filter (BAF), in a drinking water plant is a cost-effective way of dealing with contemporary drinking water sources without using membranes or other technologies which produce difficult to dispose of concentrate streams. Ozone particularly breaks down the large organic molecules in the source water and is then followed up with a biologically active filter to remove the remaining contaminants.

This paper describes a successful pilot of this technology at a drinking water plant which was experiencing high level of organic contamination and were concerned about generating disinfection products (DBPs) with their conventional treatment system.

Planning Ahead For Smart Extension – Siu Ho Wan Water Treatment Works, Hong Kong

Kin Lik Sy, Stephanus Shou, James Chan, Alex So. Water Supplies Department, The Government Of The Hong Kong Special Administrative Region (Hong Kong SAR)

To cope with developments in North Lantau of Hong Kong, the Water Supplies Department (WSD) is working on the detailed design for Siu Ho Wan Water Treatment Works (SHW WTW) extension to double its daily water treatment capacity from 150 million litres per day (MLD) to 300 MLD by 2028. Besides, WSD aimed to achieve a higher level of treatment with 4-log reduction/inactivation of Cryptosporidium and Giardia and removal of 2-Methylisoborneol (MIB) and other organic matters that cause taste and odour issues, such that the existing plant has also to be upgraded. To meet the tight programme in limited footprint while maintaining uninterrupted operations, WSD has explored several smart initiatives such as Stacked Process Design and Prefabrication. Innovative idea such as Digital Twin has also been introduced to help optimise the future plant operation.

Putatan Water Treatment Plant 2 – Delivering A New 150MLD Plant In Metro Manila To Work With One Of The World's Most Challenge Water Sources

Adrian Marsden. Arup (Phillipines)

Putatan Water Treatment Plant (WTP) 2 is a new 150 MLD plant constructed in Metro Manila, Philippines and finished in 2020. The plant was constructed in a very small footprint and working around a number of delivery constraints. In addition, the plant draws water from Laguna Lake, a

highly polluted and variable water source; experiencing high ranges of solid and dissolved pollutants including seasonal saline intrusion. During construction a number of new resilience challenges were encountered; such as earthquake induced water quality reductions. The paper will provide a background on the context of water supply in Metro Manila and some of the existing constraints that exist in a rapidly developing city in South East Asia which has suffered a major infrastructure funding gap. It will discuss some of the water quality challenges and how this led to the process selection chosen. It then discusses some of the implementation challenges of working in a lower income country. The challenges were acknowledged with the award of a Distinction in the category of Water Treatment at the 2020 Global Water Awards.

Prediction Of Algal Bloom In Reservoir Dams Using Sparse Modeling And Support Vector Machine

Yohei Miura, Shota Yashima, Hiroomi Imamoto, Yasuhiro Asada, Michihiro Akiba, Osamu Nishimura, Daisuke Sano. Tohoku University (Japan)

Algal bloom has been one of the problematic issues in the water supply industry. The present study constructed a prediction model for the bloom of Microcystis spp. and Anabaena spp. in reservoir dams using sparse modeling and Support Vector Machine (SVM). Water quality and dam operational parameters, including nutrient concentration and water discharge flow, and meteorological factors such as daily highest air temperature and precipitation, are used as input data for algal bloom prediction. The highest scores of accuracy, precision and recall of a model with SVM were 95.0 %, 77.8 % and 100.0 % for Microcystis spp., and 52.2 %, 50.0 %, 100 % for Anabaena spp. respectively. The lack of parameters and the existence of Microcystis spp. are considered as the reason for the difference between these two species.

Water Spray Reactor For Ammonia Removal Via Air Stripping

Miratul Magfiroh. University of Science And Technology (Korea Rep)

Air stripping technique for ammonia removal has been practiced to treat wastewater wherein mass transfer of gas phase from liquid is progressed under favourable circumstances. In this study we demonstrated a developed rector for ammonia removal via air stripping. The performance of our reactor was assessed by comparing the ammonia removal efficiencies and mass transfer coefficient values of the experiments. We also discussed air consumptions among the existing reactors for ammonia removal via air stripping. Water of flow of 10 L/min, air flow of 120 L/min, pH 11 and ammonium concentration at 50 mg/L were of significant parameters that facilitate higher ammonia removal efficiency when utilizing our reactor. In addition, air consumption of this reactor was considered lower than those from other existing air stripping reactors for ammonia removal.

Selecting The Right Solution For NOM Removal - An Approach, Considerations And Experiences In The UK.

Tony Koodie, Stewart Sutherland, Nicholas Booker, Andrew Elphinston. Binnies (United Kingdom)

It is well established that a significant decrease in the concentration of Natural Organic Matter (NOM) prevents the formation of disinfection by-products (DBPs) such as trihalomethanes (THMs). The UK has numerous water treatment works treating highly coloured, low alkalinity water. These waters create unique treatment challenges and a combination of several sequential treatment processes is required to ensure consistent compliance with treated water quality targets. The existing processes generate large volumes of sludge for treatment and subsequent disposal which can occasionally restrict the throughput at certain works. In addition, disinfection by-product (DBP) concentrations in the distribution network supplied from a number of these works currently threaten to exceed existing regulatory limits. It is anticipated that these limits will be reduced in the

foreseeable future, increasing the risk of exceedance. In addition, it is anticipated that additional by-products will be added to the existing list of regulatory parameters, posing further risk of exceedance. The aim of this presentation will be to highlight an approach in assessing the possible treatment options available for minimising DBP formation and highlighting specific experiences in Scottish Water with ion exchange technology used for NOM removal.

Removal Of Emerging Contaminants By Nature-Based Sorbent Materials In Advanced Constructed Wetlands – Application For Water Reuse

Marieh Fatahizadeh, Marjolaine Deschamps, Chaza Chbib, Nicolas Roche Jerome Labille. Aix-Marseille University (France)

Pharmaceuticals and personal care products (PPCPs) are one of the emerging contaminants detected in water resources and substantially affect the environment. Conventional wastewater treatment is unable to remove the most recalcitrant PPCPs completely, and there is a demand for an effective method to remove these pollutants. In this study, the adsorption of a mixture of 12 pharmaceuticals on various nature-based adsorbents was investigated. Modified clay, compost, and activated carbon from olive stone were tested as sorbent materials. In addition, their removal efficiency was compared to that of a commercial activated carbon. High removal efficiencies were generally obtained, depending on the type of pharmaceutical molecule and on the material surface area. Therefore, the use of these kind of adsorbents seems to be an effective approach for removing emerging pollutants from wastewater that can be used to improve the performance of advanced constructed wetlands.

Robust Pretreatment For Particularly Challenging Seawater Conditions

Tomer Efrat, Alex Drak. Ide Water Technologies (Israel)

Ultrafiltration (UF) is commonly considered as an ideal stand-alone pretreatment technology to treat seawater prior to the reverse osmosis step for desalination.

IDE Technologies designed and constructed a seawater desalination plant in India's arid northwestern region, with a capacity of up to 168,000 mÂ³/d (44.4 MGD) of process water from seawater of the Gulf of Kutch. The plant design had to meet particularly difficult requirements for pretreatment, with seawater that contains high concentrations of organic matter and is subject to frequent algal blooms. Different steps were considered, including operation of a pilot. Piloting results confirmed that the ultrafiltration modules could meet the very ambitious targets in terms of process stability, filtrate quality and yield, especially during the monsoon period and finally impact the process design. The paper also touches on commissioning challenges.

Mitigation Of Fouling And Wetting In Membrane Distillation Using A Multi-Layered Single-Wall Carbon Nanotube/Polyvinylidene Fluoride (SWCNT/PVDF) Membrane

Junghyun Kim. Korea University (Korea Rep)

In this study, electrical repulsion was used to overcome the vulnerabilities of MD membrane modification to fouling and wetting. The objective of this study is to evaluate the performance of a single-wall carbon nanotube (SWCNT)-coated MD membrane using electrical repulsion to mitigate fouling and wetting under high recovery conditions. Fouling and wetting was prevented by obstructing he contaminant from accessing the membrane through repulsion and increasing hydrophobicity; ultimately, this achieved the aim of sustainable MD operation without performance degradation. Under various operating conditions, the electrical repulsion of the MD process using the SWCNT/PVDF membrane was systematically evaluated by monitoring MD performance. It also involved understanding the fouling and wetting mitigation mechanisms, including analyzing the

characteristics modified membranes, calculating the repulsion force, and carrying out long-term experiments. The results showed an improvement in the stability of the modified surface under a long-term operation using the minimum applied voltage during repulsion.

Improvements In Coagulation Control Using Integrated Deterministic Modelling And Machine Learning Approaches

Chaim Kolominskas. Envirosuite (Australia)

Using an innovative combination of deterministic and regularly retrained recurrent neural network modelling Envirosuite implemented a simulation of feed water quality and forecasts coagulant mass flow/concentrations required to achieve dissolved organic carbon and turbidity setpoints at a plant in Singapore for the first time.

The combination of machine learning and empirical modelling aimed to delivers higher accuracy forecasts than machine learning only or traditional modelling approaches. Based on a calibrated digital twin of the treatment plant, the solution is optimised to forecast required dosing rates for up to 24 hours in advance. The recommended operating setpoints are delivered daily for each hour of operation and provided in a format that is easy to use by plant operators and engineers.

The solution was targeted to reduce dosing costs and maintain or improve water quality. This paper summarises the outcomes of the project and provides recommendations for similar future applications.

Multi-Agency Reuse Programs: Lessons For Successful Collaboration

Felicia Marcus, David Smith, Eric Rosenblum, Robert Raucher, Shannon Spurlock. Standford University (United States)

The water industry is in many cases fragmented into separate organizations specializing in different aspects of water such as wastewater agencies, water supply agencies, and stormwater management agencies. Water reuse, in many if not most cases, requires those agencies to work across functions and geographies. There are issues of governance, regulation, economics, operations, and leadership to be actively navigated to create successful projects. This project, supported by the US Environmental Protection Agency Water Reuse Action Plan, presents a framework for creating the necessary agreements to make water reuse projects work and presents case studies that illuminate successful collaborative endeavors that have expanded the scope and scale of water recycling in the US while presenting valuable and inspiring lessons for anywhere.

Inline UV Disinfection System, A New Approach Of Equipment Design

Gábor Gönczi, Ramón Kreka, János Farkas, István Lajtos. Budapest Waterworks (Hungary)

One of the most modern disinfection technologies for water treatment is the use of UV light as disinfectants. Our company currently operates 18 UV devices of various sizes, capacities and types. UV equipment is used at strategic points, as an additional technology to the traditional disinfection process. The aim of the development of the new UV disinfectant device was to install a completely self-designed equipment to one of our main pump houses that is more efficient than the types available on the market. We have developed a new sizing procedure that is much more efficient than a conventional method, than this the procedure was implemented to CFD modelling. With the help of this new tool we were able to design more efficient UV equipment, which has a flow-optimized reactor space. The developed new “Inline UV” design is far more efficient than competitor devices.

Ceramic Microfiltration Pretreatment; Shifting From Ionexchange To Coagulation At Wtp Andijk

Jink Gude, Bram Martijn. PWNT (Netherlands)

Feasibility of a transition from ionexchange as pretreatment prior to ceramic microfiltration to coagulation and flocculation at PWN's wtp Andijk was investigated. Drivers for this investigation are the undesired chloride addition due to the current practice of the ionexchange and the potential improved operation of the ceramic microfiltration by coagulation pretreatment. The tricky part in this investigation was the feasibility of the current ionexchange contactor infrastructure for coagulation and the need and benefit of expanded lamella settling capacity from resin settling to ferric floc settling.

Desalination Plant Safety Reliability And Efficiency; Retrofitting A Piston Style Work Exchanger With PX Technology

ERIK Tynes. Energy Recovery (Canada)

A recently commissioned 216 MLD desalination plant did not meet three key performance indicators: availability, efficiency, and safety. This case study provides an overview of the process of how the owner went about making a sustaining capital investment in order to have a plant that met their requirements.

Energy Recovery Device Deployed In A Ultra High Pressure Reverse Osmosis ZLD Application: A Case Study

ERIK Tynes, Energy Recovery (Canada)

An upstream oil and gas facility deployed Ultra PX technology in Sichuan province, China, to treat flow back water from a hydraulic fracturing shale gas exploration site that is subject to ZLD regulation. The facility currently achieves zero liquid discharge of the wastewater using RO desalination systems and a thermal process. After treatment, 60% of the fracturing fluid is reused, 30% is discharged up to the standard, and 10% of the concentrated fluid is evaporated to obtain crystalline salt. However, no ERD is currently in use for their UHPRO systems.

The UHPRO system treats 13.4 m3/h (59 gpm) of a wastewater feed with a TDS of 77,000 ppm and recovers 36% of fresh water while concentrating the wastewater to 120,000 ppm.

The required RO feed pressure is 117.2 bar (1,700 psi) and the system consumes an estimated total power of 55.5 kW, which represents a SEC of 11.5 kWh/m3 of fresh water produced. By adding the Ultra PX into the process, the power consumption dropped to 24.8 kW and the SEC to 5.2 kWh/ m3. This represents a power reduction of 55% and an annual cost saving of approximatively $27,000 st 0.10 per kWh.

*Optimizing Brine Electrolysis Processes To Minimize Chlorate Production

Andrew Boal, Jean-Paul Monali. De Nora Water Technologies (United States)

Chlorate is a well-known emerging contaminant that can be introduced into drinking water as a disinfection byproduct. Regulatory agencies such as the United States Environmental Protection Agency (USEPA), the World Health Organization (WHO), the European Commission, the European Food Safety Authority (EFSA), and several large Food and Beverage companies have noted the health effects of long-term exposure to chlorate through drinking water and are taking steps to limit human exposure to chlorate in drinking water. When using bulk sodium hypochlorite for water disinfection, chemical degradation of hypochlorite can result in the production of chlorate, which is then introduced into the water being treated. In the case of On-site Sodium Hypochlorite Generation (OSHG) systems, chlorate results from undesirable electrochemical side reactions that occur during

electrolysis. Initial research into chlorate introduced by OSHG systems did not determine causal factors that impact the relative amount of chlorate produced during electrolysis. However, recent research on OSHG systems in our laboratories has determined that the salinity and temperature of the brine solution used in the electrolysis process directly impact the relative amount of chlorate present in the produced sodium hypochlorite solution.

*Reduction Of RO Membrane Cleaning Frequency By Inserting Ceramics Adsorption Filter Between Ultrafiltration And RO Systems

Keiko Nakano, Hikaru Yoshimine, Tomonori Saeki, Kenichiro Sekiguchi, Masahiro Sato, Yusaku Maruno, Benghuat Low. Hitachi Metals Singapore Pte Ltd (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. Hitachi Metals has developed ceramics adsorption filter (CAF) which captures organic matters in seawater by the function of adsorption. Effective reduction such as ½ of RO membrane cleaning frequency has been proven in laboratory-scale case study in the collaboration research with NEWRI (Nanyang Environment and Water Research Institute) under NTU (Nanyang Technological University). Hitachi Metals is conducting the PUB testbed project, in order to prove the effectiveness of CAF in pilot-scale long-term operation. Using the ultrafiltration (UF) permeate supplied from the Tuas South Desalination Plant (TSDP) to the PUB R&D facility, Hitachi Metals operated the seawater desalination pilot plant, equipped with two sets of RO system. One of the RO systems follows a CAF unit and by comparing the RO performances of the two units, the effects of CAF can be demonstrated. The results indicating the CAF effectiveness to suppress the RO permeability decline have been obtained so far.

*Breakthrough Dry-Tested Seawater Reverse Osmosis Elements

Santhosh Ramalingam, Maria Angeles Perez Macia, Guillem Gilabert-Oriol, Lewis Liu. Dupont (Singapore)

Water scarcity is one key challenge mankind is facing. Seawater reverse osmosis desalination is a promising technology to solve it. However, further innovation to go beyond product specifications is needed to decrease the total cost of water while at the same time, improving sustainability footprint. This paper describes a breakthrough step-change in innovation within the desalination industry: transitioning from Wet-test SWRO elements to Dry-test SWRO elements. This new concept has been achieved by DuPont thanks to continuous advancements in membrane chemistry, automated precision manufacturing, a robust quality control, and enhancements in testing methods.

Dry-test SWRO elements offer significant advantages over wet-test elements. Dry-tested membranes enable longer storage times, lower labor costs and easier warehouse planning. Dry-test membranes are safer to install due to lower weight and easier to handle. The dry-test SW concept also brings plenty of sustainability benefits in eliminating fresh-water consumption for testing, eliminating wastewater generated during testing, reducing energy consumption in wet testing which can be translated to 20% lower CO2 emission per element. The lower weight for shipping will also significantly decrease the environmental footprint of these elements.

Additionally, dry-test SWRO elements offer the same water productivity and permeate quality as wet-test elements, once stabilized.

*First Stage Of Tseung Kwan O Desalination Plant – Innovations And Features

Jose Bidaurrazaga Ka Chun Yan, Andy Kwok. Water Supplies Department (Hong Kong SAR)

Increasingly frequent and extreme climate events have led to very erratic rainfall patterns all over the world, potentially disrupting fresh water resources during prolong periods of dry weather. To cater for this challenge, the Water Supplies Department (WSD) of the Government of the Hong Kong SAR is building resilience through the first stage of Tseung Kwan O (TKO) Desalination Plant, the first membrane-based desalination plant to supply municipal potable water in the Hong Kong SAR upon its commissioning in 2023.

Currently in the detailed design and construction stage, the Plant design incorporates unique and sustainable design elements and considerations with the aim to minimising environmental impacts and facilitating an effective and reliable plant operation for production of quality fresh water.

This paper will highlight the requisites and constraints of the Plant as well as present the design features and solutions to achieve a highly efficient and sustainable plant.

*The Potential Of Split-Feed Osmotically Assisted Reverse Osmosis (SF-OARO) For Low-Energy, Low Cost And High Recovery Desalination

Zijing Mo, Christian Peters, Qianhong She, Cheng Long. School of Civil and Environmental Engineering, Nanyang Technological University (Singapore)

Improving the recovery of desalination processes via brine volume minimisation (BVM) can have economic and environmental benefits. However, it is generally more energy intensive and costly. This may change, as new high-recovery membrane processes, such as split-feed osmotically assisted reverse osmosis (SF-OARO), can potentially lower the energy consumption of BVM via osmotic counterbalance. To validify these hypothesised advantages, this study explores the economic and technical viability of SF-OARO using an efficient bio-inspired approach, the Porcellio Scaber Algorithm (PSA) for optimization. The results show that the optimized SF-OARO process can reduce the UWC by 3.3% while operating at higher recovery (65% instead of 50%) than conventional RO (CRO) at an intermediate brine disposal cost of 0.30 $/m3. In summary, the presented results indicate that the SF-OARO process is the cheaper choice once the brine disposal cost (Cbrine) exceeds 0.24 $/m3.

*Zero-Liquid Discharge Made Affordable With Minimal Liquid Discharge Technology And A Circular Economy Mindset

Tina Arrowood. Dupont Water Solutions (United States)

Zero-liquid discharge (ZLD) is recognized for its benefits to preserve fresh surface waters by maximizing wastewater reuse and eliminating wastewater discharge, but it is generally found to be too expensive to be practical. Using Minimal Liquid Discharge (MLD) to reduce the volume of wastewater before resorting to thermal ZLD treatment is proving to be a more practical, cost-effective hybrid solution. MLD uses membranes to recover purified water and concentrate the wastewater contaminants. Membrane separation requires significantly less energy than thermal distillation. The Textile industry of Southern India has been using MLD-ZLD wastewater management processes for nearly 10 years. Details from their operation validate the economic advantage MLD offers ZLD systems, but also reveals the benefits of the extra value received from recycling and reusing both water and salt from the wastewater. Employing MLD and circular economy saved the textile industry from stringent discharge regulations requiring ZLD wastewater management.

***Autonomous Water Production – Should We Really Take The Human Fully Out Of The Lop?**
Mark Kaney, Chris Steele. Binnies(United Kingdom)

With technology developing at lightning speed and the drive to provide a more resilient water supply at a lower cost, we are fast approaching a point where we can run a water treatment and production facility without any human intervention. But with this comes the conundrum, just because we can do something, doesn't necessarily mean that we should!

This paper will look at the various advantages of autonomous operational control along with the challenges and ethical dilemmas we face in choosing to do so. We will look at the key components required in order to make this happen, a selection of case study examples of how companies have approached this challenge and what are some of the lessons learned have been that will help us continue to develop our thinking in the evolution of a fully digitally enabled water company.

~~***Detecting Sensor Drift In Water Treatment Plants In Singapore**~~
~~Anna Whitmore, Paul Zuber, Jamie Radford, Daniel Everitt, Ismail Weiliang Osman. Mott Macdonald (Singapore)~~

~~Accurate and well calibrated sensors are critical to the operation of water treatment plants. Undetected sensor drifts can mislead operators' decisions and negatively affect process control systems. Through the PUB Global Innovation Challenge 2020, Mott MacDonald, Ada Mode and PUB have developed a solution to identify sensor drift and miscalibration at water treatment plants. The solution combines existing water treatment process models with a sensor analytics toolkit and a machine learning driven industrial monitoring system to deliver live sensor monitoring solutions and detect anomalies in real time through the Moata platform.~~

***On-Line Tool For Ultrafiltration And Reverse Osmosis Systems Normalization And Optimization**
Javier Suarez. Dupont (Singapore)

After more than two decades of its popular excel-based data normalization tool, DuPont has launched a completely digital, user-friendly & revamped tool to allow plant operators to normalize their data. For a proper system performance assessment and optimization, Ultrafiltration (UF) and Reverse Osmosis (RO) operating data normalization is vital in all systems which treat feed water with variable salinity and/or temperature.

FT-Norm PRO (FilmTec™ Normalization of Membrane Systems) is a free online tool which makes the data normalization process simple to accomplish yet robust enough to allow for effective monitoring of UF and RO systems. This tool helps plant operators exploring how variations in feedwater temperature, salinity, or pump pressure can influence the apparent productivity and rejection of a membrane system, making it less obvious when a real change in membrane performance takes place.

The objective of this presentation is to make the audience understand the purpose and importance of data normalization in UF and RO systems and introduce the key features of this innovative online tool.

~~***MAXH2O Desalter: Breaking the boundaries of RO in Industrial water treatment**~~
~~Conghui He, Kuo Fang. Tsinghua University (China)~~

~~Water scarcity and increasing operational costs related to brine management and tightened environmental regulation motivate the industrial water consumer to maximize the reuse and recycling of water and reduce the effluent flow, in some cases up to zero liquid discharge. When~~

~~facing this challenge, standard RO systems are limited by the water's chemistry and quality, which may cause scaling and fouling on the RO membranes. The MAXH2O Desalter overcomes these limitations by implementing a unique process that integrates an RO membrane with an integrated salt precipitation unit.~~

*Novel Sandwich Structured Hollow Fiber Membrane for High Efficiency Membrane Distillation and Scale-Up for Pilot Validation

Conghui He, Kuo Fang. Tsinghua University (China)

Hollow fiber membranes were produced from a commercial polyvinylidene fluoride (PVDF) polymer, Kynar HSV 900, with the chemistry and spinning process developed by Prof. Chung's group at NUS. The membranes have a unique sandwich structure consisting of two sponge-like layers connected to the skin layers and one thin layer, consisting of macrovoids, in the middle. The novel structure is expected to render the PVDF hollow fiber membranes more efficient in terms of vapor flux as well as mechanical integrity. Using the chemistry and process conditions adopted from NUS's team, START was able to scale up the membrane fabrication from laboratory scale of 1.5 kg to 50 kg with consistent membrane performance. The membranes were then assembled into 2-inch and 4-inch diameter modules for pilot scale validation using simulated industrial wastewater. The produced PVDF membrane, with a liquid entry pressure of >3 bar and the pure water flux of >30 LMH under VMD condition at 70 – 80 ℃, are perfectly suitable for next generation high efficiency membranes for desalination and industrial wastewater applications. The technology translation efforts, including membrane and module scale up as well as the preliminary pilot scale validation study will be discussed in detail, in this presentation.

*Translation and evaluation of nature-inspired hydrophobic membranes for membrane distillation

Conghui He, Kuo Fang. Tsinghua University (China)

Current lab-scale fabrication of hydrophobic membranes for membrane distillation often involve complex surface modifications or the usage of nanomaterials. However, these methods are often difficult to be scaled up. Hence, in this work, a relatively simple rheological spray-assisted nonsolvent induced phase separation (SANIPS) approach, developed by NUS' Prof. Chung's team to fabricate hydropbic polyvinylidene fluoride (PVDF) membranes, were translated and evaluated on the pilot scale. The resulting membranes were found to have high porosity, hydrophobicity, high liquid entry pressure and ease of scaling-up. It was found that the morphological structures and other membrane properties could be tuned by varying the operating parameters. Hence, this fabrication method may pave the way for large-scale production of high-efficiency, self-cleaning hydrophobic membranes for membrane distillation.

Theme 3: Effective and Efficient Wastewater Management – Treatment & Conveyance

Rapid Removal Of Refractory Organics From Old-Age Landfill Leachate With High-Valent Polynuclear Iron(III) Hydroxo Complex

Kwok Wah Cheung, Kwok Pan Ho, Yan Xiang Cui, Ho Kwong Chui. Hong Kong Productivity Council (Hong Kong SAR)

A rapid chemical precipitation method using high-valent metal hydroxo complex was developed for the removal of refractory organics in old-age landfill leachate. The leachate contains high concentration of refractory organics which contribute to high colour intensity, high chemical oxygen demand (COD) and low biodegradability. These refractory compounds could not be removed by the ammonia stripping process, sequencing batch reactors in the existing landfill leachate system nor conventional municipal biological sewage treatment process. To explore the solution, the refractory organics removal of [Fe3(OH)4]5+ was evaluated and compared with the traditional precipitating agents (i.e., Fe2+, Fe3+ and Al3+) by the mean of jar test experiment. According to the experimental results, more than 94% of colour intensity and 70% of COD was removed in the presence of [Fe3(OH)4]5+ at pH 4. The [Fe3(OH)4]5+ demonstrate a greater performance on removal of refractory organics than the traditional precipitating agent. The precipitation mechanism could be explained by the strong electrostatic interaction between the negatively-charged groups in refractory organics and the penta-valent polynuclear Iron(III) hydroxo complex.

Evaluation Of Scouring Efficiency By CFD Analysis For Membrane Filtration System With Flat-Sheet Ceramic Membrane

Hiroshi Noguchi, Chakravarthy Gudipati, Terutake Niwa, Adil Dhalla. Meiden Singapore Pte Ltd (Singapore)

A computational fluid dynamics (CFD) model was developed to simulate the aeration process in MEIDEN ceramic flat-sheet membrane system. The CFD analysis evaluated the effects of continuous aeration, intermittent aeration, and skid layout on the aeration efficiency. The study showed that intermittent aeration significantly improved the maximum water velocity and shear force (top 80% of Vmax data) in the membrane gaps by 2-fold during 24 sec flow time. The contributions of each design variable in the CFD simulations on the improvement in water velocity and shear are ranked in the order of aerator type > cassette distance > water level. The intermittent aeration showed significant development towards high-efficiency membrane scouring and thereby viable low energy consumption of the MBR aeration process.

Enhanced Nitrogen Removal Without Extra Organic Carbon Addition By Sludge Double Recirculation-Anaerobic/Aerobic/Anoxic Process: Pilot Scale Test

Lingyun LI, Xiaoyan Yao, Yongjie Liu, Xiaofei Xue. Beijing Enterprises Water Group (china) Investment Co., Ltd. (China)

Sludge Double Recirculation-Anaerobic/Aerobic/Anoxic (SDR-AOA) is a novel nitrogen removal process for municipal sewage with a low carbon/nitrogen (C/N) ratio. The practical application feasibility of SDR-AOA should be investigated. A pilot plant of 100 m3/d was established in a wastewater treatment plant (WWTP) to evaluate the nitrogen removal performance with operating parameters optimized in this study. Results showed that under all experimental conditions, the average TN concentrations of the effluent were lower than 8.20 mg/L without extra carbon addition. Better nitrogen removal performance was achieved when the ratio of second sludge recirculation and anaerobic/aerobic/anoxic volume was 150% and 1:1:2. Average TN concentration in the effluent

was 4.34 mg/L with its average removal efficiency up to 79.68%, which was better than that of the AAO process in the same WWTP. This study laid a foundation for the further engineering application of SDR-AOA.

Monitoring Of Aeration Systems And Determination Of A-Factors With The Ex-Situ Steady-State Off-Gas Method: Sensitivity Analysis And A Novel Approach To Examine Non-Aerated Activated Sludge Tanks

Maximilian Schwarz, Jana Trippel, Martin Wagner, Markus Engelhart. Technical University of Darmstadt, Institute IWAR (Germany)

Performance of aeration systems in wastewater treatment plants (WWTP) can be quantified and monitored with off-gas tests. The ex-situ off-gas method is an alternative to measurements with off-gas hoods at the tank surface. We quantified that α-factors can be determined with a relative deviation of ± 8 % (± 2 standard deviations) with the method. Additional systematic errors below ± 2 % were common. A sensitivity analysis revealed oxygen concentration in the off-gas as the most influential measured parameter. In contrast to off-gas hoods, the ex-situ method allows to individually modify and control the implemented aeration system and examine non-aerated activated sludge (AS) zones. We defined a novel α0-factor that is standardized to zero external oxygen intake to compare oxygen transfer in aerated and non-aerated zones under non-steady-state conditions. With this feature, the ex-situ method could also be applied for research on design and operation of aeration cascades as well as measuring potential emissions of greenhouse gases from non-aerated zones such as nitrous oxide in the future.

Ozone And H2O2 In Wastewater Treatment Of A Bio-Refinery

Cristian Carboni . De Nora Water Technologies (Italy)

This work presents the results of a preliminary study on the use of ozone + H2O2 for chemical oxygen demand (COD) reduction in bio-refinery wastewater treatment. Tests and applications reveal that ozone treatment alone is ineffective, while the combination of H2O2 and ozone creates a process intensification.

The bio-refinery has a plant divided into four sections: pre-treatment of materials; transesterification of oils, glycerol distillation, and industrial water treatment; anaerobic digestion to produce biogas; and a final wastewater treatment with ozone + H2O2. The bio-refinery produces biodiesel, refined glycerol, pitch, and electricity, and the raw material comprises waste products, including cooking oils, fatty acids, and animal fat. The wastewater COD ranges from 500 up to 1200 ppm after biological treatment. During the tests, the bio-refinery wastewater was treated to achieve COD levels lower than 500 ppm and define the correct sizing of the final plant.

Computational Fluid Dynamics (CFD) Simulations For Retrofitting Lamella Plates In Primary Sedimentation Tank At Stonecutters Island Sewage Treatment Works In Hong Kong

Robert Ying Kin Chan, Henry Kwok Ming Chau, Matthew Ming Foon Tam, Yanning Zhang, Dominique Brocard, Daniel Braz. AECOM Asia Company Ltd. (Hong Kong SAR)

Stonecutters Island Sewage Treatment Works (SCISTW) in Hong Kong SAR of China is a Chemically Enhanced Primary Treatment (CEPT) facility, equipped with forty-six double-deck primary sedimentation tanks (PSTs). Currently, the PSTs are operated in pairs, except two prototype PSTs, and are heavily loaded in wet weather. The configuration provides limited maintenance window for tank overhaul. Aiming to relieve operation and maintenance pressure, retrofitting the existing PSTs with lamella plates was proposed to enhance the treatment capacity. Computational Fluid Dynamics (CFD) simulations were performed to assess the hydraulics, the flow split between the upper and

lower deck, and the settling performance of the lamella plate assembly PST. The CFD results suggested 79% of flow was split to the upper deck after adjusting the elevation of the effluent weirs and the impact to the hydraulic grade line at PST inlet and outlet of the retrofitted design was not significant. The lamella plate assembly PST would improve the effluent quality by lowering the effluent TSS concentration by 20.8% and enlarge treatment capacity by 23%. Overall, the CFD findings confirmed the lamella retrofit would be beneficial to the sewage treatment process.

In-Situ Adsorption & Electro-Regeneration Using 3d Gac Electrode System For Pharmaceutical Wastewater Treatment

JW Goh, SCK Yong, ZJ Choo, W Wu, Z Huang, SL Ong, Jiangyong Hu. National University Of Singapore (Singapore)

Despite employing the same battery of reactors and separators in pharmaceutical industries, effluent from these facilities often varies in composition and concentration. As reported by literature (Gadipelly et al., 2014), pharmaceutical wastewaters are featured with high COD (375 – 32,500 mg/L) and TDS (1,300 – 28,000 mg/L) values. The high TDS and electric conductivity of the wastewater is a propelling reason for the employment of such Electro-Advanced Oxidation Process (E-AOP) treatment. To effectively eradicate mass transfer limitation posed by 2-dimensional electrochemical reactor, granular activated carbon (GAC) is loaded in between parallel plane electrode to form 3-dimensional electrochemical reactor. Particle electrodes enhanced mass transfer by absorption and the electrochemical oxidation of the organic compounds (Zhan et al., 2019). This combination of absorption and electrochemical regeneration of GAC in a 3-dimensional reactor paves a promising process for in-situ absorption of refractory pharmaceutical wastewater and regeneration of GAC. In this study, the process achieved 84.0% and 88.0% removal efficiency for TOC & COD within an 8-hour reaction. The importance of O3 was also demonstrated by comparing different type of gas input and O3 proved superior with a rate constant of 0.8 hr-1.

Recycling System For Precision Cleaning Factory Applying Ceramics Adsorption Filters

Keiko Nakano, Chu Tee Tan, Hikaru Yoshimine, Tomonori Saeki. Hitachi Metals Singapore Pte Ltd (Singapore)

Hitachi Metals applied ceramics adsorption filters (CAFs) in the water recycling process in MClean Technologies, which provides precision cleaning for components for electronic and medical industries, and had conducted a case study to reuse the discharge water containing detergent for a year. The discharge water treated by CAFs was mixed with raw city water (NEWater) and reused in the existing deionization system. The deionization system has reverse osmosis (RO) membranes and ion exchange (IX) resin. Although frequency of replacement of RO membrane could be 1.5 times higher than that before water recycling, CAF's adsorption function suppressed the RO membrane degradation by residual detergent in reuse water and the lifespan of IX resin was not affected, In total, water usage volume became 24% of that before reuse and it was estimated that 53% of the water cost before reuse was reduced. Following this case study, CAF modules were settled as the water recycling system in MClean and it was the first use case of CAF.

Advancement Of Application Of Aerobic Granular Sludge For Large Wastewater Treatment Plants

Andreas Giesen, Sjoerd Kerstens, Mark van Loosdrecht. Royal HaskoningDHV (Netherlands)

Application examples are presented that demonstrate the practical implementation and economic advantage of Aerobic Granular Sludge (AGS) for large wastewater treatment plants in densely populated cities. The design&operation lessons learned from several such implementations will be presented. These examples will illustrate how the configuration of the AGS process can be adjusted

to meet project specific challenges, like atypical wastewater composition, minimal energy/footprint consumption and/or future load adjustment. Also the plant retrofit and start-up strategies are presented. Finally, the use of media filtration and ultrafiltration as polishing step for water reuse, or discharge to very sensitive ecosystems, will be presented.

Fluorescence Characterization And Identification Of Dissolved Organic Matter In Wastewater Through HRLC-MS/MS

Sanjeed Mohapatra. National University of Singapore (Singapore)

Sewage is characterized by a high concentration of dissolved organic material (DOM) which can participate in the fate and transport of contaminants in natural and engineered environments. In this study, wastewater from five wastewater treatment plants (WWTPs) located in the western part of India was analyzed with the help of fluorescence spectrophotometer. Additionally, three different types of resins were employed to quantify the hydrophobic and hydrophilic fractions of DOM. Among six fractions of DOM, the hydrophilic acid, and neutral fractions and among proteins, the tryptophan-like and tyrosine-like residues were found in high abundance across the WWTPs. Protein-like fluorescence was dominated by tryptophan-like proteins, which were grouped based on their role in different biochemical reactions in living organisms. Additionally, several lifestyle-related disease protein biomarkers were detected in wastewater samples indicating the potential for wastewater-based epidemiology (WBE).

Ammonia Recovery From Concentrated Solution By Designing Novel Stacked FCDI Cell

Kuo Fang, Qi Wang, Conghui He, Kaijun Wang. Tsinghua University (China)

Ammonia recovery from wastewater gained increasing attention worldwide. However, subsequent utilization of the recovered ammonia was still complex and challenging. Therefore, a proof-of-concept approach by designing a novel stacked flow electrode capacitive deionization (FCDI) cell was presented in this study, to achieve ammonia recovery and utilization. High-value ammonia sulfate was generated successfully in the product chamber with K2SO4 worked as an additive. The effect of a monovalent cation-selective exchange membrane (M-CEM) was emphasized in the stacked FCDI cell. Compared with the standard cation exchange membrane (S-CEM), the product purity increased from around 50% to 85%, while the selectivity factor of NH4+ increased almost 2 times. Therefore, this study indicated that the novel design and efficient operation of the stacked FCDI reactor is an alternative way for ammonia recovery and utilization, as well as a possible approach to scaling up.

Leveraging Real-Time Analytical Instrumentation For Anaerobic Digester Health Monitoring During And After Successful Startup Of THP Pretreatment Process

Steve Myers. Hach (United States)

To reduce overall costs, carbon footprint, and to achieve Class A sludge the Medina County Sanitary Engineers implemented a thermal hydrolysis process (THP) at the Kenneth W. Hotz Water Reclamation Facility. This process pretreats the biosolids prior to traditional anaerobic digestion using pressure and heat. Given the potential complexity for digester operations with a THP process, the county decided to attempt to de-risk their digester process by adding additional online, real-time monitoring of the digester acid/alkalinity (VFA:ALK). This paper discusses the THP process and anaerobic digester startup and operating experiences and associated pros and cons of the online digester monitoring solution to mitigating the risk of anaerobic digester souring.

Study For Seasonal Changes In Activated Sludge Dewaterability And Settleability: Insight From Qualified Image Analysis And Extracellular Polymeric Substances Measurement

Yuki Nakaya. Hokkaido University (Japan)

By a protocol for computer-assisted quantified image analysis (QIA) and extracellular polymeric substances (EPS) content analysis of activated sludge (AS) sampled from 4 wastewater treatment plants (WWTPs) in Sapporo, Japan, their seasonal changes were quantitatively traced and analyzed in terms of correlation with the sludge volume index (SVI) and specific resistance to filtration (SRF). Some parameters by the image and EPS analyses were correlated to the AS dewaterability and settleability, however, no common and comprehensive parameter for the 4 WWTPs was determined, possibly due to differences in the operating conditions and environment between the WWTPs.

High Performance Graphene-Polymer Membrane For Water And Wastewater Treatment

Yihong Lan, Huiyin Chen, Yubin Hong, Fulin Fang, Zhongxin Chen, Weiguang Lan, Kian Ping Loh. National University of Singapore (Singapore)

The R&D team at Suntar and Prof Loh Kian Ping's team at the Department of Chemistry, National University of Singapore have collaborated on analysing the microstructure and chemical composition of Suntar's patented graphene membrane that showed enhanced performance in water and wastewater treatment. Suntar's graphene membrane shows superior water flux and stability, lowering the electrical power consumption for a greener process.

Design And Commissioning Of A Large Scale MBR-RO For Newater Production

Gerin James, Ming Wei Ho, Peter Zauner. Dupont Water Solutions (Australia)

The first large scale MBR for the production of NEWater has required several unique design features to meet the needs. This article discusses these design aspects and how these were implemented during commissioning and operation, which is scheduled to commence in late 2021.

CFD-Based Design Optimization Of Secondary Sedimentation: Case Study At The City Of Kalamazoo Water Reclamation Plant (MI, USA)

Simon Duchi, Ingmar Nopens, Evangelia Belia, Mary Nykamp, Ryan Stoughton, Jim Cornell, Wim Audenaert, Usman Rehman. Am-team (Belgium)

In this study, CFD was applied to virtually test different designs for the secondary sedimentation tanks (SSTs) located at the regional Kalamazoo Water Reclamation Plant (KWRP) owned by the City of Kalamazoo (Michigan, USA). In the near future, the plant will be receiving increased loads and as a result, the City is planning upgrades to maintain optimal SST performance. CFD was used to test a multitude of designs in a relatively short timeframe. The tested designs included changes in overflow location, scraper type, sludge withdrawal system and the addition of an Energy Dissipating Inlet (EDI).

Memosens 2.0 For Simple, Safe And Connected Liquid Analysis

Salbiah Siraj. Endress+Hauser (SEA) Pte Ltd (Singapore)

Memosens has become an industry standard since its launch at 2004. Outstanding features such as contactless, digital signal transmission and simplified maintenance process in the laboratory or workshop have significantly simplified field work and reduced operation expenses.

Digitalization is a worldwide hot topic. No doubt that data is going to be the main driver for decision making process, they are starving for more and more data from the field, These data's shall be used in appropriate algorithms to obtain interpreted information, which helps them to provides better recommendation on further optimization.

Memosens 2.0 sensors can also be integrated into Endress+Hauser's Netilion IIoT ecosystem in conjunction with Liquiline transmitters or with the help of Field Xpert tablet PCs. Sensor and diagnostic data can be evaluated within this environment using different applications. This information forms the basis for accurate predictions about the sensor condition and any maintenance requirements in the future.

Sustainable Solution For The Hard-To-Treat Industrial Wastewater

Jianxiong Xu, Massimo Spina. Reacto Pte. Ltd. (Singapore)

Persistent organic pollutants (POPs) like Petrochemicals, antibiotics, pesticides, hormones, dyes and other non-biodegradable organics, are highly toxic pollutants that could accumulate and transmit through the food chain, causing serious health hazards for the environment and our health. There is no cost-effective solution to treat highly concentrated wastewaters with those POPs. reActo's disruptive solution is an electrochemical advanced oxidation process that can efficiently achieve full mineralization thanks to the integration of graphene and its system-level optimization. Our solution can achieve full mineralization of toxic wastewater with high chemical oxygen demand (COD) (> 20,000 ppm) without generating any sludge, enabling maximum water recycling and safe discharge into the sewage system at 50% of disposal costs.

Integrated Approach Of Wastewater Management For Inclusive And Efficient Service Delivery Mechanism

Suraj Kumar, Bhushan Raj Shrestha, Karthik Ravichandran, Parth GoelIsha Basyal. Citywide Inclusive Sanitation Technical Assistance Hub, South Asia (Nepal)

Asian Development Bank (ADB) provides additional financing loans to improve the urban infrastructure services for Madhya Pradesh, India. Six towns were selected for Bill and Melinda Gates Foundation (BMGF) technical advisory support through Citywide Inclusive Sanitation Technical Assistance (CWIS TA) Hub, South Asia with the main objective of integrating sanitation systems for universal coverage of inclusive, safe, and sustainable sanitation in these towns. The CWIS framework has been at the heart of the overall planning and designing of the technical interventions and robust ecosystem for the overall sustainability of these programs. A geo-spatial module of integrated municipal information system (IMIS) was applied to identify the sanitation system interventions which are built on the existing set-up, avoid effort duplication, and with system integrations approach of both sewerage and non-sewerage system. At the same time, the three dimensions of sustainability i.e., financial, environmental, and social have been applied to ensure system operations in long run.

ATP Analysis For Early Toxicity And Sludge Health Monitoring In Industrial Wastewater Treatment Systems

Stanislaus Raditya Suwarno, Nan Li. Sembcorp Industries Ltd (Singapore)

Biological system monitoring is crucial for wastewater treatment operations. In this study, ATP analysis was used as a monitoring tool to evaluate general sludge health. Experiments were conducted over 16-weeks period at three different wastewater treatment plants with different operating conditions. The results show that ATP analysis can be used as an early toxic assessment tool. Secondly, ATP analysis was found to be plant specific, and that the data may not be directly interchangeable among different plants. The ATP results were corroborated with the SOUR method and aeration test.

Virtual Piloting: The Disruptive Application Of Computational Fluid Dynamics Simulation For Process Development, Innovation And Scale-Up

Wim Audenaert, Ingmar Nopens, Simon Duchi, Miguel Daza, Cilia De Wilde, Usman Rehman. AM-TEAM (Belgium)

This paper describes the disruptive use of advanced Computational Fluid Dynamics (CFD) simulation for the acceleration of novel technology development and scale-up. This application aims at generating unprecedented process knowledge and drastic reduction of the technology development cycle times through the replacement of physical testing by computer simulation. The application of CFD for virtual prototyping and virtual piloting was illustrated by means of two different case examples: the virtual scale-up of a novel membrane bioreactor technology, and the development of a novel tubular membrane.

Biological Nutrient Removal (BNR) Through Modified Conventional Treatment System

Arthur II Villaflor. Manila Water Company, Inc (Phillipines)

This study examines a simple and cost-effective approach to comply to a new effluent standard on Biological Nutrient Removal (BNR) through flow diversion to a BNR compliant wastewater treatment plant (WWTP). DAO 2016-08, mandated by the Department of Environment and Natural Resources (DENR), imposes penalties if not complied by July 16, 2021. Eleven out of the forty-one WWTPs of Manila Water Company, Inc (MWCI) were identified suited for diversion due to its unfeasibility for BNR upgrade (e.g. limited footprint and technology unavailability) and over/under-utilization. Results show that pipelaying and pump installation provided ease and timely compliance to the new effluent standard.

Biological Nutrient Removal Compliance Through Wastewater Flow Diversion

Eunice Canlas. Manila Water Company, Inc (Phillipines)

The Department of Environment and Natural Resources (DENR) mandated a new Effluent standard known as DAO 2016-08. This Administrative Order updates the previous one by incorporating stringent limits for Nutrient parameters such as Ammonia, Nitrate and Phosphate. Manila Water Company, Inc. (MWCI), abiding by its obligation to safeguard the environment thru compliant wastewater effluent, crafted four compliance strategies to convert current Sewerage Treatment Plants (STPs) into Biological Nutrient Removal (BNR) facilities to comply with the latest discharge limits.

However, with a sudden change in the implementation timeline from DENR, MWCI focused on the Modified Conventional Treatment system solution due to its unsophisticated approach with minor modifications in the facility.

As a result, nutrient levels decreased upon applying this solution and the removal rates were, 92%, 29% and 60% for Ammonia, Nitrate and Phosphate, respectively. Applying this method aided MWCI's compliance to the new standard

Filtering The Unfilterable: The Commercialization Of Graphene Oxide Coating Technology In The Toughest Of Applications

Kangsheng Liu, Tom Pugh, Mark Parker, Fan Fei. G20 Water Technologies (United Kingdom)

By 2025, it is estimated that 2/3 of the world's population will face water shortages. Furthermore, between 2030 and 2050 it is calculated that 250,000 deaths per year will be directly linked to climate change, therefore it is critical promising technologies are exploited to limit environmental damage (Parncutt 2019, Masson-Delmotte 2021). Per site, industrial laundries dispose of tens of thousands of cubic meters of aqueous effluent per year, as the wastewater is notoriously difficult to recycle. Through detailed laboratory studies we have developed a graphene oxide containing formulation

that we can apply directly to commercially available ceramic membranes. We have demonstrated through industrial validation using real laundry wastewater that we are able to increase the permeance of commercial membranes by 2.5x, with a significant reduction in fouling. This translates to a reduction to incoming mains water by 22,000 m3/year and a site-wide saving of 1.8m kWh/year for boiler gas, translating to offsetting 350 tons CO2e/year and futureproofing the site from water shortage through the creation of a pseudo-self-sustaining process.

A New Generation Of Advanced Biological Sequenced Batch Reactor

Marlene Choo-Kun, Françoise Petitpain perrin, Alexis Daunay, Deborah Delgado, Thibaut Saur. Suez (France)

A key evolution of wastewater treatment lies in process intensification while keeping the same treatment quality. A new generation of advanced Sequenced Batch Reactor (SBR) is born through the development of Cyclor Turbo™, an SBR with constant level without decanter. A 24-month trial period on a 5-30 m3/h reactor results in the proof of concept, process and technology of this advanced SBR with biological phosphorus removal on the municipal wastewater treatment plant of Nice, France. High effluent quality is achieved: TN < 10 mg/L, P < 1 mg/L and TSS < 15 mg/L thanks to biomass intensification. This new solution offers an advanced wastewater treatment with a low footprint and reduced OPEX compared to conventional solutions.

Feasibility Study Of Cotreatment Potential In Ganga Basin Towns Of Uttar Pradesh

Sumita Singhal, Suresh Kumar Rohilla. Centre For Science And Environment (India)

Uttar Pradesh has more than 105 operational and not operational sewage treatment plants (STP) with an installed capacity of close to 3,371 million litres per day (MLD). Around 34 of these STP's are existing and other 10 are in the proposed phase along the Ganga River in Uttar Pradesh. The State is planning to make Ganga free from pollution and to mainstream and scaling up effective Faecal Sludge Management across Ganga basin towns for improved river health. So, it is necessary to know the sustainable way to manage the Faecal sludge. Therefore, a study was conducted to access the cotreatment potential in Ganga Basin Towns of Uttar Pradesh in the existing and proposed sewage treatment plant with spare capacity. Instead of setting up a new faecal sludge treatment facility, the cotreatment offers maximum use of the existing infrastructure, and is therefore advantageous.

Inflow Prognoses To A Large Wastewater Treatment Plant (WWTP) In Copenhagen Forecasted By Machine Learning (ML)

Sten Lindberg. DHI (Denmark)

The paper presents the results from a smart water project, where digital solutions have been developed and deployed to optimize management and operations of a major wastewater treatment plant in Copenhagen. The digital solutions include machine learned based inflow forecasts.

Utilizing Dissolved Air Flotation (DAF) As Pre-Treatment For Wastewater From Commercial Establishments In The Philippines

Reymaliza Santiago, Emmanuel Pineda. Manila Water Technical Ventures (Phillipines)

Despite the progress that the Philippines has made in providing access to improved sanitation facilities, there remain twenty million Filipinos that do not have access to sanitation services. Wastewater systems in the country also need to further improve to ensure that effluent complies with the standards prior to discharge to waterbodies. Most of the treatment plants constructed by wastewater service providers are designed to treat domestic/residential wastewater. Sewage from commercial and industrial establishments should have additional treatment before conveyance to

these treatment plants. In Atria Park District in Iloilo, dissolved air flotation was installed to intercept the wastewater from residential accounts and commercial establishments before processing at the sewage treatment plant and then disposal to a nearby creek. By installing DAF, BOD and COD contents were reduced to levels that the plant is capable to treat to effluent that complies with the Department of Energy and Natural Resources (DENR) standards.

Nanofiltration For Treatment Of Electroplating Wastewater

Karina Zedda, Ignacio Hegoburu, Svetlozar Velizarov. Suez WTS Germany Gmbh (Germany)

Application of nanofiltration (NF) technology at extreme pH conditions is currently hindered by the limited pH-stability of most NF membranes. SUEZ has developed a novel NF membrane (Membrane A) which hereby is compared against a commercial pH-stable NF membrane (Membrane B) in crossflow filtration tests using flat sheet coupons. A novel method is validated and applied to determine the molecular weight cut-off (MWCO) value of these membranes while operating at pH 2, showing that Membrane A keeps the same MWCO at neutral and acidic pH, unlike the competitor which substantially increases its MWCO at low pH condition. In addition, the feasibility of treating electroplating wastewater (EPWW) is studied. Membrane A achieves better rejection of heavy metals while enabling higher acid recovery in the permeate side, showing great potential for improving the process economy by recycling the purified acid stream.

Piloting Results Of A Novel Ion Exchange And Encapsulated Bacteria System For Complete Nitrate Removal

Sivan Iswaran, Gerrit Boersma, Jonathan Wright, William Mclean. Clean TeQ Water (Australia)

Nitrate pollution is a serious problem across industries, and the severe ecological damage that can occur when discharging to sensitive waterways has led to many regions of the world mandating strict discharge limits of 1 mg/L of nitrate. Clean TeQ Water's BIONEX™ technology is an integration of CIF® continuous ion exchange to remove the nitrate, and BIOCLENS® encapsulated bacteria to convert the nitrate from the smaller brine side stream into harmless nitrogen gas. By removing nitrate from the brine it can be reused to regenerate the ion exchange resin, greatly reducing the chemical consumption and waste production of the system. This paper presents the methodology and results of piloting a BIONEX™ system in China, where NOx-N in the feed was consistently reduced from 20 mg/L to <1 mg/L, and the NOx-N in the brine was reduced from 200 mg/L to <20 mg/L, a level suitable to reuse the brine to regenerate the ion exchange resin. These results form the basis for large scale water treatment plants that can polish nitrate to very low levels with small footprints. BIONEX™ can provide the missing piece for water and wastewater treatment plants looking for intensified nitrate removal capacity.

A Genome-Centric Metagenomics Approach To Explain Microbial Community Structure In Anaerobic Digesters

Soheil A. Neshat, Krithika Arumugam, Uma Shankari, Prabu Sekar, Rikky Purbojati, TQN Nguyen, Angel Anika Cokro, Ezequiel. Nanyang Technological University (Singapore)

Comprehensive ecological insights into the anaerobic digestion (AD) microbiome, and a full accounting of important microbial species, can help to improve and validate operational strategies. We analysed a time-series of metagenome samples obtained from full-scale anaerobic digesters and performed genome-resolved analysis to gain insight into the microbial community structure and potential functions of the AD microbiome. Ninety samples from three full-scale digesters were collected over a period of nine months and their nucleic acids extracted and subjected to shotgun sequencing. A genome-centric metagenomics approach was used to obtain metagenome-assembled

genomes (MAGs). From ninety metagenome assemblies, 14,236 MAGs were recovered, of which 37%,16%, and 1% satisfied medium-quality, putative-high-quality, and high-quality criteria, respectively. Taxonomical classification of the MAGs with at least medium quality revealed that 12.9%, 37.4% and 77.1% of them belong to a novel family, genus and species, respectively. A co-occurrence network analysis of the community structures in three replicate digesters suggests the presence of a backbone in a functional AD microbial community. In conclusion, we have obtained a catalogue of 166 MIMAG-high-quality MAGs from a time-series metagenome survey of three full-scale anaerobic digesters situated in a tropical wastewater treatment plant, leading to novel ecological insights into the AD microbial community.

New Method For Quick Biosolids Dewaterability Assessment, Polymer Selection And Process Improvement

Jean-Francois Mischler, Claire Courbet. Bucher Unipektin Ag (Switzerland)

Achieving the best dewatering performance is important for cost control, but also to improve energy efficiency and increase the potential for energy recovery. For the evaluation and optimization of a process, different systems exist but none are really satisfactory. Some require the use of large laboratory instruments or involve the application of laborious protocols and are therefore difficult to use on site, others, more basic, are not necessarily reproducible. Those reasons have led us to develop a new test whose purpose is to evaluate the best conditioning and maximum dewaterability of a sludge. Thanks to our experience and search for maximum dewaterability, we have succeeded in producing a quick and reliable system that is easy to use, on site or in the laboratory, either by researchers or by operators. The system achieves values very close to the maximum dewaterability tests but can also be used to optimize other processes by adapting the protocol used.

Real-Time Monitoring Of Wastewater Quality Using A Bio-Electrode Sensor

Jon Grant, Patrick Kiely, Juliana Meija-Franco, Tai Kee, Adrian Yeo, Sophia Liew. Sentry (Canada)

Use of a bioelectrode sensor can enable operators to identify and understand issues they will face prior to shocks hitting the treatment process. To that extent SENTRY in conjunction with Sembcorp conducted lab tests to evaluate the probes response to different chemical compounds. The bioelectrode sensor proved to be a reliable indicator of events and their magnitude with a low-maintenance aspect.

Preliminary Engineering, Design And Implementation Of Improvements To The MMSD Head Tanks

James Cooper. Arcadis (United States)

Milwaukee Metropolitan Sewerage District (MMSD) in the United States sought to maximize flow pumped from their well-known Inline Storage System (ISS) conveying wastewater to their two water reclamation facilities. Prior system upgrades improved the flow capacity of each from 190 ML/d (50 mgd) to 261 ML/d (69 mgd). Multiple studies evaluated why the design capacity was not fully achieved and to resolve splashing from head tanks. A hydraulic model was developed, consisting of the pumping system, Head Tanks, in-tank risers, and piping. Hydraulic restrictions were identified due to multiple reasons and a physical scale model of the system confirmed conditions and improvements. Upgrades included extending the height of one tank, adding an additional interconnect, reducing riser pipe height, replacement of instrumentation, and structural repairs. Following upgrades, MMSD successfully improved pumping capacity of the ISS, eliminated splashing,

and has allowed millions of additional gallons of wastewater to be treated during peak flow conditions.

*Wastewater Carbon Recovery Through Biopolymer Platforms: Conversion Of Polyhydroxybutyrate Monomers To Propylene Over Solid Acid Catalysts

Moses Shijie Leow, Andrew J. Koehler, Lauren E. Cronmiller, Xiangchen Huo, Gabriella D. Lahti, Yalin Li, Glenn R. Hafenstine, Derek R. Vardon, Timothy J. Strathmann. Nanyang Technological University (Singapore)

Diverse sources of wastewater organic carbon can be microbially funneled into biopolymers like polyhydroxyalkanoates (PHAs) which can be used as renewable plastics, or further valorized by conversion to hydrocarbon fuels and industrial chemicals. This presentation will briefly discuss opportunities for PHA production from Singapore's wastewater sludge streams, which contributes towards the critical needs of closing the carbon loop and diversion of sludge from landfilling. This presentation will further discuss work on vapor-phase conversion of PHB-derived monomer acids, 3-hydroxybutyric acid (3HB) and crotonic acid (CA), in water to propylene over solid acid catalysts using a packed-bed continuous-flow reactor. Propylene yields increase with increased Brønsted acidity of catalysts, with amorphous silica-alumina and niobium phosphate yielding 52 and 60 %C (percent feedstock carbon, max 75 %C) of feedstock 3HB and CA, respectively.

*Advanced Organic Recovery From Municipal Wastewater With An Enhanced Magnetic Separation (EMS) System: Pilot-Scale Verification

Conghui He, Kuo Fang. Tsinghua University (China)

We proposed a pilot-scale enhanced magnetic separation (EMS) system as an up-concentration step to maximize energy recovery from municipal wastewater. The design of EMS was based on the hypothesis that magnetic-driven separation could be a breakthrough in separation speed, and adsorption could further enhance the separation efficiency by capturing soluble substances. Over one-year operation of a 300 m3/d EMS equipment provided optimum operation strategies and evidence of system effectiveness. More than 80% of particulate organics and 60% of soluble organics were removed within 10 minutes. The anaerobic experiments demonstrated the potential value of the concentrated products. The developed EMS system exhibited significant advantages in time consumption and space occupation.

Theme 4: Cities of the Future

Conservation Of Surface Run-Off To Increase Agricultural Water Security In Water Stressed Areas Of Older Alluvium Zone – A Case Study Of Nabagram Block, West Bengal, India

Tarak Nath Roy. Water Resources Investigation & Development Department, Government Of West Bengal (India)

Nabagram, one of the most water stressed block of Murshidabad district of West Bengal, India. In spite of receiving sufficient annual rainfall, the block is severely facing water crises in dry season due to enormous agricultural growth mainly Paddy crop. The irrigation system mostly dependent on ground water due to absence of surface water sources resulting which aquifer becomes 'Semi-Critical' in nature due to excessive ground water development. In order to achieve agricultural water security, Government introduced large capacity Water Harvesting Tanks & Check Dam schemes in the F.Y.2017-2018 which appears to be a successful project for increasing agricultural water security as well as to reduce stress on ground water and in the long run, it may help to develop the nature of aquifer from 'Semi-Critical' to 'Safe' due to conjunctive use of surface and ground water resources.

Water Tariffs And Affordability In Urban Water Supply And Wastewater Systems

Stefanos Xenarios, Eduardo Araral, Joost Buurman. Institute Of Water Policy, Lkyspp, NUS (Singapore)

The current study attempted to identify the role of the most widely used physical, economic and institutional parameters that may affect water tariffs and affordability across several cities in high and upper-middle income countries. Differential inferential statistical methods were employed to explore potential associations of the water consumption, variable and fixed costs, utility management, and minimum wage, with the economic affordability on household level. The findings indicate a loose association of the tariffs with the above indicators which may not lead to certain assumptions. Although the results may be uncertain and inconclusive, however, there have only few studies till now exploring and comparing water affordability of urban water systems in high and upper-middle income countries. The findings could trigger further research on the better comprehension of affordability and water tariffs by improving social inclusion of low-income households on urban water accessibility and usage.

~~Urban Flood Risk Management Using Integrated Catchment Approach~~

~~Hrushikesh Sandhe. Walter P Moore (India)~~

~~The objective of presentation will be to focus on implementing Integrated Catchment Modelling approach for masterplanning and designing of flood risk management application. This presentation will cover the challenges and opportunities from India projects perspective.~~

Depth-Integrated Wave-Current Models

Zhengtong Yang, Philip L-F Liu. Technology Centre For Offshore And Marine, Singapore (TCOMS) (Singapore)

For developing effective coastal protection measures, accurate prediction of nearshore wave climate is of significant importance for island countries such as Singapore. In this paper, new depth-integrated mathematical and numerical models are developed, which are capable of simulating waves alone and waves interacting with vertically sheared currents from deep to shallow water. These new models are first validated with existing benchmark laboratory experiments for wave transformation over uneven bottoms. The capability of the present models in dealing with vertically sheared currents is then demonstrated. Lastly, a set of laboratory experiments planned to be conducted in the deep-water ocean basin of TCOMS will further verify the models' capability in describing wave transformation in the deep-water condition, which is particularly challenging for depth-integrated models.

Atmospheric Water Generation Via Thermal Condensation Dehumidification

Ron Dorfman, Kevin Chung. Skywell/inseat Solutions, Llc (United States)

There is a growing concern for the lack of fresh water accessibility due to environmental factors, whether natural or man-made, and these factors have been causing families and communities to struggle for decades. The current source of drinking water is heavily reliant on the local infrastructure, foreign government assistance and the weather. Research has shown that this dependency costs governments billions every year. Atmospheric water generation is one solution to minimize the dependency and impacts of this global crisis by directly tapping into the source that is available everywhere. Here we report that with an optimized refrigeration system, by utilizing thermal condensation cycle and configuring heat exchanger size, compressor power output and fan speeds, 1.7 liters of water can be generated per 1 kW power, up to 30 liter per day. Atmospheric water generation is not only a long-term option to reduce strain from the dependency of federal and

local government for a water source, but also a feasible method to adapt to the ever-changing environmental factors of global warming.

From Water Transfer To Water Purification: Addressing Water Shortage In Yan'an, China

Yikun Lan, Wenxuan Yu, Weiguang Lan. Xiamen University (China)

After visiting Singapore, the world-renown country for its water scarcity and world-leading water processing technology, Yan'an city Municipal government decided to take a bold move to revamp its water policy, both in its philosophy and its technology, to address its water shortage crisis. In 2017, Yan'an municipal government engaged a Singapore-based water technology company, Suntar international to launch its city-wide water filtration projects. This study aims to evaluate the effectiveness of these projects and examine its implications for addressing water shortage in China in general.

In 2020 and 2021, our research team visited Yan'an city to check on the projects. We found out that these projects have achieved rather significant benefits. The idea of moving from overly relying on water transfer to water purification is viable. However, we also find out that this approach requires trust and collaboration between stakeholders and partners. It also requires high level of technological expertise and management competence.

Novel Clogging Resistant Permeable Pavements

Alalea Kia, Hong Wong, Chris Cheeseman, David Balmforth. Imperial College London (United Kingdom)

Permeable pavements are one of the most promising mitigation strategies for urban flooding. However, they are prone to clogging, have relatively low strength and durability, and require regular maintenance. We have developed a new generation of permeable pavements that are not only clogging resistant but also have high permeability and strength. This high strength clogging resistant permeable pavement (CRP, also known as Kiacrete) was prepared by introducing straight pore channels of varying size and number into self-compacting cementitious material. This paper reports on new advances in permeable pavement systems and compares the permeability, clogging potential, strength and freeze-thaw durability of a range of conventional permeable concrete and the developed novel CRP of varying porosity. The results show that for the same porosity, CRP can achieve a high permeability (>2 cm/s) and compressive strength (>50 MPa), whilst being resistant to clogging and the frost action, enabling wider application of permeable pavements.

A Regional Swell Prediction Model Based On Convolutional Neural Network

Tao Ai Feng, Wang Rong. China Harbour (s) Engineering Company Pte Ltd (Singapore)

A regional swell prediction model based on convolution neural network (CNN)is established. The model is trained on the reanalysis data of ERA5. Based on the mixed wave field and wind field in the Taiwan Strait and its coastal waters, the swell field in the future is predicted. The absolute error of the significant wave height of swell within one hour is 0.07m while the absolute error of the mean period of swell within one hour is 0.21s with both correlation coefficients more than 0.94. The results show that the model can keep a low error in most areas of the prediction area. Furthermore, the model still has a good performance during typhoon and cold wave. Compared with the traditional numerical model, the calculation time of the 12 hour swell field prediction can be reduced by 96.3%.

The 6–7 April 2020 Meteotsunami Along The Coast Of Vanuatu

Wang Gang, Wang Rong. China Harbour (s) Engineering Company Pte Ltd (Singapore)

Tropical Cyclone Harold reached Vanuatu on April 5, 2020 and brought flooding rains and strong hurricane-force winds. Uncommon sea surface fluctuations and atmospheric depressions were recorded. Tsunami-like waves with height up to 0.55m and with periods in the range of 10 to 50 min are identified. Further analysis of oceanic and atmospheric data confirmed that a meteotsunami has been excited along the coast of Vanuatu. A nonlinear shallow water equation model is used to reproduce the meteotsunami. The atmospheric pressure data are used to force the sea surface, the 2020 meteotsunami generation and propagation over the coast of Vanuatu are simulated. The comparison of the simulated water surface elevation with the records shows satisfactory agreement of wave heights and periods. Propagation and amplification of meteotsunamis along the Vanuatu coast were further revealed based on the numerical results.

Study On Effective And Land Efficient Wave Overtopping Mitigations At Singapore Slope Revetment

Eunice Chin. Jtc Corporation (Singapore)

This paper describes the mitigation of excessive wave overtopping which may occur in Singapore due to sea level rise and more extreme storms. Mitigation measures that do not increase the footprint of the coastal structure and their corresponding reduction factors were sought. A reduction factor for the overtopping formula specific to the roughness of a typical Singapore pitched slope revetment was also derived in this Study.

Merging Blue-Green Infrastructure With Urban Design – A Water Master-Planning Approach In Four Quadrants

Nanco Dolman. Royal HaskoningDHV (Netherlands)

Urban design can play a key role in addressing a wide range of climate-related water challenges such as water pollution, water scarcity, floods, land subsidence, storm water management, ecosystem services and public health. Both in urban retrofit projects as well as new urban development integration of water management in the different phases of design and development is important. Design and planning approaches such as Water-Sensitive Urban Design provide useful tools for strengthening the integration of water in spatial planning and urban design processes, requiring any spatial intervention or new development to be evaluated on opportunities for sustainability and innovation. This is both an engineering and design challenge. We must consider optional alternatives during the design process by linking the water assignment (e.g. required water storage) to Blue-Green Infrastructure solutions (e.g. system and site scale measures). To support a creative, social and technical process, an all-compassing approach in four quadrants has been developed and tested, which links (Q1) urban typologies, (Q2) water systems approach, (Q3) urban water assignment, and (Q4) blue-green infrastructure. By strengthening BGI and giving water more space in both the public and private domain, cities have the potential to grow into the blue-green cities of tomorrow.

Keeping Airports Open In Times Of Climatic Extremes – Planning For Climate Resilient Airports

Nanco Dolman, Vivekanandhan Sindhamani. Royal HaskoningDHV (Netherlands)

Airports play an important role in economic growth and are essential hubs for connectivity and trade. With the growth of urban areas, air traffic is increasing consistently, marking the development of regions such as South-East Asia and others. Following cities, most of the major airports are situated in densely populated areas, next to rivers, in deltas and alongside coasts. Many of these urbanized areas are vulnerable to water extremes, which are increased by the effects of climate change, such as sea-level rise, higher temperatures and greater weather extremes. To protect vital infrastructure and ensure future service continuity for airport operations, it is necessary to develop

resilience to such risks. Several airports have recognized the threat posed by floods and have started work on flood protection efforts. Based on experience of front runner airports an incremental set of five Climate Resilient Airports (CRA) actions have been developed. Planning for climate resilient airports is not just about protecting infrastructure from flooding. It is also about enabling airports to become more sustainable and improve local climate and energy management – something which airports are going to have to embrace if they are to survive.

A Digital Approach To Identifying Land Use And Impervious Areas For New York City

Vincent Lee. Arup (United States)

The NYCDEP Citywide Impervious Area Study aimed to generate a citywide parcel-level Geographic Information System (GIS) land cover layer displaying pervious and impervious area across New York City. The deliverables, including high-resolution GIS datasets, comparative trend analysis report, detailed methodology and data maintenance documentation provide insight for the local environmental agency to understand the city land coverage types, expand and improve upon the analysis that informed the 2010 NYC Green Infrastructure Plan, inform and support city wide planning efforts, projects, policies and programs on stormwater management. In order to complete a study of this scale, magnitude and accuracy, digital approaches such as remote sensing, machine learning and automation were utilized.

Developing A Utility Strategic Plan Integrating Sustainability, Innovation And Equity: A Case Study Of The 2021-2025 MWRD Strategic Plan

Vincent Lee, Janine Witko, Ms Audrey Fremier. Arup (United States)

Arup and Civic Consulting Alliance (CCA) supported the Metropolitan Water Reclamation District of Greater Chicago (MWRD) Board of Commissioners in developing a Strategic Master Plan. The Strategic Plan was developed in collaboration with the MWRD executive team, staff, and local stakeholders, through extensive engagement, and was designed to articulate the mission, vision, and strategic goals for the MWRD for the next five years; identify a set of strategic initiatives to achieve those goals; and provide a framework for measuring progress and reviewing/updating the Plan on an annual basis. This abstract describes an overview of the overall strategic planning process, steps to make the process more inclusive, identify the industry related frameworks that were used to develop the Strategic Plan, and describe the key outcomes that will forge stronger and more equitable connections with the communities the District serves.

Water Sensitive Urban Design Performance In Singapore: Monitoring With Low-Cost Sensors

Ning Ding, Perrine Hamel, Frederic Cherqui, Jean-Luc Bertrand-Krajewski, Qingchuan Zhu. Nanyang Technological University (Singapore)

The ABC Waters Programme, with its design based on Water Sensitive Urban Design (WSUD), has successfully implemented stormwater control systems across Singapore for 15 years. Yet, there is relatively little attention paid to monitoring ABC Waters features' medium to long-term performance. Compared with traditional monitoring system, low-cost sensors' technology presents economic advantages and flexibility for operation and communication. In this study, we aim to 1) analyse the potential of low-cost sensors for medium to long-term monitoring of WSUD in Singapore; 2) propose a monitoring protocol that can be promoted and used widely. The monitoring system we present is composed of low-cost sensors and Arduino platform. Several kinds of sensors have been identified from a literature review, and lab testing for sensors is in progress. After completing the testing, the monitoring system will be established in site to monitor the performance of WSUD in improving water quality and reducing runoff.

W-Lab Resets Innovation In The Australia-New Zealand Water Industry

Alex Cech. Isle Utilities Asia-pacific (Phillippines)

W-Lab brings together a specialist network of water experts, innovators and utilities, leveraging technology and innovation to secure the future of the Australia-New Zealand (ANZ) water industry. W-Lab unifies the industry under a common future vision and provides platforms for collaboration among water utilities and external stakeholders. Since its launching in March 2020, W-Lab has produced a Technology Roadmap which guides industry stakeholders through a systematic process of defining innovation opportunities, identifying high-potential technologies, and accelerating the implementation of shortlisted solutions. To date, W-Lab has identified, filtered and assessed 322 technologies, resulting in 48 interactive presentations and 9 collaborative trial opportunities.

Modelling Stormwater Reuse Scenarios For Green Roof Irrigation Using URBIS

Vincent Pons. INSA - Lyon (France)

In this study eight different strategies for irrigation a green roof involving water reuse from a retention basin and drinking water were compared using the open software URBIS. The results allow to design a system minimizing the risk of drought in the green roof substrate and the required volume of drinking water.

Sustainable Water Solutions To Increase Yields And Improve Quality In Recirculating Aquaculture System (Ras)

Xiangyi Qiao, Diane White. Evoqua Water Technologies (Singapore)

Singapore's 30-by-30 goals has provided an impetus for the evolution of fish farms to increase local food production. RAS is the resulting product of this evolution. Although RAS has begun to be implemented in fish farms, water quality degradation that stems from water recycling is still a major concern. Evoqua Water Technologies aims to address these concerns and to provide solutions through their products. These products include ATG UV and Pacific Ozone in disinfection, and VAF V-Series™ in filtration.

Re-Imagining River Cities Of Future

G Asok Kumar, Jyoti Verma, Sharmi Palit, Ruchi Tomar. National Mission For Clean Ganga, Government Of India (India)

Since the beginning of time, water and cities have shared a close relationship wherein cities have emerged along water bodies, especially rivers. Thus, to imagine cities without rivers and other water bodies is cannot be envisaged. However, climate change and its unprecedented impacts have emerged as a growing cause of concern. It becomes critical to undertake focused interventions to reimagine our cities and make them water sensitive. As a result, this paper explores the strategy adopted and the deliberate activities that the National Mission for Clean Ganga, Government has undertaken for its Ganga Basin Cities.

Asset Management And Future Proof Drinking Water Sources In The Netherlands

Saskia Holthuijsen, Nic Grandiek, Joost Louter. Waternet (Netherlands)

We talk about the 'Gooi area' (the Dutch green heart near Amsterdam). On one hand the demand for drinking water is rising. On the other hand, the extraction of groundwater has been reduced in recent decades due to concerns about desiccation and the decrease of seepage flows. So three drinking water companies are increasingly forced to think about the reliable drinking water supply in the future. PWN suggested to research the possibility of infiltration of surface water and close the

water circuit. This technique is successfully applied for decades in the dunes near Amsterdam and Castricum.

The assetmanagement point of view, the balance between risk-cost-performance is important. Waternet uses a so-called 3x5 format as a way of thinking about the assets. The answers to the 5 questions on 3 levels, system-network-object, helps to make the transparent consideration. The case in the 'Gooi area' is used to illustrate the method.

Assessing Digital Water Governance Systems In Smart Cities

Ulf Stein, Doris Knoblauch, Benedict Bueb. Ecologic Institute (Germany)

This paper introduces a governance assessment framework for Digital Water Governance Systems developed within the EU Horizon 2020 digital-water.city (DWC) project by Knoblauch et al. (2019). The aim of this framework is to identify non-technical factors that facilitate or hinder the uptake of information and communication technology (ICT) solutions for issues of sustainability in the urban water sector. The analysis results can be used to support the research on digital water governance systems in smart cities. The paper furthermore updates the case study results for Berlin (Knoblauch et al. 2020) as one of the analyzed European cities in DWC.

Realising Local Green Infrastructure Opportunities: Stormwater Harvesting In Public Parks And Open Spaces In Delhi

Dhruv Pasircha, Suresh Kumar Rohilla, Ms Shivani Y. Centre For Science And Envrionment (India)

Delhi is one of the largest urban agglomerations in the world housing a population in excess of 25 million, spread across an area of 1,483 sq.km. The city records an annual rainfall in excess of 800 mm, generating huge volumes of stormwater run-off, which is beyond the capacity of the conventional piped drainage. Urban flooding during the monsoon is an annual affair, with 161 flood hotspots identified in the city. The drainage infrastructure needs to be augmented with local green infrastructure solutions to address flooding. This study showcases how 3,423 million Litres of stormwater can be harvested annually in 16,000+ parks and open spaces of the city using Water-Sensitive Urban Design (WSUD) strategies; by allocating 1-3% of the total park area. In addition to addressing flooding, WSUD strategies help in groundwater recharge. The study also analyses the enabling framework for implementation of WSUD in parks and open spaces of Delhi.

Liability Turns Resource: Transforming Cities Of Uttar Pradesh Into Water-Sensitive Cities With Stormwater Harvesting In Parks And Open Spaces

Suresh Rohilla, Shivani, Dhruv Pasricha. Centre For Science And Envrionment (India)

Floods are a well-known phenomenon in South Asia, with India being the second worst flood-affected country in the world. Floods do not just occur due to overflowing rivers, they are also caused by the uninformed manner in which cities are interfering with the natural water cycle. This holds true for cities in the most populous river basin in the world: the Ganga river basin – has witnessed rapid urbanization over the past two decades. For instance, Uttar Pradesh has witnessed a 33 per cent increase in urban built-up area from 2005 to 2015. The study is followed by a comprehensive review of the natural resource profile of Uttar Pradesh, land cover pattern, issues related to urban flooding and depleting groundwater table. The research focuses on select parks and open spaces in five cities of Uttar Pradesh, with an aim to assess untapped rainwater or stormwater as well as demonstrate potential of capturing runoff by implementing suitable WSUDP interventions in these cities.

How CDS Technology Can Help To Retrofit And Upgrade Existing Aging Stormwater Infrastructure Into Smart Stormwater Treatment System In Order To Improve Water Quality

Yale Wong. Ecoclean Technology Sdn Bhd (Malaysia)

CDS stands for Continuous Deflective Separation which is an innovative screening technology for the separation of solids from liquid streams by working in conjunction with hydraulic principles of balancing of high flow carrying particles across the face of the screen to deliver a process of removing solids. PUB Singapore features this in the current website as ""Indirect screening for silt/debris control: a non-powered, low maintenance alternative to traditional screening systems. Its unique and non-blocking screen design is capable of deflecting silt/flotsam for removal while allowing clean water to flow back the waterways".

This paper shall shed some light on: i) how the aging infra-systems can be retrofitted and upgraded to be better equipped for more considerable stormwater runoff, and ii) the upgrading of water quality of township waterways by application of CDS. Using CDS technology and coupling with appropriate eco or bio-systems, it is possible that a degraded aquatic biodiversity can be reinstated to meet some of the requirements of UN's Sustainable Development Goals (SDGs').

Water Scarcity And Its Solutions: A Comparative Study Of Singapore, Muscat And Gwadar

Aadersh Humza. Balochistan Think Tank Network (bttn) (Pakistan)

This paper aims at carrying out a comparative study of three of the water stressed port cities around the world; Singapore, Muscat and Gwadar. Gwadar and Muscat share a close vicinity in the Arabian Sea and both have had major water scarcity issues to deal with. Muscat is developing into one of the better managed cities in the Middle East, while Gwadar is pitched as a future big thing in the region lying at the heart of China-Pakistan Economic Corridor (CPEC). However, Singapore, as a city state remains the global hydro hub and role model for many states around the world in water management. This paper would seek examples from each of the three port cities, how they have evolved over the years to manage the water scarcity and what they offer to learn from each other. This paper would conduct qualitative research using both primary and secondary sources of data by adopting descriptive and analytical approaches. Water helps nature to keep the wheels turning and its shortage can be deadlier for the living beings. It is therefore, quite significant to find adoptable and workable solutions of the water problem for the nature to remain productive, as it should be.

A Review Of Water Demand Management Practices In ASEAN

Corinne Ong, Cecilia Tortajada, Ojasvee Arora. Institute Of Water Policy, National University of Singapore (Singapore)

Around 326.8 million people in the Association of Southeast Asian Nations (ASEAN) countries lived in urban areas in 2019. By 2025, 70 million more people are expected to inhabit ASEAN cities. Water demand is expected to double by 2050, amid other challenges to water security as induced by climate change and inefficient uses of water. These issues indicate a need to improve water demand management (WDM) outcomes in ASEAN, thereby fostering resilient cities. Our study applies a WDM typology to review how water demand and supply services, and policies, are governed in the region by exemplifying promising WDM initiatives in selected cities. Our findings suggest that governments have developed policies and strategies to improve urban water supply and population access to water. However, interventions are not consistently implemented in ASEAN due to differential stages of country- or city-level urban development, institutional and financial capacity, manpower and technology access, etc.

Saniti – New Innovative Non-Sewered Sanitation Startegy As The Big Game Changer For Water Security

Jayant Shagwan, Sudhir Pillay. Water Research Commission (South Africa)

"We need to acknowledge that now and the near future the water crisis and water security will be key risk factors for the socio-economic stability of many nations. Though many strides have been made in both developed and developing countries, the challenge is far from over as we deal with the last mile issues and those related to that of climate reality.

It is time for some SaNiTi in the sanitation sector. Through the use of innovative technical solutions, we can shift the paradigm in which we serve our towns and cities towards more responsible use of our water while achieving the main aim of sanitation: protecting public and environment health. There is an opportunity to grow a resource recovery and usage industry, and a service industry for operation and maintenance through the use of innovative products which result in smart supply chain management.

The Sanitation Transformation Initiative (SaNiTi) is an approach aimed to disrupt the current sanitation paradigm by presenting a new pathway, which alone will free up nearly 30 to 50% treated domestic freshwater in our water environment and eliminate pollution pathways from our overburdened water courses, contributing to more longer term security in water quantity and quality.

Monitoring Water Activities And Quality In Reservoirs Through Beyond Visual Line Of Sight (BVLOS) Drone Operation

Ng Yong Chok. ST Engineering (Singapore)

The use of drones in commercial applications has increased rapidly in recent years. Using drones with the ability to fly beyond the visual line of sight unlocks the full potential for water activities and water quality monitoring in reservoirs as it allows the drone to cover far greater distances without the need for the pilot to keep an eye on the drone at all times, thereby improving the economics and efficiency of the operations.

In this presentation, we will review on the key technologies used to develop a complete end-to-end drone solution for operation in the reservoirs. We will also look at how data and video analytics can be incorporated into the system to provide benefits in terms of reducing human workload and providing spatial data insights not possible with existing manual approach.

Battery-Free Smart Water Meter Using Wireless Power Transfer Technology

Zaw Thet Aung. Waveboost Pte Ltd (Singapore)

The adoption of Internet-of-Things (IoT) devices in water-related applications is growing rapidly. The data collected enable real-time monitoring to enhance performance efficiency, reduce operational costs, and allow the users to gain actionable insights. However, as most devices are powered by batteries which have limited lifespan, this causes service disruption from device downtime, increased maintenance cost from regular battery replacement, and higher risk of water contamination from heavy metal released by the disposed batteries. In this paper, a novel battery-free system is introduced that can eliminate battery-related issues and enhance operational efficiency. The system is tested on automated meter reading (AMR) applications and has been demonstrated to collect more data points than battery-powered systems, without the concern about the battery lifespan. Higher data resolution helps users learn about their water consumption pattern and promotes water saving habits. The technology can be applied to many water-related

applications such as leakage detection and water quality monitoring to enable real-time insights with battery-free and maintenance-free operation.

Cool Cities In The Era Of Urban Heat

Adrian Moredia Valek. Arcadis Netherlands BV (Netherlands)

The climate change phenomenon continues to affect urban areas and their populations. Some of the most pressing climate impacts are related to changes in rain precipitation patterns (droughts and floods) and incremental heatwaves. The study analyses state of the art in urban cooling techniques, prioritizing the use of water, but not limited to other passive techniques, design strategies and technologies to maximize the cooling effect at the local scale. Developing innovative water-based cooling systems (prototypes), adequate to specific microclimate conditions. Applying a research through design approach to optimize and document the result of each of the prototype´s performance, in a series of iterative design-optimization processes. The cooling effect of two different prototypes (geothermal and downdraft cooling) is evaluated and compared.

Prediction Of Domestic Wastewater Management Systems In Sumatera Island On 2030: Cost Investment And Benefit Analysis

Nasrul Putra, Ahmad Daudsyah Imami, Radhitya Al Furqon, Dion Awfa. Institut Teknologi Sumatera (Indonesia)

The inequality on the development of sanitation across Indonesia has risen a serious issue for the government of Indonesia. Various program have been developed by the government. However, the main program (i.e., domestic wastewater management) is still mainly focusing on the development of sanitation in Java Island. In this study, Sumatera Island has been selected as a location of the study. The results showed that the 100% basic sanitation access in Sumatera Island could be achieved by the government in 2030 under the minimum condition (i.e., in an onsite system or community-based system). It costs around $156,61 per-capita to achieve this target in 2030. Moreover, the relatively high benefit value from this sanitation investment should trigger the Indonesia government to accelerate the basic sanitation access in Indonesia, especially in Sumatera Island.

Meeting The Finance Challenge: An Approach Of Sustainable Financing Model For Water Security In Growing Cities

Ganga Datta Nepal. Tribhuvan University (Nepal)

Growing water crisis, proper water resources management: realistic planning and investment for water and sanitation can only achieve Sustainable Development Goals 2030. In Nepal, government alone cannot deliver required water services for growing cities, still private sector is not prepared to invest due to low returns risks. Likely, in other side climate change variability have impaired water utilities' capacity to finance operations of water Utility. Objective of study is: suggest sustainable financing model for water security in goring cities. Study carried out on researcher's observation and secondary information of water utilities. Study find that Public Private Partnership in water utilities have provided mixed results of sustainable service delivery. To achieve set target of managing water services; need to understand economic value and financing water resources. For better living environment in cities, financing water services likely blended finance, leveraging services, private sector involvement, promote commercial banks for financing of infrastructure services.

High-Relief Artificial Reefs For Biodiversity Enhancement And Coastal Defence

Santosh Kumar Srirangam, Loke Ming Chou, John Kiong, Karenne Tun. HSL Constructor Pte Ltd (Singapore)

In response to areal loss of natural reefs and degradation of existing reefs due to coastal urbanization, high-relief artificial reef structures were deployed in Singapore to assess their contribution to ecosystem recovery service. Mimicking natural reef slopes, these high relief structures make habitat expansion possible as they support the development of new reef habitats in open water over deeper seabed. The structures are designed to provide 1000m2 of new space for the development of corals and reef-associated biota. The “Reef Garden Project” was developed by Jurong Town Corporation and the structures, built by HSL Constructor, were deployed in the Sisters’ Islands Marine Park in collaboration with National Parks Board. Prior to that, DHI conducted an Environmental Impact Study to understand the impact of artificial reef structures. In addition to enhancing marine biodiversity, these structures can also provide a coastal defense service by buffering wave energy.

*Postcards From The Anthropocene: A Sea-Level Rise Toolkit For Urban Waterfront Resilience In Singapore

Gabriel Kaprielian (United States)

A rise in sea level poses an imminent risk to Singapore. This research project seeks to reframe the challenges of sea-level rise as an opportunity for innovation to create a shared vision of resilient and sustainable urban waterfronts. The project represents an international and interdisciplinary collaboration between climate change scientists at the Earth Observatory of Singapore at Nanyang Technological University and an architecture professor from Temple University as part of a U.S. Scholar Fulbright. The project proposes to develop a sea-level rise toolkit that serves to (1) visualize past, present, and potential future transformations of the urban waterfront in Singapore, (2) apply a methodology of site analysis to inform potential resilience strategies for climate change adaptation, and (3) develop an interactive digital platform that builds place-based knowledge, communicates sea-level rise risk, and enables collaboration between diverse stakeholders in Singapore, the United States, and globally.

*CDM Smith - Digitalizing: Harnessing The Potential Of Digital Transformation In Data-Driven Water Solutions

Eklavyya Popat, Ilja Prinz, Amy Corriveau, Ralf Bufler. CDM Smith Europe GmbH (Germany)

The water industry is currently undergoing an accelerated paramount transformation with digital solutions as a solution to counter issues like increased water demands, impacts of climate change and poor water quality. Digital solutions like internet of things (IoT) with advanced data analytics, augmented intelligence and block chain are empowering us with new capabilities to analyse, monitor in real time, automate and predict system behaviour to minimize risks and enhance operation. In this paper, we highlight our digital transformation strategy and discuss different in-house developed digital solutions in the water sector, such as PipeCASTTM and others, as well as their applications in different projects around the world. Additionally, observed overall 137ositive of these solutions on different sectors such as an improved revenue, increased efficiency, additional agility, and improved potential to optimized use of resources are also discussed. Furthermore, the main challenges required to overcome are explored with a glimpse to the further digital water road map and prospects of digital water solutions in water industry.

*Advanced Urban Water Management To Efficiently Ensure Bathing Water Quality: The Ibathwater Project

Jordi Cros. Adasa (Spain)

The iBathWater project is a real scale demonstration project for a new integrated management system for the urban drainage system.Its application is expected to reduce untreated wastewater spills, reduce pollution and environmental impact in the receiving water bodies and minimise the sanitary risks of bathing areas during and after episodes of intense rainfall.

To accomplish these challenges, the solution comprises the development of open platform capable of combining operational and managerial information with innovative online and in real time microbial measurements to ensure bathing water quality during rain events. A risk assessment model to estimate the health risk during and after short term pollution episodes at bathing waters is developed. These technologies provided in iBATHWATER will be installed and validated in Barcelona (coastal waters) and Berlin (river water) where the pilot tests are being carried out.

*A New Chapter Of Our Multi-Functional Drainage Infrastructure: Drainage Improvement Works In Mong Kok

Pui Shan Yuen, Ming Yueng Kwan. Drainage Services Department (Hong Kong SAR)

The Tai Hang Tung Stormwater Storage Scheme (THTSSS) is Hong Kong SAR of China's first large-scale underground stormwater storage scheme, which was commissioned in 2004 and designed to alleviate the flood risk of the Mong Kok area. In view of the existing dilapidated drainage networks, updated hydrological statistics and climate change impacts, further drainage improvement works are under planning to enhance the flood resilience level for the region. This paper presents the method to enhance the flood adaptive capacity of the urban drainage system and introduces the concept of multi-functional blue-green-grey water infrastructure adopted in Hong Kong.

Theme 5: Water Quality & Health

Effect Of Extended Stagnation On The Quality Of Drinking Water In An Above-Ground Network In The Tropics

Dan Cheng, Mats Leifels, Sophia Wu, Nadhirah Nasha, Jiawei Cai, Eric Hill, Nico Boon, Jorien Favere, Andrew Whittle, Stefan Wuertz. Nanyang Technological University (Singapore)

Extended stagnation is known to cause deterioration of drinking water quality and has affected public buildings during lockdowns in the current COVID-19 pandemic. The impact of biofilm on the bulk water due to extended stagnation from national or regional lockdown remains unknow. The aim of this study is to understand how extended stagnation in the absence of monochloramine influences potable water quality, to assess the changes in biomass (detached biofilm) with resuming operations, and also to determine how long the bulk water microbiome takes to regain its equilibrium. Here we use an above-ground testbed to simulate stagnation of drinking water distribution systems (DWDS) in five replicate pipes and over nine weeks. Extended stagnation in the absence of the disinfectant monochloramine coincided with a significant increase in total bacterial cell counts and augmented the fraction of viable cells from 0.2 to 0.6 as shown by flow cytometry. A subsequent flushing experiment revealed rapid detachment of biofilm in the first 60 s, which affected the bacterial concentration and community composition in the outflowing bulk water. We propose conductivity as a potential water quality indicator in DWDS, as it correlated strongly with the more expensive flow cytometry and 16S rRNA gene metabarcoding methods.

MICA Legionella: A Rapid Fluorescence-Based Enumeration Of Culturable Legionella Pneumophila Of All Serogroups In Domestic Hot Waters And Cooling Towers Waters

Sam Dukan, Fanny Passot, Sabine Peslier, Elsa Fanchon, Eric Agostini, Audrey Dumont. Diamidex (France)

Legionella pneumophila is a pathogenic bacterium involved in regular outbreaks characterized by a relatvely high fatality rate and an important societal impact. Frequent monitoring of the presence of this bacterium in environmental water samples is necessary to prevent the epidemic events, but the traditional culture-based detection and identification method requires up to 10 days. MICA Legionella allows identification of Legionella pneumophila (L. pneumophila) by metabolic lipopolysaccharide labeling which targets specifically the O-antigen of the bacterium. This new approach allows easy detection and enumeration of culturable L. pneumophila within 48h, while other Legionella species are not labeled.The labeling process relies on two phases: i) the metabolization specifically by L. pneumophila of DIAMIDEX's patented molecule, a precursor legionaminic acid-N3 (pLeg-N3), and ii) its association with a fluorophore via bio-orthogonal click-chemistry reaction.(2) The fluorescent signal emitted by the labeled bacteria is read after 48 hours of incubation, with MICA Fluorescence equipment, and automatically counted by MICA Legionella Artificial Intelligence able to discriminate L. pneumophila microcolonies signal from their background. The whole process is non-destructive for the bacteria.

Water Usage Pattern In The Aftermath Of Covid-19

Naveena K. Centre for Water (India)

Maintenance of good health and avoiding a viral infection is the prime focus for an individual during COVID-19 pandemic. Water being a universal solvent widely used to clean the disinfectants at household level. This study was designed to find any change in the water consumption pattern among the households after the emergence of COVID-19. To study this, more than 800 respondents were surveyed through Google Form. The results indicate that there was a significant change in the

consumption pattern of drinking water from cold to hot water and the total water usage of the respondents to clean and disinfect the surface areas, washing hands, etc. This eventually has a significant burden on the water resources in countries where water is already deficit like India. It is recommended that the Government can ensure the supply of adequate quantity and quality of water to the residents to meet the future demand of water.

Disinfection By-Products Formation In Reclaimed Water By Ozone/BAC And UV/Chlorine Treatment Processes

Y Zhong, S L Ong, Jiangyong Hu, W S Ang, B Viswanath. National University of Singapore (Singapore)

A multi-barrier advanced treatment process consisting of ozonation (O3), biological activated carbon (BAC) and ultraviolet/chlorine (UV/Cl2) has been reported to be an effective process that can realize considerable organics removal, resistant contaminants abatement, and pathogens inactivation. However, the presence of disinfection by-products (DBPs) in the reused water has been recognized as a risk to environment and human beings, which makes the control of DBPs a significant issue to ensure water safety. UV light-emitting diode (UVLED) lights at different wavelength have been reported to have various impacts on DBPs formation. This study investigated the formation of DBPs in an effluent treated with O3/BAC/UV/Cl2 process and the associated toxicity of treated water. Two wavelengths of UV light resources (254 and 285 nm) and two oxidants (chlorine and chloramine) were used in advanced oxidation process (AOP) treatment. This study also evaluated the effects of various operating conditions such as pH, UV exposure and oxidant dosage on DBPs control.

Prevalence Of Antibiotic Resistant Genes (Args) In Urban Rivers

Mohomed Niyaz Mohomed Shayan, Takashiro Onodera, Ryuuta Miyajima, Yuuya Akazawa, Hisashi Satoh. Hokkaido University (Japan)

Dissemination of antibiotic resistant genes (ARGs) through urban rivers is a contemporary issue. This study focused on fluctuation of Escherichia Coli (E. coli) and ARGs and their sources in Toyohira River (Sapporo city, Japan). E. coli concentration was quantified using Colilert and Quanti-Tray/2,000. Bacterial 16S rRNA gene and two ARGs (blaIMP and mphA) were quantified using qPCR in sampling sites (S-1 to S-4) covering over 40 Km span. Results demonstrated that E. coli loads at S-1 were below 0.43 MPN/mL while increased at S-2 and S-3 by several folds (possibly due to discharge from WWTP and combined sewers) and decreased at S4 (possibly due to dilution by chlorinated WWTP discharge). Conversely, 16S rRNA, blaIMP and mphA genes increase towards downstream. This indicated that E. coli and genes were discharged from sewer systems and trend of variation of blaIMP and mphA was similar with 16S rRNA gene but different from E.coli in the river.

Mitte X – Healthy Hydration For Everbody In A Sustainable And Delightful Way

Moritz Waldstein-Wartenberg, Lucie Durand, Marc Barbance. Mitte (Germany)

Mitte X is the social endeavor of Mitte that is dedicated to bringing healthy hydration to everybody, by providing support and technology to water organizations and NGOs that are already delivering safe water, to help them deliver healthy water. Many SWEs, water nonprofits and social businesses are doing an admirable job in creating access to safe water and ensuring that it is properly filtered and safe from contamination. And we believe there is a missed opportunity to add to that work in the form of re-mineralizing and enhancing water to create healthy water. To design the ideal solution, we started conversations with several organizations in the water sector and started a market research afterwards to co-create 3 concepts of water enhancement in collaboration with our partners. In the next months we are starting our pilot with a qualitative test and a sensory test to validate our hypothesis.

Marine And Coastal Planning In The Context Of Singapore's Seawater Quality Conditions

George Foulsham, Robert Nichols, Andre Low. DHI Water & Environment(s) Pte Ltd (Singapore)

Singapore has limited sea space and large demands on its use. Strategically and synergistically locating future coastal developments and activities is critical to Singapore's future prosperity. This involves deconflicting the use of the sea space to minimize deleterious direct or cumulative impacts on each of the users. Marine water quality plays an important role for optimizing the location of future developments and activities. A review of available water quality data collected by DHI over multiple years highlights some trends in the local marine water quality characteristics which provide useful insights for planning.

Drone-Based Spectrometric Monitoring Of Water Quality Parameters In Reservoirs: Algorithm Development And Validation

Soo Chin Liew, Chun Keong Chu. National University of Singapore (Singapore)

In this paper, we describe our works in developing a compact spectrometric sensor system and algorithms for retrieving water quality parameters in Singapore’s reservoirs. This water quality sensor system is suitable for deployment on a mobile platform such as a drone. Water leaving reflectance is first derived from 3 radiance measurements and an on-board processor calculates the water quality parameters (namely, Chlorophyll-a, Colored dissolved organic matter and turbidity) in real-time and relays the results to a ground base station. The retrieval algorithm has been improved to facilitate real-time calculation. The system has been deployed over 3 different reservoirs for algorithm calibration and validation. The algorithm is robust in the sense that a single regression relation can be applied to derive each water quality parameter under diverse conditions of the reservoirs. The chlorophyll-a concentration and water turbidity estimated using this model correlate well with field sampling measurements, with coefficients of determination (R-squared) exceeding 0.75.

Characterization Of Stormwater Runoff Based In Microbial Source Tracking Methods

Ricardo Santos, Silvia Monteiro, Gaspar Queiroz, Filipa Ferreira. Instituto Superior Técnico (Portugal)

Rainfall and associated urban runoff have been linked to an increased deterioration of environmental waters, carrying several pollutants including pathogenic microorganisms. Stormwater has not been extensively characterized as it is, because most studies are performed either on drainage pipes that are often impacted by sewage leakage or directly in environmental waters following a rain event. In this study, stormwater collected directly from the streets, was monitored for the presence of fecal indicator bacteria (FIB) and three important sources of fecal contamination in urban environments (human, cats, and dogs), in three basins in Lisbon, Portugal. High concentration of fecal contamination was detected with the majority of the samples displaying at least one source of contamination. A strong relationship was found between the number of detected sources and the precipitation levels. The results show a trend in geographical information on the type of urban use in each basin. This study suggests that, in urban areas, stormwater runoff is highly impacted by fecal matter from domestic animals and human origin, before any cross-contamination in the drainage system and may, by itself, pose a high risk to human health and the environment.

Removal Efficiencies Of Human Coronaviruses (Hcov-OC43 And Hcov-229e) By Simulated Coagulation-Flocculation Process With Fecl3 And Polydadmac

Muhammad Hasif Jemain, Nusrat Jahan, Caixia Li, Shane Snyder, Mauricius Marques Dos Santos. NEWRI-NTU (Singapore)

Given the emerging risk posed by coronaviruses, evaluation of water treatment processes is key knowledge gap in the water/wastewater industry as much of the current studies are focused on waterborne viruses. In this study we present removal efficiencies of surrogate coronaviruses (Human coronavirus 229E and Human coronavirus OC43) by coagulation/flocculation processes. A laboratory scale system using different full-scale treatment plant water matrices was used and viral detection done by RT-qPCR. While under optimized conditions FeCl3 coagulant can achieve more than 90% of virus removal, the use of polyDADMAC as a coagulant aid can improve treatment efficiency by more than one log virus removal (LVR) unit.

Use Of Wastewater-Base Epidemiology (WBE) To Monitor Temporal Consumption Patterns In Singapore

Jia Wei Yuen, Wen Jun Stanley Khor, Nusrat Jahan, Caixia Li, Mauricius Marques Dos Santos, Shane Snyder. NEWRI-NTU (Singapore)

In this work we present the use of WBE to monitor temporal variations of chemical markers of consumer patterns in Singapore. Using direct injection LC-MS method for 20 different chemicals, we established a monitoring network to cover 100% of local population in the WBE assessment. Daily mass loads of monitored chemicals show that socioeconomical trends can be monitored; during periods where higher incidence of COVID-19 was observed, an increase in household cleaning chemicals was alsodetected. On the other hand, with the reduction of restricted movement measures, we observed a surge in the usage of the insect repellent DEET that also correlated with the Northeast monsoon season, where heavy rains create a conducive environment for mosquito breeding.

Single Cell Detection For E. Coli Using A Digital Microwell Array Chip

Ai Qun Liu, Wenshuai Wu, Thi Thanh Binh Nguyen, Yang Liu. Nanyang Technological University (Singapore)

Plate counting is the standard method for bacteria identification and quantification in water and food quality, as well as the diagnosis of bacteria infecting disease. However, it suffers from long cultivation time to grow visible colonies. We developed a self-driven microwell array chip and digital β-glucuronidase assay for rapid and accurate quantification of viable E. coli in 4 hours. The performance of this method was assessed against the factors of total solid suspensions (TSS), heating and chlorination.

Is The Global Water Sector Meeting The Challenge Of PFAS?

Tony Koodie, James Kennedy, Andrew Elphinston, James Ostrowski. Binnies (United Kingdom)

PFAS are an emerging pollutant of concern within the water industry because of the associated health concerns they can cause such as cancers and birth defects. PFAS are non-degradable so despite some countries starting to restrict their use, historical uses of PFAS mean they will always be present in water supplies unless removed by treatment. PFAS were first widely detected in water supplies across the US yet only 15 states have enforceable limits on the PFAS concentration in drinking water. PFAS are now being found all over the world with legislation starting to be put in place in other regions such as the EU however, no Asian countries have yet put legislation in place.

GAC adsorption is the most widely used technology for PFAS removal; ion exchange is also used, depending on specific circumstances.

The Microplastics Dilemma For The Water Industry.

Tony Koodie, Linley Hastewell, Anne-Marie Palfrey, Dylan Powell, Fay Couceiro. Binnies (United Kingdom)

The global impact of microplastics pollution and its prevention within the water industry is one of the biggest environmental challenges of our time. There is growing evidence to suggest that microplastics pose a significant risk to organisms, either by the direct physical ingestion of particles or indirect exposure to organic contaminants and heavy metals adsorbed on the surface of microplastics or pathogenic microorganisms attached to the surfaces. Consequently, the presence of microplastics in the environment is contributing increasing concerns within the water industry and the role it will play in reducing this emerging contaminant. The aim of this presentation will be to provide an understanding of why microplastics are an important concern; the issues relating to measurement and monitoring of microplastics; and treatment works effectiveness for microplastics removal. In addition, the presentation will highlight some of the critical initiatives that are being taken globally to formulate legislative strategies and approaches within the water industry.

Soil-Sediment Microbial, Geochemical Connectivity In Naturalized Urban Waterways: Bishan Ang-Mo-Kio Park, Singapore Case Study

Canh Tien Trinh Nguyen, Qi En Ooi, Aditya Bandla, Yi Zi Koh, Andrew Laloo, Sanjay Swarup. Life Sciences Institute, National University of Singapore (Singapore)

A naturalized urban waterway was studied for its geochemical and microbial composition to investigate the connectivity between surrounding landscape soil and sediments in the stormwater channel to trace the source of sediments and their associated microbiomes. A preliminary survey collected sediment samples from the river and soil from various surrounding land covers. The samples were analyzed via amplicon sequencing, and geochemical profiles. Microbial source tracking was done via sourcetracker2, while SedIment Fingerprinting Tool (SIFT) and MixSIAR were used to elucidate landscape sources from a geochemical perspective. A minimal proportion of the microbial community in river sediments originated from landscape soils, except for one deposited sediment sample. Geochemically, both models suggested sediments were most likely derived from erosion prone Inland Channels and Floodplains. Disparity in results and inability for microbial source tracking to identify sources in coarse sediments could be attributed to dispersal limitation, priority effects, or possible environmental filtering.

Scale-Up Testing Of Para-D 4.0 In Water Plant

Qian Bin Zhao, Thi Thanh Binh Nguyen, Hai Long Li, Yang Liu, Jing Bo Zhang, Chang Nong Lim, Shao Bo Luo, Prakash BN, Yuan Cheng Zhan, Naveen Chandhavarkar, Jian Jun Qin, Chin Wei Chow, Erica Michelle De Souza, Jeff Aw, Ai Qun Liu. Nanyang Technological University (Singapore)

Protozoan parasites (Cryptosporidium and Giardia) are among the most common cases of infection and disease of public water supply accidents. In this work an intelligent water quality monitoring instrument, Parasitometer (Para-D 4.0), has been developed for the automatic, real-time and online detection of Cryptosporidium and Giardia in water plants and laboratories. In 2020, the onsite detection testing of Cryptosporidium and Giardia using Para-D 4.0 was conducted with the filtrate in water plant, including the performance evaluation of specificity (true negative rate), sensitivity (true positive rate), limit of detection (LOD), recovery rate, reliability and stability.

A Focus-Forming Assay (Ffa) For The Detection Of Human Coronavirus (Hcov-Oc43)

Mauricius Marques Dos Santos, Nusrat Jahan, Caixia Li, Shane Snyder. NEWRI-NTU (Singapore)

With the recent COVID-19 pandemic the monitoring of viruses in water has gain new attention. While the use of wastewater-based epidemiology (WBE) has been demonstrated in different settings, most of the results provide no information regarding viral viability/infectivity that could also be useful for water/wastewater treatment utilities. In this work we present the use of a focus forming assay (FFA) for the monitoring of viable human coronavirus (HCoV-OC43) in water and wastewater. Compared to traditional plaque assays, FFA offers the advantages of greater specificity and higher throughput (96 well-plate format) while providing viral viability information not possible traditional with PCR assays. To demonstrate our assay, we applied the developed assay to study the viral inactivation process through chlorine disinfection and compare it to RT-qPCR results.

Regulated Chlorate Generation Using On-Site Electro-Chlorination (OSEC®) B PLUS System

Xiangyi Qiao, Romulo Conde. Evoqua Water Technologies Pte Ltd (Singapore)

On-site hypochlorite generation has been a popular means for disinfection worldwide. By producing hypochlorite on-site and on-demand, eliminates concerns associated with transportation and storage of liquefied chlorine gas or commercial sodium hypochlorite solutions. During electro-chlorination process, hypochlorite is produced as the major product, while chlorate is generated as a byproduct. The World Health Organization (WHO) issued guideline for chlorate at 0.7 mg/L. This study aimed to evaluate effects of various operation parameters on chlorate generation during hypochlorite production and apply these results to on-site electrolytic chlorination (OSEC®) B Plus system installed in drinking water system. The system generates a 0.8 % sodium hypochlorite solution through the electrolysis of brine, consuming only water, salt and electricity. It is proven that chlorate generation during the hypochlorite production process can be controlled and hypochlorite degradation to chlorate in the post-production stage can be mitigated to certain extent.

Fully Automated Rapid Microbiological Measurement Approach For Water Quality Monitoring

Keith Kee, Wolfgang Voghl. Asian Resources Centre Pte Ltd (Singapore)

One of the common waterborne contaminants is microbial and organic contaminants which cannot always be detected by human senses. This is especially for water storage over long periods of time. What if your water looks, smells, and tastes just fine — is it?

In order to measure viability, some time and reagent is required. This can be done by observing a biochemical reaction (using some kind of reagent). The incubation time required for cultivation culture-based approaches are not suitable for rapid microbiology. The technology is measuring the metabolic activity of microorganisms present in the sample.

The technology is measuring the metabolic activity of microorganisms present in the sample. The metric is the enzymatic activity of the concentration of living target organisms, which represents the degree of contamination

Detecting All Serogroups Of Legionella Pneumophila In Proficiency Testing Samples Using A Rapid On-Site Test

Michael Connolly, Greg Rankin. 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 LpSG1 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. Currently the most common method of detecting Legionella in water is by culture method. Accredited laboratories will use Proficiency Testing (PT) as it allows the accredited laboratory to offer significant performance data to monitor and prove competency to its customers, accreditation bodies or both. Furthermore, PT provides the organisation with an insight into their laboratory's performance, (i.e., accuracy and reliability) and allows for direct comparison of performance with that of other laboratories, nationally and internationally. This poster reports the advancements made by the Hydrosense Ltd technical team in developing a rapid on-site testing method for Legionella pneumophila serogroups 1-15 (LpSG1-15) and demonstrating its ability to accurately identify Legionella pneumophila serogroups 1-15 in PT water samples.

Water Resources Challenges And Mitigation: Alignment And Response To UN SDG's In Philippines Setting

Robinson Salenga, Maria Sophia Orticio. Maynilad Water (Phillippines)

In reference to the year 2020 data, Philippines' total water use as percentage of the total renewal water resources is only 7%. The reality is that there is a decline in per capita water availability in the country. Such that the Philippine fresh water ecosystem faces severe problems of pollution and the cost of supply potable water are rising. However, the problem is not absolute shortage of water. The problem is mismatch of supply-demand, mainly due to inadequate infrastructure to store water, low water use efficiency and management weaknesses.

Achieving Sustainable Water Resources By Adopting Technological Advancement In Preserving Water Sources And Delivering Safe Water In Accordance To UN SDG's Mandate

Robinson Salenga, Maria Sophia Orticio. Maynilad Water (Phillippines)

This discussion will merely focus on the current undertakings made on how organization tasked to operate, manned and maintained existing water sources facilities conducts and foresee the condition that may affect and at the same time will have effect to those said facilities as well as to align the mandate set forth by UNSDG as well as the roles of each stakeholder in fulfilling these goals into reality.

In areas wherein, the water resources are limited, in-depth and thoroughly and viable studies and conceptualization for water resources development is a necessary condition for optimum social and economic growth with respect to the environmental implication and effects. In water resources development, there are many aspects of a question – the demand is often complex and has multiplicity of targets and options. Different entities can have politically and professionally opposite views on various aspects and each of this may claim to be right

SARS-Cov-2 Detection In Water Via Photonic Sensor Chip

Binh Ngyuen, Min Min You, S.C Chen, Zhenyu Li, Jinguan Liu, Yuzhi Shi, Hongwei Zhao, Xiaohong Zhou,Yi Zhang, Eric Yap, Ai Qun Liu. Nanyang Technological University (Singapore)

The great advances of silicon photonic sensor technology have manifested itself as a promising paradigm for wide sensing applications. The miniaturization of the chip and detection system makes facilitates photonic sensor chip to be used in clinic for early detection of diseases. Here, we put forward a highly sensitive photonic sensor for the detection of SARS-CoV-2 virus through its spike proteins in water. The system consumes very small amount of sample in 50 µL and detects an imperceptible variation of refractive index at a high sensitivity of 0.1 ng/mL in 1 h without the requirement of pretreatment. The measurement is sensitive and fast and can be automatic with a minimum human intervention. Moreover, the system can be multiplexed to detect multiple target and analytes of virus, toxic and pathogenic parasites etc. in water simultaneously.

*Chlorination Disinfection By-Products Of Nonylphenol Induce Cellular Metabolic Changes In Vitro

Jewel Zi Le Toh, Caixia Li, Shenglan Jia, Mauricius Marques Dos Santos, Shane Snyder (Singapore)

Assessment of public health risks related to disinfection by-products (DBPs) is a complex task and requires a comprehensive analysis of possible effects. Here we present the toxicity of DBPs of nonylphenol and evaluate the use of an untargeted metabolomics approach to evaluate the impact of DBPs on different cellular pathways. Samples after a simulated drinking water chlorination process show increased cytotoxicity when compared to the parent product, with some of the main affected pathways including the alanine, aspartate, and glutamate metabolism and arginine biosynthesis. This approach reveals the potential of untargeted metabolomics for comprehensive the assessment of potential health effects of DBPs.

Theme 6: Nexus & Circularity

eCircleSystem Project: A Serious Game For A Holistic Approach To Circular Economy Policies And Strategies In The Water Sector

Juan Jose Iervasi Scokin, Rodrigo Vallaro, Alejo Berg. Universidad Argentina De La Empresa (Argentina)

The circular economy in the water sector requires a multisectoral approach and coordination that includes the diverse actors involved. In its urban cycle, water crosses different communities, jurisdictions, industries and several uses, a holistic approach to its circularity requires consensus and collaboration to achieve governance objectives. In order to build a tool promoting interaction between the stakeholders and generate a pool of specific knowledge and strategies, video game technology is used, with a serious game approach. The result is the creation of an application that allows exploring the elements present in different scenarios together with the policies and actions to be implemented, overcoming the different barriers on the way to circularity in the water sector. Modeled scenarios include basins with inhabitants in a situation of sanitary vulnerability, which requires the incorporation of actions related to inclusive sanitation to be resolved along with the rest of the issues.

Water and Energy Circularity – Promoting Water Resiliency And Energy Recovery Through Used Water Treatment Plant At KC Valley, Bengaluru

Gaurav Bhatt. Jacobs (India)

KC Valley Used Water Treatment Plant, built in early 70s, is one of the oldest plants in Bengaluru managed by the Bangalore Water Supply and Sewerage Board (BWSSB). For the past 3 years, treated water from KC Valley Plant is supplied to Kolar, a very dry and drought prone region about 100 km away from Bengaluru, and the treated water is stored in village ponds for groundwater recharge. Currently, there is no beneficial utilisation of biosolids. Recently, the National Green Tribunal has mandated that all the older used water treatment plants in the Mega and Metro Cities of India must be upgraded to meet the new treated effluent requirements (TN<10ppm, TP<1ppm). KC Valley Used Water Treatment Plant is now undergoing for upgradation to meet the revised mandated standards, making it First of Kind Brownfield Upgrade in India of this size. The improved treated water quality will be beneficial for farmers wherein they would be able to use the stored water for irrigation purposes. The treated water will also be supplied to local industries to meet their non-potable water needs. Biosolids produced will be used as fertilisers, and the energy will be recovered to be used within the plant.

An Integrated Water, Energy, Food Security Solution

Thomas Murphy. Water Life Systems Africa (pty) Ltd. (South Africa)

Humanity must effectively plan for infrastructure required to adapt to climate change realities. Previous work fails to consider distributed Water, Energy, Food Security (WEFS) solutions as integrated systems. Considering civil infrastructure from the centralized viewpoint misses the opportunity to add significant resiliency for water stressed areas. The value of integrating centralized with distributed water systems has become evident throughout the world. Distributed WEFS systems integration into centralized infrastructure has the potential to alleviate centralized infrastructure weaknesses and provide resiliency benefits that centralized systems are unable to provide. The key impact of this paper is to explain the importance of integrated WEFS systems with closed loop plumbing system to conserve resources in a cost-effective manner. Utility services and city planners are given the justification to proactively integrate distributed WEFS systems into their centralized systems for greater sustainability and resiliency of core human living systems. Distributed infrastructure assets and their associated IoT Connectivity solutions alleviate centralized system stressors that allow for more effective population growth, reorganization, and migration logistics, all the while providing sustainability and resiliency to the population's life support systems. The democratic decentralization of civil infrastructure allows a growing human population to survive and thrive in the face of adversity.

Virtual Water Trade And Its Geo-Political Implications In The Context Of Building Up Climate Change Resilience

Bhaskar Tatwawadi. Double Shotz Pte Ltd (India)

Virtual water trade refers to the import and export of hidden water in the form of products such as crops, textiles, machinery and livestock. The Chinese claimed that Virtual Water as an integrated component of their Belt & Road Initiative would help all the involved nations. Post 2019, in the SARS-COV-2 Pandemic era, virtual water has emerged as a potent geo-political weapon. Trade balance based on the virtual water component of the exports and imports will now shape the commerce and future of the global trade. A new framework of Hydro-Hegemony will call the shots. An ADBI paper on The Trade and Water Nexus explored the linkage between the virtual water trade and SDG-6. As we experience extreme climate episodes with increasing frequency and ferocity, the continuous shift of water imbalance across regions creates corresponding imbalances in virtual water trade. This offers both - challenges and opportunities. Considering the global water consumption statistical data available, it is likely that water rich regions will benefit and grow at the cost of the more unfortunate water deficient regions and communities.

This paper seeks to identify and quantify these imbalances in an attempt to develop equitable water sharing policies and solutions.

A Nexus Approach To Achieving Sustainable And Resilient Food Systems: A Focus On Sub-Saharan Africa

Stanley Liphadzi, Sylvester Mpandeli, Luxon Nhamo, Dhesigen Naidoo, Albert Modi, Tafadzwanashe Mabhaudhi. Water Research Commission (wrc) (South Africa)

Despite the many divergent opinions expressed before, during and after the United Nations' Food Systems Summit, what becomes clearer is that the world's current food systems are unsustainable. There are still many people facing hunger and malnutrition. The interconnectedness of food systems with multiple other sectors such as agriculture, environment, biodiversity, water and healthy has also taken centre stage. Concurrently, the inadequacy of sector-based approaches to dealing with complex systemic problems is now widely recognised, with calls for systematic approaches, such as nexus planning, which consider broader systemic issues and promote a sustainable, equitable, inclusive transition and resilient food systems. We conducted an initial systematic review to identify the drivers of food systems unsustainability. We developed and applied sustainability indicators to identify trade-offs and synergies for food systems transformation. We also developed causal loop diagrams to identify plausible pathways and entry points for transitioning towards sustainable and resilient food systems.

Institutional Arrangement For A Successful Transition To A Circular Economy In Water Sector: A Review Of Related Knowledge

Fayaz Riazi, Teresa Fidélis, Filipe Teles. Univeristy of Aveiro (Portugal)

The deficiencies of past water resources development and the increasing pressures to achieve sustainable goals raise the need to transition to Water Circular Economy (WCE). However, the transition toward a WCE requires new possible Institutional Arrangements (IAs) and associated social innovations as well as preferred policy tools. This paper reviews the literature conducted on IA crossing WCE and water reuse to understand the development of the knowledge within the research field, and to know what is already known and must be explored in the topic. Results suggest that the successful transition toward a WCE depends on several institutional features including formulating a robust policy framework and regulation containing quality standards and policy guidelines, well-defined responsibilities in an innovative and cooperative governance, supportive legal framework and the recognition of risk and fairly share the cost, benefits and risks.

*Smart Water Cities Certification Scheme: Standards And Developments

Monica Garcia Quesada. International Water Resources Association (Belgium)

The presentation will provide an overview and a progress update on the research project Smart Water Cities. This is a three-year research project, run collaboratively between IWRA, K-water and the Asia Water Council. The project seeks to develop a Global Standard and Certification scheme for Smart Water Cities to allow cities around the world to measure and evaluate their urban water services provision. The presentation will introduce the rationale for the project, the definition of Smart Water city and the approach for developing Key performance Indicators and certification protocols.

~~***Implementing Water Accounting And Water Governance Analysis To Support Water – Energy-Food Nexus In The MENA Region: The Lessons Learned And The Way Forward**~~

~~Marwa Ali, Adham Badawy, Amgad Elmahdi, Dubravka Bojic, Domitille Vallée. International Water Resources Association (Egypt, Arab Rep.)~~

~~The region of Middle East and North Africa (MENA) is water scarce. It is predicted that water scarcity will increase with several drivers including population growth and its related food demand. Moreover, the region is exposing to frequent, severe and prolonged extreme events -droughts and floods- aggravated with climate change. The combination of these drivers and uncertainties aggravates the risk of increasing gaps between demand and water availability, groundwater overexploitation impacts, and degradation in the quality. Water accounting (WA) and Water Governance Analysis (WGA) are complementary and provide comprehensive information related to hydrological processes and water consumption for better communication, policy, and decision-making in a geographical domain. This paper, hence, reviews the implementation of the WA and the WGA framework and lessons learned gained from practice in some MENA countries. It offers an approach to inform strategic planning for sustainable water use and trade-off decisions for the nexus water-food-energy-climate change. The way forward will be also discussed.~~

***The Davao City Bulk Water Supply Project "Water – Energy Nexus"**

Shake Tuason, Libert Lomuntad. Apo Agua Infrastructura, Inc. (Philippines)

The Davao City Bulk Water Supply Project (DCBWSP) incorporates a Hydroelectric Power Plant (HEPP) in its water supply system that is designed to provide the required energy for the Water Treatment Plant (WTP). It fully utilizes the benefits of the closed loop "water-energy nexus" to its advantage. The DCBWSP will alleviate water stress in the city by providing a more sustainable surface water source and lead the shift from groundwater dependence. The DCBWSP is a pioneering project in the country that offers the "water-energy nexus" which has significant benefits from an environmental and operational perspective.

***An Operational Framework To Quantify The Sustainability Of Water Resource Recovery Facilities**

Maria Faragó, Martin Rygaard, Anders Damgaard, Morten Rebsdorf. Technical University of Denmark - DTU Environment - Water Technology & Processes (Denmark)

Typically, wastewater utilities use economic analyses to evaluate new investments. However, recently there has been the need to include other criteria such as environmental, technical and societal criteria. Such a decision support tool is not least relevant in the transition from conventional wastewater treatment plants to water resource recovery facilities, having focus on recovering energy, nutrients etc. Together with universities and wastewater utilities, we developed a sustainability framework to quantify environmental, societal and technical impacts along with economic analyses. We identified 22 criteria and associated quantitative and semi-quantitative indicators. We demonstrated the framework through real cases within wastewater treatment. Results indicated that this framework can both support simple decisions dealing with material choices and high-level decision making such as the implementation of novel technologies for carbon and energy recovery. The framework helped utilities prioritize options that reduce environmental impacts and increase technical and societal value rather than the cheapest solutions.

*Acceptability Towards Water Reuse In Middle School Students – A Case Study From Delhi, India

Neha Gupta. Teri School of Advanced Studies (India)

Public acceptance plays a major deciding role for water reclamation projects but the irony is that till date a lot has been spend in terms of efforts and funds only on technologies and little/ less has been spent on the soft component i.e. public views and very little information is available on any community surveys conducted, public education or involvement programs. The study dives deep to understand the perception of the middle school students (10-14 years) who are residing in Delhi, India, and are suffering due to water scarcity but are/might not be aware of water conservation techniques and use of reclaimed water to meet water (potable and non-potable) demands. The study suggests the best engagement techniques to educate the students that can be utilised by the authorities to gain acceptance for their reclaimed water projects to meet the ever-increasing demand.

*Microbial Protein Production Through Mixed-Culture Anaerobic/Aerobic Fermentation Of Soybean Processing Wastewaters Of Variable Chemical And Microbial Composition

Ramanujam Srinivasan Vethathirri, Ezequiel Santillan, Sara Swa Thi, Hui Yi Hoon, Stefan Wuertz. Nanyang Technological University (Singapore)

The conversion of food-processing wastewaters (FPWW) into microbial biomass-derived single cell protein (SCP) represents a sustainable way to meet the world's growing food demand. Despite the potential benefits of lower production costs and greater resource recovery than conventional single-microorganism fermentation processes, microbial community-based approaches to SCP production have received little attention. Here, SCP production from soybean processing wastewaters was evaluated, providing controlled fermentation conditions to upcycle nutrients using the microbial communities already present in these wastewaters. Six sequencing batch reactors of 4.5-L working volume were operated for 34 d, in 3 h anaerobic and 9 h aerobic phases. Lower carbon-to-nitrogen ratio and higher soluble total Kjeldahl nitrogen wastewaters yielded a higher protein content. Firmicutes was the predominant phylum identified in such wastewaters. The genera prevailing in SCP-enriched reactors included Azospirillum, Gemmobacter, Lactococcus, and Novosphingobium. Further, mixed-community strategy can identify relevant SCP-producing taxa that can be enriched by FPWW fermentation.

*Water/Energy Nexus: Exploring Opportunities To Link Water Projects To Energy Independence And Sector Decarbonization

Emma (Ruqiao) Shen, Julian Sandino, Bill Desing. Jacobs (Canada)

Wastewater has been increasingly recognized as a valued source of renewable resources over the past two decades. As more countries, cities and companies set their long-term climate goals, the water/energy nexus approach will play a significant role in combating the climate emergency. This paper presents three case studies, focusing on the strategic approaches taken at different levels to identify and implement water projects that contribute to energy and carbon neutrality goals, including: 1) NEW Water Solids Management Facilities Plan for Resource Recovery and Electrical Energy (Green Bay, US); 2) Long-term Energy Strategy for Peel Region's Wastewater Treatment Plants (Peel Region, Canada); and 3) Ejby Mølle WWTP Beyond Energy Neutrality Program (Odense, Denmark).

***Saline Water-Based Mineralization Pathway For Gigatonne-Scale CO2 Management**

Gaurav Sant. UCLA (United States)

This perspective proposes a potential pathway to diminish atmospheric CO2 accumulations which is distinct from traditional carbon capture and geological sequestration strategies and from existing negative emissions technologies (NETs). Unlike conventional sorbent- or solvent-based CO2 capture processes where substantial energy expenditures are associated with demixing and desorbing CO2, the single-step carbon sequestration and storage (sCS2) approach relies on electrolytic carbonate mineral precipitation using renewable energy within a simple and scalable process design. Although numerous approaches have implied electrolysis for carbon management, the sCS2 approach is unique in the following ways: (1) CO2 mineralization for promoting solid carbonate formation. (2) Flow-through membrane-less electrolysis. (3) Integrated electrolytic reactor−rotary cathode filter. These attributes render sCS2as an approach worthy of more detailed evaluation, development, and scaling for global-scale carbon management.

** Note: These papers are also selected as oral reserves.*

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CORPORATE WRITE-UPS OF ORGANISERS

<Insert International Water Association Logo>

International Water Association (IWA)

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

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

<Insert PUB Logo>

PUB, Singapore's National Water Agency

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

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

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

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