SINGAPORE INTERNATIONAL WATER WEEK 2021

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

SIWW2021 SPOTLIGHT

21 June 2021

SIWW2021 ONLINE

21 June – 2 July 2021

WATER CONVENTION 2021
ADVANCE PROGRAMME

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Updated as of 8 June 2021

Legend:

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

22 June 2021 (Tuesday)

7.00pm-8.30pm (SGT) (GMT +8)
Session 1.1 – Network Planning for Resilience

Session Chair(s): Ridzuan Ismail, PUB, Singapore's National Water Agency (Singapore)

Creating Resilient Systems

P. Plowman. Sydney Water (Australia)
Presenter is an invited speaker. No executive summary is available

Streamlining Delivery Of A 24X7 Water Supply Scheme In India

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

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

Network Resilience – Asset And Operational Point Of View

J. Lei. Macao Water (Macao (China))
Presenter is an invited speaker. No executive summary is available

Planning for a Drought Resilient City

K. Sorensen. Kyl Center for Water Policy at Morrison Institute, Arizona State University (United States)
Presenter is an invited speaker. No executive summary is available

23 June 2021 (Wednesday)

7.00pm-8.30pm (SGT) (GMT +8)
Session 1.2 – Optimising Network Operations

Session Chair(s): Raziyeh Farmani, University of Exeter (UK)

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

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

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

Optimisation Of Pump Operations: NRW Management And OPEX Reduction

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

Maynilad Water Services, Inc. (Maynilad) has recently shifted its focus on the optimisation of pump operations. Its main objective is to maximize the operational efficiency of all water supply facilities and their influence areas. This comes with a plethora of benefits such as reducing non-revenue water (NRW) and electrical consumption, and prolonging asset life.
There are three components of the optimisation: (1) pre-screening -- uses criteria scoring matrix to determine prioritisation, (2) pump establishment -- ensures that a pump's physical condition, status and influence area are within accepted parameters, and (3) pump monitoring -- uses SPRA which provides the optimal setting for a pump.
On April 2018, the Sta. Quiteria Inline Booster was chosen as the pilot facility for this study. Instead of the usual 7-day operation during its peak hours, the pump operation schedule was optimised to weekend mornings, and later on, the pump status itself was tagged for standby. The same process can be applied to other water supply facilities in order to minimize operational expenses.

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

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

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

Data Driven Decisions - Operational Analytics To Inform Network Performance And Operations

P. Bonk, J. Klaric. Innovyze (Australia)

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

24 June 2021 (Thursday)

7.00pm-8.30pm (SGT) (GMT +8)
Session 1.3 – Water Conservation and Efficiency Measures

Session Chair(s): Darryl Day, The Peter Cullen Water and Environment Trust (Australia)

Sustainable Water Conservation In Brisbane

D. Brooker. Queensland Urban Utilities (Australia)
Presenter is an invited speaker. No executive summary is available.

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

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

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

Using Data Science to Drive Water Utility Decisions: A Case Study in a Medium-Sized Utility

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

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

Incorporating Behaviour Insights in Smart Water Meters Programme

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

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

25 June 2021 (Friday)

7.00pm-8.30pm (SGT) (GMT +8)
Session 1.4 – Non-revenue Water

Session Chair(s): Chau Sai Wai, Hong Kong Department of Water Supplies (Hong Kong)

Overview of Non-Revenue Water and Looking to the Future

KC. Lai. PUB, Singapore's National Water Agency (Singapore)
Presenter is an invited speaker. No executive summary is available

Leak Detection Through Mobile Acoustic Monitoring

O. Fruchtman. Aquarius-Spectrum (Israel)

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

EchoShore® - TX Leak Monitoring System For Transmission Mains – Using An Integrated Approach Using Single Channel And Correlation Analysis

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

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

Case Studies For Non-Revenue Water Reduction Technologies

R. Clarke. Xylem Inc (UK)
Presenter is an invited speaker. No executive summary is available

28 June 2021 (Monday)

4.00pm-5.30pm (SGT) (GMT +8)
Session 1.5 – Smart Water Grid

Session Chair(s): Lucia Cade, South East Water (Australia)

Recent Developments and Applications Of Sensor Networks In UK, Australia And Singapore, and Its Challenges

M. Iqbal. Xylem Water Solutions Singapore Pte Ltd (Singapore)
Presenter is an invited speaker. No executive summary is available

TWINET TM: Operational Real-Time Tool Based On The Hydraulic Model And Sensors Data

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

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

Digital Twins For Resilient Water Infrastructure

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

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

29 June 2021 (Tuesday)

4.00pm-5.30pm (SGT) (GMT +8)
Session 1.6 – Smart Metering

Session Chair(s): Zdravka Do Quang, SUEZ (France)

The Digital Utility Journey: From Reactive To Predictive To Precise

D. Sullivan. Iota Services (Australia)
Presenter is an invited speaker. No executive summary is available

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

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

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

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

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

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

Acoustic Leak Detection Using Data From Smart Meters

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

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

30 June 2021 (Wednesday)

4.00pm-5.30pm (SGT) (GMT +8)
Session 1.7 – Asset Management for the Distribution Networks

Session Chair(s): Albert Cho, Xylem (USA)

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

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

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

Failure Risk Analysis For Asset Renewal Prioritisation

M. Nicol, (Mueller Water Products, Singapore), GC. Yong (PUB, Singapore), K. Claudio (SUEZ, Singapore), E. Goh (Mueller Water Products, Singapore)

As water infrastructure ages, utilities face the looming questions of: whether or not to replace pipes, which pipes should be replaced and when to replace the pipes. A combined approach of Condition Driven Asset Management (CDAM) and Asset Management Desktop Models (AMDM) can be utilised to enhance the replacement plan. This approach minimises failure risks whilst optimising the use of limited capital. A project was conducted in Singapore with this approach on approximately 450 kilometres of cast iron water mains. The results of the project included deferred replacement of 161 kilometres of cast iron mains equating to a saving of approximately SGD $72.9 million in capital investment.

Pipeline Condition Monitoring Using Permanent Acoustic Sensing

M. Stephens. SA Water (Australia)
Presenter is an invited speaker. No executive summary is available

Asset Management Customer Value 2020 Benchmarking Industry Outcomes

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

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

22 June 2021 (Tuesday)

4.00pm-5.30pm (SGT) (GMT +8)
Session 2.1 – Improving Water Treatment

Session Chair(s): Seungkwan Hong, Korea University (Republic of Korea), Sri Hernani Affandi, Binnies Singapore (Singapore)

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

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

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

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

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

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

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

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

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

Removal of Disinfection By-product Precursors in Drinking Water Treatment Processes: Is Fluorescence Parallel Factor Analysis A Promising Indicator?

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

Disinfection by-product (DBP) precursors removal was regarded as the most important method for DBPs control in drinking water treatment plants. Removal efficiencies of DBP precursors by conventional and advanced treatment processes were investigated via fluorescence PARAFAC analysis and DBPs formation potential (DBPsFP) test. Conventional treatment processes exhibited overall higher performance than advanced treatment processes. Coagulation-sedimentation process performed best, and preferentially removed humic-like component. Efficiencies of O3 and BAC processes were much better than ultrafiltration. The highest reduction ratio was observed for tryptophan-like and tyrosine-like components across O3 process, but for protein-bound component across BAC process. Reductions of carbonaceous DBPs were generally best correlated with humic component removal, while reduction of dichloroacetonitrile exhibited the strongest correlation with protein-bound component. The results reflected that fluorescence PARAFAC analysis was a promising tool to indicate DBP precursors removal.

23 June 2021 (Wednesday)

4.00pm-5.30pm (SGT) (GMT +8)
Session 2.2 – Innovation in Desalination

Session Chair(s): Nikolay Voutchkov, Water Globe Consultants, LLC (USA), Miguel Angel Sanz, SUEZ (France)

Innovation in Desalination

B. Liberman. IDE Technologies (Israel)
Presenter is an invited speaker. No executive summary is available

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

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

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

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

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

Pre-treatment processes are important for seawater reverse osmosis desalination that serve as the first barrier to remove contaminants and protect the downstream reverse osmosis (RO) systems from severe fouling and scaling. The current study implemented an aluminium oxide (Alumina, Al2O3) coated ceramic filter, known as ceramic adsorption filter (CAF), as pre-treatment process for SWRO. The performances of two RO systems with two pre-treatment approaches were compared. One pre-treatment approach was UF filtration (denoted as UF-RO) and the other was UF followed by CAF (denoted as UF-CAF-RO). The presence of CAF treatment prior RO showed positive effect on the downstream RO filtration system, showing less fouling as compared to the system without CAF. The flux enhancement was promoted from 10% to 30% with more frequent CAF backwash, i.e., from weekly to daily. The autopsy analysis found that UF-CAF-RO membrane had less inorganic scaling, EPS content and bacteria accumulation compared to UF-RO.

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

J. Cen. Desolenator (The Netherlands)

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

24 June 2021 (Thursday)

4.00pm-5.30pm (SGT) (GMT +8)
Session 2.3 – Membranes - Fast Forward

Session Chair(s): Yang Min, Chinese Academy of Sciences (China)

Effect Of Stabilized Chlorine-Based Agent In Controlling Biofilm Formation And Its Impact On Reverse Osmosis (RO) Membrane Degradation

LN. Sim, JS. Ho. Nanyang Technological University (Singapore)

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

A Novel Hollow Fiber Nanofiltration Membrane For Domestic Water Application

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

Nanofiltration (NF) is defined as a filtration technology involving a pressure driven membrane with pore size in the range of about 0.5nm to 5nm in diameter. NF membrane has good potential in the water treatment area. One of the important applications for NF membrane is to remove hardness from source water to provide healthy water for drinking. So far, most commercially available NF membranes are made from interfacial polymerization and exhibited negative charge. This kind of NF membrane is unsuitable for hardness removal. A novel NF hollow fiber membrane has been designed and developed by Century Water Systems & Technologies Pte. Ltd. This novel hollow-fiber NF membrane has positive-charged surface demonstrating higher flux and higher rejection of Mg2+ and Ca2+ up to 94%.This hollow-fiber NF membrane also exhibits advantage as higher packing membrane area and lower operation pressure while treat the same sources of water.

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

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

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

25 June 2021 (Friday)

4.00pm-5.30pm (SGT) (GMT +8)
Session 2.4 – Expanding Ceramic Membrane Applications

Session Chair(s): Jonathan Lim, Binnies SIngapore (Singapore)

Long-Term Operation Experience Of Ceramic Membrane Microfilter Plant

YI. Song, Clean Water Supply Facilities Maintenance Department, K-water (South Korea)
Presenter is an invited speaker. No executive summary is available

Upgrading Of Choa Chu Kang Waterworks With Ozonated Ceramic Microfiltration

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

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

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

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

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

Chemical-grafting of Graphene Oxide Quantum Dots (GOQDs) onto Microfiltration Ceramic Membranes (CMs) for Anti-organic Fouling Potential

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

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

28 June 2021 (Monday)

7.00pm-8.30pm (SGT) (GMT +8)
Session 2.5 – Emerging Contaminants - Practice and Science

Session Chair(s): Hadas Mamane, Tel Aviv University, Israel

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

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

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

AMOZONE: A Novel Kinetic Ozonation Model For Prediction Of Bromate Formation, Bromate Mitigation and Trace Organic Contaminant Removal

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

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

State Of The Art On Suspended Ion Exchange (SIX®): Essential Design Parameters For A Full-scale Application

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

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

29 June 2021 (Tuesday)

7.00pm-8.30pm (SGT) (GMT +8)
Session 2.6 – Integrated Water Reuse

Session Chair(s): Puah Aik Num, PUB, Singapore's National Water Agency (Singapore)

Perspectives on the Future of Water Reuse

I. Law. IBL Solutions (Australia)
Presenter is an invited speaker. No executive summary is available

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

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

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

Pulse Flow RO (PFRO) Technology

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

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

Improvement of the Resilience of the NEWater Treatment Processes: A 1.7 MGD Demo Plant of Low Pressure UV Based Advanced Oxidation Processes in Singapore

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

A two year comprehensive Low Pressure UV based Advanced Oxidation Processes (AOP) study has come to completion in December 2019 by Xylem and PUB. The project is situated at Singapore's national water agency at one of the NEWater Factories in Singapore, from designing, building and operating a 1.7 MGD demo plant in real world conditions. The study focused on oxidative removal of over 20 spiked organic contaminants by using UV based AOP (UV/HOCl and UV/H2O2) in the process of NEWater production after Reverse Osmosis (RO) system. Target compounds selected include disinfection by-products (DBPs), Pharmaceuticals and Personal Care Products (PPCPs), Volatile Organic Compounds (VOCs) and Artificial Sweeteners. Variations of different operational parameters combination like UV dose, chemical dose and pH conditions were systematically studied for the evaluation of optimized operation conditions for AOP treatment plants. Results indicate that UV based AOP technology has the capability of removing certain targeted compounds effectively, without significantly changing the NEWater quality in terms of the generation of unwanted oxidation by products.

30 June 2021 (Wednesday)

7.00pm-8.30pm (SGT) (GMT +8)
Session 2.7 – Intelligent Plant of the Future

Session Chair(s): Peter Grevatt, The Water Research Foundation (USA)

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

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

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

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

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

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

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

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

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

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

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

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

01 July 2021 (Thursday)

7.00pm-8.30pm (SGT) (GMT +8)
Session 2.8 – Source Control in Advanced Reuse Application

Session Chair(s): Adam Lovell, WSAA (Australia)

Source Control In Advanced Reuse Applications - International trends
I. Law. IBL Solutions (Australia)
Presenter is an invited speaker. No executive summary is available

Singapore's Approach to Managing Trade Effluent
L. Goh. PUB, Singapore's National Water Agency (Singapore)
Presenter is an invited speaker. No executive summary is available

Development and Application of Source Control in Perth's Groundwater Replenishment Scheme
S. Hamilton. WA Water Corporation (Australia)
Presenter is an invited speaker. No executive summary is available

DPR Research: Mitigating Chemical Peaks in Purified Water
J. Debroux. Kennedy/Jenks Consultants (United States)
Presenter is an invited speaker. No executive summary is available

22 June 2021 (Tuesday)

4.00pm-5.30pm (SGT) (GMT +8)
Session 3.1 – Resource Efficient Treatment I

Session Chair(s): Ng How Yong, NUS (Singapore)

Implementation of Side-Stream Nitrogen Removal at Changi Water Reclamation Plant

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

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

Simultaneously Anaerobic Digestion and Low-Carbon Denitrogenation in Sewage Mainstream by Integrating Anaerobic Membrane Bioreactors With Nitritation-Anammox

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

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

Ultralow Energy - No Bubble Deammonification

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

Deammonification is commercially applied to treat ammonia rich digestate from the side stream of water resource recovery facilities (WRRFs) however its broader adoption is challenged by process complexity, inefficient oxygen transfer, and greenhouse gas (GHG) emissions. A new solution called ZeeNAMMOX overcomes these challenges by leveraging the counter-diffusion benefits of membrane aerated biofilm reactor (MABR) technology to enable a resilient and energy efficient deammonification process. The diffusion of N2O into the lumen captures any N2O produced and provides the ability to reduce GHG emissions of this efficient process. Two pilots employing this solution were operated to treat digestate and demonstrated the performance of ZeeNAMMOX.

Optimisation of Wastewater Treatment Process Improvement Through The Use of "Live" Dashboards, Process Engineering, Artificial Intelligence and Machine Learning

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

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

22 June 2021 (Tuesday)

7.00pm-8.30pm (SGT) (GMT +8)
Session 3.2 – Resource Efficient Treatment II

Session Chair(s): Mads Leth, VCS Denmark (Denmark)

Resource Efficient Wastewater Treatment

M. van Loosdrecht. New York City Department of Environmental Protection (DEP) (United States)
Presenter is an invited speaker. No executive summary is available

In-sewer Purification Pipe Technology In Wastewater Management

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

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

Carbon Management In Water Infrastructure

M. Manidaki. Mott Macdonald (United Kingdom)

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

LESSWATT Model-Based Protocol For Mitigation Of N2O Emissions

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

In view of reducing WWTP's carbon footprint, the EU-Life project Lesswatt is developing a protocol for dedicated model formulation and data collection in view of optimising for both energy expenditure and N2O emissions. The protocol builds on existing protocols and expertise derived from modelling the Eindhoven WWTP. However, for the objective at hand, more emphasis is needed for a good hydrodynamic model of the bioreactors, preferably using a compartmental model based on either computational fluid dynamics (CFD) or expert knowledge. Moreover, the protocol includes a risk-based approach for N2O prediction. From an experimental viewpoint, it extends earlier protocols by measuring local oxygen transfer efficiencies (OTE) and dissolved oxygen (DO) using the Lessdrone, a dedicated device that facilitates this. Finally, the protocol comes with an optimisation step. A first version of the protocol is presented based on a past case and is applied to another combined municipal-industrial WWTP.

23 June 2021 (Wednesday)

4.00pm-5.30pm (SGT) (GMT +8)
Session 3.3 – Intensification of Anaerobic Digestion

Session Chair(s): Peter Nicol (Canada)

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

M. Theodoulou, Y. Hong, A. Bentham, Z. Xu, T. Robertson, J. Lim, H. Ding, H. Chen, S. Chang. SUEZ Water Technologies & Solutions (Canada)

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

Achieving Energy Positive Wastewater Treatment, Enabled By Biological Hydrolysis -- A Demonstration Of Sustainable Performance At The Bristol WwTW At Avonmouth, UK

M. Theodoulou, G. Stock, Y. Hong, W. Wong. SUEZ Water Technologies & Solutions (Canada)

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

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

D. Buxton. Mott MacDonald Ltd (United Kingdom)

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

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

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

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

23 June 2021 (Wednesday)

7.00pm-8.30pm (SGT) (GMT +8)
Session 3.4 – Advancement in Solids Treatment

Session Chair(s): Pang Chee Meng, PUB, Singapore's National Water Agency (Singapore)

Resource Recovery and the Circular Economy

C. Peot. DC Water (USA)
Presenter is an invited speaker. No executive summary is available

Anaerobic Co-digestion Of Food Waste And Municipal Wastewater Sludge At Demo Scale

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

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

Thermal Hydrolysis Process For Enhancement Of Anaerobic Digestion

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

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

New Technologies And Methods For Optimizing Wastewater Treatment Plant Processes

H. Karaila. Valmet (Finland)

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

24 June 2021 (Thursday)

4.00pm-5.30pm (SGT) (GMT +8)
Session 3.5 – Membrane Bioreactor Processes

Session Chair(s): Avner Adin, The Hebrew University of Jerusalem (Israel)

MBRs: Academic Research vs Practitioner Needs

S. Judd. Cranfield University (United Kingdom)
Presenter is an invited speaker. No executive summary is available

The Resource Efficient Integrated Membrane Bioreactor System

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

Integrated Validation and Demonstration Plant (IVP Demo) was commissioned in 2017. The fully automated plant with a domestic used water treatment capacity of 12,500 m3/d (peak 18,750 m3/d) simulates the process selected for the future Tuas Water Reclamation Plant (initial domestic used water treatment capacity of 650,000 m3/d). IVP Demo consists of an enhanced primary treatment with biosorption, a compact lamella plate primary clarifier and a 5-pass step-feed low energy membrane bioreactor (MBR). The results from over two years of continuous operation and demonstration study indicate that the integrated system is reliable and energy and resource efficient. The MBR filtrate had a typical turbidity less than 0.1 NTU. Enhanced biological nitrogen and phosphorus removal was achieved without external carbon addition and without pH adjustment in tropical climate conditions. MBR energy consumption was less than 0.25 kWh/m3 including membrane scouring energy of 0.04 kWh/m3, and the nett process energy consumption (process energy consumption - energy generation) was less than 0.05 kWh/m3. Using MBR filtrate as feed, the RO permeate had a low TOC of 24.1 to 31.3 ppb.

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

SH. Koh, S. Athreya. Binnies (Singapore)

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

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

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

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

24 June 2021 (Thursday)

7.00pm-8.30pm (SGT) (GMT +8)
Session 3.6 – Nutrient Removal

Session Chair(s): Sudhir Murthy, NEWhub Corp (USA)

Denitrifying PAOs For Low-Carbon And Low-Energy Nutrient Removal At The Ejby MøLle WRRF

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

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

A Systematic Approach To Select BNR Technologies To Retrofit Manila Water's 36 Sewage Treatment Facilities

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

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

Maximising AOB Activity The Key To Optimised Performance In Short-cut Nitrogen Demonstration Trial

A. Vellacott. Jacobs (Australia)

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

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

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

Partial-denitrification (PD) has been proposed as a promising alternative for stably efficient production of NO2--N from nitrate (NO3--N) reduction for anammox process. In this study, an innovative PD coupling with anammox (PD-AMX) process was developed for mainstream municipal wastewater treatment. With the influent NH4+-N of 53.68 mg/L, total nitrogen (TN) removal achieved a relatively high level of 94.8% with a significantly low effluent TN concentration below 5 mg/L. Moreover, the aeration energy and N2O production would be efficiently reduced compared to the traditional biological nitrogen removal process. Genus Thauera possibly responsible for PD coexisted stably with the anammox bacteria (Candidatus Brocadia). The novel integration of PD and anammox provides a promising approach towards an energy-efficient mainstream treatment.

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

B. Stinson. AECOM (United States)

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

25 June 2021 (Friday)

4.00pm-5.30pm (SGT) (GMT +8)
Session 3.7 – Process Intensification: Integrated Approaches

Session Chair(s): Sock Hoon Koh, Binnies Singapore (Singapore)

Process Intensification Of Continuous Flow Bioreactors In Europe: Controlled-shift Of Microbiome Towards Densified Biomass Outstanding Performance Results Challenging Status-quo

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

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

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

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

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

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

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

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

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

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

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

25 June 2021 (Friday)

7.00pm-8.30pm (SGT) (GMT +8)
Session 3.8 – Biofilm Processes

Session Chair(s): Glen Daigger, University of Michigan (USA)

Maximizing Asset Capacity And Performance Via Process Intensification Using MABR Technology

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

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

Testing MABR technology at Ejby Mølle

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

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

DHS System: Quick And Compact Package Type DHS Pilot Plant In Khon Kaen City, Thailand

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

Khon Kaen, which is a major and a rapidly growing city in North-East Thailand, has an existing sewage treatment system using aerated lagoons with a large footprint (area). However, the efficiency and the capacity are shortening due to the population increase and other causes.
Downflow Hanging Sponge (DHS) reactor is an economical and an ecological wastewater treatment technology originated in Japan. This project aims to achieve the discharge standard in Thailand using DHS reactor with short hydraulic retention time (HRT), and to demonstrate its compactness, odorless, efficiency and quick installation.
The pilot plant, which is a combination of a primary sedimentation (hereinafter PS) tank and DHS reactor with the capacity of 160 m3 per day when operating HRT 30 minutes for sponge media volume, achieved the compactness, odorless and stable effluent quality within two (2) weeks after installation.

MABR - An Innovative Solution For Resilient Wastewater Treatment

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

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

28 June 2021 (Monday)

4.00pm-5.30pm (SGT) (GMT +8)
Session 3.9 – Advanced Modelling, Sensing & Control I - Outside the Fence

Session Chair(s): Tan Cheng Ann, DHI Singapore (Singapore)

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

L. Montestruque. Xylem Inc. (United States)
Presenter is an invited speaker. No executive summary is available

Efficient Integrated Real-time Control in Urban Drainage Systems for Environmental Protection

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

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

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

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

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

A Systems Thinking Approach to Asset Optimization

T. Debruyne, G. Simpson, T. Önnerth. Veolia Water Malaysia (Malaysia)

AQUAVISTA™ is a comprehensive digital solutions package offered by Veolia. The AQUAVISTA™ Plant module is a holistic solution Software As A Service (SaaS) offering real-time optimization through state-of-the-art online control, monitoring and forecasting principles. This system utilizes real time and forecasted information to meet operational targets. Benefits include reduced overall capital and operations costs, increased hydraulic capacity, and improved operation in terms of efficiency, stability, and safety. The savings are achieved through prioritization of the optimal performance during all load situations without compromising a compliant effluent quality. This paper demonstrates how AQUAVISTA™ Plant, using an integrated Plant/Network systems approach, can improve the overall performance of the entire sewage system by combining forecasts of the upstream urban drainage system with information from the wastewater treatment plant and provide insights on this approach implemented with the municipality of Kolding's (Denmark), which manages the treatment of 15 million m3 of wastewater per year.

28 June 2021 (Monday)

4.00pm-5.30pm (SGT) (GMT +8)
Session 3.10 – Advanced Modelling, Sensing & Control II - Inside the Fence

Session Chair(s): Andrew Shaw, Black & Veatch (USA)

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

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

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

Building A Smart Water Reclamation Plant

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

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

Using Advanced Real Time Analytics to Optimize the Energy Usage at WWTP

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

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

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

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

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

29 June 2021 (Tuesday)

4.00pm-5.30pm (SGT) (GMT +8)
Session 3.11 – Used Water Asset Management

Session Chair(s): Richard Lewis, Tideway London (UK)

Holistic Approach To Planning And Prioritizing Investments - From Chaos To Order

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

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

Designing a Robotic Platform for Deep Tunnel Sewerage System

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

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

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

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

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

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

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

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

29 June 2021 (Tuesday)

7.00pm-8.30pm (SGT) (GMT +8)
Session 3.12 – Microbial Ecology

Session Chair(s): Kartik Chandran, Columbia University (USA)

Mechanistic Modelling Provides Useful Operational Guidance For Highly Loaded Anaerobic Sludge Bioprocesses

C. Wilson. Hampton Roads Sanitation District (HRSD) (United States)
Presenter is an invited speaker. No executive summary is available

Microbial Ecology Of Anaerobic Membrane Bioreactor (AnMBR) And Its Relevance In Mitigating Membrane Biofouling

P. Hong. King Abdullah University of Science and Technology (Saudi Arabia)
Presenter is an invited speaker. No executive summary is available

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

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

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

Microbial Acclimation Towards Substrate Overloading Via Recurring Solids Retention Time Disturbances in Anaerobic Digesters

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

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

Novel Nutrients Removal Pathway in Wastewater Treatment Plants

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

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

30 June 2021 (Wednesday)

4.00pm-5.30pm (SGT) (GMT +8)
Session 3.13 – Industrial Wastewater Treatment and Reuse

Session Chair(s): Reddy Chirla Chandra Sekhara, Singapore Refining Company Private Limited (Singapore)

Development Of Potato Chip Process Water Treatment & Reuse Technology

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

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

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

J. Liu. CITIC Envirotech Ltd (Singapore)

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

Evaluation Of Toxicity In Industrial Wastewater Treated By Electro-Fenton

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

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

Demonstrative-scale SIAM Technology Trials In Dairy And Slaughterhouse Factories

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

Water reclamation and energy-efficient systems were the main drivers on SIAM (Spanish acronym of methanogenic Anaerobic reactor and Membrane bioreactor Integrated System) birth. Industrial wastewaters from different sectors were explored and prioritized by the physico-chemical characteristics and the water flows generated to be treated. Once selected the sectors, this technology has been demonstrated with dairy and slaughterhouse industrial wastewaters in two pilot-plants of 4 and 3 m3, respectively. Effluent characteristics complied: in-force discharge limits, the latest revision of the best available techniques (BAT) for food, drink and milk industries, reuse quality standards (excluding the productive process in which the reuse is forbidden), with competitive design parameters in both pilot trials. Environmental studies, life cycle analysis (LCA) and economic estimations indicated that this SIAM technology was more beneficial than the conventional activated sludge (CAS) systems.

TERI Advanced Oxidation Technology (TADOX®) As An Integrated Approach To Treat Industrial Wastewater: Case Studies from India

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

In India, wastewater treatment suffers from two major limitations: (i) similar treatment of wastewater streams having different nature and constitution (ii) the effluent remains 'inadequately' treated, probably because of use of conventional, costlier and redundant approaches. As the result re-use, re-cycle and achieving ZLD is not possible in true sense. In this pursuit TERI has developed a novel and patented 'Advanced Oxidation Technology', which aims at complete end-to-end treatment of wastewater effluent streams having high color, COD, BOD, TOC, dissolved organics, non-biodegradable and persistent organic pollutants (POPs), generated from highly polluting industries and/or mixed streams having municipal sewage. The protocol involves innovative primary treatment, followed by Heterogenous Photocatalysis (HP) involving nano-TiO2/UV as secondary treatment and suitable filtration leading to treated water meeting process water quality enhancing water re-use efficiency and enable Zero Liquid Discharge (ZLD); These are discussed in the light of successful case studies developed at a pilot scale.

30 June 2021 (Wednesday)

7.00pm-8.30pm (SGT) (GMT +8)
Session 3.14 – Wastewater Treatment for Developing Countries

Session Chair(s): Dayanand Panse, Ecosan Services Foundation (India), Nupur Bahadur, The Energy and Resources Institute (TERI), New Delhi (India)

Technologies/Case Studies To Achieve Safe Reliable Drinking Water In Resource Constrained Communities

G. Hawkins. Moonshot Missions (United States)
Presenter is an invited speaker. No executive summary is available

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

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

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

Innovations in Decentralised Wastewater Treatment

S. Pillay. Water Research Commission of South Africa (South Africa)
Presenter is an invited speaker. No executive summary is available

Integration of MBR and Hybrid Constructed Wetlands for Enhanced Treatment of Rural Domestic Wastewater

J. Zhang CITIC Envirotech Ltd (Singapore)

Decentralized wastewater treatment systems have drawn increasing attention in recent years, especially in the rural communities of China. In this study, a combined MBR and hybrid constructed wetlands (CWs) system was proposed to achieve the aforementioned goals. The combination leveraged the ability of MBRs to remove organic pollutants and all suspended solids effectively. The CWs are able to achieve high NH3-N removal which contributes to substantial total nitrogen (TN) removal in a cost-effective manner. The combined MBR and hybrid CWs system could be an effective and affordable technology for wastewater management in rural areas and developing countries.

23 June 2021 (Wednesday)

4.00pm-5.30pm (SGT) (GMT +8)
Session 4.1 – Water Circular Economy in Cities of the Future I

Session Chair(s): Tony Wong, CRC for Water Sensitive Cities (Australia)

Circular Water Economy

S. Tahir. Arup London (United Kingdom)
Presenter is an invited speaker. No executive summary is available

Water Circular Economy In The Cities Of The Future

X. Litrico. SUEZ (France)
Presenter is an invited speaker. No executive summary is available

Circular Water 2050: Impact and Opportunities For The Fully Circular Urban Water Cycle

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

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

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

A. Struker. Waternet (Netherlands)

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

24 June 2021 (Thursday)

4.00pm-5.30pm (SGT) (GMT +8)
Session 4.2 – Water Circular Economy in Cities of the Future II

Session Chair(s): Suresh Rohilla, Centre for Science and Environment, New Delhi (India)

Tuas Nexus - An Example of Industrial Ecology

C. Lim. PUB Singapore (Singapore)
Presenter is an invited speaker. No executive summary is available

Owner And Operator Benefits Of The Digital Delivery Of Infrastructure

C. Newbery, L. Connor Jacobs (Singapore)

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

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

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

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

Designing Water Sensitive Cities of the Future

S. Kenway. Advance Water Management Centre of the University of Queensland (Australia)
Presenter is an invited speaker. No executive summary is available

25 June 2021 (Friday)

4.00pm-5.30pm (SGT) (GMT +8)
Session 4.3 – Hybrid Blue/Green/Grey Infrastructure

Session Chair(s): Mark Fletcher, ARUP (UK)

Multi-Functional Hybrid Infrastructure Delivering Multiple Benefits For Cities

J. Wang. Water Sensitive Cities Institute (Australia)

Presenter is an invited speaker. No executive summary is available

CWOS

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

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

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

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

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

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

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

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

28 June 2021 (Monday)

4.00pm-5.30pm (SGT) (GMT +8)
Session 4.4 – Water for Liveability

Session Chair(s): Xavier Litrico, SUEZ (France)

Improving Access To Water For Communities In Indian Cities

V. Joshi. SUEZ India (India)
Presenter is an invited speaker. No executive summary is available

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

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

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

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

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

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

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

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

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

Amsterdam And The City Swim (ACS): Swimming In Surface Water In The Dense Urban Area of Amsterdam

S. Holthuijsen. Waternet (Netherlands)

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

29 June 2021 (Tuesday)

4.00pm-5.30pm (SGT) (GMT +8)
Session 4.5 – Basin Connected Cities

Session Chair(s): Tao Li, International Water Association (IWA)

Basin-Connected Cities: Moving From Vision To Action

K. Cross. IWA (Thailand)
Presenter is an invited speaker. No executive summary is available

Bangladesh Delta Plan 2100: Bangladesh In The 21st Century

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

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

An Integrated Approach To Coastal Climate Resilience

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

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

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

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

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

01 July 2021 (Thursday)

4.00pm-5.30pm (SGT) (GMT +8)
Session 4.6 – Social Resilience of Communities to Climate Extremes

Session Chair(s): Tony Wong, CRC for Water Sensitive Cities (Australia)

WaterUP: Empowering Local Communities Through Sustainable Water Management

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

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

A Smart Transition To Water Resilient Communities

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

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

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

R. Khemka. World Bank (India)

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

Water Wise Cities of the Future - a summary of highlights from the Water Convention 2021

T. Wong. CRC for Water Sensitive Cities (Australia)

Presenter is an invited speaker. No executive summary is available

22 June 2021 (Tuesday)

7.00pm-8.30pm (SGT) (GMT +8)
Session 5.1 – Systems Approaches and Enabling Environment

Session Chair(s): Jennifer de France, WHO (Switzerland), Prof Hiroyuki Katayama, The University of Tokyo (Japan)

The Systems Approach To Sustainable Water And Sanitation Service Delivery

P. Moriarty. IRC (The Netherlands)
Presenter is an invited speaker. No executive summary is available

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

P. Byleveld. Australian Red Cross (Australia)

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

An Innovation Framework For The Philippine Water Market

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

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

23 June 2021 (Wednesday)

7.00pm-8.30pm (SGT) (GMT +8)
Session 5.2 – Source Tracking

Session Chair(s): David Cunliffe, SA Health (Australia), Daisuke Sano, Tohoku University (Japan)

Current Trends In Microbial Source Tracking (MST)

A. Farnleitner. Vienna University of Technology (Austria)

Presenter is an invited speaker. No executive summary is available

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

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

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

Community-based Microbial Source Tracking of Fecal Impairment in Watersheds and Reservoirs in Singapore

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

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

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

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

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

25 June 2021 (Friday)

7.00pm-8.30pm (SGT) (GMT +8)
Session 5.3 – Wastewater Monitoring and Management

Session Chair(s): Akica Bahri, Tunisia
Panel Moderator: Joan Rose, Michigan State University (USA)
Panellist: Masaaki Kitajima, Hokkaido University (Japan)

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

G. Medema. KWR Watercycle Research Institute (The Netherlands)
Presenter is an invited speaker. No executive summary is available

Wastewater Based Epidemiology: Monitoring of SARS-CoV-2 and Related Markers in Singapore

S. Snyder. NEWRI, NTU (Singapore)
Presenter is an invited speaker. No executive summary is available

Global Water Research Coalition Activities to Advance Wastewater Surveillance of COVID-19

S. Rinck-Pfeiffer. GWRC (Australia)
Presenter is an invited speaker.No executive summary is available

Wastewater-based Epidemiology For SARS-CoV-2 Virus In South Korea

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

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

28 June 2021 (Monday)

7.00pm-8.30pm (SGT) (GMT +8)
Session 5.4 – Water Resources in Catchments/ Reservoirs

Session Chair(s): Fiona Waller, Affinity Water (UK)

River Basin Management Integrating Water Quality and Human Health – How Food Systems Can Help

M. Smith. International Water Management Institute (IWMI) (Sri Lanka)
Presenter is an invited speaker. No executive summary is available

Rapid Monitoring Of Algal Bloom Dynamics With Flow Cytometry

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

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

Impact Of Floating Solar Panels On Surface Water Reservoirs For Drinking Water Production

B. Martijn, E. Prest, A. Waagenvoort. PWNT (Netherlands)

Drinking water utilities in the Netherlands intend to install floating solar panels on open reservoirs for surface water storage before treatment. However, floating solar panels may impact the quality of water used for drinking water production. Here we studied the impact of reduced light input into the water on water quality. The study was performed using an aquarium set-up under controlled conditions. The absence of light significantly reduced phytoplankton growth in the water. As a result, the low biopolymers production by phytoplankton caused a lower dissolved organic carbon concentration. In contrast, the inorganic matter concentrations (nitrate, phosphate, silicate, bicarbonate) were higher in the absence of light, as nutrients are not utilized by phytoplankton activity. This preliminary study shows that floating solar panels can have both a positive and negative impact on water quality used for drinking water production. Careful monitoring before and after installation of solar panels is required.

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

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

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

30 June 2021 (Wednesday)

7.00pm-8.30pm (SGT) (GMT +8)
Session 5.5 – Water Quality in Distribution Systems and Buildings

Session Chair(s): Regina Sommer, Medical University of Vienna (Austria)

WSPs for Distribution and Plumbing Systems

D. Cunliffe. SA Health (Australia)
Presenter is an invited speaker. No executive summary is available

Estimating the Burden of Waterborne Infectious Disease in the United States

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

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

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

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

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

Risk Exposure During Showering & Water-saving Showers

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

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

01 July 2021 (Thursday)

7.00pm-8.30pm (SGT) (GMT +8)
Session 5.6 – Bio-sensing

Session Chair(s): Robert Bos, International Water Association (Switzerland), Marion Savill, Affordable Water (New Zealand)

An Overview Of Biosensor Technologies For Virus Detection In Water And Wastewater

M. Kitajima. Hokkaido University (Japan)

Presenter is an invited speaker. No executive summary is available

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

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

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

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

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

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

23 June 2021 (Wednesday)

6.00pm-6.30pm (SGT) (GMT +8)
Poster Session 1

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Fruition of Long term UF Product Development @ Jurong Island SWRO Project

H. Lazaredes. DuPont Water Solutions (Australia)

DuPont has a long history of working together with the Singapore PUB to deliver successful water projects. These have included the 13 ML/d Bedok pressurized ultrafiltration (UF) demonstration plant in 2000, the 40 ML/d submerged UF Kranji NEWater project in 2002, the 288 ML/d pressurized UF plant at the Sembcorp NEWater project in 2009, and more recently the Jurong Island SWRO next generation pressurized UF project awarded in 2018. These 4 projects showcase the evolution and advancement of UF membrane technology over nearly 20 years, which are culminated in the design of the Jurong Island Desalination plant which incorporates the Memcor CPII UF technology.

Nearly 20 years of innovation in membrane technology and product development are inherent in the CPII product, which was put to the test through the Jurong Island Desalination Plant (JDP) tender process. Challenges to overcome for the project included minimizing the plant footprint; maximizing access & ease of maintenance; as well as minimizing backwash downtime, chemical use & energy demand. These were realized through a high surface area module design, low volume compressed air backwash process (requiring no super duplex backwash pump), compact low profile/height equipment design, and design innovations that solved chemical rinsing issues.

In this paper we will discuss lessons learnt from the development and operation of ultrafiltration products in SWRO pretreatment plants, and discuss how these experiences helped developed solutions to challenges and needs of the Jurong Island Desalination Plant project design.

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

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

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

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

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

The effects of step-wise solids retention time (SRT) reduction from 30 to 15 days on process performance and microbial community were investigated in four mesophilic anaerobic digesters (MAD) treating mixed sewage sludge. The reactors were grouped into two clusters (Clusters 1 and 2) each consisting of two replicate reactors. In Cluster 1, the observed average volatile solids (VS) removal was 46 ± 13 %, 52 ± 6 %, and 45 ± 6 % while average methane yield was 602 ± 212, 474 ± 137, and 502 ± 100 mL CH4/g VS when the SRT was 30, 25, and 15 days, respectively. Metagenomics and multivariate analysis showed that the abundance of bacteria and archaea (i.e., methanogens) was not impacted by the reduction in SRT. Hence the latter did not negatively affect digestion of sewage sludge, and it was not a driver for community structure within the range used in the study.

Membrane Fouling Control In A MBR System Under Higher MLSS Concentration

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

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

New Method For Integrity Monitoring Of Membrane Bioreactors

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

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

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

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

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

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

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

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

Relationships Of Water And Mineral Ion Channels With Mineral Balance

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

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

Review of 100 Commercial MABR Installations in China

Y. Gilad, L. Dagai, X. Chen, M. Qi, H. Zhang. Fluence Corporation (Israel)

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

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

A. Gulam. Adzaan Consulting Pte ltd (Singapore)

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

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

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

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

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

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

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

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

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

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

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

S. Sathyamoorthy, K. Gordon, D. Coutts. Binnies (United States)

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

24 June 2021 (Thursday)

6.00pm-6.30pm (SGT) (GMT +8)
Poster Session 2

Advanced Nephelometry Coupled with Real Time Membrane Integrating Turbidity Monitoring

V. Rajasekharan, C. Jackson, R. Leggett. Hach Co (United States)

Increasing water costs, climate change, ageing infrastructure, water scarcity and increasing compliance regulations have led to rise of water re-use in many sectors of the water industry. Even-though water re-use appears like a promising way forward there are several caveats that needs to be addressed before widespread adoption. Towards this end advanced monitoring techniques are required to ensure that the treated water quality meets the strict compliance discharge requirements. To achieve this, we have developed a real time monitoring turbidity solution for wastewater and drinking water effluent to provide the operators with information that they need to assess the effluent quality and provides them with decision to improve the efficiency of the treatment processes. This talk will discuss the turbidity technology that can be used for these purposes.

An Integrated Approach To Smart Water Remineralization

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

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

Automated Nutrient Loading Computation for Identification of Hotspots in Catchments

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

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

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

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

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

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

F. Barbour. Mott Macdonald (United Kingdom)

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

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

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

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

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

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

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

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

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

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

Fuzzy Logic-based Geographic Network Reconstruction Planning

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

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

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

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

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

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

M. Padayachee. Rand Water (South Africa)

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

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

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

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

Prediction Accuracy And Effectiveness Of ICT Systems For Urban Flood Control

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

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

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

D. Bromley. DBE Hytec Ltd (Canada)

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

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

E. Tynes. Energy Recovery (United States)

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

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

V. Malkov. Hach (United States)

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

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

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

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

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

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

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

Tai Po Water Treatment Works: A Model Of Sustainability Innovation

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

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

The Bankable Resilience Tool (BaRT)

P. Dircke, E. Schellekens. Arcadis (Netherlands)

To implement urban climate resilience strategies successfully and efficiently, and help cities to adapt to a changing climate, financial barriers need to be overcome. This requires identifying and developing investable and bankable opportunities in early stages of project and program development. In this paper, the Bankable Resilience Tool (BaRT) is presented as a valuable tool to overcome these barriers. By monetizing all cost and benefits, including social and ecosystems benefits of blue-green resilience measures per stakeholder, BaRT can remove financial barriers for investors, be used as a decision support tool and accelerate implementation of climate resilience in urban areas.

The Promises Of Next-Generation Membranes For Seawater Desalination

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

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

The Water and Resources Refinery® Concept: Innovative Separation Technologies Enabling A Completely New Used Water Approach

A. van Nieuwenhuijzen, H. Evenblij, J. Dan, F. Visser. Witteveen+Bos Consulting Engineers | AMS-institute (Netherlands)

The Resource Refinery Factory® concept is an innovative water reuse and resource recovery plant ready to create high quality water and produce several circular material streams. To step away from biological treatment process is a paradigm change in used water treatment. The RRFÂ® includes fine screening to recover celluloses, electrocoagulation followed by dissolved air flotation to recover organics and phosphorus, direct nanofiltration and ion exchange unit to recover nitrogen. A large scale pilot test is currently running to proof the concept and first results will be presented. Contrarily to present uwtp's where biological process are applied that destroy the organic components, here only physical processes are applied. The organic matter and nutrients remain intact and can be upcycled to raw materials for several (bio based) value chains. In this way waste water will be used for the production of high quality water for: ecological development & recreation area's; industrial process water; agriculture/ horticulture and the the production/recovery of valuable products; like Cellulose, Ammonium, Phosphorous; Organic biomass (for further up-processing) and Minerals.

Towards High Recovery In Water Reclamation Processes: High Performance NF-MBR+RO System

H. Xu, S. Lee, MF. Tay, K. Jeong, C. Liu, E. Cornelissen, B. Wu, TH. Chong. Nanyang Technological University (Singapore)

A hybrid NF-MBR+RO process was developed to achieve >90% of recovery in water reclamation. The results showed that the NF-MBR achieved superior permeate quality due to enhanced biodegradation and excellent rejection properties of the NF membrane, leading to high RO recovery rate of >90% (i.e., compared to 75% in conventional UF-MBR permeate as RO feed). Furthermore, the salt accumulation (i.e., build-up of divalent ions) observed in the NF-MBR did not have negative impact on the organics removal efficiency and biomass viability. However, more severe NF membrane fouling was observed in the NF-MBR at elevated salt levels, which was attributed to the greater formation of calcium phosphate scale and Ca-polysaccharides complex (i.e., irreversible fouling layer) as well as the cake-enhanced-osmotic-pressure (CEOP) effect. Since the salt accumulation in NF-MBR is a function of sludge retention time (SRT) as well as NF membrane rejection, the NF-MBR membrane fouling and permeate quality can be controlled through manipulation of these parameters.

Use Of Simultaneous Absorbance-Transmittance And Excitation-Emission Matrix (A-TEEM) Spectroscopy To Monitor Source Water For Waterworks

A. Gilmore, L. Chen, S. Teng, C. Kow, E. Mok, N. Afira. HORIBA Instruments Inc. (United States)

Conventional oil-in-water analyzers used by waterworks have hydrocarbon detection limits at mg/L levels and do not identify the type of oil compounds. The primary objective of this study was to develop a more sensitive optical instrument and analysis method to 1) detect trace level (microgram/L range) of organic pollutants in raw and treated water, 2) identify the compounds and 3) alert plant operators. The patented simultaneous Absorbance-Transmittance Excitation Emission Matrix (A-TEEM) instrument method was used to identify and quantify low levels of organic contaminants present in a much higher background of other dissolved organic matter components in raw and treated water. Multivariate regression and machine learning techniques were applied and shown to have potential for alerting plant operators to organic contamination events.

Water Quality Monitoring Using Machine Learning

T. Farahmand, S. Hamilton. Aquatic Informatics (Canada)

Monitoring the water quality of reservoirs increasingly conducted using automated in situ sensors, enabling timelier identification of unexpected values or trends enabling safe management of reservoirs in real-time. However, some critical water quality parameters such as phosphorus, chlorophyll (for detecting various types of algae) and E.coli can only be accurately measured in controlled laboratory conditions which make it impossible to be used in the real-time decision making. We presented a probabilistic machine learning framework for automated estimation of those critical water quality parameters for the safe management of rivers, reservoirs, lakes and public beaches in real-time. The results indicated that our framework using Gaussian Processes (GP) has two main advantages compared to traditional water quality surrogate modeling; 1) it minimizes the efforts to build, test and deploy the model and 2) it performs well for estimating the parameters with uncertainty in real-time capturing the dynamical changes in time and nonlinearities.

WaterWise - An Operational Testbed For Real-Time Assessment Of A Drinking Water Distribution System

M. Leifels, D. Cheng, S. Wuertz. Nanyang Technological University (Singapore)

The innovative WaterWiSe test-bed allows for the real-time evaluation of physicochemical, biological and hydraulic parameters in two university-based drinking water distribution systems in Singapore through a network of water quality sensors. Initial results revealed the presence of bacteria and archaea associated with monochloramine degradation and pipe corrosion as well as biofilm formation.

25 June 2021 (Friday)

6.00pm-6.30pm (SGT) (GMT +8)
Poster Session 3

A Case Study On The Performance Of A Transmission Pipe Leak Monitoring System

W. Khan, P. Murray, J. Koh. PUB, Singapore's National Water Agency (Singapore)

In 2018, a transmission pipe leak monitoring system was installed on approximately 100 kilometers of mains owned by the Public Utilities Board (PUB) of Singapore. Tracking leak indications in both time and space allows water asset owners to rapidly and effectively deploy their transmission main repair crews. This paper provides a narrative description of the design and deployment for this novel leak monitoring system with advanced detection and notification capabilities. General and site specific deployment considerations are presented. With investment in new technologies there is a need to define, measure, and evaluate the program success. Technology implementation effectiveness is a qualitative measure of project success. Quantitative performance metrics around leak monitoring performance, and value for money are evaluated and presented as well.

A Pilot Aquaponics Project On The An Intermediate Floor Of A High Rise Building In Malaysia

Y. Wong. EcoClean Technology Sdn Bhd (Malaysia)

This is the first of its kind of Aquaponics system in the world, utilizing town water for only once to raise 6000 Tilapia and Jade Perch fishes, 1000 vegetables and 300 panels of vertical sun shading green walls at the intermediate floor of high rise building. The system is fully integrated as the wastewater from the fishes are treated with a specially designed treatment plant and by the very vegetables and green walls themselves before returning to the same channel. Both volcanic aggregates and floating boards in trays are used instead of soil for growing vegetables and green wall plant. The fish channel is created from the building's balcony itself. All the fish and vegetable harvests will travel down by a cargo lift to a " farm-to-plate" restaurant on the lower floor.

Application Of Deep Learning Models In Radar Rainfall Nowcasting And Flood Forecasting: A Case Study Of Singapore

KW. Teo, D. Solomatine. Ministry of Sustainability and the Environment (Singapore)

In light of the recent advancement in deep learning many studies have cited promising results of deep learning models (ConvLSTM) on radar rainfall nowcasting. This research was dedicated to pilot study the application of deep learning models (ConvLSTM and its variants) in radar rainfall nowcasting and flood forecasting, for the case of Singapore. The deep learning model adopts a hybrid combination of convolutional neural network (CNN) and recurrent neural network (RNN). Past observed radar images from Meteorological Services Singapore (MSS, NEA) between 2011 and 2015 were processed and used The deep learning models were used to forecast future water levels at 5 locations in Bedok Catchment of Singapore using observed radar images of last 30 minutes. It was found that the deep learning models can obtain an average Root-Mean-Square-Error of 0.19m across all 5 sensors, indicating its potential as a possible alternative to flood forecasting. The results of this research would also be useful for tropical countries with dynamic weather patterns like Singapore.

Assetmanagement And Safe Drinking Water For Amsterdam

S. Holthuijsen. Waternet (Netherlands)

Traditionally, Amsterdam won its drinking water partly from the dunes. From 1853, the first drinking water companies pumped the water for Amsterdam directly from the deeper layers of the dunes. Due to the increasing demand, the sand bottom was found to dry out and salt water was coming up. From 1940 river water was infiltrated into the dunes. In the seventies it was discovered that this technique polluted the dune bottom. So the water companies proceeded to infiltrate pre-purified river water to great depths into the dunes. Nowadays, Amsterdam's drinking water is mainly coming from the river Rhine. From the assetmanagement point of view we use a so-called 3x5 format as a way of thinking about our assets. We answer 5 questions on 3 levels, object-network-system. It leads to transparent choices for investments and maintenance of our assets. The delivery of drinking water and the associated assets are used to illustrate the method.

Case Study - Demonstration Plant Of Water Recycling Of Treated Industrial Wastewater Using Microfiltration/Reverse Osmosis And Activated Carbon Filter For Process Use In A Petrochemical Plant

KS. Sim, F. Tan, BS. Ee. Petrochemical Corporation of Singapore (Private) Limited (Singapore)

The aim of this case study is to demonstrate a phased approach of carrying out technological and economic assessment in adopting membrane technology for water recycling of treated industrial wastewater for process use. It was co-funded with a grant from National Research Foundation (NRF) Singapore. Due to the large variability of industrial effluents, this demonstration plant was developed in-house following a rigorous Phase 1 - Pilot Plant testing with different configurations of pre-treatment membrane (MF/UF) and material selection for RO membrane. Actual treated wastewater effluent was used for the testing process, particularly on the susceptibility of membranes fouling and formulation of membrane cleaning solutions for membrane flux recovery. Phase 2 demonstration plant was then constructed, followed by trial runs with enhanced cleaning regimes for fouling control, carried out to validate critical parameters such as allowable flux for a pressurised pre-treatment membrane units and RO permeate quality. The implemented treatment system consists of MF/RO and Activated Carbon Filtration (ACF).

Colorectal Cancer And Nitrates: Implications For Health And The Economy

A. Humphrey, M. Savill, J. Mike. Affordable Water (New Zealand)

Nitrate concentrations have been increasing steadily in New Zealand groundwater over the last two decades. This has coincided with an unprecedented increase in intensified dairy farming. Monitoring has demonstrated that increases in nitrate levels in the South Island province of Canterbury were initially mainly confined to shallower bores, but deeper, community supplies are increasingly threatened as nitrate permeates deeper aquifers. Modelling from the Canterbury Regional Council indicates that the Christchurch (population 400,000) urban supply is likely to experience a significant increase in nitrate contamination within 100 years. This is particularly concerning considering a recent population based Danish study which indicated that the risk of colorectal cancer from nitrate in drinking water begins well below the current maximum allowable value (MAV) of 50mg/L nitrate ion (nitrate measured as nitrate ion. This is equivalent to 11.3 mg/L nitrate as nitrogen). Although nitrate leaching is limited using the land-use consenting process, compliance, monitoring and enforcement of land-use rules is difficult. Moreover, such rules may be too little, too late, as nitrate in groundwater can take many years to build and conversely, many years to diminish – the nitrate levels in New Zealand groundwater today are a consequence of farming practices twenty or thirty years ago. If drinking water suppliers are to avoid the expense of nitrate removal, radical measures may be required more urgently, such as destocking intensified farming areas.

Deterioration Diagnosis For Underwater Equipment By Vibration Analysis

J. Nakazawa, Y. Masuya, D. Kawataka, A. Nagao, N. Kanemaru. NJS Co., Ltd. (Japan)

The development of equipment diagnosis technology using Vibration Analysis aims to improve the quality and efficiency of asset management for preventive maintenance of sewage treatment plant equipment. The main function of this development is to comprehend the deterioration signs of sewage facilities and to estimate and identify the cause of deterioration using IoT such as wireless sensors on equipment and a cloud centre, and automatic analysis of photographs taken by an onsite robot. Comprehending deterioration signs is necessary to screen which STP machines are deteriorating. The deterioration causes of the screened STP machines are estimated and identified to be checked by IoT, using information picked up in the previous process. When actually using this system, repair work can be carried out considering the cost and timing. In this paper, we targeted the sludge scraper because it is normally underwater and difficult to comprehend the deterioration signs and report the technology development for identifying deterioration signs and estimating the cause.

Driving Economic Prosperity, Through BIM Adoption

D. Murray, S. Kearney. Mott MacDonald (Singapore)

BIM adoption can improve lives, by reducing poverty in the world's fastest growing communities. That's the view of the UK Foreign & Commonwealth Office (FCO) who have allocated part of the Cross-Government Prosperity Fund (Fund) to the BIM delivery methodology, via the Global Infrastructure Programme (GIP). The Fund aims to remove barriers to economic growth and promote sustainable development in partner countries. The Fund's focus is on middle-income countries (MICs), where 59% of the world's poor live and 60% of global growth will occur by 2030. BIM supports the efficient design, delivery and maintenance of infrastructure and buildings. There is a strong link between infrastructure development and increased prosperity, including supporting gender equality and inclusion. Additionally, the Fund seeks to improve trade links between partner countries and the rest of the world, including the UK.

Energy Efficiency And Generation Opportunities For Wastewater Services - Perspective From A Developing Country

J. Zvimba, E. Musvoto. Water Research Commission (South Africa)

About 55% of energy used in the South African water cycle is for wastewater treatment, with bulk of energy used for aeration. However, up to 15% of wastewater energy demand can be offset by energy generation from sludge, while best practices adoption can deliver energy efficiency gains of 5 to 25% in the water cycle. Advanced process modelling and simulation was applied to evaluate optimal process and aeration control strategies, including investigation and prediction of potential energy consumption and consumption cost pattern by the sector resulting from implementation of optimal process and aeration energy use reduction strategies. Aeration energy consumption and cost savings of 9 -- 45% are achievable through implementation of energy conservation measures without compromising effluent regulatory compliance. Energy savings of 50% and 78% from implementation of simple and complex measures respectively are achievable, while coupling energy efficiency with generation ensures maximum consumption and cost saving benefits are achieved.

Full Scale Reality Of Micropollutant Removal With Ozone

T. Puehmeier, A. Wieland, H. Stapel, S. Bressmer, C. Abegglen. Xylem Services Germany GmbH (Germany)

The term "micropollutant" stands for thousands of man-made substances such as such as residues of pharmaceuticals, cosmetic products, pesticides and biocides. The conventional sewage treatment does not provide a sufficient barrier to protect drinking water sources from micropollutants discharged with the treated effluent. The realization approach of micropollutant removal processes of two countries (namely Germany and Switzerland) is being addressed. In particular, the micropollutant removal process of one reference -- Werdhoelzli, the largest sewage treatment plant in Switzerland -- is being further explored.

Maximum Likelihood Estimation Of Inactivation Kinetic Parameters For *Escherichia coli* In Concentrated Urine

W. Oishi, D. Sano, I. Kato, O. Nishimura. Tohoku University (Japan)

The present study investigated the inactivation kinetics of Escherichia coli and relevant biocidal factors in concentrated urine. The inactivation rate constant was calculated using the maximum likelihood method, which well simulated the measured concentration of E. coli. Higher osmotic pressure caused faster inactivation of E. coli in hydrolyzed urine, while inactivation rate of E. coli was much smaller in non-hydrolyzed urine.

Metal-Free Graphitic Carbon Nitride Photocatalyst For Environment Remedy

D. Lu, FYS. Li. National University of Singapore (Singapore)

Graphitic carbon nitride (GCN) has emerged as a promising metal-free photocatalyst because of its suitable bandgap, low cost of starting material, facile in preparation, highly chemical stable and pollution-free features. However, the photocatalytic activity of GCN is limited by the unsatisfactory photocatalytic efficiency, mainly because of fast recombination of charge carriers and insufficient visible light range absorption. With solvothermal method, red in color graphitic carbon nitride (RGCN) had demonstrated significant improvement in its absorption edge in the visible range. Further carbon doping reduced the charge carrier recombination and improved the activity 5.68 times as compared to GCN.

Performance Of Reverse Osmosis Membrane For Water Reuse And Reclamation -- Rejection And Fouling Investigation

J. Ogier, U. Doelchow, J. Lipnizki, D. Lau. IAB Ionenaustauscher GmbH (Germany)

Chemical pollution of water poses a threat to the environment and human health and the water scarcity is a clear on going challenge for the mankind. Water reclamation is implemented to reduce this water shortage and treat its contamination. Reverse osmosis membrane can provide an efficient step in that water reclamation treatment process. Therefore the performances of ultra-low pressure reverse osmosis membrane were investigated in laboratory and in a pilot-study on the reclamation of municipal waste water for the production of high quality process water. The efficiency of the RO-membranes were evaluated thoroughly in term of contaminants and micro pollutant removal and fouling impact on performances. The results showed a high rejection capacity even under fouling conditions.

Prussian Blue @ Reduced Graphene Oxide Aerogel As An Intercalation Anode To Remove Sodium Ions In Hybrid Capacitive Deionization System

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

With rapid population growth, and spreading environmental pollution, freshwater shortage has become one of the most significant global challenges nowadays. As a result, many research efforts have been devoted to exploring new methods to overcome the water scarcity. Hybrid Capacitive Deionization (HCDI) has been attracting the attention as a high performance, energy-efficient, cost-effectiveness, and environmentally friendly method. In HCDI, desalination is running based on a faradaic reaction with salt ions to boost the removal capacity of the systems. In this study, we introduced an efficient Hybrid Capacitive Deionization (HCDI) system for removal of NaCl from brackish water. In this study, Prussian blue (PB) Nano cubes embedded in a highly conductive reduced graphene oxide aerogel (rGA) has been used as a binder-free intercalation anode to remove Na+ ions. Furthermore, the real-time intercalation process was verified by In-situ XRD measurements, which confirmed the intercalation and deintercalation processes during charging and discharging, respectively.

Reduction Of Energy Consumption In MBR With New High Performance (NHP) Module

KK. Latt. Toray International Singapore Pte.Ltd. (Singapore)

Membrane bioreactor (MBR) process with low energy consumption was studied using our newly developed MBR module, New High Performance (NHP) module which has a higher membrane packing density compared to the previous MBR module fabricated with rigid plate type membrane element. Energy consumption was reduced by increasing product capacity with higher membrane packing density. In this study, NHP module was operated under higher flux (42 LMH) and investigated a stable operation for about 6 weeks. Maintenance cleaning (MC) with sodium hypochlorite resulted to keep transmembrane pressure (TMP) increasing rate less than 0.05 kPa/day. Aeration energy consumption per product water was reduced 60% in high flux operation. The feature of NHP membrane element is thin and semi-flexible which helps to dislodge the sludge foulant and improve cleaning efficiency with scrubbing air.

Seawater RO Facility Optimizes Membrane Performance With Novel Hydro-Optic UV Technology

Y. Rozenberg, A. Felder. Alantium Technologies (Israel)

A seawater reverse osmosis (SWRO) facility in Asia with a 100,000 m3|day drinking water capacity undertook a comparative study to evaluate the disinfection efficacy of a novel hydro-optic (HOD) ultraviolet (UV) technology to provide enhanced protection of the RO elements and positively effect overall RO system and facility performance. Membrane system operation and maintenance from a six-month period prior to and following the installation of the HOD UV technology were evaluated; data was also compared to performance from unprotected RO trains. Following the installation of the HOD UV technology, the facility experienced significant operational improvements, including a 50% decrease in SWRO clean-in-place (CIP) frequency and a 65% decrease in the number of micron filter replacement events. Membrane performance also improved, evident from a 11% decrease in post CIP differential pressure (DP). The HOD UV technology offers the facility a proven and economical non-chemical disinfection treatment approach to protect RO membranes.

Siloxane Based Ions Imprinted Sensor For Lead Ions Detection Using Quartz Crystal Microbalance

S. Li, XH. Lin, Q. Li. National University of Singapore (Singapore)

Traditionally lead ions are tested in laboratory by sophisticated instruments AAS, ICP/AES, and ICP/MS. However, they are lack of mobility for onsite and online monitoring and need well-trained personnel and high maintenance cost. Here we report a selective, sensitive, simple and cost-effective siloxane based ions imprinted sensor for the detection of Pb2+ ions in water using QCM 1,2. Siloxane monomers, cross-linker, and lead ions template were mixed in water. When siloxane hydrolyzed and condensed to form polysilane, lead ions coordinated by the functional groups were removed to form complementary cavities, which are able to recognize target lead ions. The IIP based lead sensor exhibited high selectivity toward Pb2+ ions against other interfering ions with a LOD as low as 1ppb. The sensor was well characterized by SEM, FTIR, ICP-AES. The developed silaxone based IIP sensor has great potential for the high through-put monitoring of Pb2+ ions in water quality control.

Sustainability Reporting By Companies Listed In SGX

C. Tortajada, W. Lim, I. Bindal. National University of Singapore (Singapore)

From 2018, companies listed on Singapore Stock Exchange needed to report their environmental, social, and governance (ESG) practices. Following a "comply or explain" approach, company reports must include board statements that describe their sustainability actions, identify ESG factors that affect business strategy, as well as explain their practices and performances, and set sustainability targets. Using the annual and sustainability reports these companies submitted to SGX in 2018, our study aims to understand the sustainability efforts companies had espoused to perform or commit to after the new SGX ruling. Specifically, our ongoing study plans to investigate how sustainability reporting relates to firm industry, business strategy, and financial performance, especially their utility disclosures on water, energy, emissions, and solid waste disclosures, particularly water. Our research has the potential to inform research and policymaking on how businesses can become better members of water-wise communities, particularly in fostering innovative business models and public-private-people partnerships.

Towards A Rapid On-Site Test That Can Detect All Serogroups Of *Legionella Pneumophila*

M. Connolly, G. 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-lp sg1 bacteria are more prevalent. The development of a test that can rapidly detect all serogroups of legionella pneumophila on-site would therefore be of value for reducing global legionella risk. The immediacy and easy to use nature of a rapid legionella pneumophila lateral flow test has the potential to provide accessible, fast actionable results at the site of testing - thus supporting effective water system management and protecting public health. This paper reports the advancements made by the hydrosense ltd technical team in developing a rapid on-site testing method for legionella pneumophila serogroups 1-15 (lp sg1-15) in water. The test is based on the detection of lp sg1-15 antigens using specific antibodies, which have been shown to detect lp serogroups in under 25 minutes.

Towards Drinking Water Quality Monitoring Directly At The End-point Of Use: Evaluating An In-pipe Monitoring System For Drinking Water Networks

C. Wagner, B. Buysschaert, B. De Gusseme, A. Weingartner. s::can Messtechnik GmbH (Austria)

One case study is presented where s::can's technology was used to monitor the drinking water quality directly in the pipeline of a water distribution network. The used monitoring system was installed directly in a high-pressure pipeline and measured turbidity, UV254, color, TOC, DOC, free chlorine, temperature, pressure and conductivity. The in-pipe system proved itself as a valuable tool in Belgium during the burst of the main pipe connecting Sint-Pieters-Leeuw with Brakel. Using the data from the in-pipe system the change in water quality due to the burst and the necessary rerouting of water could be monitored in real time.

Understanding The Needs Of The Individual User Leads To Organisational Adoption Of Digital Twins

P. Bonk. Innovyze (Australia)

Prospective technologies, even when accepted by an organisation in theory for the problems they may solve, do not necessarily lead to adoption in day to day practice by prospective users and practitioners. Universal reasons exist within the global water industry why adoption of emerging technologies remains a challenge.

Technology adoption occurs at the organizational level when the trust of the individual users is established by solving a problem and improving their daily workflows, has a simple interface that allows for timely interpretation of results and allows the user to solve problems more effectively than their current tools and software applications. Digital Twins adoption use cases to be discussed include: Day to day decisions on construction crew deployment, crew safety when in live sewers mitigating the risks associated with failing depth monitors and predictive incident management for deploying tanker trucks to strategic spill locations prior to an incoming storm event.

The intent of this paper is to methodically demonstrate how Digital Twin technology has been successfully adopted by meeting the needs and workflows for individual users.

Wetting Characteristics And Progression Of Polyvinylidene Fluoride Hollow Fibre Membrane Contactors

W. Ge. Memstar (Singapore)

This paper involves the studying of wetting in two Thermally Induced Phase Separation (TIPS) hydrophobic membranes as hollow fibre membrane contactors used for the removal of ammonia from wastewater. By comparing key characteristics and observing the wetting progression, we can avoid the wetting of membranes and optimize ammonia removal. Two dry TIPs membranes with different hydrophobicity and gas flux are characterized for physical and chemical characteristics. Both membranes are deliberately wetted to define wet characteristics to understand the definition of wet membranes. Membranes were then soaked in water for 60 days to observe wetting progression and phenomena. Dry membranes progress to partially wet membranes almost immediately after the first day. Partially wet membranes remain stable for quite some time (30- 60 days) depending on the type of conditions. However, the partially wet status does not affect the transfer of the gas.

28 June 2021 (Monday)

6.00pm-6.30pm (SGT) (GMT +8)
Poster Session 4

An Effective Measure For Evaluating Sewer Condition: UAV Screening In Comparison With CCTVs And Manhole Cameras

H. Ikeda, Y. Inagaki, PK. Takeuchi, Y. Yato. NJS Co., Ltd. (Japan)

NJS has searched for a way to inspect sewer pipes efficiently and considered a focus on UAV (Unmanned Aerial Vehicle) to be beneficial. However, one that could stably fly through a confined space, such as a sewer, did not yet exist. Hence, NJS decided to develop a UAV for this purpose. To evaluate the performance, an actual sewer section has been inspected. The result shows that the UAV is capable of inspecting more than 1,000 m a day without personnel needing to enter a manhole. The team has also inspected the same section by CCTV and manhole camera to compare the inspection speed, operator's safety and the reliability of data. From the obtained result, it can be said that UAV is an effective screening method to efficiently conduct CCTV inspection, in other words, to prioritize the sections that need a detailed inspection.

An Integrated Countercurrent Two-stage Adsorption And Membrane Separation Process For Decontamination Of Radioactive Iodide Water

X. Zhang, Y. Liu, G. Zhang, P. Gu. Tianjin University (China)

Nowadays, radioactive iodine has been widely employed in medical diagnosis and treatment, which may enter the aqueous environment after such medical applications. In addition, radioiodine has been detected in surface water, drinking water, and seawater in Japan after the accident of the Fukushima nuclear power plant. Faced to such an emerging situation, innovative technology for quickly and adequately treating radioactive iodine-contaminated water is urgently needed, and strategically it should serve as a technology reserve. Therefore, an integrated countercurrent two-stage adsorption and membrane separation process was developed by combining the advantages of enhanced adsorption of soluble radioiodide and membrane filtration for solid-liquid separation. For this purpose, a novel tailored-designed adsorbent was prepared and used. It turned out that about 90% of radioiodide ions could be removed in the integrated system, with less generation of radioactive waste. It is expected that this study may provide a promising technological approach for handling radioactive iodide ions present in various kinds of radioactive waters.

Automated Micro-invertebrate Detector

L. Lei, Y. Du, M. Tay. NM3 Tech(s) Pte Ltd (Singapore)

Micro-invertebrates such as copepods, cladocerans, nematodes, rotifers and chironomids etc. are ubiquitous in raw water and these micro-invertebrates are monitored as part of the water quality programme by PUB. The monitoring for these micro-invertebrates are usually done through manual analysis under the microscope and requires trained and skilled expertise. An automated micro-invertebrate detector with image analytics capabilities is developed to meet this monitoring requirement. This system provides a new approach to achieve automated, continuous online monitoring with the advantages of being manpower-saving, lower cost, faster, accurate and potentially able to monitor chironomid larvae.

Case Study For The Implementation Of A Digital Solution To Optimise Wastewater Treatment Plant Operations

CMJ. Hui, WPA. Yuen, M. Wu, SZ. Goh, M. He, E. Leow. Sembcorp Utilities Pte Ltd (Singapore)

Virtual Brain (VB) is an intelligent operations management system for process prediction and troubleshooting. Developed by Sembcorp, it allows for centralised monitoring and control of Sembcorp's water facilities around the world. This paper provides an overview of the different modules that make up the product, as well as the implementation efforts in multiple wastewater treatment plants in a timeframe of six months. These digital initiatives allow for efficient management of existing and future assets and optimise monitoring capabilities. Using machine learning and data science modelling, predictive accuracy of up to 80% is achieved. This has also been implemented across all Sembcorp China and Singapore water and wastewater treatment plants in 2019.

Conserving Freshwater From Existing Cooling Tower Water System Via Indirect Supplemental Seawater Cooling

BS. Ee, L. Ng, CK. Eu. Petrochemical Corporation Of Singapore (Singapore)

The Company applied its initiative of supplemental seawater cooling via a cascade loop to cool the hot returning cooling water of its existing cooling tower water system to reduce the evaporative loss of fresh water. This retrofitting project does not require any change in the existing heat exchange equipment as the same cooling tower water is flowing through the existing equipment. It not only conserves substantial quantity of fresh water in making-up to the cooling tower, but also eliminate the concern of metallurgy of using seawater to the existing facilities. The same model can be applied to other similar cooling tower water systems whether large or small that has accessed to seawater. The conservation in fresh water by this initiative will translate to less investment in energy intensive desalination facilities for carbon savings. The main hurdle will be the investment in the once-through seawater supply and return-back-to sea infrastructures.

Effect of Data Quality on AI Prediction Capability in WWTPs

E. Ekklesia, A. Sipila, T. Koskinen, S. Pattanayak. Ramboll (Singapore)

Most wastewater treatment plants (WWTPs) adopt reactive approach towards process abnormalities. An artificial intelligence (AI) based preventive tool is being developed for accomplishing proactive operations and decision making in WWTPs. The Platform is based on prediction-solution-guidance structure. Initial trials have found that typical WWTP data are suitable for the Platform algorithm. Moreover, the developed algorithm was able to predict targeted next-day effluent quality parameters, such as phosphorus, ammonia, chemical oxygen demand (COD), nitrate, and sludge volume index (SVI), with promising accuracy. An Early Warning Index (EWI) has been developed for the Platform to evaluate effectiveness of the prediction algorithms to prevent discharge limit violations.

Estimating The Cost Of Climate Change To Water Utilities In Victoria, Australia

K. Karunaratna. Marsden Jacob Associates (Australia)

Climate change has a significant influence on the operations of Victorian water corporations. Victoria's climate has become drier and warmer over the past few decades and water corporations were severely impacted by the recent Millennium Drought. This study provides a consistent approach that can be used by water corporations to quantify the cost of climate change under the BAU pathway. Understanding the cost of climate change for BAU pathway allows water corporations to make investment decisions and select suitable adaptation pathways that are more economically efficient than BAU. The framework; * focuses on financial costs incurred by the water corporations, * considers costs in short, medium and long term, * identifies the BAU expenditure pathway and current climate scenario, * identifies suitable climate change scenarios to be tested as per the guidelines developed by CSIRO, * provides a risk based approach for quantifying the costs of climate change, adapted to suit water corporation activities; * identifies a consistent approach for establishing the levels of service delivered

Green Deep Eutectic Solvents For Pulp And Papermaking Industry

LY. Ee, S. Li. National University of Singapore (Singapore)

The study into preparation and characterization of cellulose prepared by deep eutectic solvents (DES) facilitate a deeper understanding of their favourable characteristics such as low cost of preparation, environmentally-friendly and high degree of cellulose dissolution that show great potential as cost-effective and sustainable solution in the pulping process for papermaking industries. Herein the conference paper, we compare the effectiveness of biomass fractionation using alkaline treatment to shadow kraft process and using prepared choline chloride (ChCl)/urea binary DES. The treated cellulosic fibers are then characterized with Fourier-transform infrared spectroscopy (FT-IR), X-ray diffraction and Scanning Electrion Microscopy (SEM) to investigate possible difference in their physicochemical properties. From the study, it was found that molar ratio of 1:2 for ChCl/urea DES was most suitable for the treatment of biomass due to its lower viscosity and hence ease of mixing that would lower cost in industrial scale.

High Recovery RO In Potable Reuse Applications

U. Erdal, Z.Erdal. ARCADIS (United States)

Reducing RO concentrate flows generated from RO based advanced treatment facilities has become a major interest of agencies located in inland areas where a surface discharge of RO concentrate is not possible. To meet this objective, many agencies are considering incorporating a high recovery RO concept into the design. However, depending upon nature of secondary treatment provided at the wastewater treatment plants, high recovery RO may pose challenges to satisfy nitrogen discharge limits in certain potable reuse projects. The findings of this paper are highly valuable for agencies, regulatory agencies, consultants and individuals who are considering a high recovery concept while meeting very stringent nitrogen limits in IPR via reservoir augmentation projects.

Improvements In Ceramic MBR System For Industrial Used Water To Achieve Higher Operational Stability And Energy Efficiency

SC. Lee, N. Hiroshi, Q. Yin, T. Xia, T. Niwa, W. Lay, SC. Chua, L. Yu, SL. Lim, MJ. Nassir, G. Tao, C. Gudipati, ST. Ooi, A. Dhalla. Meiden Singapore (Singapore)

Performance tests for new-type of membrane, new-design cassette, new MC regime and mew membrane aeration methods were carried out by using two cassettes in a membrane tank of the 1-MGD MEMO plant at JWRP. New-type membrane has new active layer with higher water permeability. Tubing between permeate pipe and membrane was removed and they were directly connected for the new-design cassette. Larger permeate pipe was also used for new design. Intermittent dosing of hype was used for new MC regime, which resulted in lower chemical consumption with longer soaking time. Intermittent membrane aeration was tested to reduce energy. Stable operation was achieved for these new items and methods. It was estimated that more than 30% of operating condition can be reduced with new items and methods.

Inactivation of methicillin-resistant *Staphylococcus aureus* by Chlorination, Chloramination, UVC irradiation , and UVC based advanced oxidation processes

S. Ghosh, L. Wang, Y. Chen, S. Peng, Q. Cai, and J. Hu. Department of Civil and Environmental Engineering, National University of Singapore (Singapore)

The extensive application of antibiotics around the world is fostering the development of antibiotic-resistant bacteria (ARB) and antibiotic-resistant genes (ARGs). Presence of ARB and ARGs in the drinking water treatment system has been identified by various researches. Therefore, removal of ARB and ARGs at drinking water treatment plants has become a significant issue to protect human health. This study assessed the removal efficiency of three commonly used disinfectants (free chlorine, mono-chloramine, and UVC) to inactivate E. coli TOP10 carrying sulfonamide resistant sul1 genes. The inactivation rate was faster for UVC whereas the chloramine was the least efficient among the three treatment methods. This study also evaluated the impact of various operating conditions such as pH, turbidity and natural organic matter (NOM) on disinfection performance. An effort has been made to develop the disinfection kinetics for chlorination and UVC for ARB removal.

Inter-Basin Water Transfer - Planning To Implementation Solution To Water Crisis In India

U. Joshi. Xylem Water Solutions India Pvt. Ltd. (India)

Year 2019 is a going to be a very critical and decisive year for India in terms of their water infrastructure. We will see many water related problems in different parts of India that have a geographical dis-advantage. Sixty percent (60%) of the population will live in urban areas by 2030, which will greatly increase the stress on water resources. The solution to various issues depicted above is to have a Smart Basins (smart, inter connected, sustainable water network) which serves the growing needs of the nation, with drinkable water at the taps and abundant water for agriculture and urban living. There are three phases to create smart basins. 1. Planning, 2. Execution and 3. Maintenance (Sustainability). The planning phase include the understanding the changes in geographic area over the years, Changes in Rain fall patterns, negotiated catchment area depiction, etc. The execution phase will be critical where rejuvenation and creation on basins, connectivity, creating buffer zones will be part of this challenge. The maintenance phase will ensure sustainability of solution.

Management Of Anion Exchange Spent Brine Through Secondary Products Creation: Humic Substances And NaCl

E. Vaudevire, J. Post, W. van der Meer, I. Daniel. PWNT (Netherlands)

This paper highlights the main discoveries from six years of R&D effort toward developing a treatment solution for a waste brine from a drinking water plant using anion exchange for natural organic matter (NOM) removal. Due to the nature of NOM in the brine i.e. humic (HA) and fulvic acid (FA), which find a number of applications in the agriculture industry, their recovery as a secondary product was assessed on pilot scale; in addition to the recovery of monovalent salts for onsite recycling. The research considers the technologies for secondary product extraction, the potential application of HA and FA and the regulatory quality requirements.

Phytoplankton Monitoring Based On Deep Learning

H. Liu, Y. Wang, H. Liu, S. Hu, Y. Peng. Zweec Analytics Pte Ltd (Singapore)

Phytoplankton, or planktonic algae, are the main primary producer in water bodies, and their quantity, species, and distribution have a decisive influence on the aquatic ecosystems. Regular monitoring of phytoplankton in terms of identification and enumeration is an important means for the diagnosis and maintenance of aquatic ecosystem's health. However, currently, the frequency and timeliness of such monitoring by manual microscopic examination method are limited severely by a shortage of algae identification professionals. Harnessing the recent progress Deep Learning, we are developing an intelligent planktonic algae recognition and counting system using microscopic images from the Yangtze river basin as a training database. The preliminary training and test on 6 common freshwater algae genera reached a recognition accuracy of 76%, which proved that the deep learning-based phytoplankton monitoring is practical and can evolve to solve the manpower problem in this field.

Potable Water Reuse: Communication As A Policy Instrument

C. Tortajada, I. Bindal. Lee Kuan Yew School of Public Policy, National University of Singapore (Singapore)

All over the world, there is an increasing demand for water available in the necessary quantities and qualities for growing numbers of uses and users. Water resources, however, are every time scarcer, and more polluted, mismanaged and misgoverned, limiting the amount of water that can be provided for any use. With extreme events resulting from climate variability and change, coupled with population growth, the availability of water has become a serious concern globally. Based on several case studies, this presentation discusses the potential of reused water for potable purposes to become a feasible source of water supply for domestic use.

Process Intensification By Using Hybrid Integrated Fixed Film - Membrane Bio Reactor (IF-MBR) For Treatment And Reuse Of Refinery Wastewater

SK. Chee, G. Wu, KP. Chiu, K. Khoo, C. Koh, HQ. Li, SK. Woon. AECOM (Singapore)

Refinery wastewaters can be difficult to treat due to the inherent variability of the inlet streams which contain difficult to treat compounds. The conventional processes typically require a large footprint and suffer from operational problems leading to environmental non-compliances. The Hybrid Integrated Fixed Film Membrane Bio Reactor (IF-MBR) combines the benefits of both IFAS and MBR into a more compact and robust treatment process. The IF-MBR process can achieve a high resistance to organic and hydraulic shock loadings due to the fixed film process and provides process flexibility with total solids retention with the membrane system, all within a much smaller footprint than a standalone MBR or IFAS-Clarifier process. A pilot plant is currently being operated to validate the concept using actual wastewater from the refinery. The results are expected to validate the main design parameters of the IF-MBR system.

Project Implementation And Strategies For Design, Procurement And Implementation For Upgrading Of Online Large Scale Water Treatment Plants Development Projects

R. Salenga, N. Lethan, S. Moore. Maynilad Water Services Inc (Philippines)

This work focuses on development of project management strategies, methods, and tools to be applied for rehabilitation, retrofitting and process improvement of large scale water treatment plants. We emphasize on the application and implementation of asset management approach in examining the plant's condition and performance and development of risk management tool to monitor risks in all project's phases. We define the entire project duration into three phases: Engineering Phase is the phase when conditional assessment of plant's assets is conducted that serves as input for generating conceptual reference design; Procurement Phase is duration of tendering and selection of prospective bidders; Construction Phase is phase when detailed design work done by the selected Contractor shall be realized and subsequently put into physical installation and construction works.

Rethinking Urban Resilience: The Impact Of The COVID-19 Pandemic On Urban Water Resilience

P. Dircke, D. de Weerd. Arcadis (Netherlands)

COVID-19 has brought into sharp focus how unprepared cities around the world were for the impact of a pandemic. There currently is a window of opportunity to use the COVID-19 pandemic experiences to rethink urban resilience. To maximize this opportunity this paper depends on a throughout literature review and the expertise and experiences of Arcadis consultants from around the world. From this various important new and reaffirmed insights can be gained with regards to urban resilience in general and urban water resilience. While in recent years water resilient cities approaches and water sensitive design (both climate resilience related) have already gained momentum both in academia and in practice, the pandemic reaffirms their importance. The pandemic has highlighted the importance ensuring urban water resilience through appropriate sensitive urban design to prevent crisis-on-crisis situations, provide public shared blue-green space, and to bring back the balance between natural and engineered processes.

Soft Sensing Of Water Depth In Combined Sewers Using LSTM Neural Networks

R. Palmitessa, M. Borup, PS. Mikkelsen, WKA. Law. Nanyang Technological University (Singapore)

We investigate the efficacy of LSTM neural networks as a soft sensing tool to perform gap filling in scenarios of missing or limited antecedent observations. Particularly, we compare the prediction accuracy of different LSTM networks: i) without knowing the antecedent water depth, ii) with different gaps in the antecedent observations and iii) with different amounts of training data. We present and discuss results obtained from a large set of real observations from a combined sewer in Copenhagen, Denmark. The results showed that the prediction error significantly decreased when the antecedent observations of water depth were used as input. For gaps longer than 30 min, the LSTM neural network was capable of exploiting the rainfall data to generate a better prediction than a naïve model. When the model relied solely on the rainfall data, longer learning periods improved the prediction accuracy.

Wet Chemical Analyzer With Minimum Reagent Consumption

F. Honold, M. Rosenauer, P. Rauch, R. Schuhmacher, U. Franke, N. Leiprecht. Xylem Analytics Germany GmbH (Germany)

Sensors and analyzers are essential for providing information on monitoring and treatment of water. Devices like optical oxygen sensors do not consume reagents. But there are parameters like phosphate and others, which require a wet chemical analyzer in order to convert the interesting molecules into a detectable measurand. So far bigger and unwieldy amounts of chemicals were needed to operate such instruments. A new type of analyzer has been developed which reduces the reagent volume down to 5 µL and daily consumption to less than 1 mL. Additionally lifetime of reagents could be improved up to two years simplifying the handling for users distinctly. Also the amount of waste is minimized and its collection and orderly disposal is possible now. Small bags enable harmless handling of reagents.

29 June 2021 (Tuesday)

6.00pm-6.30pm (SGT) (GMT +8)
Poster Session 5

A Comparison Of Real World And Modeled Performance For An Osmotic Brine Concentration System -- Defining The Process Window

A. Al Amoudi, E. G. Beaudry, S. Ihm, J. E. Tracy, N. Voutchkov (United States)

A novel, membrane based water treatment process has been developed and deployed in pilot and commercial projects, based on the principals of osmotically assisted reverse osmosis (OARO). The economics of this process, defined as the combination of process flow capital cost and process flow operating cost, are such that a higher level of water recovery, beyond that of reverse osmosis stages alone, can be justified in many more cases. This paper will study the economics of several operating cases, and offer guidance on the process window within which the technology offers strong value for providing higher levels of fresh water recovery from industrial effluent streams.

A Solution to Cyanobacterial Blooms: Insights from Thousands of Field Applications Using the Lake Guard® Technology

M. Harel. BlueGreen Water Technologies (Israel)

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

Clean Water And Sanitation: Laguna Water's Experience In Ensuring Safe And Reliable Water To 500,000 People In Laguna

M. Alcasid, V. Rivera. Manila Water Company (Philippines)

Eighty percent of World mega cities in Asia are highly dependent on groundwater. In the Philippines, groundwater resources supply the water needs for most households, agricultural activities, and industrial processes, among others. However, even with the abundance of the country's groundwater source, different raw water quality issues still exist. Considering the dependence of most households on groundwater for drinking water, protecting its quality is critical to ensure safe and reliable water supply. In exerting all its effort to provide safe and potable water to almost 500,000 residents of Laguna, Laguna Water, being the largest groundwater service provider in the Philippines, faced various challenges to address raw water quality issues of groundwater sources. This paper focuses on the raw water quality concerns encountered in Prima Casa, Binan and Victoria, both located in Laguna. This also aims to discuss subsequent strategies and technologies including Catalytic Water Filtration and Nanofiltration used by Laguna Water to address these challenges which could help other countries in Asia in coming up with sustainable solutions in the use of groundwater sources.

DeCaIon TM Ultimate Solutions For Cooling Water Management

BK. Ng, Innovative Polymers P|L (Singapore)

DeCaIonTM (DCI) is a revolutionary approach to eliminating scale, controlling corrosion and bio-fouling in cooling water systems. Through applied electro-chemistry and a patented intelligent controller, DCI removes water hardness from cooling systems without the need for hazardous chemicals. The innovation provides a green solution to scaling and corrosion in HVAC systems and industrial chiller. The DCI system removes existing scale and prevents further scale formation. SiO_2 is also removed along with the hardness. The system ensures heat transfer efficiency is maintained at all times and the requirement for routine shut downs and chemical descaling is no longer required. Water blow-down quantities are also substantially reduced. In addition, Legionella and heterotrophic bacteria counts of less than 10 and 100,000 CFU/ml respectively will be maintained at all times and corrosion for copper of less than 1 mpy (mil per year) and carbon steel of less than 3 mpy can be well controlled.

Demineralization-Remineralization Dynamics In Water

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

Mineralization is a dynamic, complex, lifelong process to control precipitations of inorganic nanocrystals within organic matrices to form unique hybrid structures, for example, hydrogen atoms, oxygen atoms and water molecules. Understanding the process of mineral deposition is important for the developments of treatments for mineralization of water and also for the innovation and development of water. This review provides an overview of the possible mechanisms and the factors implicated as agonists and antagonists of mineralization. Then, the role of calcium, magnesium, potassium, sodium and sulphate ions in the maintenance of health and well-being is described. The new technologies of reversing through demineralization and boosting remineralization in water are discussed. Turning these new technologies to products and practices would improve health care and well-being worldwide.

Disruptive Quantum Water Filtration Technology "QTI"

P. Marconi. Wiracocha (China)

Qti is a new quantum technology of water filtration. No loss of water, no plastic waste, keeps mineral salts, reduces salt and the main pollutants: bacteria, pesticides, endocrin disruptor,heavy metals, arsenic 3 & arsenic 5 , antibiotic , tritum and uranium. The refills consist of carbon tube ; fill with different component , which are returned to the laboratory for analysis and recycling . See video :Leautus Home tap water testing https://www.youtube.com/watch?v=fkwTodtOeKw Global warming and melting glaciers will cause rising waters and submergence of coastlines and infrastructure. The technology is ready to remove salt from water. This technology can be implemented in different portable or fixed machines, it does not require a connection to the network. It is a mini autonomous filtration station.

Effect Of The Home Improvement Programme On Residential Water Consumption In Singapore

M. Fan, S. Agarwal, E. Araral, Y. Qin, H. Zheng. Lee Kuan Yew School of Public Policy, National University of Singapore (Singapore)

Water efficient appliances play an important role in water conservation in Singapore and worldwide. To evaluate the effectiveness of these appliances, water utilities and researchers alike have mostly relied on small-scale randomized control trials with uncertain external validity. In this paper, we evaluate a nation-wide program, the Home Improvement Programme (HIP) with an optional upgrade of toilets and water taps, to provide insights on the effect of the installation of more efficient appliances on residential water consumption.

In Singapore, close to 80% of the population lives in public housing developed and managed by the Housing and Development Board (HDB). There are more than one million HDB flats, some of them built in as early as 1960s. HIP is an upgrading program, introduced in 2007, to resolve common maintenance problems of aging HDB flats. As of December 2019, 55% of all HDB blocks were eligible for HIP, out of which 56% had been or were being upgraded. Using monthly water billing data for all households residing in HDB flats from 2011 to 2019, we will employ a staggered difference-in-difference regression approach to evaluate the average treatment effect of HIP by comparing the monthly water consumption by flats that completed HIP before and after the upgrades with the consumption by flats that are not being upgraded. We will further study the evolution of the treatment effect over time and the heterogeneous effect on housing characteristics and consumption quintiles. Last but not least, we will investigate how the effect of water efficient appliances interacts with climate change and extreme weather events.

Enabling Operational Efficiencies Through Decision Intelligence In The Water Supply Network Of Singapore

M. Iqbal, A. Preis, KC. Lai, SF. Hew, JK. Pang, N. Lim. Xylem (Singapore)

This paper describes how the smart water system has evolved to support two main applications: (i) online management of response to incidents in the pipe network and (2) planning dashboard to assess performance of the network for targeted management. The enabling technology for these two applications is the digital twin of PUB's pipe network. The digital twin incorporates an online calibrated nationwide hydraulic model that allows accurate simulations of operational scenarios (e.g., valve closure, hydrant flushing, and demand change), water age/TRC prediction, water quality source tracing and a framework that assesses the performance of the network from various singular or composite perspectives such as material, age, customer complaints, pipe fatigue due to surges, thereby allowing targeted rectification for day-to-day operations as well as long-term planning.

Field Experiment On SMS And Household Water Conservation

M. Nakajima. Lee Kuan Yew School of Public Policy, National University of Singapore (Singapore)

Information campaigns have long been adopted as a tool to promote water conservation in many countries. Short Message Service (SMS) is a recently emerged tool used in information campaigns which can reach a broad target at a low cost. This study conducts a field experiment to investigate the effect of messages delivered via SMS about one's weekly water use on household's water conservation behavior. By combining the weekly water consumption data with household level data, the analysis can identify how household characteristics affect water conservation through the weekly SMS about water use. The findings from this study can provide valuable insights into the expected effect of information campaigns through mediums like SMS in the field of resource conservation.

Financial District And Seaport Climate Resilience Master Plan: Building A Comprehensive Resilience Strategy For Lower Manhattan

R. Deitz, E. Hutchinson. Arcadis (United States)

In October 2012, Hurricane Sandy hit New York City and exposed Lower Manhattan's vulnerabilities to climate change. To reduce flood risk to the Financial District and Seaport, NYC Economic Development Corporation retained the Arcadis-led consultant Team to study climate adaptation strategies for both neighborhoods. This work is part of the City's broader strategy to invest over $500 million in capital projects in Lower Manhattan beginning in 2021. Given the unique convergence of climate risk and physical constraints, it is critical to examine both on-land and in-water solutions (i.e., extending the shoreline of Lower Manhattan) to implement a comprehensive resilience strategy. Our presentation will explore (1) the process to develop project alternatives to reduce flood risk -- including sea level rise, coastal storms, and precipitation; (2) key project challenges and solutions, including siting blue-green drainage infrastructure, complex transportation and maritime infrastructure; and, (3) funding and financing strategies, including phasing and governance.

Fully Automated Rapid Microbiology - Basic Considerations Regarding Different Measurement Approaches And Evaluation Of The Enzymatic Measurement Approach.

W. Vogl, J. Koschelnik, I. Dubek. VWMS GmbH (Austria)

A safe and efficient water cycle requires efficient processes and therefore sufficient process control and monitoring. Water quality monitoring is therefore a crucial task throughout the complete water cycle, to effectively control treatment processes and safeguard the water quality throughout the distribution network. The physical and chemical quality of water, unlike the microbiological quality, is automatically monitored by various sensors. While microbiological quality is still being determined by manual, culture-based lab procedures. These evaluations take 24 hours or longer to deliver a result and are therefore not suitable for process control or short-term decision making. Basic considerations regarding possible approaches of rapid microbiological measurements are being presented. One rapid measurement approach, based on direct measurement of enzymatic activity of target organisms, is being evaluated in detail. Effects of different types of disinfection in parallel test series with traditional methods are presented to evaluate advantages and limitations of the enzymatic measurement approach.

IIOT Thermodynamic Pump Condition Monitoring System For Maintenance & Performance Management

S. Barrett, MA. Samadi, SC. Cheung, Y. Qin, R. Hale, T. Lam. Public Utitilities Board (Singapore)

Real-time pump condition monitoring together with a Decision Support Interface can guide operations personnel to ensure the most efficient pump operations. Real-time monitoring of pump operational parameters such as Pump Head, Input Power, Hydraulic Efficiency, and Flow Rate provide insight to pump performance. Pump with higher hydraulic efficiency can be favored to run more often and remedial action can be taken on pumps with lower hydraulic efficiency. The FREEFLOW system also compares between single pump pumping against parallel pumping (concurrent running of two pumps) to increase pump station efficiency. The system allows monitoring of performance with different pump combinations. Moving forward, data and insights from this project will be used to optimise our pumping station operational and maintenance efficiency

Improved Management Of *Legionella* Risks Using Rapid On-Site Testing

G. Rankin, M. Connolly. Hydrosense Ltd (United Kingdom)

The widely performed laboratory culture testing method for legionella lacks the required accuracy and speed to properly manage legionnaires' disease risk in the built environment. Factors such as transportation time, lack of biocide neutralisation, exposure to variable temperature and presence of background flora can affect the performance of lab culture results. This research examines the effect of biocide exposure and sample transport time/temperature, on the accuracy of the lab culture method and offers an effective complimentary legionella testing solution which can be used in conjunction with the lab culture method to improve water system management and public safety.

Improved Transparency With Digital Twins Of Urban Drainage Systems

A. Pedersen, M. Borup, A. Brink-Kjær, LE. Christiansen, PS. Mikkelsen. VCS Denmark (Denmark)

VCS Denmark is currently reconstructing its digital twin (DT) to include new and more optimized features. A DT can provide increased transparency throughout the entire utility thereby improving the support of employees for taking better actions. The utility's primary needs are within better models for planning and design as well as improving operational tasks, all with help from the DT environment. Features that need upgrading are identified and replaced with better and more flexible solutions. In the future error diagnostics will be a part of the DT toolbox, in order to reduce model uncertainty and the risk of operational errors. The DT is expected to reduce the environmental impacts from the urban drainage system and to support smarter investments.

Investigating Adsorption Of Natural Organic Matter By HAOPs Via Molecular Dynamics Simulation

Y. Ma, S. Velioğlu, MB. Tanis-Kanbur, R. Wang, JW. Chew. Nanyang Technological University (Singapore)

Heated aluminum oxide particles (HAOPs) have been used as dynamic membranes pre-deposited onto the primary membrane to effectively remove natural organic matter (NOM) and thereby significantly diminish the fouling potential. Molecular dynamics (MD) simulations were conducted to compare the performance of HAOPs with the conventional powdered activated carbon (PAC) adsorbent. Results indicate that the mechanisms underlying the effective removal of high molecular weight (HMW) NOM by HAOPs include: (1) higher foulant-HAOPs interaction energy; (2) greater hydration of the HMW NOM; and (3) diminished mobility of the foulant once adsorbed, which deters desorption.

Keppel Marina East Desalination Plant (KMEDP) Design Approach To Energy And Water Sustainability

KP. Chiu, EK. Goh, PT. Tay, TM. Leong, KS. Goh. AECOM (Singapore)

Desalination and water reuse provide circular economy solutions for water-scarce environments. However, seawater desalination draws general concerns on energy consumption and sustainability. Keppel Marina East Desalination Plant (KMEDP) addresses these through a dual-mode solution and other designs. KMEDP is located in Singapore Marina East, near an urban catchment reservoir and the sea, allowing the Plant to feature dual intake from both sources. In dry season, when the water level in the reservoir is low, seawater is desalinated to produce drinking water. In rainy season, the Plant draws water from Marina Reservoir instead, which requires less energy and fewer treatment process steps compared to desalination. Other than the dual mode, KMEDP implements a direct coupling design which significantly reduces the energy consumption. Besides the innovative technologies and process design, the architectural design incorporates environmental friendly elements into its landscaping such as collecting rainwater for irrigating the green roof, supporting the facility's water features and landscaping needs. Its design enhances the overall water and energy consumption efficiency of the plant.

Leveraging Dual Polarimetic X-band Radar Rainfall And Nowcast For Urban Flood Management In Singapore

M. Keem, A. Goedbloed, M. Vierstra. Hydroinformatics Institute (Singapore)

To improve the performance of the X-band radar system nowcasting model operated by PUB, we evaluated new nowcasting models using various distributed advection vectors with the semi-Lagrangian persistence-based extrapolation scheme. The optical flow model shows the best skill scores in predicting rainy area with the lowest computational load. The numerical diffusion and the Lagrangian persistence model without the growth and decay cause the deficiency in accurate rain rate predictions, which will be investigated as a part of this project in the future.

Managing A Structural Improvement Project -- Marrying Structural And Project Management Principle Into Action Plan (Water Treatment Facilities Upgrading Project)

R. Salenga, E. Malahito, MS. Orticio. Maynilad Water Services Inc (Philippines)

Retrofitting works for structures of existing industrial plants are challenging and have tendency to cause major negative impacts on Revenue, Reputation, and Regulatory (the 3 Rs) for stakeholders. For instance, an existing large scale water treatment plant, serving millions city-dwellers, cannot partially or totally shutdown as the shutdown might cause extreme negative impacts such as Revenue (e.g. owner of the plant cannot sell water, resulting loss in revenue); Reputation (e.g. the reputation of the owner decreases as he cannot meet the demand of water daily); Regulatory (e.g. the owner might face business penalty and loose business chance when not meeting the requirement from the regulatory authority).

Pilot Gravity-driven Membrane (GDM) Reactor For Seawater Reverse Osmosis Desalination Pretreatment

B. Wu, S. Lee, TH. Chong. University of Iceland (Iceland)

Seawater pretreatment by a pilot gravity-driven membrane (GDM) filtration system (operated over 500 days) was investigated. This study aims to (1) examine the effects of membrane module and system configurations on the GDM permeate flux and permeate water quality; (2) compare the performances of reverse osmosis (RO) membranes fed with the pilot GDM reactor permeates and full-scale ultrafiltration (UF) permeate. The results indicated that (1) the gravity-driven flat sheet membrane module achieved higher permeate flux than hollow fibre; (2) the GDM reactor produced superior permeate quality than the UF pretreatment, leading to less RO membrane fouling; (3) Integration of a biofiltration process with the GDM system further improved subsequent RO membrane performance.

Portable Rapid Bacteria Detector

L. Lei, CM. Yeo, Z. Wang. Zweec Analytics Pte Ltd (Singapore)

Globally, regulators are increasingly paying attention to the biosafety of the drinking water especially in a pandemic. Real time and direct detection of biological suspensions with high sensitivity and accuracy remains an extremely difficult task in the water monitoring industry. In this work, we developed a revolutionary enzyme-assay based bacteria detection system that can realize rapid bacteria detection with high sensitivity and specificity, and low cost. The innovation is expected to exceed the current detection limit and be able to build up a new water monitoring standard.

Removal Of Organic Micropollutants From Wastewater By Ozone-Activated Carbon Filtration And Porous Cyclodextrin Polymers Adsorption: A Laboratory Batch Study

JP. van der Hoek, C. de Jong, TK. Liu, T. Spit, H. Schijfsma. Delft Univesrity of Technology (Netherlands)

Wastewater treatment effluent contains organic micropollutants. The removal requires advanced treatment technologies. The removal efficiency of ozonation-granular activated carbon (O3-GAC) and porous cyclodextrin polymers (P-CDP) was investigated in laboratory batch experiments. O3-GAC and GAC as single process were very effective, while adsorption by P-CDP lagged behind. However, fast kinetics, selectivity and easy on-site regeneration of P-CDP may make this process potentially more competitive and attractive.

Short-Term Water Quality Prediction Using Tree-Based Classification For Coagulation Control In Drinking Water Treatment Plant To Improve Waterworks Operation Efficiency And Event Detection

P. Cai, V. Sim. Surbana Jurong Consultants Pte Ltd (Singapore)

The SJ Solution harnesses the power of Data Science & Analytics, and Machine Learning/Artificial Intelligence to help water treatment plants maximize efficiency and reduce manpower reliance. The machine learning models perform fault identification via root cause analysis and prediction of anomalies before they happen. This data modelling has set as a precedence to other processes and create a value chain optimization for the future. The solution makes the currently reactive SCADA system more intelligent through descriptive and predictive analytics. Operators will reap the benefits of AI-assisted models that comes with an interactive dashboard and improve the efficiency of operations through diagnostic troubleshooting and assisted decision-making.

Smart Water Model - A Case Study At Anderson Road Quarry Site Development, Hong Kong

H. Lee, HS. Tsang. Government of Hong Kong Special Administrative Region (China)

Like many water utilities around the world, the Water Supplies Department ("WSD") of the Hong Kong Special Administrative Region Government has been facing challenges which include rising water demand due to continuous population and economic growth, diminishing water resource due to impact of climate change, and increasing water loss due to aging of water supply network, etc. WSD has found that use of advanced technologies is a sustainable mean to cope with the challenges and has therefore recently implemented many smart water initiatives such as Grey Water Recycling and Water Intelligent Network ("WIN"). While the application of these smart water initiatives could be constrained by the developed environment of Hong Kong, WSD takes the opportunity of the new Anderson Road Quarry Site Development ("ARQD") and plans to implement various smart water initiatives therein with a view to formulating a Smart Water Model to facilitate the formation of a Smart City.

The Importance Of Designing For The Real-world And Not Just To Meet The Specification

D. Nicklin, L. Rusiecki. Xylem (United Kingdom)

Standards are acknowledged as being beneficial for manufacturers and users alike. They provide a minimum level of performance and conditions a meter must meet in order to become certified as compliant to the standard. However, meeting a specification under controlled test bench conditions may not be the best measure of performance in real-world field deployments. For example, the OIML test designed to examine whether a meter can work within defined error limits should there be upstream and downstream pipe bends and valves, only applies across a very short part of the range -- from 0.9Q3 -- Q3. A meter can easily meet the error bands for that short section to claim compliance but fall rapidly outside the bands for large parts of the range, making it totally inaccurate for a real-world installation. In addition, specifications initially developed to test mechanical metrology do not necessarily provide the best basis for qualifying new solid state meter technologies. Utilities should be sure to consider other factors that are not covered in the standard tests and evaluate whether these may be significant to the how the meter may perform in their network.

30 June 2021 (Wednesday)

6.00pm-6.30pm (SGT) (GMT +8)
Poster Session 6

Degradation Of Carbamazepine By UVA-LED/WO3/peroxydisulfate Process: Effects Of Light Wavelength And Water Matrix

D. Han, J. Hu. National University of Singapore (Singapore)

Carbamazepine (CBZ), a widely used prescription drug for seizure treatment, has been frequently detected in effluents from wastewater treatment plants due to its high recalcitrance to conventional wastewater treatment processes. In this study, an advanced oxidation process -- UVA-LED/WO3/peroxydisulfate process -- was applied to degrade CBZ. The effects of light wavelength and water matrix on CBZ degradation was investigated. The results of this study indicated that UVA-LED/WO3/PDS process was a powerful and promising process for CBZ degradation.

Design Features And Initiatives At Tuas Water Reclamation Plant

ZE. Lim. Public Utilities Board (Singapore)

The Tuas Water Reclamation Plant (WRP) will be the largest Membrane Bioreactor (MBR) treatment facility in the world, treating up to 800,000m3/day of used water with a 30% more compact footprint compared to conventional WRPs. Domestic and Industrial used water will be treated in two separate liquids treatment modules and further purified to NEWater and Industrial Water respectively. Sludge produced will be treated in a common Biosolids treatment facility. With the adoption of MBR technology, higher treated effluent quality can be produced and discharged via near shore outfall in a responsible manner. The Tuas WRP will be co-located with the National Environment Agency's Integrated Waste Management Facility (IWMF) to harness potential synergies in the water-energy-waste nexus. This paper focuses on highlighting the Tuas WRP Process Design and its co-location synergies along with the SMART initiatives which leverage on technology enabling tools to improve performance of used water treatment.

Design Methodology for Next-Generation Smart Water Quality Analyser System in Water Supply Network

D. Yong, MH. Teh, KK. Toh, CW. Lim, ZY. Ye. PUB (Singapore)

Water quality, pressure and flow monitoring has historically been conducted by constructing permanent sensor installations. There is a need for mobile instrumentation units to support transient, short-term operations and monitoring purposes for the Water Supply Network island-wide. This will drive agnostic decision support capabilities. PUB and Flotech Controls have entered a joint collaboration to develop a comprehensive island-wide mobile instrumentation scheme covering a suite of monitoring capabilities integrated with the smart water grid. The mobile instrument station was designed to overcome operational challenges by addressing design objectives on reliability, mobility and application. Experimental results show that key design considerations in sensor selection, station configuration and panel design allow for a robust integration of the mobile stations to the smart water grid. A successful program for storage, deployment and sustainable use in the field has allowed PUB to conduct real-time ad-hoc monitoring of water quality across the entire Water Supply Network.

Developing A Novel Non-Invasive Method For Imaging Of Flow Profile Using Ultrasonic Flowmeters

Q. Yi, MH. Teh, RA. Ooi, MR. Mohd Akip. PUB (Singapore)

Ensuring good flowmeter accuracy is an important tenet in PUB Water Supply (Network)'s Non-Revenue Water (NRW) management strategy to allow for accurate accounting and for mass balance. Two important factors to ensure flowmeter performance are its site installation conditions and a well-developed ideal flow profile similar to that encountered in the calibration test-rig. This project has developed a novel non-invasive method of investigating and classifying flow profile characteristics within the pipeline which can be used to determine impacts on flowmeter accuracy. Using multi-path data from clamp-on ultrasonic flowmeters (USFM), mathematical algorithms were designed to determine the type of flow profile within a pipeline. An application was then developed using these algorithms to allow the user to obtain important flow characteristics and visualise possible flow profiles.

Development Of 3D Visualization Platform For Compound Flooding and Transport Resiliency In Coastal Cities

P. Yang, AW. Law, F. Zhu, H. Ho, VST. Sim, X. Wu, Y. Liang, JH. Loh, H. Chan, D. Chitwatkulsiri, KN. Irvine. Nanyang Technological University (Singapore)

Coastal cities around the world are increasingly facing the threats of compound flooding, caused by intense rainfall events due to global climate changes coupling with extreme storm surges and sea level rise. Direct visualization of the predicted impacts due to compound flooding can provide useful insights to effective flood resiliency solutions for city planners and government officers. In this project, a 3D visualization platform is developed which integrates the layers of assessment data, including coastal storm surges and sea level fluctuations, inland flood simulations and transportation processes in order to assist non-experts with an authentic view of the urban infrastructure alternatives and enable real-time operational decision-making and evacuation activation with flood control strategies. The usefulness of the platform is demonstrated in two ASEAN study sites, the first in the province of Samut Prakan, Thailand and the second at Vung Tau, Vietnam.

Direct-coupling UF-RO Desalination Plant; A Keppel Marina East Desalination Plant Perspective

AL. Lim, F. Knops, PT. Tay, EK. Goh, YX. Chua, CL. Lee. Pentair Water Asia Pacific Pte Ltd (Singapore)

The Keppel Marina East Desalination Plant (KMEDP) is the first desalination plant in Singapore to adopt direct-coupling UF-RO (DC-UF/RO) design. While DC-UF/RO plants have existed in plants in Europe, Middle-east and Australia, it is uncommon for East and Southeast Asia. This poster aims to provide a comparison of DC-UF/RO desalination against conventional UF/RO desalination plant design from the perspectives of KMEDP. It will compare the pros and cons of DC-UF/RO in general; and the decision of adopting DC-UF/RO design at KMEDP. The startup and operational challenges of DC-UF/RO coupled to the dual feed source operations at KMEDP is discussed. Lastly, recommendations are made on the use of DC-UF/RO design for future plants based on the KMEDP experience.

Integrated Anaerobic Fixed-Film MBR-Reverse Osmosis-Chlorination Process: An Environmentally Sustainable Approach For Reclamation Of Municipal Used Water

S. Wang, Y. Liu, H. Liu, J. Gu, M. Zhang. Nanyang Technological University (Singapore)

Nowadays, the reclamation of municipal used water to high-grade water (e.g. NEWater) has been widely accepted as a feasible alternative to achieve water sustainability. However, there may be some room to further improve the current NEWater production line in terms of energy consumption and excess sludge production. To address these emerging issues, an integrated anaerobic fixed-film MBR (AnfMBR), reverse osmosis (RO) and chlorination process was developed for producing high-grade product water from municipal used water. It turned out that the product water could meet typical NEWater quality in terms of TOC, ammonium, phosphorous, chlorine and other major ions, with net energy consumption estimated to be 0.30 kWh per m3 product water. Consequently, this study may open a new window for reclamation of municipal used water to high-grade product water with reduced energy consumption and negligible excess sludge production.

Macro-patterning Of Micro-crumpled Nanofiltration Membranes By Spacer Imprinting For Low-scaling Desalination

C. Shang, S. Zhang. National University of Singapore (Singapore)

Surface patterns provide a chemical-free approach to reduce fouling by mimicking nature, and are yet limited by their complicated fabrication procedures. Here we develop readily scalable methods to create sub-micrometer- and millimeter-scale patterns on membrane surfaces for low-scaling desalination, with a focus on the anti-scaling mechanism. Specifically, a robust polyethylene (PE) lithium battery separator prepared from melt casting and stretching has been used as the support for nanofiltration (NF), giving micrometer-scale crumples on the surface. Then the PENF membrane is imprinted by permeate spacer during tests, leading to millimeter-scale patterns. A comparison of the impact of different feature sizes on scaling, ranging from smooth-, nm-, µm- and mm-levels, was given through no-stirring dead-end and crossflow tests. Results indicate that µm-scale patterns are resistant to scaling through both spatial and hydrodynamic effects, and mm-scale patterns are also effective in reducing scaling solely due to hydrodynamic effects.

Maximizing RO Recovery At The World's Largest Potable Reuse Plant

M. Boyd, M. Plumlee, H. Gu, J. Lozier, M. Hwang. Desalitech (United States)

The Orange County Water District (OCWD) Groundwater Replenishment System (GWRS) is the world's largest potable reuse plant, treating secondary effluent to produce purified water for groundwater recharge as a drinking water supply augmentation and for injection into coastal wells that form a barrier to prevent seawater intrusion. Currently the GWRS has a production capacity of 100 million gallons per day (MGD), with the existing three-stage, 85% recovery reverse osmosis (RO) system generating 18 MGD of RO concentrate that is discharged to the ocean. Upon completion of the final GWRS plant expansion in 2023, full production capacity will increase to 130 MGD while the RO concentrate flows will increase to 23 MGD. To further increase GWRS purified water production, OCWD has been pilot testing CCRO for two years to recover additional water from the RO concentrate and generate a new water supply for the region. This paper summarizes the long-term results.

Polyamide Thin Film On PTFE Hollow Fibres For Nanofiltration

JY. Chong, G. Yang, H. Yi, L. Du, R. Wang. Nanyang Technological University (Singapore)

Polytetrafluoroethylene (PTFE) is an excellent material for membrane applications due to its highly inert property. However, it is still challenging to produce PTFE membranes with small pore size (<1 nm) for nanofiltration. In this study, nanofiltration PTFE hollow fibres were successfully synthesized by coating a polyamide thin film layer on the inner surface. Surface modification was first carried out to improve the hydrophilicity of the PTFE substrates, followed by the synthesis of polyamide through interfacial polymerization. This simple coating method can effectively transform commercially available microfiltration PTFE substrates to high value nanofiltration membranes. The prepared polyamide-PTFE composite membranes showed good permeability for both water and organic solvents, and had a small MWCO of ~350 Da in water. This highly stable membrane can potentially be used in applications involving harsh conditions such as organic waste treatment and organic solvent nanofiltration.

Regional Water Security Study (RWSS): Defining No-regret Measures And Investments To Sustainably Improve Water Security In The Short And Medium Term In The Yangon Region In Myanmar

T. Huizer, R. Steijn, J. de Groot, D. Spaans, H. Nandar Aye. Arcadis (Netherlands)

Yangon Region, the former capital and fast-growing economic engine of Myanmar is facing various water related challenges. Coastal and riverine flooding, saltwater intrusion and insufficient water supply for public, commercial, industrial, and agricultural use jeopardize sustainable future growth of the area. As part of the Regional Water Security Study (RWSS), three interlinked investment programs were developed that aim to secure the future water security in the Greater Yangon Region. The regional water system was analyzed with the use of a specially developed hydrodynamical model (Delft3D FM), which also served to study the cumulative impact of proposed or new measures. The programs with measures are focusing on Weakest Link Strengthening (hotspots for embankment improvements and flood protection), Freshwater Supply in the rural areas and Drainage System Improvement.

Strategy For Phosphorus Recovery And Wastewater Treatment In Amsterdam

M. Amosov, JP. van der Hoek. Organic Village (Netherlands)

The wastewater chain in Amsterdam offers an opportunity to recover up to 100% of phosphorus (P) per year, versus 47% currently recovered. For water boards, like Waternet, it is difficult to scale-up centralised, decentralised or hybrid P-recovery solutions. Because widely-used methods like Total Cost of Ownership, Mass Flow and Life-Cycle Analysis are limited in providing systemic assessment of risks and propagation among linked stakeholders e.g. municipalities, customers. The Multi-Domain Mapping Model was applied to evaluate risks propagated by four scales of P-recovery solutions - city, block, house, hybrid - onto infrastructure, stakeholders and resources in the region. Change Propagation Indicator showed that centralised solution creates a system where Waternet is the Top-Absorber of risks/costs; and customers are Multipliers. Scenario with house-scale solution shifted risks from Waternet, indicating potential value models with other actors e.g. utilities, biotech startups, citizens, business. Scenario comparison allowed deriving system-wide patterns and change management strategies for identified actors. The developed toolkit allows integration - analysis of new data.

WOW! - A New Business Approach For Resource Recovery From Sewage

S. Venditti, J. de Best, G. Kolisch, A. Christen, J. Hansen, K. Bijl. Regional Water Authority Vallei en Veluwe (Netherlands)

Did you know that even used toilet paper can get a second life? Sewage contains valuable substances that could be used as circular raw materials for biobased products. The WOW! project aims to capitalise on these opportunities and work towards a more circular approach. We do this by a) demonstrating the technical feasibility for recovery & upcycling techniques for cellulose, lipids and PHA from sewage, b) Investigating the market potential and creating five high potential value chains for raw materials and c) addressing policy barriers for the circular uptake of raw materials from sewage. Preliminary results are promising. So far we successfully produced biobased products from sewage and are currently upscaling the pilots. Furthermore, current market potential shows that the markets for biobased alternatives for conventional products are increasing. Current national and European legislation however doesn't always permit the reuse of raw materials from sewage.