

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 Moraxellaceae were consistent between mature and young biofilms (pipe coupon samples vs sensor surfaces) on each campus. The community of very young biofilms on sensor surfaces gradually shifted from Firmicutes to Alphaproteobacteria, and a change in conductivity coincided with changes in nascent communities of both young and mature biofilms regardless of testbed location, suggesting an effect of source water.

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

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

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

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

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

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

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 $46 \pm 13 \%$, $52 \pm 6 \%$, and $45 \pm 6 \%$ 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 nitrification is an important step in the removal of nitrogen via anaerobic ammonium oxidation. Sustained disturbances can lead systems to alternative stable states that may not be reversible. We tested the effect of a sustained organic loading disturbance to inhibit nitrite oxidation, as well as its reversibility. Using replicate lab-scale activated sludge bioreactors, we demonstrated stable and reproducible nitrite accumulation (~77%) at tropical temperatures based on a combination of high F:M and C:N in the influent. The resilience of the nitrification function differed from nitrifying community structure resilience, as reactors with recovered function after reversing the disturbance remained distinct in terms of the predominant nitrite oxidizers present. Overall, the ammonia oxidizing bacteria were more diverse and resilient than the nitrite oxidizing bacteria. We showed that functional recovery and resilience can vary across replicate reactors, and that nitrification recovery need not coincide with a return to the initial nitrifying community structure.

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

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

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

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

S. 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 carbon diversion process, there is evidence of some denitrification using endogenous biodegradable carbon from within the MABR biofilm. Evaluation of the oxygen utilization suggests that the MABR is approximately twice as efficient as fine bubble aeration diffusers. Results from our research suggest that MABR technology holds potential to sustainably enhance and intensify BNR processes.