

id #2233

### Effects of inoculum sources on autotrophic nitrogen removal behavior in hollow fiber membrane reactors

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This study introduced laboratory-scale upflow anaerobic reactors installed with hollow fiber membrane units as gas-diffusers for autotrophic nitrogen removal treatment. Enriched sludge from previous studies and paddy soil were separately inoculated in reactor 1 and 2, respectively. After 50-day enrichment in recirculation phase with nitrate and ammonium as the nitrogen sources and CH<sub>4</sub> as the carbon source, the reactors were operated in continuous phase during 90 days with HRT of 9.5 hours, the temperature of 30°C and gas supply speed of 3.6 L/day. The performance of both reactors was compared under different nitrogen (i.e. NO<sub>3</sub><sup>-</sup>, NO<sub>2</sub><sup>-</sup>, NH<sub>4</sub><sup>+</sup>) and carbon sources (i.e. with or without CH<sub>4</sub>) during the continuous phase. The nitrogen removal rate of reactor 2 is higher than reactor 1 under the condition combining denitrifying anaerobic methane oxidation (DAMO) and anammox processes, particularly reactor 1 and 2 removed 11.9 mgNO<sub>3</sub><sup>-</sup>-N·L<sup>-1</sup>·day<sup>-1</sup> and 15.5 mgNO<sub>3</sub><sup>-</sup>-N·L<sup>-1</sup>·day<sup>-1</sup>, respectively. Meanwhile, under the condition for either DAMO or anammox process, reactor 1 surpassed reactor 2. Under anammox condition, reactor 1 removed more total nitrogen than reactor 2; besides, the actual rNO<sub>2</sub><sup>-</sup>/rNH<sub>4</sub><sup>+</sup> and pNO<sub>3</sub><sup>-</sup>/rNH<sub>4</sub><sup>+</sup> ratios in reactor 1 followed the theoretical anammox process's ratios. Under nitrate/nitrite-DAMO conditions, reactor 1 had higher nitrate or nitrite removal rate. The reactors' performance and the microbial community analysis indicated that the reactor 1 inoculated with enriched sludge performed well under conditions favor for either DAMO or anammox process, while the diverse microbe community in soil can adapt and remove more nitrogen in other conditions.

id #2467

### Water Services Development for Ajyal Home Ownership Project by Saudi Aramco

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Saudi Aramco commenced Ajyal project in 2014 to provide affordable and quality housing in a modern community for the company's employees. Once fully developed, the Ajyal Community will comprise of more than 8500 housing units, schools, mosques and recreation centers spread across an area of 10 sq km with an ultimate population of 67,000 residents.

The aim of this paper is to discuss the experiences gained during water services (water, wastewater, and stormwater) development for the Ajyal Project. Since Ajyal site is located outside the municipality jurisdictions, the water services of the project required new decentralized RO Plant and Wastewater Treatment Plant of 50,000 m<sup>3</sup>/d and 22,000 m<sup>3</sup>/d capacities respectively. After conducting a feasibility study, the new RO plant and Wastewater Treatment Plant were located within the premises of the existing Desalination Plant and Wastewater Treatment Plant in Al Khobar at an approximate distance of 17 and 18 km respectively from Ajyal Site. Three new pumping stations and associated pipelines were provided for Potable Water, Wastewater and Treated Sewage Effluent.

The size of RO Plant was increased from 50,000 m<sup>3</sup>/d to 200,000 m<sup>3</sup>/d as three other entities joined with Ajyal Project for their water requirements. This increase in size resulted in a reduction of 50% of the capital cost/(m<sup>3</sup> of the plant size). The size of WWTP was also increased from 22,000 m<sup>3</sup>/d to 70,000 m<sup>3</sup>/d. This was done to decommission the existing old WWTP of another Saudi Aramco community and divert its flow by gravity to the new WWTP.

The water services development experience at Ajyal Project demonstrated that considerable benefits can be achieved in terms of cost, operability, service reliability, sustainability, and environmental protection when different organizations/communities join hands for common goals.

id #2500

### The cultivation of Macroalgae for the treatment of anaerobically digested abattoir effluent

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The growing demand for meat as a source of protein has resulted in the significant increase of wastewater produced from abattoirs containing animal fluids (i.e. blood, manure, urine, and fats), mixed with the water used for various operations processes at meat processing plants (MPPs). The current treatment options employed in abattoirs for the treatment of wastewater is not beneficial in terms of cost, efficiency and simplicity. As such, bioremediation methods using micro/macro algae can therefore be of great interest for not only treating the wastewater but also for generating the profit from waste (in terms of algal biomass). Despite the extensive research on the application of microalgae for the treatment of wastewater, there are limited studies that have looked at macroalgae which are much easier to harvest, lowering the cost of downstream processing. In this study, the growth and nutrient removal efficiency of two locally isolated freshwater macroalgae strains, *Cladophora* sp. and *Rhizoclonium* sp. in anaerobic digestion abattoir effluent (ADAE) at different dilution rates (25%, 50% 75% and 100%) - up to the concentration of 250 mgNH<sub>4</sub><sup>+</sup> - N/L - were evaluated.

Maximum Nitrogen removal rate, Photosynthesis, and biomass productivity were investigated at different dilution of ADAE and the results proved the highest productivity on 25% and 50% dilution of ADAE.

Based on the results *Cladophora* sp., and *Rhizoclonium* SP., are in great of value for the bioremediation of even high strength wastewaters such as ADAE.

### AI and IoT: Advancing Urban Hybrid Water Systems

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AI and machine learning techniques have already demonstrated significant outcomes in various water industry applications such as water quality monitoring, chemical dosing, prioritising active leakage detection areas, intelligent network optimisation, and the prediction of water pipe failure. Can these techniques be extended from water utility operations into home and commercial water usage?

The rapid rate of global development in ultrasonic, revenue grade advanced metering technology is allowing the emergence of a new cost-effective approach to smart urban water management. In particular it can enable hybrid water systems – those utilising alternative and non-potable water sources – to be accurately quantified in a continuous manner without meter fouling. This in turn paves the way for hybrid water systems to be utilised in urban water trading – a novel market-based approach to a specified band of water use to enable higher levels of water efficiency.

Over 60 ultrasonic smart water meters were deployed in 2018-19 across 40 participating households within the City of Fremantle, Perth, Western Australia as part of the RENew Nexus project (Resilient Energy and Water Systems) which is a federally-funded initiative being delivered under the national Smart Cities & Suburbs program. The approach adopted for the water component of RENew Nexus integrates the smart metering of hybrid water systems, household participation and data analytics at the residential scale within the traditional centralised urban water network.

Since installation, water volume data has been recorded every 30 minutes with each meter uploading this data daily via the Telstra NB-IoT network to a dedicated data management platform. The water usage data is then analysed and water balance modelling undertaken. The water balance quantifies the volume of water used by source (rainwater, groundwater, greywater, mains), the volume of wastewater produced, as well as the amount of local abstraction and recharge to aquifer. This in turn enumerates mains water savings, reductions in discharge to sewer, and abstraction/discharge to aquifer for each site.

The introduction of a reward credit system to those residents who actively save energy-intensive mains water and wastewater, whilst optimally managing aquifer recharge, can support localised, hybrid water sources at residential and community scale. While currently, machine-learning algorithms are being used to detect inaccuracies or anomalies in water meter data, in the future, AI and machine learning techniques can be used to better manage the use of alternate water sources in cities to achieve sustainable hybrid water systems.

### Renewable Energy Powered Electrodialysis Reversal (EDR)

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Currently the drinking water supplies in the towns of Cue, Meekatharra, Mount Magnet and Sandstone do not comply with the 2011 Australian Drinking Water Guidelines (ADWG) due to excessive nitrate levels. Each towns supply is sourced from bores that are already at or near capacity, therefore the treatment process used to remove the nitrates needed to have an overall water recovery of at least 90%. This led to the selection of Electrodialysis Reversal (EDR) as the preferred treatment process.

After the selection of the EDR process the Water Corporation became aware that the power intensive nature of EDR would result in 3 of the four towns requiring major electrical upgrades equating to millions of dollars. As a result and with a new corporate objective to reduce greenhouse gas emissions, the Corporation investigated ways in which renewables could be used to mitigate the need for these major electrical upgrades.

### The politics of Decentralization and Deconcentration (D&D) Reform: the case of sanitation under the WB pilot project

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The politics of Decentralization and Deconcentration (D&D) reform has been seen as a key constraint for function transfer that is a promising sign for the improved quality of sanitation services and the rural household participation for latrine uptake at the subnational governments. In 2002, the Government has started the first D&D reform for most Ministries, but only in 2016 that the Ministry of Rural Development (MRD) has started its first function transfer on sanitation to the subnational governments. This paper will use the existing data and information from 2017 to 2019 pilot project at the World Bank Cambodia in its intervention to promote active participation and improved governance at the subnational levels, for the increase of the sanitation coverage in three provinces (Tboung Khmum, Kompong Speu, and Kompong Chhnang). The pilot is considered as a platform to increase concrete efforts at the subnational governments, especially the district sanitation committees (the third tier of Government levels) who have built capacity on promotion of sanitation coverage in their respective communities. With the pilot experience under the World Bank support, there is a promising sign of latrine uptake, with an average of 8% of the rural households gaining access to latrine installation annually. Such high proportional increases of latrine uptake has a lot of economic sense and has brought many benefits to rural households through the D&D reform investment compared to other development intervention. Although subnational governments have a strong commitment and readiness to receive functional transfer including decision making, power, and budget for promoting active participation in sanitation increase coverage among the rural households, there are still a lot of challenges and constraints in the policy coordination, policy implementation, and commitment at the ministry level for a

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smoothly transfer of function to the subnational governments. These challenges and constraints are inevitably causing a major delay and slow function transfer to the subnational governments. This paper hypothesis is that national low commitment and hesitant functional transfer due to the fear loss of power and budget transfer are the key causes to the complexities of function transfer to the subnational governments.

**id #2203**

### **Improving Urban Slum Sanitation Management by Connecting Decision Making to Stakeholder Needs, study case; Indonesia**

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In urban slums, most people live in informal settlements. From various studies that have been in done in urban slum areas, it is known that problem of sustainability are affected by the inability of stakeholder to provides wastewater technologies but failed to ensure sustainability in operation and maintenance. Some evidence shows that communities only accept technologies that are a close match to their culture, habit and lifestyle. Stakeholder participation is a crucial component of decision-making within slum communities application, which have to allow the ability to use the sanitation technology. Indonesia requires the government to strive harder to achieve the universal access target of 0% slum and 100% sanitation service coverage by 2019. Policy efforts that have been implemented by the Indonesian government in achieving the target in 2019 through the National Program for the Acceleration of Development of Settlement Sanitation (ADSP). One form of implementation of the policy is the construction of Community-Based Waste Water Treatment Plant (WWTP) facilities in urban slums. There are many challenges in stakeholder arrangement in Indonesia due to sanitation implementation. Each stakeholder has its purpose. Therefore, one platform to integrate all the sanitation policy is considered.

This study is developing the computer-based decision support system (DSS) to plan sanitation responses in Slum area, which focus in Indonesia. DSS considered useful for planners to decide in a relatively short time. The DSS will be determined by research. Sets indicators will be determined to evaluate the effectiveness and limitation of the system. The case, as mentioned earlier studies, will be used to input parameters to indicate what happened with a recommendation by the decision support system. The system did not use appropriate and specific content of the case studies will also be identified. the DSS addresses several provision of sanitation in a slum area, including the application standard practices and current condition, the highlight criteria for sanitation aspect, the limited knowledge by the slum area investigator.

**id #2564**

### **Management and Accountability are the Key to Unlocking the Potential of Decentralised Wastewater Systems**

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Traditional regulatory, management and funding models have evolved from the two extremities of wastewater servicing. It is reasonable to say that they have proven successful when applied to highly urbanised (sewer) and rural areas (owner managed on-site systems).

In the post war period, it was largely assumed that reticulated sewerage would be rolled out progressively anywhere that it was needed (i.e. money is no object) using a postage stamp pricing approach. This has proven to be unrealistic even in metropolitan cities, let alone rural towns and villages where the cost to provide reticulated sewerage services has begun to exceed land values in some cases. It has also been influenced by the shift in pricing to a more user pays structure where there are regulatory restrictions placed on the ability of water corporations to amortize costs for network extension over large service areas.

Regulatory frameworks for on-site systems overwhelmingly place responsibility for day to day management and financing of sanitation on individual property owners. Historically, this was acceptable because a) on-site systems were predominantly passive septic tank systems that required minimal maintenance; and b) properties being serviced were sufficiently large and isolated that the consequence of failure was often low in all but exceptional circumstances. Come forward to 2019 and on-site and decentralised systems are being asked to manage increasingly complex risks on increasingly constrained sites with increasingly stringent community expectations of performance. It is unrealistic to expect these systems to deliver on regulatory and community expectations whilst they are managed in an ad hoc manner by individual property owners.

Looming over both of these challenges is the uncertainty associated with rapid population growth and climate change. As is often the case, much of the focus on overcoming this inconvenient and unpalatable challenge has been on technological innovation. Whilst technological innovation can assist in achieving some efficiency gains, it avoids facing two increasingly inevitable facts.

Firstly, we cannot afford to provide reticulated sewerage to every community in need of improved servicing. Secondly, there is a limit on the willingness and capacity of individual property owners to fund and manage on-site and decentralised wastewater systems that meet current and future regulatory and community standards.

This paper will present a series of case studies to illustrate this misalignment between regulatory and management frameworks for on-site and decentralised wastewater systems. The case studies then offer examples of how DWC and our clients are developing and testing engineering and management strategies to overcome the seemingly eternal challenge associated with delivering high quality services via on-site and decentralised systems.

**id #2579**

### Development of image processing technique for tracking microbial communities on immobilized media in onsite treatment system

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Nowadays, immobilized microbial on media is used to apply in onsite treatment system such as the attach growth type. Specific species of microbes are selected and used for specifying objectives. In order to keep tracking the process of immobilized media, microbial measurement is required to be performed. Microbial culture is the method used to grow microbial colonies, then each colony with different characteristics will be isolated and sub-cultured in order to obtain pure microbial cultures. After that, the counting of colonies on the sample is performed to calculate the number of colonies forming units (CFUs). Colony counting is still widely used even though it is a time-consuming, labor-intensive and manmade error. In order to solve the problems, image processing can be applied to solve those problems. Image processing is a technique that performs on an image in order to retrieve, process and provide input from image or set of images.

The objective of this study is to detect and count microbial colonies forming units on a petri dish by using image processing. The samples that have been used are obtained from the Internet. The process of detecting the colonies performed by using circular object detecting function. However, the sample images that obtained from the Internet have different size, quality, and distance between camera and petri dish. Therefore, there was some inaccurate result for some sample images. However, the sample images that are in high-quality, produced an accurate result. Comparing between the ground truth result with the result from the program, the correlation graph was  $r^2 = 0.985$ .

id #1935

### Defluoridation and removal of pathogens from groundwater by hybrid cross-linked biopolymeric nanocomposite: A green technology concept

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The application of adsorbents containing natural polymers has received great attention in order to develop a high capacity, eco-friendly and sustainable multifunctional biopolymeric-reinforced composites to solve recurring water-borne epidemics. This study investigates the removal of fluoride ions and pathogens from contaminated aqueous solution using synthesized glutaraldehyde crosslinked cellulose-chitosan supported by a hybrid 3 layered metal-metal oxide nanocomposite material (CECS@nHapAgMgO). Various techniques like Fourier Transform Infrared (FTIR), Brunauer-Emmet-Teller (BET), X-ray diffraction (XRD), scanning electron microscopy and elemental composition determination (SEM-EDS), transmission electron microscopy (TEM), and XPS were used to analyze the morphology, structure and surface and physicochemical properties. Batch sorption experiments were conducted to evaluate the adsorption kinetics, isotherm, effect of pH and the effect of co-existing anions on fluoride uptake. The synthesized CECS@nHapAgMgO nanocomposite showed crystalline irregular multiple layered structural arrangements with a thickness of 23.74 nm, pore and particle sizes of 0.062  $\mu\text{m}^3/\text{g}$  9.89 nm respectively. It possessed a fluoride sorption capacity of 26.11 mg/g with an optimum pH 5.0 ( $\pm 0.5$ ) and inclined to higher temperature and  $\text{pH}_{\text{pzc}}$  of 7.27. Freundlich isotherm was more applicable for describing the fluoride sorption equilibrium compared to other adsorption isotherm models. Although, results of sorption kinetics study indicate that the pseudo-second-order model best fitted to the experimental data, intraparticle diffusion and boundary layer mechanisms were also involved in the fluoride sorption rate. The thermodynamic analysis demonstrates that the fluoride uptake process was feasible and exothermic in nature with non-spontaneity mechanisms. CECS@nHapAgMgO showed an effective antibacterial property to gram positive and gram negative strains. This material has shown excellent potential applications for household water treatment technology.

id #2210

### The Use of Single Emitter Ultrasound Sensors to Detect Solid Particle Concentrations in UASB Reactors

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The excessive solids wash out within the effluent of Upflow Anaerobic Sludge Blanket (UASB) reactors compromises the overall performance of sewage treatment plants. The effluent quality of such anaerobic reactors is of utmost importance, as they are the most adopted technology for sewage treatment in Brazil (Chernicharo *et al.*, 2019). To assure a reliable operation of UASB reactors, the maximum total solids (TS) concentration at the highest point of the digestion compartment should be less than 0.5% (Chernicharo *et al.* 2019). Therefore, the systematic TS monitoring is of interest to establish proper sludge withdrawal routines. Real time TS measurements in UASB reactors could replace current time-consuming gravimetric analysis, enabling more efficient and accurate operation of the system. However, high capital and operational expenditure costs related to real time measurement usually hamper its adoption by sanitation companies in developing countries (Lira, 2001). The aim of this work

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was to evaluate the application of a low-cost ultrasound sensor for indirect determination of TS concentrations alongside the depth of UASB reactors.

A low-cost sonar transducer was used as ultrasound sensor for indirect TS measurements and a digital oscilloscope was used as data acquisition unit. A device being able to send pulsed signals to the transducer and able to filter the incoming signals properly has been developed. The received ultrasonic signals were compared to a reference signal processed in Octave® 5.1.0. The ultrasound sensor was installed in a demo-scale UASB reactor (320 population equivalent, H = 4.5m) operated for 70 days under constant flow rate, located at the Centre of Research and Training in Sanitation UFMG/Copasa (Belo Horizonte city, Brazil). TS sampling points were installed at 1.10, 1.60 and 2.10 m from the reactor bottom. Direct measurements of TS concentrations were performed through gravimetric analysis (APHA, 2012) to validate indirect measurements provided by the ultrasound sensor.

A remarkable correlation ( $R=0.998$ ) was noticed between the indirect (ultrasound sensor) and direct (gravimetric analysis) measurements, with mean relative error values between 0.02 and 0.06 for all of the evaluated sampling points. As the TS concentration increased the relative error also increased, which is probably related to the maximum TS detection limit of the sensor (1%). Therefore, the relative error was enhanced towards the bottom of the UASB reactor (lowest sampling points). Throughout monitoring, TS concentrations remained below 0.5% due to proper sludge withdrawal routine established from indirect measurements. Despite that, a slight dispersion of TS concentration was observed when the tested methods were compared during specific monitoring periods, possible due to physical conditions present in the UASB reactor, such as upflow velocity and temperature, which may affect the propagation of ultrasound waves. The low-cost sensor developed for real time solids monitoring in UASB reactors seems to be a promising technology for effectively prevent solids washout with the anaerobic effluent.

**id #2489**

### **Pre-feasibility study of storing surface drainage for a new agricultural precinct- A case study of managed aquifer recharge application in Transform Peel**

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Using alternative water resources is the key element for sustainable management of the growing water demands. This study is a part of Peel integrated water initiative (PIWI) which is a sub-project of the Transform Peel Program (TP). TP focuses on diversifying the Peel economy, creating jobs, protection and enhancement of the natural environment and building resilience in Peel region. With limited water availability, increasing water demands and dryer climate projection in the South-West Western Australia (SWW), PIWI aims to identify a range of technically viable water supply options to support the new developments. The Peel Development Commission's business case is based on the 1,000 ha Business Park being fully developed, and 3,000 ha inland (of the 42,000 ha study area) being developed for intensive agriculture. In this study future water demand for 78 different land scenarios for equivalent of 3000, 2000 and 1500 ha inland horticulture are projected. As a preliminary indication of when the supply-demand gap could arise and what the volume of a water deficit could be by 2050, current allocation limits and anticipated revised allocation limits are considered as the future water supply. Based on the agricultural development scenarios, gap can start increasing as early as 2025 or as late as 2040. Consequently, the water deficit could vary based on development intensity. To meet the extra gap, different supply options are considered. Managed Aquifer Recharge (MAR) represents an opportunity to capture and store water locally during periods of high availability for use in drier periods. It may also be used to bank water for years until growth in demand reaches a point where the water is required. A range of potential source water for MAR has been identified, including sub-soil drains, surface drainage and treated waste water. Stage 2 MAR investigations and assessments in accordance with the Australian Guidelines at the proposed Nambeelup industrial area site is implemented. The key outcomes from this preliminary assessment are that a MAR system at the site targeting the deep Cattamarra Aquifer is technically feasible. In this paper application of using and storing the extra surface drainage water for supporting the development of 30 ha of greenhouse in Hopelands Rd and 90 ha of new greenhouse precinct in Paterson Rd by 2050 as two potential case studies are assessed. Using the excess drainage flow for these greenhouses, could meet their demand fully till 2039. Alternatively, by storing the extra drainage water through MAR, all greenhouses demand can be met by almost 2050.

**id #2458**

### **Treatment of poultry slaughterhouse wastewater using an Static Granular Bed Reactor coupled with a single stage nitrification-denitrification and ultra-filtration membranes systems**

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This study evaluated the performance of a lab-scale poultry slaughterhouse wastewater (PSW) treatment system consisting of a static granular bed reactor (SGBR) coupled with single stage nitrification-denitrification (SND) bioreactor and ultrafiltration membrane module (ufMM) systems. The feasibility of treating PSW to a water quality standard compliant with industrial wastewater discharge standards was investigated. The SGBR was operated at hydraulic retention times (HRTs) ranging from 24 to 96 h and organic loading rates (OLRs) ranging from 0.73 to 12.49 g COD/Lday, for 138 days. The chemical oxygen demand (COD), total suspended solids (TSS), biological oxygen demand (BOD<sub>5</sub>) and fats, oils and grease (FOG) removal efficiencies achieved by the SGBR averaged 80%, 95%, 89% and 80%, respectively. The SND bioreactor achieved total nitrogen (TN) removal efficiencies of 33% and 79 % for the SGBR effluent, when operated in down-flow mode without aeration and up-flow mode with aeration, respectively. The ufMMs, operated in dead-end filtration mode, were able to further reduce the COD and TSS by an average of 65% and 54%, respectively. The results for the PSW treatment system demonstrated the combined benefits of biological and physical treatment processes, with averaged COD, ortho-phosphate (PO<sub>4</sub><sup>3-</sup>-P), TSS and total dissolved solids (TDS) removal efficiencies of 91%, 51%, 97% and 52%, respectively, being achieved over 52 days. The final effluent was deemed suitable for discharge; although, the PO<sub>4</sub><sup>3-</sup> and NH<sub>4</sub><sup>+</sup>-N requires further monitoring and the PSW treatment system design requires refinement.

id #1862

### Co-designing decentralised water infrastructure for livability in London

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Integrated, sustainable water management requires wide stakeholder engagement, including with local communities and households. This is a challenge for water professions, organisations and policies that have established cultures and expertise in top-down, centralised management of infrastructure. Engaging with communities is necessary to reduce demand for water and to ensure acceptability of new infrastructure options. It also provides opportunities for innovation, particularly in small, decentralised systems.

With an annual average rainfall of less than 600mm and a population of 8.7 million, forecast to grow to at least 9.5 million by 2050, London faces a deficit in water resources and lack of capacity in drainage and wastewater infrastructure. The Mayor of London has set targets for building 66,000 new homes each year. Delivering housing growth within constrained water and wastewater infrastructure and resources, whilst improving quality of life for Londoners presents a complex challenge for the city.

The Community Water Management for a Liveable London (CAMELLIA) project aims to address these challenges. The project is led by Imperial College and other research organisations, with support from the water utility Thames Water, the Greater London Authority, local governments, house builders, social landlords and local environmental groups. This paper will describe CAMELLIA and its focus on bottom-up solutions. It will present a case study of co-designing a community garden for optimal water performance on the Kipling Estate in the London Borough of Southwark.

Built in 1965, Kipling Estate has a large concrete play space (0.2ha) sited on top of the estate's garages, which residents would like to convert into a roof garden. Kipling Estate is served by combined sewers, which overflow into the River Thames during high rainfall events. Capacity for growth in the area is constrained by sewer capacity. The local government and Thames Water are aim to reduce runoff into sewers and promote sustainable drainage measures such as green roofs. The proposed roof garden on the Kipling Estate has the potential to reduce runoff into the sewers, meeting both residents' and infrastructure managers' objectives.

Designing a garden that can meet residents' aspirations, deliver on sustainability targets and be easy to develop and manage, is complex. Residents worked with researchers and stakeholders to co-design a garden that meets their needs while also delivering additional benefits for local water management. This was based around 3 workshops between March – September 2019. Each workshop involved a series of activities that enabled residents to collectively explore what they would like in the space and what environmental benefits could be produced. Participants undertook an 'infrastructure safari', mapping where water goes and how it could be diverted to enable a garden, and made short films depicting their ideas for the space. Custom-built software helped participants to analyse the water impacts of their design ideas, which provided the basis for a business case for funding for implementation. The final outcome of the co-design was a detailed design brief for a community garden to form the basis for obtaining funding to implement it.

id #2328

### Impact of HRT on Phosphorus Removal from Wastewater using Reactive Media

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Phosphorus (P) discharge from wastewater treatment plants into the environment contribute to increasing levels of eutrophication. Reactive media filters represent an efficient, simple and cost-effective solution to decrease the phosphorus content of the wastewater by adsorption and precipitation processes. The passive media system is potentially a more sustainable alternative to chemical or biological P removal technologies as a tertiary treatment for small sites due to low maintenance and operational simplicity.

In this study, different media were compared in batch and column experiments for their P removal performance. For the first time, real wastewater rather than synthetic solution was used to compare the efficiency of four materials over a long period of time. Different hydraulic retention times (HRTs) were applied to the lab scale columns using final effluent over six months, which revealed a HRT of >14 h is required to achieve high P removal. Results showed that initially the media achieved low P effluent concentrations of 0.02-0.1 mg/L PO<sub>4</sub>-P but increased over time to 0.05-5 mg/L PO<sub>4</sub>-P at the end of the experiment. Best P removal was observed for the highest HRT of 23h with on average >99%. As the contact time is higher between the P in the water and the media, the more P can be adsorbed onto the media's surface and/ or precipitate.

Between 0.5 and 5 mg P per gram of media were removed depending on the material and load applied. HRT seemed to be the driving factor for P removal rather than media capacity. Three of the four materials had an effluent pH higher than 12 initially, decreasing over time.

Additionally the removal of metals by the media filters was tested. All four media decreased metal contents in regards to Zn, Pb and Fe and increased the concentration of Ca, Mg and Al. XRD and SEM analysis confirmed formation of calcium phosphate precipitation on the media's surface. Overall, the results suggest the importance of an optimal choice of HRT for the design of a full size filter application, depending on the media, to achieve high P removal performance. In general a higher HRT means increased P removal but at the same time higher pH values.

Therefore this study shows that the reactive media application is an appropriate technology for P removal on small sites if the elevated pH is addressed, preferably with a passive system.

id #1405

### Comparative Studies on Fluoride Abatement using Mineral Adsorbent and its Modified Form in Batch and Column Contactor

# SWWS2019 Abstracts

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Coalmine-waste (Shale) was used for defluoridation both in batch and column contactors. Shale was loaded with  $\text{Ca}^{2+}$  to increase active adsorption sites for defluoridation. Response-Surface-Methodology was employed to optimize the calcium loading condition. Kinetic and equilibrium studies were performed to assess the adsorption potential of Ca-loaded-Shale and showed maximum removal of 89.7% within 8h at 10 mg/L of initial fluoride concentration. During column-experiments, the said adsorbent had showed that fluoride concentration in effluent exceeded permissible limit after 164th and 136th h, with simulated-solution and groundwater, respectively, which revealed the efficiency of column. Fluoride loaded spent adsorbents passed TCLP (Toxicity-Characteristics-Leaching-Procedure) tests successfully and categorized as a less toxic waste, which may be reused in road construction activities.

id #2237

## Study of the Brazilian energy efficiency scenario in the basic sanitation.

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Energy efficiency is made up of systemic activities that together aim to bring improvements and optimize the use of non-renewable energy sources of our environment. Intelligent use aims to use less to provide the same amount of energy, the concept of energy efficiency is considered as a pillar of sustainable energy policy. (Pereira, Mario, 2009).

Basic sanitation has a great impact on the quality of life, work and environment. According to Brazilian law 11.445 / 2007, the basic sanitation service must meet all of the requirements of access to quality water supply and in sufficient quantities for the consumption, collection and treatment of sewage and garbage and the correct management of rainwater. In Brazil, according to Gonçalves; 2009, about 3% of the total energy consumed in the country goes to basic sanitation, within that 90 to 95% for powering pumps and electric motors.

In the water supply system, in order to ensure a quality service under the law, it is necessary to use a lot of energy for the generation and distribution of water. In this way the water utilities need studies and technologies to improve their processes aiming at energy efficiency in the supply system that feeds the city.

In this work, actions, technologies used and improvements made at a national level at energy efficiency were identified. It was pointed out that actions such as pressure control, reduction of losses and reduction of maintenance in the distribution networks can lead to continuous process improvement, minimization of future failures, environmental and financial problems for the institutions responsible for water supply and sewage activities.

id #1672

## Legionella Risk Understanding & Management in Regional Water Treatment Plants

**Ian Bradley<sup>1</sup>**

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In 2014, the Water Corporation instigated the "Legionella High Level Risk Assessment Initiative" (LHLRAI), a prioritised work plan to capture cooling tower assets subject to AS3666.1-4 and the Department of Health WA requirements for assessing Legionella risk (Code Of Practice, 2014). As part of this initiative, inclusion of other "aeration" type assets such as plate aerators and spray basins were assessed and the outcomes compared with compliance against national and available industry best practice standards. Aeration typically forms part of the primary or first treatment step in water treatment. Prior to the LHLRA initiative, treatment efficacy in the context of the level of Legionella challenge was simply not known.

This presentation will focus on and highlight outcomes showing that Legionella control and management in plate aerators and spray basins used in water treatment are not captured within State or National Legislative Frameworks. Furthermore, Legionella monitoring and management in Corporate Systems (I.e. water and maintenance management systems), are considered either inadequate or not captured as a risk. Assessment from End to End engineering suggests that current design, maintenance and operational activities pertaining to Legionella control in drinking water treatment are retrospective perhaps even ad-hoc by nature. This view is deemed consistent where aeration is employed by utilities across the nation

This presentation will explain the background driving the need to understand the growth of Legionella within treatment processes across the organisation.

It will show the methodology developed to understand and assess the risks of Legionella:

- How a multi-stage assessment approach was developed and utilised to gain understand of the risks,
- The tools that were developed and executed to assess the risk of the process assets (including the development of a Legionella High Level Risk Assessment tool),
- The outcomes of those assessments and the mitigations that were deemed required to control the development of environments that promoted biological growth including Legionella.
- It will show the communication methods adopted by the Water Corporation to give the workforce and business a greater understanding of the risks and mitigation being put in place.

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- It will explain the development of an auditing/ sampling process which continues today, which demonstrates improvements in the condition within treatment process assets and shows the effectiveness of the controls and mitigation.

Further to this the paper will explain how the Water Corporation's journey has aligned and increased industrial understanding into a 3-year research and development project that the Water Corporation is performing with the University of New South Wales. Ultimately this has led alignment of engineering and maintenance activities conducted by the Corporation associated with aeration assets across the state with Occupational Health Regulations

id #2457

### Pathogens removal in UASB reactors followed by Sponge-Bed Tricking Filters treating sewage

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The system comprised by UASB reactors followed by sponge-bed trickling filters (SBTFs) has been presented as a promising technology for sewage treatment in developing countries, especially as decentralized systems. Moreover, a further important constructive and operational simplification by eliminating the secondary settling step has been currently addressed (Bressani-Ribeiro *et al.*, 2018). Interstitial biomass retention within the sponge-based media leads to a higher HRT ( $\approx 1.5$ -2.5 h) and sludge retention time (SRT) ( $> 100$  days), which ensures significant improvement for the removal of organic matter and ammonium in SBTFs (Onodera *et al.*, 2013). Nevertheless, the removal of pathogenic organisms in the final effluent is an important aspect frequently not addressed in the literature. This work assessed the influence of a high-rate settler and different types of polyurethane sponge in the removal of total coliforms - TC and *Escherichia coli* - *E. coli*, in a UASB reactor followed by SBTFs without the secondary settling step. A demonstration scale UASB reactor (useful volume: 16.8 m<sup>3</sup>) was operated under a variable flow rate, according to a typical hydrograph flow observed in decentralized sewage treatment plants (PE < 10,000). In the settler compartment of the anaerobic reactor, a high-rate settler comprised by lamellar plates was introduced. The effluent was then routed to the post-treatment, composed of three pilot-scale SBTFs in parallel. For each SBTF, a different sponge was used in terms of average pore size (<0.5 mm, 0.5 mm and 1.0 mm). The UASB/SBTFs system was operated for 6 months, with samples collected weekly. The high-rate settler at the settling compartment of the UASB reactor and the pore size reduction associated with the SBTFs positively influenced the removal of TC and *E. coli* (removals up to 4.9 log units). The high rate settler contributed to the increased removal of fecal contamination indicators (CT and *E. coli*) in the UASB reactor probably because of the greater removal of total suspended solids (TSS), as also suggested by Stevik *et al.* (2004). Therefore, advances in the use of such a structure in UASB reactors can be an important aspect for the improvement of the technology. Even without the use of a secondary settling step after the SBTFs, the system produced a final effluent of similar or higher quality than that observed for natural systems (e.g. wetlands - Calijuri *et al.* 2009) in terms of CT and *E. coli* concentrations. Therefore, the UASB/SBTF system is indeed a valuable alternative when area limitation and discharge restrictions in relation to pathogenic organisms are relevant aspects. This work is important because it presents the influence of design and operation aspects aimed at the operational simplification of UASB/SBTF systems considering the removal of pathogenic organisms.

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id #2186

### A Holistic Approach Making the Island Communities Resilient Against Climate Change Challenges

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This paper will cover the topics of water supply and hygiene, good practice, sustainability of the projects, governance & financial management, and the achievement of SDG 6 to meet the WHO water quality standard.

Presenting 3 projects in implementing solar power water treatment plants in Uripiv, Vanuatu Island, East Cape Village in PNG and on Samarae Maternal Clinic on Solomon Islands. This holistic approach makes the Island communities resilient against climate change challenges.

By implementing simplified technologies, easy access and affordable water is now available in rural remote island areas. In order to guarantee the sustainability of the projects, the paper shows the necessity of intense training of the local operators and service technicians. This enables the community to build up the capacity and ensures that all projects are locally managed.

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We will highlight the technical content, the innovation of the project and the sustainability as well as the potential for scaling up.

- 1. Vanuatu Uripiv Project:** The installation of a solar powered reverse osmosis plant, providing 2300-3000 liters of fresh water per day, is covering the basic needs of 800 villagers every day and the surrounding islanders during the drought season. The project also demonstrates the successful co-operation between 5 different governmental and non-governmental donors.
- 2. East Cape Village, PNG:** A solar powered purification system has been installed to supply approximately 800 people in the village and surrounding 2,000 people with 1,000 litres of safe drinking water per hour. The project was funded by the Alotau Administration in Milne Bay Province. Now the schools do not have to close anymore because of a lack of drinking water.
- 3. Samarai Maternity Clinic, Solomon Islands** In March 2018 a solar-powered direct driven 100 l/h desalination plant had been installed, providing a reliable supply of safe drinking water. Clean drinking water in this rural community's only clinic provides mothers and their newborn babies as well as the surrounding fishermen with a safe source of water.

The paper shows that the operating costs are reduced significantly by using solar power only instead of grid or diesel generators.

id #2281

### Performance monitoring and sludge characterisation of a pilot scale up-flow anaerobic sludge blanket reactor treating domestic wastewater under different organic loading rate

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Domestic wastewater treatment using up-flow anaerobic sludge blanket (UASB) reactor has been successfully demonstrated in the past (Behling et al., 1997). However, proper operating conditions such as optimum organic loading rate (OLR > 1 kg COD m<sup>-3</sup> d<sup>-1</sup>) and limiting up-flow velocity is required for proper granulation in the UASB reactor (Bhunia & Ghangrekar, 2008). A pilot scale 500 m<sup>3</sup> d<sup>-1</sup> capacity UASB reactor located in the campus of IIT Kharagpur, India was monitored for a period of four months at low flow rate of 150 m<sup>3</sup> d<sup>-1</sup>, with the intent to evaluate effect on change in sludge characteristics. Parameters, such as organic matter removal efficiency in terms of chemical oxygen demand (COD), pH and sludge characteristics were estimated using Standard Methods (APHA, 1998). This work was done in continuation to our past work during which, the same UASB reactor was operated at full flow condition making OLR in the range of 0.52-0.81 kg COD m<sup>-3</sup> d<sup>-1</sup> (Chatterjee & Ghangrekar, 2017). Comparison of the UASB reactor performance at low flow rate to the previous full flow rate reflects that the size of the biomass granules was decreased to maximum 1-1.5 mm as compared to the previous stage of operation where the higher granule size up to 3 mm was observed. The total COD removal efficiency was also reduced to 69.41 ± 5.81% as compared to previous phase of full flow rate of operation, when the COD removal efficiency was as high as 84 ± 1%.

Temporal trend of organic matter removal showed higher removal in summer season (69.41 ± 5.81%) and lower removal in the winter season (58.2 ± 4.32%). Lower performance of the UASB reactor at low flow rate can be attributed to the resulting lower organic loading rate (0.34 kg COD m<sup>-3</sup> d<sup>-1</sup>) as compared to the OLR of 0.52-0.81 kg COD m<sup>-3</sup> d<sup>-1</sup> under full flow rate operation. The lower OLR and low substrate availability decreased the granulation in the sludge bed of the reactor. The average settling velocity of sludge was estimated as 33.91 m h<sup>-1</sup>. This was consistent with the settling velocity of granular biomass (31.72 m h<sup>-1</sup>) reported by Bhunia and Ghangrekar (2007). Further, the sludge volume index (SVI) for 5 minute and 30 minutes were estimated to be 19.34 and 22.17 ml g VSS<sup>-1</sup> as compared to the previous phase of operation wherein, the SVI<sub>5</sub> and SVI<sub>30</sub> were reported to be 18.2 and 21.15 ml g VSS<sup>-1</sup> (Chatterjee & Ghangrekar, 2017). Hence, from the above discussion, it may be concluded that the operation of the UASB reactor at low flow rate though marginally has reduced its performance, however it indicated satisfactory performance of UASB reactor even at such low OLR resulting in more than two-third of organic matter removal from the low strength sewage. Variation in UASB reactor performance and characteristics of the sludge developed in the UASB reactor under the different OLRs have been reported in this article, which will benefit the designers and operators of the UASB reactor for sewage treatment.

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id #2476

### Phosphorus fractionalization of hydroxyapatite crystallization process for wastewater effluent

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## SWWS2019 Abstracts

In Korea, T-P value of domestic wastewater effluent standard has been regulated under 0.2 mg/L in water resource conservative areas to prevent eutrophication and algal bloom. Wastewater plants under 500 m<sup>3</sup> capacity have limitations to adapt advanced phosphorus treatment processes including coagulation. There are difficulties of operating coagulation process to dose coagulant, sludge treatment and recovering phosphorus. HAP (Hydroxyapatite) crystallization can be an alternative solution to remove low concentration of phosphorus in wastewater effluent. And also its sludge containing HAP and calcite can be valuable resource without additional sludge treatment. HAP (Ca<sub>5</sub>(PO<sub>4</sub>)<sub>3</sub>OH) is grown by crystallization of phosphate (PO<sub>4</sub><sup>3-</sup>), calcium (Ca<sup>2+</sup>) and hydroxyl ions (OH<sup>-</sup>) in relatively high pH condition. On the other hand, phosphorus exists in various forms and simply classified as reactive/non-reactive, soluble/particulate and organic/inorganic. Physicochemical phosphorus removal treatment could convert soluble phosphorus to particulate phosphorus to achieve extremely low total-phosphorus limits. In this research, transition HAP of phosphorus form is studied according to pH condition in HAP crystallization with additional filtration process.

Experiments were carried out to simulate HAP crystallization and filtration process. Batch reactor (4 L) is installed for dosing 150 mg/L of Ca<sup>2+</sup> and NaOH with pH value 9.0 – 11.0. Filtration column (0.35 L) was filled with 2 – 3 mm limestone media and operated 1 m/hr of linear velocity. TP (total phosphorus) was analyzed in detail as STP (soluble total phosphorus), PTP (particulate total phosphorus, TP-STP), TRP (total reactive phosphorus), SRP (soluble reactive phosphorus), PRP (particulate reactive phosphorus, TRP-SRP), SnRP (soluble non-reactive phosphorus, STP-SRP), and PnRP (particulate non-reactive phosphorus, STP-SRP) to characterize the behavior of phosphorus formation.

The experiment was consisted of 4 steps which were Ca<sup>2+</sup> adjusting, pH adjusting, 10 min slow stirring and filtration. TP concentration was 0.97 - 1.21 mg/L in raw water (wastewater effluent) and consisted of SRP more than 75%. After Ca<sup>2+</sup> adjusting, transition of phosphorus was happened only less than 10%. After pH control, SRP ratios decreased 62 – 80% in pH 9.5 – 11.0. In pH 9.5 and 10.0, SRP was changed to PRP mainly; on the other hand, principle transitions in pH 10.5 and 11.0 were SRP to PnRP. In pH 9.0, less than 1% of SRP had been changed. After filtration step, most PTP (PRP and PnRP) portion was removed so that SRP ratio out of TP became more than 67%. Before the filtration process, TP removal efficiencies were 9 – 50% by PTP settling except pH 9.0 condition. Then, TP concentration of filtration effluent was 0.17 (86% removal in pH 11.0) - 0.69 (28% removal in pH 9.0) mg/L.

In HAP crystallization process, SRP ratios were remarkably changed to PTP (mainly PnRP) in relatively higher pH condition (10.5 -11.0) by hydroxyl ion supply. And also, additional filtration step was necessary to remove PTP effectively. Overall, sufficient hydroxyl ion supply (pH > 10.0) and serial filtration process were recommended for successful operation of HAP crystallization process.

This research was financially supported by Korea Institute of Civil Engineering and Building Technology (KICT), project No. 2019-0229.

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id #2454

## Conceptualizing a Sustainable Water Management System for Rural Human Settlements

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Rural Human settlements (villages) of India suffer from severe water supply and sanitation problems. The problems encountered in the rural human settlements include, a) availability of and access to safe drinking water, b) cattle, cattle dung and urine, and other wastewaters from cattle sheds, c) open defecation and urination and not having toilets, d) not having well defined sewerage and storm water drainage systems, e) heavily polluted and weed infested village ponds, f) declining ground water table and e) deteriorating groundwater quality. In the proposed water management system an integrated approach has been adopted by encouraging the conservative use of water, segregation of wastewater into black and grey water, adopting eco-sanitation for the minimization of black water generation and conveyance of grey water and stormwater into village ponds. Two villages in Doaba region of Punjab state of India were selected for the development of the storm water and domestic wastewater treatment and disposal system. The village pond and its premises have been used for the wastewater and storm water treatment and disposal. Village pond has been conceptualised as comprising of natural treatment systems and low cost treatment techniques like catch basin, constructed wetland, facultative pond, roughing filter, slow sand filter and a provision for recharging of groundwater by the treated water through vadose zone wells. Pond based treatment system works as a passive system requiring no human intervention except for a few pre-monsoon works. In most of the cases the additional land requirement for treatment system was extremely low ranging from 0.06 acre to 2.30 acres which can be easily fulfilled in rural areas. Protecting the groundwater resources and not allowing decline of the ground water table needs groundwater recharging specially with the treated storm water and reclaimed water.

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id #2572

### Treatment of urban Stormwater in pilot-scale vertical flow wetlands packed with different substrate materials

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The objectives of the study were to investigate the pollutants (sediment, organics, and nutrient) removal and the distribution of clogging matters in vertical flow constructed wetlands treating stormwater from urban area. The study site was located at the side of a highway in Seosan City, South Korea. Three parallel pilot-scale stormwater wetlands were designed to treat the first flush collected from the road. Each of the treatment units had a dimension of 1.3×0.6×1.1 m (L×W×H), and consisted of a sedimentation tank for pre-treatment and a vertical flow wetland bed for filtration. These treatment systems were operated in a batch mode, and the water levels in the wetland beds were maintained at the middle of the main substrate to give a saturation and unsaturation zone, which were expected to enhance the nitrogen removal by sequential nitrification and denitrification. These wetlands were packed with woodchip, pumice and volcanic gravel as main media, respectively, and planted with *Acorus Calamus*.

The substrate material affected the treatment performance of the wetlands. The pumice and volcanic gravel wetlands achieved similar and efficient TSS removal of 90%, while woodchip wetland performed worse. Woodchip wetland was the best one in reducing nitrogen due to the enhanced denitrification by the carbon source released from the woodchip. All the wetlands achieved good nitrification that  $\text{NH}_4^+\text{-N}$  was transformed by more than 80%. However, the reduction of TKN by woodchip was poor, which was attributed to the release of organic-N from woodchip. The retention of phosphorus was closely related to the material adsorption capacity. Pumice wetland was the best one in removal of TP by 81% due to the highest adsorption capacity. However, woodchip and volcanic gravel materials were potential of leaching phosphorus, especially in the initial stage, which resulted in worse removal of  $\text{PO}_4\text{-P}$ .

In woodchip wetland, more clogging matters were found both in the top layer and the bottom layer. The reason might be due to the biodegradability of woodchip under wet condition. The clogging matters in the top layer were mainly from the biodegraded woodchip and attached biofilm, while that in the bottom mainly contributed to the settling of the debris peeled from woodchip. For pumice and volcanic gravel wetlands, low densities of the clogging matters in the top layers indicated high content of biofilm. The nutrients from inflow were always firstly trapped by the top layer, which as well as good aeration enhanced the growth of the biofilm. On the other hand, the clogging matters in the bottoms were probably resulted from the broken debris from the media during the packing and discharging.

In conclusion, the gravitational settling could efficiently remove particle and particle-associate pollutants. The difference of substrate material not only affected the removal of TSS, organic matters and nutrient, but also influenced the growth of wetland plants as well as the distribution of clogging matters. For the purpose of optimizing the wetland performance, multiple substrate layers including woodchip and pumice would be preferred.

id #2465

### Pathway to the Adoption of High Rate Algal Ponds for Wastewater Treatment in Rural South Australia

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Rural South Australian communities often depend upon on-site treatment systems for wastewater treatment. Community wastewater management schemes (CWMS), where the wastewater is centrally treated, are implemented where on site disposal results in environmental or public health risks. Many CWMS use 1.4 m deep waste stabilisation ponds (WSPs) requiring a design hydraulic retention time (HRT) of 66d, resulting in a large area requirement, increased capital costs and evaporative loss of water. This paper presents a case study describing the pathway to gain regulatory acceptance and wider adoption of high rate algal ponds (HRAP) as suitable alternate treatment systems for CWMS.

HRAPs are shallow (0.3 -0.5m) raceway ponds, usually mixed (0.2m/s) surface water velocity) by a simple paddlewheel, operated at an HRT between 4 – 10 d. A 250m<sup>2</sup> HRAP has been operated for 10 years treating wastewater from Kingston on Murray, South Australia (population 300). The research demonstrated that the wastewater treatment performance of the HRAP operated at a 10d HRT was at least equivalent to that of a WSP operating in similar climatic conditions.

In 2016, an independent validation, consistent with the Australian *National Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 1)* (NHMRC, 2006,) determined the disinfection performance of the HRAP in winter, by measuring the log<sub>10</sub> removal values for *E. coli* and F-RNA phage. Subsequently, the Local Government Association of South Australia in association with the Department of Health and Wellbeing published *Design Guideline for a High Rate Algal Pond (HRAP) as an Element in Wastewater Treatment Trains*, to facilitate wider adoption of HRAP technology for CWMS in South Australia. Validation using national guidelines also facilitates adoption elsewhere in Australia.

This validation and regulatory acceptance of HRAP technology is unique. The results and the methodology, using risk based national guidelines, to gain adoption of a new technology for rural communities was, in 2019, incorporated as a case study within the *Global Water Pathogen Project* ([www.waterpathogens.org](http://www.waterpathogens.org)).

The shorter HRT of HRAPs reduces the area requirement, the capital cost and evaporative loss of wastewater during treatment when compared with WSPs. Since 2017 the paddlewheel mixing at Kingston on Murray HRAP has been powered using solar panels with battery storage demonstrating potential for adoption by remote communities for wastewater treatment.

The presentation will also consider the unique design and operation of a new CWMS commissioned for the township of Peterborough (population 1700) in South Australia's mid-North. The CWMS is treating wastewater (470m<sup>3</sup>/d) from the township and local abattoir. The treatment plant comprises two anaerobic ponds and two 5,000m<sup>2</sup> HRAPs. The treated wastewater is reused for irrigation of a golf course.

id #2538

## **SWWS2019 Abstracts**

### **Screening and limits to the growth of Microalgae in Anaerobic digestate Food waste effluent.**

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The treatment and valorization of wastewater using microalgae have gained significant attention. Microalgal biomass obtained from the treatment process can be turned into a range of valuable products while simultaneously removing CO<sub>2</sub> and generating clean water. The main purpose of this study was to find microalgal species suitable for the treatment of Anaerobic digestate food waste effluent (ADFE). This effluent has ammonia nitrogen (NH<sub>3</sub>-N) concentrations up to 2000 mg L<sup>-1</sup> which can be toxic to most organisms. In here, we investigated growth and photosynthesis of six (6) microalgae (two *Chlorella spp* termed MUR1 and NIG 1 and four *Scenedesmus spp* termed MUR 2, MUR 3, NIG 2 and NIG 3) in ADFE with various ammonium concentrations. The aim was to screen and identify the most suitable species for the treatment of ADFE. The selected microalgae were previously isolated from other wastewaters and water logs. The results indicated that *Chlorella sp*, MUR 1, could grow well in up to 600 mg L<sup>-1</sup> NH<sub>3</sub>-N and showing a maximum increase in chlorophyll 'a' content of 16.05 µg mL<sup>-1</sup> at NH<sub>3</sub>-N concentrations of 300 mg L<sup>-1</sup>. Through the course of the study, the limits to the growth of the microalgae species will also be studied with emphasis on NH<sub>3</sub>-N concentration, light, mixing rate and the effect of CO<sub>2</sub> addition. Also, the most suitable cultivation system for long term growth of the microalgae species on ADFE will be studied. Findings from this study will provide insight on the effect of NH<sub>3</sub>-N on photosynthesis, the effect of light scattering and shading due to the turbidity and the limit of light absorbance by microalgae in digestate effluent, the effect of varying rates of mass transfer and the effect of CO<sub>2</sub> in relation to pH and carbon utilization.

**id #2560**

### **Sludge Analytics: Design, implementation and performance of a sludge management research programme in Australian water utilities**

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Traditional techniques of measuring sludge height, and thus sludge volume, in waste stabilisation ponds/lagoons (WSPs) include sludge judge. Sludge surveys using these methods are conducted in rectangular grids, with measurements with the apparatus taken from a boat. The number of point measurements taken in each pond is dependent on both the size of pond and the grid spacing chosen by the operator (e.g., 10 m × 10 m spacing). Conducting surveys using these techniques are time consuming, and result in low spatial resolution data. Despite this, the data from these surveys is vital for sludge management, and in the past have been used to create three-dimensional plots of sludge accumulation and distribution. Through the use of GPS-equipped sonar coupled with a remotely operated vehicle (ROV) that we have developed, high-resolution (2-3 m spacing) spatial information of sludge distribution can be collected in less time, with reduced safety risk in a shorter period of time. The sludge management package, called Sludge Analytics, not only includes a boat, but also a simple software package, SludgePro, to manage to interpret the collected data.

We have developed a remote control boat fitted with a sonar unit, to measure sludge height in WSPs. The boat has been tested extensively on ponds to ensure 1) its suitability for operation on WSPs, 2) accuracy of measurements, and 3) high replicability of results. In addition, a data processing system has been developed to help to manage and interpret collected data, and ensure its accuracy. This software developed reads, filters, and plots the height of the sludge measured in WSPs with the sonar. The software package includes a user interface that allows for easy manipulation of files and pond data, as well as a script to perform all of the relevant calculations.

To date the remote control sludge measurement technology has been used on >400 WSPs Australia-wide, and is the standard operating procedure for sludge measurement at four major Australian water utilities. The implementation of this technology by these utilities has not only reduced costs of sludge profiling, but has also contributed to in-house capacity building and improved sludge management planning across the board. In addition to water utilities, the ROV technology has been used to assess bathymetry at WSPs operated by local government councils and major mining companies, as well as rivers and lakes managed by state government agencies.

**id #2272**

### **Genomic and transcriptomic analysis of antibiotic resistance genes in biological wastewater treatment systems treating domestic and hospital effluents in Durban, South Africa**

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The discharge of antibiotics and its residues into the wastewater treatment plants (WWTP's) creates a conducive environment for the development of antibiotic resistant pathogens. This presents a risk of potential dissemination of antibiotic resistant pathogens and antibiotic resistance genes into the environment. It is therefore necessary to study the level of antibiotic resistance genes (ARG's) among bacterial pathogens that proliferate in biological wastewater treatment systems. In the current study, metagenomic and meta-transcriptomic sequences of samples collected from the influents, secondary effluents and post chlorinated effluents of three wastewater treatment plants treating domestic and hospital effluents in Durban, South Africa, were analyzed for profiling of ARG's among bacterial pathogens. Results show that a variety of ARG's, mostly, aminoglycoside, β-lactamases, tetracycline and sulfonamide resistance genes were harbored by diverse bacterial genera found at different stages

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of treatment. A significant variation in diversity of pathogen and ARGs between the treatment plant was observed, however, treated final effluent samples from all three plants showed a significant reduction in bacterial pathogens and detected ARG's. Both pre-and post-chlorinated samples showed the presence of mobile genetic elements (MGE's), indicating the inefficiency of chlorination to remove of ARG's integrated with MGE's. In conclusion, the study showed the wastewater treatment plant efficiently caused the reduction and removal of certain ARG's, even though the initial focus was the removal of biological nutrients.

id #2496

### Beyond residential water efficiency – the case for greywater reuse and the West Australian Greywater Guide

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Perth has the second highest per capita water consumption of any Australian capital city with 42% of its mains water supply used on residential lawns and gardens<sup>1</sup>. This amounts to around 116,000 litres per year for the average Perth household. Public education campaigns and improvements in technologies have been effective in slowing Perth's per capita water consumption, however the available benefits from water efficiency measures alone must naturally decline to a point where substitution with fit-for-purpose water is required if any further savings in mains water supplies are to be achieved. Household greywater, which amounts to 146,000 litres per year on average for a family of four<sup>2</sup>, can make a substantial contribution towards reaching this goal.

The West Australian Greywater Guide – a multiple State agency funded initiative – has recently been published as an initiative of the Greywater and Wastewater Industry Group (GWIG) to provide a freely available, authoritative and informative guide on how to reuse greywater for residential irrigation in a digital format. It is envisaged that the Guide will not only dispel many of the myths surrounding greywater in the broader community, it will act as a helpful 'go to' source of reliable information for builders, architects, developers and the general public.

The Guide represents one part of a larger strategy that GWIG has articulated in an attempt to increase the uptake of residential greywater systems in Western Australia. Broader acknowledgement of the multiple benefits of greywater reuse that flow to the state and the environment, such as the potential to defer energy intensive mains water and wastewater infrastructure upgrades, is required if greywater's full potential is to be realized.

id #2450

### Enhanced power generation in microbial fuel cell by the application of novel low-cost goethite supplemented clayware proton exchange membrane

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Microbial fuel cell (MFC) is a wastewater treatment system where electricity can be recovered as an added advantage. Proton exchange membrane (PEM) plays a significant role during proton transport between anaerobic anodic and aerobic cathodic chamber, and maintains anaerobicity in anodic chamber in membrane based MFCs. Nafion 117 is the most commonly and widely used PEM having excellent proton conductivity and considered as one of the best PEM [1]. In spite of its excellent proton transport capacity, excessively high cost, less proton selectivity [2] makes this membrane unsuitable for scaling-up of MFCs. Clay mineral based membranes have been previously reported as a low-cost alternative PEM [3] and popularly used for scaling-up [11, 12]. Low cost, thermally and chemically stable nature, suitability to withstand higher water head, and easy availability make these membranes most suitable for scaling-up [6]. Terracotta [7], red soil (typically rich in aluminium and silica) [8], black soil (rich in calcium, iron and magnesium predominant) [8], kaolinite and montmorillonite blended [9] clayware membranes have been experimented in MFCs and excellent performance was reported by previous researchers. Montmorillonite blended (20 %, M-20) clayware cation exchange membrane [9] demonstrated comparable cation transport number when compared with Nafion 117. Among different clay based PEMs, M-20 was found superior to other clayware modified membranes, however the proton diffusion coefficients of montmorillonite membrane was reported approximately 30 % lesser than Nafion 117 membrane [9].

Mining mud goethite comprising of oxides and hydroxides of iron is a waste material and it was previously used as an anode catalyst in MFCs [10]. As a waste material, goethite is very low cost and reusing it is advantageous from the environmental point of view. Goethite also forms through weathering of other iron-rich minerals and it is commonly found in laterite soils [11]. The goethite is having loosely bonded hydrogen ions [12]. Presence of loosely bonded protons in goethite enables it for protons transport. An excellent proton dynamics on goethite mineral surface was also previously investigated [13]. A novel membrane containing 5 % goethite (G-5) and natural clay as base material was synthesized and used in MFC as separator. The G-5 membrane was found to be six fold cheaper than costly Nafion membrane, which is generally used in MFC owing to its higher proton conductivity. Relevant membrane properties like water and acetate uptake, proton conductivity etc. of G-5 membrane was tested and compared to that of Nafion. Power generation using MFC with G-5 as membrane (112.81 mW/m<sup>2</sup>) was also slightly higher as compared with the MFC using Nafion membrane (106.95 mW/m<sup>2</sup>). Thus, the low-cost G-5 membrane can replace costly Nafion in MFCs, hence reducing the fabrication of MFCs. Simultaneously; G-5 membrane would also recover comparable power from wastewater using MFC in comparison to expensive Nafion. Thus, the novel low-cost goethite supplemented clayware membrane can replace costly Nafion in MFC, thus paving the way for successful field scale applications of MFCs.

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id #2591

### Water Generation by Condensation for Stand-Alone Autonomous Hydrogen-Based Energy Systems

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A remote 100% renewable stand-alone energy systems using hydrogen-based energy storage is a promising pathway for supplying energy to isolated autonomous systems. The 100% renewable hydrogen-based energy system reduces the wasted excess energy and increases the reliability by extending the system energy autonomy. The cleanest hydrogen production pathway is water electrolysis which is interoperable with solar PV and wind renewable energy generation. The main challenge of utilising hydrogen in isolated autonomous locations is the water requirement for hydrogen electrolysis. The water required for hydrogen production is ten litres of water per kg of hydrogen which contains 33.33 kWh of usable energy at the lower heating value.

In this research study a water condensing system from atmospheric air was modelled, simulated and evaluated to supply the electrolyser for hydrogen production. The water condensation from the atmospheric air depends on the ambient temperature and absolute humidity. The energy requirement for the condensation system have been calculated and interconnected to the energy system size and the ambient temperature and humidity. Water claiming system from the fuel cell power regeneration to reduce the water intensity of the power to hydrogen to power system has been introduced for further investigation.

id #2208

### REMEDICATION OF NITRATE-CONTAMINATED GROUNDWATER IN A BIOELECTROCHEMICAL SYSTEM

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Nitrate-contaminated groundwater is one of the main water pollution problems in several regions around the world. Among the most recent alternatives for nitrate removal, the Bioelectrochemical Systems (BES) stands out. The BES employs bioelectricity generated from oxidized organic compounds to improve nitrogen reduction to nitrogen gas by heterotrophic denitrification. The objective of this study was to evaluate a BES, in pilot-scale, applied to nitrate removal from synthetic groundwater in different operation modes: open circuit (OC), the microbial fuel cells (MFC) mode (without externally applied potential), and the Microbial Electrolysis Cell (MEC) mode (with an externally applied potential). With the addition of an external potential, nitrate removal improved. Nitrite production had a significant value only through OC mode (1.1 mgN.L<sup>-1</sup>). The denitrifying BES reduced nitrate mean concentration from 26.0 mgN-NO<sub>3</sub><sup>-</sup> to less than 8.3 mgN-NO<sub>3</sub><sup>-</sup> in all operation modes. This concentration was even lower through MEC modes (less than 3.1 mgN-NO<sub>3</sub><sup>-</sup>). The system was able to improve water quality to meet the standards by the World Health Organization and the evaluation of different operation modes showed that the highest removal efficiency achieved was 96.3% through MEC mode with 0.5 V. **BES performance:** The COD/N rate applied mean values were 2.2, 2.1, 1.9, 1.9 and 1.8 (mg.mg<sup>-1</sup>) on OC, MFC, MEC 0.3V, MEC 0.5V and MEC 1.0V modes, respectively. Although it was a smaller C/N rate than the usually applied, it was observed a significant nitrate removal rate, especially through MEC modes. The applied nitrate concentration rate had an average of 0.06, 0.061, 0.062, 0.063 and 0.063 gNO<sub>3</sub><sup>-</sup>.L<sup>-1</sup>.cathode.d<sup>-1</sup> and resulted in nitrate rates in the treated effluent of 0.020, 0.010, 0.08, 0.002 and 0.006 gNO<sub>3</sub><sup>-</sup>.L<sup>-1</sup>.cathode.d<sup>-1</sup>. Thus, removal efficiencies were 67.8, 77.6, 87.9, 96.3 e 90.6%, for OC, MFC, MEC 0.3V, MEC 0.5 V and MEC 1.0 V modes, respectively. **Conclusions:** All different configurations resulted in a nitrate mean concentration compatible with the WHO guidelines. CEM mode was statistically superior to OC and MFC modes, especially with voltage application of 0.5 V. It has achieved the highest removal efficiency (96.3±4.6%) and the

lowest mean concentration of nitrate in the treated effluent ( $0.96 \text{ mgN-NO}_3 \cdot \text{L}^{-1}$ ) of this study. Despite the lower efficiency, OC and MFC modes are a better alternative when considering the energy costs, once there is no need to apply external voltage. OC mode achieved a nitrate removal efficiency of  $67.8 \pm 15.4\%$ , but nitrite accumulation occurred, characterizing incomplete denitrification. MFC mode achieved a nitrate removal efficiency of  $77.6 \pm 6.3\%$ , without nitrite accumulation and with a positive energy balance of  $0.03\text{-}0.10 \text{ V}$ . Some aspects of bioelectrochemical systems performance still need to be evaluated by further studies, as the long-term and real-scale implementation. However, bioelectrochemical systems are a promising economical and efficient alternative for nitrate-contaminated groundwater treatment.

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id #2597

### Innovative decentralized water treatment and reuse project for 400 households and local industry, including water, nutrient and energy recovery (Run4Life)

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In the perspective of a sustainable urban bio-economy, there is an urgent need to redesign the currently used centralized WWTPs<sup>1</sup>. A paradigm shift is needed to cope with the global challenge of water scarcity and the WWTPs in the cities of the future should be regarded as an integral part of the municipal water production process<sup>2</sup>. Instead of centralizing sewage treatment in major WWTPs considered as a cost factor, we want to demonstrate the possibility to decentralize municipal wastewater treatment and to develop small-scale and profitable water resource recovery facilities (WRRFs).

To demonstrate the potential of urban resource recovery, a remarkable decentralized wastewater treatment project is developed in a new eco-district in Ghent, Belgium, called the "Nieuwe Dokken". An innovative multi-step treatment concept, referred to as ZeroWasteWater<sup>3</sup>, is set up at full-scale for 400 households (1265 IE). The approach is based on source separation of the grey (GW, sanitary) and black (BW, toilet) wastewater. The water cycle will be closed by capturing  $>35.000 \text{ m}^3/\text{j}$  treated effluent directly and restore it to process water for the nearby industry. Innovative online monitoring is applied to manage and control the microbial water quality of the reused water.

The BW is collected undiluted by means of vacuum toilets and a vacuum collection system. The segregated BW is mixed with collected kitchen waste (KW) and treated anaerobically in an anaerobic digester. The produced biogas energy is recovered as heat ( $50\text{-}100 \text{ MWh}_{\text{th}}/\text{y}$ ) and distributed back to the households by a district heating system. The effluent is further treated in a struvite crystallization reactor, allowing phosphate recovery and reuse as fertilizer ( $>1600 \text{ kg}/\text{y}$ ) in urban farming projects.

GW has the highest energy potential to recover, about  $700 \text{ MWh}_{\text{th}}/\text{y}$  by collecting it at  $25\text{-}28^\circ\text{C}$ . Separate collection and heat recovery through heat exchangers allows to transfer most of the energy to the district heating system. Together with the energy recovery through biogas, almost  $1/3$  of the total heat demand of the urban area ( $2,1 \text{ GWh}/\text{y}$ ) is provided by the WWTP. The GW is further treated in a membrane bioreactor (MBR). The MBR consists of two compact units with  $90 \text{ m}^2$  membrane surface each, using newly developed PVDF ultrafiltration membranes.

Close to the new urban area, a hygiene chemicals producing factory is located. The production process requires  $>35.000 \text{ m}^3/\text{y}$  soft process water and  $15.000 \text{ m}^3/\text{y}$  demineralized water ( $<20 \mu\text{S}/\text{cm}$ ). This complete water need is met by reusing the treated effluent of the decentralized WRRF. To meet the quality requirements, reverse osmosis is the key technology. High quality water, free of pathogens, nutrients and hardness is achieved and completely reused in the factory. Hence, the decentralized WRRF can be considered as a zero-discharge installation. Online flow cytometric monitoring is being used to continuously measure the bacterial cell concentration in the reclaimed water, in order to safeguard the bacterial water quality of the water, and to increase the trust and public acceptance for urban water reuse<sup>4</sup>.

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The Nieuwe Dokken project is part of Run4Life, funded by the EU H2020 program CIRC-01-2016-2017 (<https://run4life-project.eu>).

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id #2553

### Set up Reverse Osmosis (RO) Desalination Plant, Testing Operation, Brine Disposal and Photovoltaic (PV) Standalone Power System

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The Murdoch University and Alliance Moerk Water Solutions have set up solar PVRO desalination plant at Muresk Institute Farm, Northam on 21st, June 2019. The reverse osmosis (RO) desalination unit model 500BW-lily with an assembly of solar photovoltaic (PV) will shortly undergo construction, testing, and commissioning.

A suitable bore will be necessary nearby in which the influent has salty water. There were three existing bores where at the windmill, old well and piggery site, respectively. Among the three bore locations, the water at the piggery site bore water has the lowest pH, the highest conductivity, and the highest amount of chloride, and sulphate. However, it is not practical to use it as the source of brackish water due to the high potential to be contaminated and high risk to be flooded when the rain comes. As a result, the management decided to use to the old well bore as the source of water (site 16B). The water quality at the old well was tested on June 10th, 2019, and the result was 7.22 for pH, 1.988mS/cm for conductivity, and other water quality parameters in minimal results.

The RO desalination unit model 500BW-lily which was designed and manufactured by Moerk Water Solutions and aimed to produce 500L/h of potable water from the salty water. It was estimated to be operated of 6 to 8 hours per day, depending on the weather conditions and seasons and producing up to four thousand liters per day with the recovery rate, depending on the raw water quality, of approximately sixty percent (Moerk Water Solutions 2019).

The RO desalination unit powered by 5kW solar PV standalone power system, which was made up of 14 solar modules and 320W per module, charge controller Victron Energy, inverter Victron Phoenix, 4 x 12V deep cycle batteries to ensure safe shutdown of the plant, and other components (Moerk Water Solutions 2019).

A literature review focused on brine disposal methods and recommendations. The recommended brine disposal is the focus of the present study. It is a series of the small ponds and valve piping systems, which provides profitable and sustainable grazing by the perennial forage shrubs in the 200meters distance between the RO desalination unit to the evaporation ponds. Therefore, it is likely to bring a parallel income to the farmers. The early results of this brine disposal methods will be presented in the paper.

id #2470

### Selected freshwater Macrophytes to assess lakes macro and micro Elements contamination of Thaltej and Nikol lakes at Ahmedabad, Gujarat, India.

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Ahmedabad is unique in the whole of India in matter of environmental neatness and flourishing conditions and it is superior to other cities in the excellence of its monuments. Ahmedabad Urban Development Authority (AUDA) proposes to undertake work for revival, development of catchments areas and beatification of few lakes under the present project. Thaltej and Nikol lake's waters were analysed for macro and micro contaminations. The results values of the metals estimated through 2 lakes during - 2011. Their ranges of concentration were comparing to permissible limit of WHO, ICMR. Na<sup>+</sup> content of *Eichhornia crassipes* spp. And syprus spp. from all localities were within the permissible limit of WHO except of Thaltej lake -2011. Potassium content of *Eichhornia crassipes* spp from Thaltej lake was within the permissible limit of WHO. Fe<sup>2+</sup> contents of *Eichhornia crassipes* spp. From Thaltej lake-2011. Zn<sup>2+</sup> Content of *Heliotropium europaeum* L. spp from Nikol lake-2011, Copper content of *Eclipta alba Hassk.* spp from Nikol lake were within the permissible limit of WHO except -2011. Mn<sup>2+</sup> contents of *Lemna* spp from Thaltej lake-2011. Based on the concentration and toxicity status observed in the lakes vegetation, the six element are arranged in the following descending order: Cu > Zn > Mn > Fe > K > Na compared with the standard, normal and critical toxicity range in plants. Were analyzed for, Na, K, Fe, Zn, Cu And Mn Contamination. The greater accumulation of nutrients was observed in Thaltej *Eichhornia crassipes* and poor content in *Eclipta alba Hassk.*

id #1587

### Participatory Water Security Planning to Transform Water Stressed Apartment Buildings to Become Water Sufficient - Case Study of a Pilot Program in the city of Bengaluru, India

# **SWWS2019 Abstracts**

## **Bhakti Devi<sup>1</sup>**

1. *NEER Infinite, Bangalore, KARNATAKA, India*

Bangalore had an estimated population of 12.34 million in 2017. It is the fastest-growing Indian metropolis, growing a whopping 38% from 1991 to 2001. Bangalore water supply from Cauvery has been unable to keep up with the city's rapid growth in population. It is further challenged by the fact that groundwater reserves under the city have been polluted and over-exploited. It is estimated that the groundwater resources have declined on an average by 130% over the past 10 years. Bangalore's centralised water system along with its sewerage system has reached a near crisis point which has manifested in the form of the water authority of the city - Bangalore Water & Sewage Service Board (BWSSB).

1. restricting the Cauvery mains water supply to existing buildings
2. not providing its water and sewerage services to several buildings that have been constructed in recent years outside the areas of the current water distribution & sewerage system
3. mandating rainwater harvesting for all buildings & on-site sewage treatment plants (STPs) for new buildings.

Consequently, a growing number of existing residents in Bangalore are forced to make their own arrangements to secure their water without much support in helping them navigate through numerous vendors & suppliers offering many different types of technologies. This has resulted in.

1. Residents relying on unsustainable water sources such as - private water tankers and by deep bore-wells
2. Poor execution of rainwater harvesting and sewage treatment plants with no improvement to water security status.

This paper presents the findings of a pilot program that is being run with select number of apartment buildings in the city of Bengaluru to help them transform from being water stressed to becoming water sufficient by taking a participatory approach involving the residents in identifying full suite of decentralised water solutions to retrofit the buildings. The findings and insights from the pilot program will be analysed and discussed with respect to

- 1) the outcomes of the pilot in terms of the water sufficiency achieved from implementation of the solutions that were identified
- 2) what elements of the program design worked well and which ones did not
- 3) transformation in the capacity and behaviour of residents in their understanding of how the water system works in the building of their residence
- 4) the type of decentralised water solutions that emerged for different typologies of apartment buildings
- 5) lastly, implications of scaling the pilot program across the city for city's water security status and the investments planned for expansion and upgrading of ageing and under capacity centralized infrastructure for water, sewage and storm-water

**id #2672**

## **Regional Towns Water Quality Improvement Program - Innovative approach to meet community needs**

### **Dharma Dharmabalan<sup>1</sup>**

1. *Dharmabalan, Highton, VIC, Australia*

Capital cities do generally have access to many facilities for livability and enjoy life. However regional towns across the country are left to battle to gain access to basic needs such as safe drinking water and sanitation. Even though the regional towns contribute to the economic well being of the city population, due to their size and distributed population spread, water and waste water systems are considered to be unviable on financial merits.

The state of Tasmania with a population of 500,000 people spread across the state are serviced by 64 water and 113 wastewater systems managed by TasWater. There were number of water systems (>30), on permanent boil water advisory due to poor assets able to deliver and to meet the safe drinking water guideline requirements. The presenter will talk about how the whole states water systems were transformed into good drinking water supply systems within a short time frame (24 months) by adopting innovative designs, construction and operations.

The presentation will also provide details on the challenges faced, community feedback from schools, nursing homes, hotels, the improved economic activities in the regional townships and increased tourist numbers spending more time in the townships, since the introduction of safe drinking water.

Strong bold leadership coupled with political Will contributed to the successful completion of this regional towns water quality program in Tasmania which **Won the National Infrastructure Partnership Australia Operator & Service Provider Excellence award 2019**

**id #2318**

## **The Triple Bottom Line: Meeting Promoter Budgets, Patron Expectations and Regulatory Approval At Music Festivals in Australia**

### **Strider Duerinckx<sup>1</sup>, Heather Murphy<sup>1</sup>, Mei Wong<sup>1</sup>**

1. *Whitehead & Associates Environmental Consultants, Bellingen, NSW, Australia*

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Music festivals in Australia are big business, attracting thousands of patrons for short periods of time, and generate large quantities of waste. And because their locations are often remote to provide appropriate noise buffers to offsite residents, but as a result reticulated services are not provided.

These festivals usually operate on strict time limited development approvals of 2-5 years, and as they occur once or twice a year at a location management of wastewater generation is problematic. Who wants to invest in sophisticated wastewater treatment plants and land application solutions when the plant sits idle for months on end, or there is a risk that the system will only be in the ground for <5 years?

Regulatory authorities struggle to deal with the approvals process for the management of the wastewater generation, and their own sewage treatment works cannot cope with the sudden influx of hundreds of thousands of litres of wastewater. And what do the patrons expect or even care about given the <20 year age profile?

This paper compares and highlights four music festivals around Australia, in Queensland, New South Wales and Victoria (Woodford Folk Festival, Splendour in the Grass / The Falls Festival, Rabbits Eat Lettuce, and Rainbow Serpent Festival): the original approved wastewater management systems; and the refinement of upgraded wastewater systems through discussions and education between the three stakeholders – promoters, regulatory authorities and patrons.

**id #2190**

### **Faecal Sludge Management Diagnostics**

**Mark Ellery<sup>1</sup>**

1. *Self Employed, Fremantle, WA, Australia*

The sanitation sustainable development goal (SDG) is primarily defined by target 6.2 *“By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations”*

The WHO / UNICEF Joint Monitoring Programme (JMP) has defined the attainment of a safely managed service as the *“use of improved facilities which are not shared with other households and where excreta are safely disposed in situ or transported and treated off-site”*.

For on-site sanitation systems, this has increased the emphasis on the ensuring that faecal waste from improved facilities are safely emptied, transported, treated, disposed of and/or re-used. This increased focus on faecal sludge management has led to the evolution of a series of diagnostic tools (e.g. [Shit Flow Diagram](#)) to estimate the levels of access to a 'safely managed sanitation service'.

Drawing on the faecal sludge management assessments in various country contexts (Bangladesh, Nepal, Bhutan, Papua New Guinea, Kiribati and Rwanda), this presentation seeks to highlight the:

- common failures in the maintenance,
  - associated with failures in the operation,
  - associated with failures in the design,
- of on-site sanitation systems.

In almost all cases assessed, the major faecal exposure risks arise from a failure to manage the faecal liquid (supernatant / effluent) rather than the faecal sludge. In responding to these failures, it is recommended that sanitation practitioners need to:

- better understand the comparative advantages of aerobic and anaerobic digestion processes
- pay greater attention to the management of the liquid entering and leaving on-site systems
- utilize pit emptying information to more accurately diagnose faecal exposure risk pathways

**id #2541**

### **A quantitative and qualitative assessment of hybrid water systems: integration of smart metering technology and community participation**

**Roberta Dr Fornarelli<sup>1</sup>, Martin Anda<sup>2</sup>, Stewart Dallas<sup>2</sup>, Mario Schmack<sup>1</sup>**

1. *Curtin Institute for Computation, Curtin University, Bentley, WA, AU*

2. *Murdoch University, Murdoch, WA, AU*

Smart metering and data analytics enable the implementation of a range of onsite infrastructures for energy, water and waste management to demonstrate the interconnected infrastructure of future smart cities. A smart city funded project in Western Australia enabled the integration of hybrid water systems, smart metering technology, household participation and data analytics. Better understanding of hybrid water systems at residential scale, as socially accepted solutions to promote water efficiency and economic savings, within the traditional centralised urban water network was targeted.

As part of the smart city funded project, 66 ultrasonic smart water meters were installed in August/September of 2018 at 36 participating households within the City of Fremantle, Perth, Western Australia. The number of sites with hybrid water systems (rainwater tank, greywater recycling diversion system and groundwater bore) was 16 and the sites with mains connection only was 19. Water usage data has been collected at half an hour intervals from the mains water connection, rainwater tank outlet, greywater diversion system and groundwater bore.

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The objective of this paper is to characterise and compare water demand and supply across the cohort of selected households characterised by either a traditional water system (i.e., connected to the centralised water supply and sewerage network) or a hybrid water system. The analysis of water usage data is supported by qualitative data on the residents' water practices, collected through community participation initiatives such as sites assessments, community focus groups and workshops.

The same trend in time is measured at mains-only and hybrid sites with higher water demand during the summer months from December to March. The total water demand is statistically similar between mains-only and hybrid sites, however the demand of energy-intensive potable water from the mains connection is significantly lower in hybrid sites comparing to mains-only ones. At the hybrid sites with a groundwater bore, a large portion of water demand was supplied by bores for outdoor irrigation. Water from the mains connection was the main source of water at the hybrid sites with rainwater tanks and greywater diversion systems with the lowest contribution of rainwater during the summer months. Recycled greywater usage for outdoor irrigation of private gardens was stable for the whole year around, making this water sources particularly interesting as it is climate independent.

The integration between hybrid water systems, advanced metering technology, data analytics and community engagement is beneficial to inform researchers, engineers, water utilities and policy makers towards an optimal, sustainable and holistic integration of decentralised and centralised water resources at urban scale.

**id #2640**

### **Greywater reuse – scale opportunities and risks**

**Eran Friedler**<sup>1</sup>

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Population growth, accelerating urbanisation and climate change, continuously exert pressure on existing water resources all over the globe. One possibility for alleviating this everlasting pressure is to develop alternative water sources to be used for non-potable uses, such as toilet flushing and garden irrigation. Decentralised greywater (GW) treatment and reuse can act as one of these alternative water sources, reducing domestic water consumption and contributing to more sustainable water use in urban (and rural) areas. Indeed, in recent years, onsite GW treatment and reuse has gained attention by researchers, practitioners and governments, with tens or hundreds million units worldwide. However, GW contains various pollutants that potentially can pose threat to public health and impair the environment if not performed after proper treatment. Furthermore, onsite water reuse reduces domestic sewage flow and thus may affect existing sewer network and municipal wastewater treatment plants.

The talk will portray a holistic overview of of GW reuse. It will first discuss motivations, benefits and impediments. Then, associated risks and the way to reduce them will be quantified, among them: presence of micropollutants of emerging concern and performance of a unique AOP (advanced oxidation process) to remove them will be described; concentrations of selected pathogenic microorganisms and QMRA (quantitative microbial health risk) of untreated and treated GW will be described. Finally, the sustainability of GW reuse systems will be assessed using LCA methodology. If time permits, interactions with existing sewer infrastructure will be also discussed.

**(This is an invited talk)**

**id #1969**

### **From energy consumption to energy production: blackwater anaerobic treatment in modern sanitation**

**Mengjiao Gao**<sup>1</sup>, **Bing Guo**<sup>1</sup>, **Lei Zhang**<sup>1</sup>, **Yingdi Zhang**<sup>1</sup>, **Najiaowa Yu**<sup>1</sup>, **Yang Liu**<sup>1</sup>

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New sanitation with source separation accompanied by on-site treatment is gaining attention as a result of greenhouse gas emissions from fossil fuels, fresh water deficiency and pollution, and inadequate hygiene in impoverished areas throughout the world. Human excreta, as blackwater, can be treated separately from remaining domestic wastewater to achieve the recovery of nutrients (Nitrogen & Phosphorus) and energy (biogas) during the removal of organic pollutants through anaerobic digestion. This would allow for the remainder of the less polluted wastewater, greywater, to be treated for domestic reuse. The feasibility of anaerobic blackwater treatment has been demonstrated in the past decades, yet insightful investigations regarding the optimal operational conditions, inhibitions and limitations, metabolic pathway, and microbial community development remain insufficient. This study systematically examined blackwater anaerobic digestion by investigating blackwater characterization, inhibition factors, the microbial consortia establishment, and treatment and process optimization. The aims of this study are to maximize blackwater treatment efficiency and minimize capital and operational costs.

Laboratory-scale batch test results revealed the limitation that the high free ammonia concentration of 393 mg/L in vacuum toilet blackwater could reduce the reactor's methanisation rate from 48% to 34% of the total chemical oxygen demand (COD) input at 35 °C. This inhibition was then successfully mitigated in continuous vacuum toilet blackwater treatment by step-wise acclimatizing the microbial communities to the ammonia tolerant groups using an up-flow anaerobic sludge blanket (UASB) reactor. The 16s rRNA gene sequencing results indicated that unlike most digesters dominated by acetoclastic methanogenesis, the microbial composition of the blackwater was altered by hydrogenotrophic methanogenesis, with specific hydrogenotrophic methanogens enriched throughout the treatment. These methanogens generated relatively high specific methanogenic activities (SMA) (up to 0.49 [±0.01] g CH<sub>4</sub>-COD/g VSS/day utilizing H<sub>2</sub> and CO<sub>2</sub> to produce CH<sub>4</sub>), which enabled superior methanogenesis. In this case, a high COD removal efficiency of 84% and a high methanisation rate of 44% (close to the maximum feed digestibility 48%) were achieved under a maximum organic loading rate (OLR) of 4.1 kg COD/m<sup>3</sup>/day in the vacuum toilet blackwater UASB operation. This OLR resulted in the lowest reactor volume (capital cost) required for vacuum toilet blackwater treatment to date.

Overall, our study has provided insightful operational and fundamental information on blackwater anaerobic treatment. This solution offers a sustainable net-energy-positive alternative to treat domestic wastewater with minimized capital cost.

## A preliminary sewerage & waste water treatment design for the Gympie Music Festival

**Ted E GARDNER<sup>1</sup>, helen H FAIRWEATHER<sup>2</sup>, wade W WALSH<sup>2</sup>**

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Over the last few years, wastewater management for the Gympie Muster event has become a financial burden, with costs becoming economically unsustainable. A new method of wastewater management is required by the Gympie Muster Ltd to meet regulatory and society's expectations, address environmental concerns, provide assurance of wastewater management, and to achieve an economically viable solution for future years. The primary objective of this thesis is to review wastewater treatment and sewerage reticulation technologies that is appropriate to decentralised music festivals such as the Gympie Muster, as well as develop a specific, high-level costed preliminary sewerage proposal for Gympie Muster Ltd that it can use for subsidy applications and business case developments. The most economical way to handle wastewater is the primary concern, but any of the proposed collection and treatment systems must provide a waste disposal service for patrons that is safe, effective and efficient. There is no sewerage infrastructure on the Muster site. Four potential sewage collection options are considered in this thesis; gravity, pneumatic, vacuum and pressurised sewerage collection systems. A subsequent treatment system was designed based on literature findings, discussions with practising professionals, and infrastructure limitations at the Amamoor Creek site on which the Muster is held each year. The treatment method consists of pre-screening, anaerobic pond primary treatment, a single-pass sand filter, disinfection and storage for subsequent irrigation end-use on adjacent pasture. The water balance of the pond-irrigation area was explored using the effluent irrigation model, MEDLI. Costings of the proposed reticulated sewerage options found no options were economically viable, incurring a substantial loss over 20 years compared with the existing truck pump out system. However, the proposed treatment system, including an enlarged, covered anaerobic pond, and a single-pass sand filter, followed by spray irrigation on adjacent pasture land, had substantial positive economic benefits. It is strongly recommended to Gympie Muster Ltd as a practical means of sustainably and economically treating the wastewater generated at their yearly Muster events.

## Low-energy water sterilization in a hot bubble column evaporator (HBCE)

**Adrian Garrido Sanchis<sup>1</sup>, Ric Pashley<sup>1</sup>**

1. University of New South Wales, Canberra, ACT, Australia

The use of recycled water, for example in agriculture, is an invaluable resource that presents clear advantages for the environment, reducing the pressure on water resources, as it is a constant water source. However, it also presents some potential risks, such as by the presence of enteric pathogens, that could contaminate vegetables and fruit.

In this work, a laboratory scale hot bubble column evaporator (HBCE) was developed into a small-scale pilot plant, named the hot bubble pilot plant (HBPP). In the hot bubble column, pathogen inactivation occurs due to the hot gas bubble-pathogen collisions. The laboratory HBCE was used to acquire the necessary data for the first pilot plant design and construction. Several variables were studied: **first, MS2 virus (ATCC 15597-B1) and bubble charge interactions**, based on the reduction of their repulsive forces, were controlled by the use of appropriate electrolyte solutions[1]; **second, inlet gas temperatures were varied** and when increased[2], so did the thickness and the temperature of the transient heated water layer surrounding the rising bubble surface (according to our model) and **third, inlet gas type was varied, and it was found that CO<sub>2</sub> gas and combustion gases** gave the best inactivation results with viruses and O<sub>2</sub> gas was found to be the most effective for the destruction of *Escherichia coli* C-3000 (ATCC15597)[3,4].

The experimental studies and data acquired in this work have provided the basis for the hot-bubble pilot plant design and construction. The new pilot plant used hot air and hot combustion gases to successfully inactivate *E.coli* (ATCC15597) in the laboratory experiments in different synthetic solutions, and then at the farm with real pathogens such as: bacteria (salmonella, *E.coli*, and Thermotolerant coliforms); protozoa (*Giardia*); and *Cyanophyta* algae present in the real effluent.

Many industries, such as pig farms, landfill, biogas plants, and coal power plants, emit large amounts of hot combustion gases. The potential use of these hot combustion gas bubbles in water-treatment processes to sterilize water offers an attractive new energy-efficient technology. This new technology would then be able to compete with other water-disinfection technologies, such as UV irradiation, ozonation, and even chlorination, due to its low operating costs and its energy efficiency.

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## **SWWS2019 Abstracts**

### **The cultivation of a mixed microalgal consortium in the optimal concentration of anaerobically digested domestic effluent (ADDE)**

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Publish consent withheld

**id #2283**

### **Hydrothermal carbonization for treatment and reuse of wet organic waste**

Amit Gross<sup>1</sup>

1. *Zuckerberg Institute for Water Research , Blaustein Institutes for Desert Research, Ben Gurion University of the Negev , Midreshet Ben Gurion, Israel*

Wet organic waste such as, sludge, manures and food waste require treatment prior to disposal or reuse. Traditional treatments are often not complete and generate pollution. Hydrothermal carbonization (HTC) has been recently suggested as an attractive alternative for treatment of wet organic waste. During HTC wet organic waste transforms into value-added products while minimizing excess pollution. HTC is a thermochemical process that typically, ranges between a few minutes and several hours, in which wet biomass is heated to temperatures ranging from 180–250 °C and self-generated pressure that maintains water in a subcritical state. During the process, mainly hydrolysis, decarboxylation and dehydration reactions occur, resulting in mass loss, mainly of oxygen and hydrogen molecules. As a result, a carbon-rich solid phase with high calorific value, referred to as hydrochar, a nutrient-rich aqueous phase and some excess gas are formed. Depending on the feedstock material, hydrochar has various potential applications, such as nanostructured and adsorbent materials, soil amendments, and biofuels, while the aqueous phase can be potentially used as a nutrient-rich solution such as for fertilization and biological processes.

Followed by an overview on the basic thermochemical processes occurring during HTC, the talk will include a range of examples that were studied by our research team (relevant to decentralized/onsite solutions) of which HTC was used to treat and reuse agro-waste, human excretions (black water), and domestic sludge.

**id #2326**

### **Removal of organic micropollutants in selected waste stabilisation ponds in Western Australia: Implications for water reuse**

Yolanta Gruchlik<sup>1</sup>, Cynthia Joll<sup>1</sup>, Francesco Busetti<sup>2</sup>, Deborah Liew<sup>1</sup>, Kathryn Linge<sup>1,3</sup>, Arron Lethorn<sup>4</sup>

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2. *Edith Cowan University, Perth*

3. *ChemCentre, Perth*

4. *Water Corporation of Western Australia, Perth*

Waste stabilisation ponds (WSPs) are large shallow ponds that utilise physical and biological processes to remove organic materials, pollutants and pathogens present in raw wastewater. Many regional areas and remote communities use WSPs to treat wastewater, with a variety of end uses, including using the treated wastewater for irrigation of public spaces (e.g. parks and ovals) or for crop irrigation. Thus, it is essential that the treated wastewater meets the required quality for beneficial reuse. Although some aspects of WSP treatment performance, such as pathogen removal and nutrient removal, have been well studied, the performance of WSPs in the removal of organic micropollutants has not been widely investigated. This study investigated the occurrence and removal of organic micropollutants in three Western Australian WSPs and one activated sludge metropolitan wastewater treatment plant (WWTP). The three WSPs differed in geographical location, climate and pond configuration.

Out of 232 organic micropollutants analysed, only 36 were detected at least once in raw wastewater, including ten pharmaceuticals, five antibiotics, four corrosion inhibitors, seven pesticides and related chemicals, two fragrance musks, one artificial sweetener, three flame retardants, and four other compounds. Wastewater treatment reduced the concentrations of most micropollutants, but some were persistent throughout treatment. Best chemical removal was observed in a complex WSP, with multiple maturation ponds, where removal was comparable to the oxidation ditch system. Chemical removal in simpler WSPs was typically better in summer than winter, possibly related to higher summer temperatures and increased algal populations. Concentrations of chemicals observed in this study were generally below environmental guideline values in the final effluents, even when they were frequently detected in the wastewater influent.

**id #2279**

### **Metagenomic analysis of facilitation mechanism for azo dye degradation with the dosage of ferrous oxide**

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#### **Introduction**

Anaerobic-aerobic process is widely used for dyeing wastewater treatment. Several bacteria have been reported to produce azoreductase, such as *Staphylococcus aureus*, *Escherichia coli*, *Bacillus* spp., and *Chromobacterium violaceum* (Suzuki et al., 2001; Verma et al., 2019). Redox mediators can assist efficient electron shuttling to the breakdown or degradation of compounds, such as azo dye (Dos Santos et al., 2005; Sreelatha et al., 2015). However, the facilitation mechanism and functional

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microorganisms in azo dye degradation with the addition of redox mediators from the perspective of electron transfer still require further investigation.

This study focused on effects of Fe<sub>3</sub>O<sub>4</sub> on the degradation of Reactive Red 2 (RR2, a typical azo dye) in the hydrolysis/acidification process. Structure of microbial communities, functional microorganisms involved in organic carbon metabolism, electron transfer and azo dye degradation were clarified through metagenomic analysis. Finally, a novel facilitation mechanism for azo dye degradation with the dosage of Fe<sub>3</sub>O<sub>4</sub> was proposed.

### **Methods**

Four sequencing batch reactors (SBRs) were used to remove color through hydrolysis/acidification. The dosage of Fe<sub>3</sub>O<sub>4</sub> was 0, 5, 10 and 15 g/L in reactors SF<sub>0</sub>, SF<sub>5</sub>, SF<sub>10</sub> and SF<sub>15</sub>, respectively. The SBRs had the volume of 2 L and were operated at 30°C. Peptone, starch and sodium acetate were used as the organic carbon with the chemical oxygen demand (COD) ratio of 6:3:1 in the synthetic wastewater.

### **Results and Discussion**

The removal percentage of color improved with increasing Fe<sub>3</sub>O<sub>4</sub> concentrations in four SBRs. The microbial community structure containing AzoR indicated that the dosage of Fe<sub>3</sub>O<sub>4</sub> could affect the structure of functional microorganisms. The dominant azo dye degrading bacteria was changed from *Bacillus*, *Aeromonas* and *Lysobacter* to *Acinetobacter* and *Desulfovibrio* with the dosage of Fe<sub>3</sub>O<sub>4</sub>. *Geobacter* and *Staphylococcus* were detected possessing AzoR and their dominant role in SF<sub>5</sub> and SF<sub>10</sub> revealed that they might have crucial functions in azo dye degradation.

Organic carbon metabolism is the main electron donor for azo dye degradation. *Geobacter* was the dominant azo dye degrading bacteria involved in organic carbon metabolism and the relative abundance remained stable with the dosage of Fe<sub>3</sub>O<sub>4</sub>.

*Geobacter* and *Staphylococcus* could not only participate in organic carbon metabolism with the generation of NADH and succinate, but also could transfer electrons generated during transformation between NAD<sup>+</sup>/NADH and succinate/fumarate. In addition, they both contained AzoR and enriched with the dosage of Fe<sub>3</sub>O<sub>4</sub>, indicating that these two bacteria might provide a novel mechanism in the facilitation of azo dye degradation with Fe<sub>3</sub>O<sub>4</sub>.

A novel possible facilitation mechanism for azo dye degradation with the dosage of Fe<sub>3</sub>O<sub>4</sub> is proposed. It could be proposed that the addition of Fe<sub>3</sub>O<sub>4</sub> could facilitate the extracellular electron transfer or enrich functional microorganisms to promote azo dye degradation.

### **Conclusion**

*Geobacter* and *Staphylococcus* could not only participate in organic carbon metabolism but also had potential to degrade azo dye. The addition of Fe<sub>3</sub>O<sub>4</sub> could facilitate azo dye degradation with either the promotion of electron transfer or the enrichment of functional microorganisms.

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**id #2309**

## **Odor assessment from on-situ sewage sludge aerobic composting throughout different seasons and during anaerobic digestion with hydrolysis pretreatment**

**Zhangliang Han<sup>1</sup>**

1. *Beijing Forestry University, Beijing, BEIJING, China*

Aerobic composting and anaerobic digestion with hydrolysis pretreatment are two mainstream methods used to reduce harmful contaminants from sewage sludge and convert it into a useful resource. However, many odors (i.e. ammonia and five volatile sulfur compounds) are emitted during these two sludge treatment processes and may harm human health. Determining the amount of odor pollution will be beneficial in developing strategies for odor elimination. This study identified odor pollution (i.e. sensory influence, odor contribution, and human risks) caused by ammonia and five volatile sulfur compounds from sludge aerobic composting throughout different seasons as well as during anaerobic digestion with hydrolysis pretreatment according to assessments of odor intensity, odor active values (OAVs), and permissible concentration-time weighted averages. Results revealed serious odor pollution from all sampling sites during aerobic composting, especially in winter. Excessively strong odors were identified in the composting workshop, with total OAVs between 997-8980 which accounted for 78.45%-96.18% of the total sludge aerobic composting plant. Levels of ammonia and dimethyl disulfide in the ambient air were high enough to harm employees' health. During anaerobic digestion, excessively strong odors were identified in dehydration workshop 2, and the total OAVs of six odors reached 32268, with ammonia and hydrogen sulfide levels significant enough to harm human health.

**id #2527**

## **The use of 'Integrated Constructed Wetlands' (ICW) for the treatment of polluted water sources: domestic, industrial and mining**

**Rory Harrington<sup>1</sup>**

# **SWWS2019 Abstracts**

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The use of 'Integrated Constructed Wetlands' (ICW) for the treatment of polluted water sources: domestic, industrial and mining

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Emerging more than 30 years ago, the reanimation of helophyte wetlands, treating a diverse range of polluted water sources have been demonstrated – successfully delivering a range of effective and sustainable treatment capacities. This presentation focuses on some of these capacities, ranging from the treatment of wastewater from single dwellings and conurbations greater than 1,000 people equivalent (PE) to that of industrial and mine waters. These exercises in wetland reanimation, through the explicit integration of all potential intercepted water, landscape-fit and biodiversity, are termed Integrated Constructed Wetlands (ICW).

## **OBJECTIVES**

Initially the main focus associated with the construction of wetlands is on economic cost-benefits. The intended work is often not viewed in the context of wider social, economic and environmental factors. The relationships between the beneficiaries and long-term enterprise, particularly regarding the management of water in the wider landscape, has been understood only gradually through demonstration. Analysis of performance factors is required to advance their application. The benefits and costs associated with a range of polluted water treatments are examined with particular regard to delivered water quality outcomes and associated ecosystem services.

## **METHODS**

Through design, construction and application a range of ICW systems were undertaken to treat a diversity of polluted water sources with the following requirements:

1. Regulated water quality discharges and hydraulic integrity.
2. Accessibility for maintenance.
3. Comprehensive and linked objectives.
4. Addressing land/capital, ancillary resources, alliances (collaborations) and related interests.
5. The application of the defined 12 principles and accompanying rationale of the UNEP/CBD's 'Ecosystem Approach'.
6. Accepting that complex 'open' biological (eco) systems are typically subject to limitations of understanding and may require adjustment.

## **RESULTS**

Data on the performance of a range of ICW systems treating different polluted sources are presented. The sources range from single dwellings to industrial/mining effluents, addressing variable flows and seasonal impacts. The Integrated Constructed Wetland (ICW) concept has increasing environmental appeal amongst water regulatory bodies. They are now often seen as more economically competitive – with the added advantage that the public are more appreciative of the natural and aesthetic landscape they provide.

## **CONCLUSIONS**

Reanimating lost hydrological ecologies and associated ecosystem services within catchments requires the collaboration of landowners, experienced direction and planning, as well as State engagement. Innovative demonstrations of what can be done is the initial priming factor, provided requirements regarding water quality and hydraulic integrity are achieved. Applying the ICW concept through the construction of secure and effective water-retentive structures, built cost effectively using local soil material with minimal hard construction and embedded carbon provides a basis for enhanced aesthetics and biodiversity. As complex 'open' biological systems they can typically be subjected to limitations of understanding and 'systems blindness', especially where competitive interests may prevail.

## **ACKNOWLEDGEMENTS**

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**id #2232**

## **Self-Sustaining Resource Circulated Sanitation: A Nature-Based Sanitation Solution toward Leaving No One Behind**

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Water and sanitation are important global challenges. The sixth item for sustainable development goals (SDG6) was defined to provide sustainable access to adequate sanitation for all. In the year 2018, the United Nation has proposed investigating nature-based solutions (NBS) for water problems and the World Health Organization (WHO) published guidelines on sanitation and health.

Accordingly, an innovative sanitation system named as "Self-Sustaining Resource Circulated Sanitation (SSRCS)" has been developed along with a showcase project objecting to investigate the technical efficiency and sustainability of it for implementation

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in a remote area. Consequently, one set was installed at a farming center located in a suburban area of Seoul to offer public hygiene services. The system includes four main parts: dry toilet seat, urine reactor, feces reactor, and rainwater harvesting system to provide water for sanitary applications. The seat efficiently separates urine from feces, storing them in their reactors. Urine is stored in a tank-in-series reactor while feces along with other hygienic materials, such as biodegradable toilet papers, are led into a batch reactor including sawdust for the composting process. The reactors are well-designed based on the estimated amount of usage and retention time of 10 to 15 days. The nature-based treatment process includes adding a microflora, containing nitrifying microorganisms, to urine and feces reactor. The nitrification process gives benefits for reducing the stabilization time for urine and enhancing biodegradation of feces. Thereafter, treated urine is collected from the last tank and composted feces is collected from its reactor and mixed with agronomic soil to prepare soil samples for plant cultivation. Similarly, another cultivating soil sample was made by mixing the agronomic soil with commercial fertilizer. These soil samples were used to cultivate white radish plants under the same planting to harvest procedure. This treatment showed efficiency in increasing the fertilizing potential of urine by modifying its nitrogen profile. Moreover, pH reduction as a result of nitrification led to reducing ammonia losses as gas along with odor production. This treatment method also enhanced the feces composting process by providing a more favorable condition for feces biodegradation. Moreover, this method was useful in the efficient removal of fecal indicators. Results of white radish cultivation show that there was no statistically significant difference for nutrient release in soil samples treated with the products of SSRCS and commercial fertilizer. Thus, the water and sugar content along with the accumulated nutrients in leaves and roots of white radish plants cultivated in soil treated with the SSRCS produces was more than the other ones. The sustainability of the SSRCS system was proved in this project by its efficiency in reducing water and energy consumption along with recycling urine and feces to be utilized as fertilizer and soil conditioner. The benefits acquired by fertilizer production, water saving, and higher agricultural productivity are substantial. This system meets the recommendations of WHO guidelines, does not need complicated infrastructure, and provides NBS for sanitation problems, make it suitable for remote areas. It can also be considered as a step ahead toward SDG6.

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id #2234

### The Role of Precinct Based Rainwater Harvesting Systems for Climate Resilience – A Perth Case Study

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Rainwater harvesting can play an important role as a valuable supply source with high water quality, and can integrate with stormwater management of urban precincts. The Australian Fine China (AFC) project, located in Perth, WA is an example of a sustainable inner-city high density, mixed-use redevelopment which incorporates a precinct based centralised rainwater system. This system functions as an alternate water supply (for hot water), storm control asset, and local recharge system, with groundwater abstracted for irrigation of POS. The quality of the treated rainwater supplied is high as the system incorporates several layers of treatment to protect the quality of the rainwater and prevent impacts to public health. Treatment layers include first flush diversions, sediment traps, a three-step filtration system as well as UV disinfection and internet-of-things remote control telemetry. Weekly testing of the system has been consistently compliant with the Australian Drinking Water Guidelines for all parameters. The system management plan and water quality data generated from commissioning of the system was endorsed by the Western Australian Department of Health, which highlighted the importance of an effective risk management plan in order to achieve regulator endorsement. The system has had a long commissioning phase (since 2017) due to the lag in build out phase, as well as regulatory and governance processes, which has demonstrated consistently high water quality and provides a compelling dataset for support of similar systems. Adopted at a large scale, this model can potentially help to offset the increase in scheme water demands (in Perth estimated to increase 30% over the next 20 years), support biophilic cities and improve climate resilience.

id #2322

### SPRAS: JINLUO WATER Decentralized Sewage Treatment System.

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The main purpose of this paper is to address the sludge generation challenges from decentralized sewage treatment systems and the effectiveness of Jinluo Water patented technology (SPRAS) in the reduction of the surplus sludge to minimal amounts in comparison with other technologies.

The methodology followed by Jinluo Water was to apply the SPRAS (Sludge Process Reduction Activated Sludge) patented technology in the line of decentralized STPs (JL Series) and record the findings from operational plants on the quantities of sludge produced.

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The case studies of installed STPs in the United Arab Emirates (Emirate of Sharjah and Dubai) have collectively and effectively proven the reduction in surplus sludge from the installed STPs and the cost savings associated with very low sludge production. In conclusion, Jinluo Water patented technology "SPRAS" was a very effective solution and application for decentralized sewage treatment plants in remote communities where the sewerage network is not yet available.

**id #2229**

### **DYNAMICS MODEL OF THE DISSOLVED OXYGEN SYSTEM IN THE BRANTAS RIVER FOR A WATER QUALITY MANAGEMENT POLICY APPROACH**

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Management of river quality in developing countries faces challenges from the opposite human interests. On one side of the river serves as a waste storage medium. While on the other side of the river as a source of water for clean water, agriculture, fisheries, electricity generation and recreation. In addition, the river is a life medium for freshwater biota that must be preserved so that the functions that support human life are maintained. The Brantas River is the main river that crosses 15 cities and counties in the East Java province in Indonesia with a catchment area of 14,348 km<sup>2</sup> and a watershed of 320 km. At present the river class determination policy still does not show the importance of managing river quality. In the Brantas river segment used as a source of PDAM water, river quality classes are set for fisheries purposes (class 2). As a water source, class 1 should be determined. This policy is to facilitate the interests of industrial wastewater disposal and households along the lower Brantas river. In this problem a policy is needed to optimize the waste capacity and carrying capacity of the river. In addition, the policy of determining river capacity uses normative river quality standards. Each river should have different self-recovery capabilities so that the quality standard also depends on the condition of the river. The quality of rivers that fluctuate with the pattern of the dry season and the rainy season in the tropics should have a management policy that optimizes river conditions in both seasons and functions of waste capacity and carrying capacity. Fluctuating water quality behavior is the response of the elements that influence it. Dissolved oxygen parameters (DO) are water quality parameters that are very important for the life of river water biota. DO kinetics is determined from the reaeration process, photosynthesis of algae as a source of DO and the oxidation process of organic matter and sediments that require DO. Dynamic DO systems need to be understood, formulated, modeled and simulated to evaluate river water quality management policies. This understanding begins with making the system of DO the river. This paper will examine the forming structure of DO behavior of the Brantas river to be formulated in the system dynamics model. The system dynamics model simulation will produce alternative quality management scenarios that are expected to assist in the Brantas river water quality management policy

**id #2474**

### **HYDROTHERMAL CARBONISATION OF CATTLE PAUNCH WASTE**

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Meat processing and abattoir operations face several issues in regards with solid waste management worldwide. Presently, most wastes from slaughterhouses are landfilled, which not only cause major environmental damage, but also add to running costs of the abattoir. In order to combat these issues, several waste treatment methods have been trialled, including conventional thermochemical processes such as pyrolysis and torrefaction. However, these methods were found to be economically unviable because the waste has to be dried prior to treatment. Hydrothermal carbonisation (HTC) overcomes this challenge and treats waste having moisture content of up to 90% at lower temperatures, while generating value added products. The project presented in this paper focused on a particular abattoir waste known as paunch. Paunch waste is the undigested feed of cattle and makes up to 10% of the animal's weight. Different reaction temperatures (150, 180 and 200 °C) and times (1 and 4 h), as well as varied feedstock moisture contents (75 and 90%), were used in order to produce different grades of products. The fuel characteristics of the solid products were tested for potential use as energy source for electricity generation and the nutrients in the liquid products were analysed to verify their suitability as soil amendment. The carbon content of the paunch waste increased by 10 to 15% after HTC and was also reflected on the calorific content of hydrochar, which increased by up to 27%. The atomic H/C and O/C ratios decreased considerably from 1.760 and 0.633 to 0.451 and 0.234, respectively. The evolution of the H/C and O/C atomic ratios of the hydrochar were analysed using the van Krevelen diagram and it was found that the fuel properties of the hydrochar improved noticeably after carbonisation. The nutrient concentrations in the liquid phases were found to increase significantly with increasing reaction temperature and time. With increased moisture content, nutrient concentrations decreased, because of higher water content. The liquid phase can therefore be used as fertiliser while the properties of the hydrochar suggest it can be used as a fuel for electricity generation.

**id #2513**

### **Wastewater: creating benefits for the Kimberley community**

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The Water Corporation of Western Australia (WA) has established partnerships with community groups and not-for-profit organisations to successfully deliver a number of community-based projects that provide economic and social benefits for people in the remote Kimberley region of WA. These projects are centred on the environmentally sustainable and innovative disposal of treated wastewater at a facility in Broome. Water Corporation treats the community's wastewater and uses it to irrigate Rhodes

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grass, which it turns into hay and sells to local farmers as a climate independent food source for local cattle. The funds raised by the sale of hay are used to fund community initiatives that primarily benefit disadvantaged sectors of society.

These projects include;

1. Delivery of a community grants scheme, funded solely through the Corporation's wastewater disposal process;
2. Projects providing Aboriginal trainees with practical agricultural experience and employment and training opportunities in native horticulture and land management;
3. Partnership with Mamabulanjin Aboriginal Corporation to establish a native tree seed bank, using recycled water for irrigation;
4. Various community partnerships including with Wunan Foundation, which supports an education program for Aboriginal girls from the East Kimberley to attend high-performing schools across Australia.

The Water Corporation has benefited directly from these projects by way of stronger stakeholder relationships, new partnerships with Aboriginal and community groups and a strengthened brand and social licence to operate. Viewed together, these projects redefine the value of recycled water in delivering social, economic, training and employment opportunities in regional communities. They also provide a practical model for other water utilities to follow.

**id #1664**

### **Novel UV process development and application in water treatment and reuse**

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Recognising the potential harmful health effects of disinfection by-products generated by chlorination and its inability to inactivate some pathogenic microorganisms such as protozoa, the water industry has been looking for new disinfection technologies in recent years. Among the available technologies, UV disinfection has been receiving a lot of attention due mainly to its ability to inactivate protozoa as well as bacteria and viruses without generating harmful disinfection by-products. Besides its good disinfection capability, UV disinfection also appeals to water authorities due to its small footprint requirement. Being a physical process, UV system does not need to incur costs and risks associated with the transportation, handling and storage of toxic chemicals (e.g. chlorine gas) as required by chlorination system. Another important factor that contributes to UV disinfection's rising popularity is its lower capital cost requirement compared with chlorination system. However, there are a few challenges relating to this technology that merit attention. These include: some pathogenic microorganisms may repair their DNA damage induced by UV radiation and thus negatively impact the overall efficiency of the UV disinfection process, and some viruses may be very resistant to UV and thus require a much higher dosage.

In UV disinfection industry, there was a lack of understanding concerning standard protocol to assess the level of repair and how to suppress the repair and regrowth phenomena. Various strains of *E. coli* (wild-type, UV-resistant and antibiotic-resistant strains) for their ability to perform dark repair and photoreactivation under different lamp sources, and their final repair levels as well as repair rates were investigated. To tackle the challenge of resistant Adeno (AD) virus, a comprehensive study on the LP and MP UV dose requirements of different AD serotypes under similar experimental settings was conducted. The question of whether the use of three different cell lines for AD enumeration would influence the UV dose response of AD was addressed. Novel UV technologies has also been explored for simultaneous organic contaminant removal and pathogen inactivation. The practices and application of UV and UV AOP technologies in Singapore for both water treatment and water reclamation was also introduced.

**id #2292**

### **Governance, Policy and Regulation of an Integrated Rural Water Supply System, Kerala Model**

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Safe drinking water to all its population is the mandate of every Central Government and its implementation, operation and maintenance is governed by the respective State Governments. The 29 States and 7 Union Territories in India consists of 702 Districts having 258707 Gram Panchayats which consists of 1725932 Rural Habitations (wards). Out of that 1396348 Rural Habitations covering 698 million Rural population were covered with a water supply of minimum 40lpcd. The uncovered population out of 220 million Rural population is 24 % and they lack any drinking water sources within in a reachable distance. When we look into the number of Rural population provided with a protected piped water supply, it is only 18 % and the remaining households are having other sources, open wells/ tube or bore wells/ hand pumps etc. Though the Government of India took earnest attempt in "providing safe drinking water supply to all by 2020", the goal is not achieved even after 70 years of its independence.

There are number of Stake holders taking up the task of implementation and maintenance of small and medium level Rural Water Supply Schemes in India. But due to lack of source sustainability and quality of service the number of defunct schemes are coming up regularly and resultant Habitations coverage does not shows a linear increment proportional to the number of schemes implemented every year.

Various models in Implementation and Operation and Maintenance were tried in the Rural sector during the past centuries following the terms and conditions of the Donor Countries or Government of India. But no system proved to be fully successive.

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There are resources- water sources, technology and finance to meet the drinking water need of all the people in the country. Then what is lacking? Is it the policies and regulations or the Management system or something else?

Being the second largest populated country in the World having 918 million Rural population scattered across the country, a uniform pattern of Planning, Design and Maintenance is not feasible or adaptable. In this paper we are trying to develop a model of an Integrated Rural Water Supply System adaptable for Indian conditions especially suitable for the state of Kerala.

id #2577

### Alternative Nitrogen Removals in Wastewater and Aquaculture Through Adsorption Utilising Bio-Sorbent Matrix

Wastewater, especially wastewater from aquaculture, can contain a high level of nutrients such as nitrogen (N) and phosphorus (P) [1]. High level of nutrients in aquatic system adversely affected water quality, leading to the deterioration of water quality, and eutrophication [2]. Nutrients removal is essential to the aquaculture industry as this process protects receiving water bodies from excess nutrient, and eutrophication as well as allowing the treated water to be recirculated in the aquaculture system [3]. Adsorption is one of the effective methods for removing nutrient from effluent [4]. Due to variation in nutrient removal efficiency ranging from 40 to 100 percent nitrogen removal, adsorbent such as chitosan and various forms of activated carbon such as granulated, maize cob, and bamboo were used in aquaculture wastewater treatment [5, 6, 7]. An alternative to the aforementioned adsorbent is bio-sorbent. A bio-sorbent matrix is defined as a biological material that could adsorb desired substances from aqueous solution [8]. Eggshell, with calcium carbonate as the main composition, is a cheap and readily available biological material for the adsorbent matrix development [9].

This study aimed to develop an effective and economical alternative adsorbent matrix with eggshell incorporated for the adsorption of nitrogen for the treatment of effluent from aquaculture and high nutrient effluent. Eggshell was collected and washed with distilled water several times and dried in an oven at 150°C overnight. Washed eggshell was, then, ground into different sizes of 250-151, 150-75, and less than 75 µm using sieve number 50, 100, 200 respectively. Batch experiments were performed with 250-151, 150-75, and less than 75 µm under simulated aquaculture effluent condition with ammonium sulfate concentration of 1, 2.5, 5, 10 g/L at room temperature and pressure for 24 hours. The nitrogen removal efficiency of the sieved eggshell was approximately ranging from 20 percent to 44 percent with 150-75 µm, and less than 75 µm sieved eggshell being most effective in comparison to 250-151 µm. From the experiment, 150-75 µm, and less than 75 µm sieved eggshell were formed into matrixes with a diameter of 10 mm. The formed eggshell matrix underwent tablet hardness test with 150-75 µm matrix peaking at 19.03 N, and less than 75 µm matrix peaking at 31.71 N. Eggshell matrix also underwent batch experiment with the nitrogen removal efficiency of the sieved eggshell was approximately ranging from 16 percent to 41 percent. In conclusion, eggshell can be used as bio-sorbent for nitrogen removal in aquaculture and nutrient-riched effluent.

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id #2312

### Feasibility of Stormwater/Greywater Dual-Mode Biofilters as Effective Pathogen Barriers

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Securing alternative water sources, i.e. greywater (GW) or stormwater (SW), received high attention in the research fields and water industries due to water scarcity under increased population over the years. Harvesting and treatment of alternative water sources via passive filtration system such as biofilters or wetlands became popular as a Water Sensitive Urban Design (WSUD). Biofilters have been optimised for pathogen removal from GW treatment and SW harvesting and they demonstrated moderate

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pollutants removal from SW and GW at low carbon footprint. However, biofilters' treatment efficiency was found to decrease after extended dry periods. Therefore, operating SW biofilters with GW during the intermittent dry period (hereafter referred as dual-mode biofilters) was considered to overcome this problem and provide benefits such as cost saving for installation/maintenance and increased treated water production. In this study, 70 biofilters (fourteen configurations x five replicates) were investigated for pathogen removal under dual-mode operation. During the first 17-weeks of dual-mode operation, pathogen removal was monitored based on design factors (i.e. insertion of copper coated zeolite (CuZ) antimicrobial media, SZ types, vegetation types) and operational conditions. After this initial period, monitoring of CuZ columns continued for another eight months to investigate the impact of dual-mode on CuZ media. Results demonstrated that the event size affected the removal efficiency via 'old water effect' significantly regardless of inflow water types. CuZ-amended columns were the best performers for microbial removal during the dual-mode but CuZ became inactive after dual-mode. *Phormium spp.* and *L. japonica* maintained an adequate performance in both *E. coli* removal and hydraulic performance during the dual-mode as promising alternatives to *Carex appressa*. Therefore, dual-mode operation of the biofilters is plausible with careful design of standard SZ size, and selection of vegetation types, which could overcome the deterioration of performance during the extended dry period as well as increased treated water generation.

**id #1595**

### **Overseas expansion of dual dissolved oxygen control system for oxidation ditch process**

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#### **INTRODUCTION**

The 17 Sustainable development goals (SDGs) and 169 targets set by all United Nations Member States in 2015. The target 6.3 includes "halving the proportion of untreated wastewater", and the indicator 6.3.1 "Proportion of wastewater safely treated" has been monitored to progress the target. To cope with this situation, it is important to spread sewage treatment facilities in developing countries.

The Japan Sewage Works Agency (JS) was established in 1972 as a joint fund-raising organization to enable the Japanese central government and local municipalities to pool technical experts in the sewage works. The JS contributed to the rapid development of sewerage systems in Japan and also contributed to technological development on water pollution control for possible practical applications.

Oxidation ditch (OD) is the most frequently used sewage treatment process in Japan, and it was introduced in 45 percent of the wastewater treatment facilities (978/2144 facilities) as of the end of March 2017 (Sewerage Statistics 2017 published by Japan Sewage Works Association). For further energy and space saving in OD process to meet the need of small municipalities with a severe financial base, "Dual dissolved oxygen (DO) control system for OD process" was jointly developed by JS, Kochi University and Maezawa Industries, Inc.

The objective of this manuscript is to introduce one of the possible practical applications of this system that can be applied overseas as well.

#### **METHODOLOGY & IMPLEMENTATION**

The automatic control system individually controls aeration intensity and circulation flow rate based on DO values at two points in the ditch to stabilize the DO gradient. This control mechanism solidly creating aerobic and anoxic zones makes treatment stable and reduces electric power consumption.

#### **CONCLUSIONS**

The dual DO control system can stabilize effluent quality and reduce power consumption in OD process.

The advantages of the dual DO control system are summarized below.

- Generate effluent with stable quality
- Reduce power consumption by approximately 30% compared to OD using vertical aerators
- Adaptable to high-load operations such as a temporary excess of peak flow and highly concentrated influent depending on inflow condition

Because dual DO control system for OD process generates very low nitrogen concentration in the effluent, this process is recommendable to mitigate eutrophication if the effluent water is to be discharged to closed water areas such as lakes and gulfs.

In my opinion, dual DO control system for OD process is a proper process because of its automatic control and energy-saving system. The automatic control system is very preferable because skilled operation and maintenance engineers are insufficient in developing countries. The energy-saving system is also acceptable in such areas where high electricity charges disturb introduction of wastewater treatment plants.

Currently, dual DO control system for OD process has been installed only in Japan. It is expected to be introduced especially in developing countries that will implement sewage treatment from now on.

**id #2195**

### **Performance of green walls irrigated with greywater, under a Mediterranean climate: a pilot-scale study**

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In Australia, almost 40 percent of household potable water is used outdoors, mostly for garden irrigation; this provides an opportunity for recycled water use. Small-scale decentralised and cost-effective water treatment technologies that require low energy, are ideal for implementation in both residential and commercial areas. Biofilters have been implemented in urban areas to treat storm water and greywater for nutrients, and to provide wetland habitat. Recent studies on green vegetated walls acting as biofilters and treating greywater are encouraging, however a key challenge remains their performance in areas that experience hot, dry summers. While green wall systems have long been used for thermal comfort in drier climates, there is a paucity of research on their performance, and therefore a lack of understanding on how to optimise that performance. This pilot-scale research project uses planters (2.5 m x 0.7 m x 0.75 m) to establish detached green façades irrigated by greywater, and to then test different planter orientations and plant species. The project aims to determine how the water balances of the different green façades change seasonally, with orientation, and across different plant species. The project also aims to identify suitable plant species for Mediterranean climates that are not impacted by the higher nutrient supply in greywater, and to quantify the nutrient treatment performance of the green façades. The results from the water balance measurements and establishment-stage nutrient budgets, will be presented

**id #2451**

### **Inclusive and Sustainable faecal and wastewater sludge management in Udaipur City**

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Udaipur is one of Class I (population more than 1,00,000) and important tourist city in India with a population of 451,735 as per census 2011. The city has experienced a steady growth in the population in past two decades which has led to rapid and often unplanned urbanisation resulting in stressed urban infrastructure and poor basic public utility service delivery. With Urban growth rate of 15.83%, the population projection for the year 2021 estimates an increase in population by 155,927. As of now 20% of city is covered with sewerage network. Remaining 80% of city is based on on-site sanitation system for managing the black water, whereas the grey water is disposed into open drains or open space. With the successful implementation of National Program for improving the Urban Infrastructure Program and National River Conservation Program, the sewer cover will increase to almost 63% from 20% by 2021 which still results in 37% households depending upon onsite sanitation system.

Being cognizant of the fact that Udaipur has seen rapid urbanization over the last few decades, especially in areas adjoining the Municipal limits, and, further, since expanding the net of sewerage system to cover the remaining population, including those living in peripheral areas, is expected to be a financially crippling task, the need for a sustainable FSM system is not at all obviated. This is almost the similar situation in other Class I cities in India.

In absence of regulated FSM system, the rapid increase of toilet coverage with on-site sanitation system in a non-sewered urban area will not translate into health benefits. In comparison to only laying a sewer network across the city, an integrated co-location model offers a sanitation solution for both sewerage and non-sewered areas which is economically viable and promotes a better governance model. By adopting such model, Udaipur city has moved beyond towards a safe urban environment without any risk to land and rivers.

Citizens' participation drive and regulated FSM system in Udaipur city have created awareness towards regular de-sludging of septic tanks among public and no dumping of the collected Faecal Sludge into the open environment by the service providers. Also, skill trainings imparted to the sanitation workers have led to eradication of manual scavenging and safe FSM operation.

The circular FSM model adopted in Udaipur has not only included safe handling and transport of the sludge but also a resource recovery mechanism from faecal sludge matter, which can be re-used for multiple applications.

This co-production project was named as "Partnering for MEWAR (Managing Environment through WASTE Re-use)" and targets to benefit approximately 700,000 people by establishing an "inclusive and resilient FSM system". Within this context, this co-production project intends to pioneer a robust and replicable partnership model between governmental, commercial and academic actors to bolster market oriented public good developmental interventions; ultimately accelerating progress towards safe and sustainable water and sanitation through FSM.

**id #2575**

### **Development of Immobilized Bacteria on Sludge Based Adsorbent for the Treatment of Total Dissolved Solid (TDS) in Wastewater**

**Sirinthip Kedsana<sup>1</sup>, Nawatch Surinkul<sup>1</sup>**

1. Mahidol University, Salaya, NAKHONPATHOM, Thailand

High of TDS in wastewater is affect to human health when the potential groundwater rating has been contaminate. Both of principle physical and biological treatment are used in this study for reducing TDS in the septic tank. The media for experimentation is include of wastewater sludge, fly ash, and charcoal (40:60:5) forming spherical adsorbent at 1,000 °C for 3 h. The particle sizes of media were 9.13 – 16.56 mm.

The main objective of this study was to follow up the bacteria (*Bacillus subtilis*) on the immobilized media from freeze-dried of preservation technique in the wastewater treatment system for TDS removals in the septic tank. Sterile sludge based adsorbents (SBAs) was cultured with 10% inoculum of bacteria (*Bacillus subtilis*) in sterile nutrient broth (NB) at room temperature until bacteria cell is exponential phase. These bacteria are often found in wastewater and they can reduced TDS in wastewater. Scanning electron microscope (SEM) was used analyze to confirm the bacteria can be adhered on SBAs. Immobilized media was preserved at 4°C, -20°C with skim milk (SM), and room temperature and 4°C with freeze-drying for the long period storage. Immobilized media was followed for a month to observe the rate of bacteria survival. In term of pH, DO, BOD, COD, and TDS were parameter for measurement immobilized media in wastewater of septic tank.

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Cell number of *B. subtilis* are still increasing in freeze-drying at room temperature (13.43%), and freeze-drying at 4°C (1.22%). The rate of population survivors have been 1.54%, 15.28%, 10.00%, 14.67%, 30.0%, and 49.47% (Control at 4°C, control at -20°C, 10% of SM at -20°C, 20% of SM at -20°C, 10% of SM and NB (1:1) at -20°C), and 20% of SM and NB (1:1) at -20°C, respectively. Wastewater was treated by immobilized media and SBAs in reactors for 15 day. The range of pH is 8.50 to 8.72. The removal efficient of BOD and COD were 83.25%, 40.91% (15 day), respectively. 15 days for treatment of TDS with immobilized media (*B. subtilis*) is still high value.

id #2578

### Development of Immobilized Bacteria on Sludge Based Adsorbent for the Treatment of Organics Removal in Wastewater

Sirinthip Kedsana<sup>1</sup>, Nawatch Surinckul<sup>1</sup>

1. Mahidol University, Salaya, NAKHONPATHOM, Thailand

High of organics in wastewater is affect to human health when the potential groundwater rating has been contaminate. Both of principle physical and biological treatment are used in this study for research organics and amount of bacteria immobilized can be activated in septic tank system. The media for experimentation is include of wastewater sludge, fly ash, and charcoal (40:60:5) forming spherical adsorbent at 1,000 °C for 3 h. The particle sizes of media were 9.13 – 16.56 mm.

The main objective of this study was to follow up the bacteria (*Bacillus subtilis*) on the immobilized media from freeze-dried of preservation technique in the wastewater treatment system for organic removals in the septic tank. Sterile sludge based adsorbents (SBAs) was cultured with 10% inoculum of bacteria (*Bacillus subtilis*) in sterile nutrient broth (NB) at room temperature until bacteria cell is exponential phase. These bacteria are often found in wastewater and they can reduced TDS in wastewater. Scanning electron microscope (SEM) was used analyze to confirm the bacteria can be adhered on SBAs. Immobilized media was preserved at 4°C, -20°C with skim milk (SM), and room temperature and 4°C with freeze-drying for the long period storage. Immobilized media was followed for a month to observe the rate of bacteria survival. In term of pH, DO, BOD, and COD were parameter for measurement immobilized media in wastewater of septic tank.

Cell number of *B. subtilis* are still increasing in freeze-drying at room temperature (13.43%), and freeze-drying at 4°C (1.22%). The rate of population survivors have been 1.54%, 15.28%, 10.00%, 14.67%, 30.0%, and 49.47% (Control at 4°C, control at -20°C, 10% of SM at -20°C, 20% of SM at -20°C, 10% of SM and NB (1:1) at -20°C), and 20% of SM and NB (1:1) at -20°C, respectively. Wastewater was treated by immobilized media and SBAs in reactors for 15 day. The range of pH is 8.50 to 8.72. The removal efficient of BOD and COD were 83.25%, 40.91% (15 day), respectively.

id #2521

### Reducing the Sodcity Risk of Recycled Water by Ion Exchange with Zeolite and Scoria Volcanic Rock

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The sodium adsorption ratio (SAR) indicates the sodicity risk of an irrigation water to certain types of soil. The SAR compares the concentration of sodium in relation to calcium and magnesium. If the water is relatively high in sodium ions and it is irrigated onto clay soils then the soil structure may be harmed through dispersal. The majority of on-site and decentralised wastewater treatment technologies do not adjust the SAR of a treated water (VanDeGraaff & Patterson, 2001). The removal of sodium from water typically requires complex treatment technologies, such as reverse osmosis membranes, that are not practical in the on-site and decentralised wastewater industry (Arienzo et al., 2012). Some volcanic rocks, such as zeolite can cation exchange sodium out of solution and replace it with calcium and magnesium ions. This has the impact of reducing the SAR of the water (Mumpton, 1999). Scoria is another pyroclastic rock that can cation exchange sodium out of water (Kele, et al., 2017). This paper will describe how filters containing zeolite and scoria media can be used to reduce the SAR of irrigation water. The high SAR wastewater was sourced from a coal seam gas operation. The trials were conducted on 7 different types of media. The cation exchange process within these rocks is predominately determined by cation selectivity preference of the media and the concentration of ions in the inflow water. Tests were conducted on individual media, blends, and the media used in sequences. Results were recorded for SAR, sodium, calcium, magnesium, and other cations such as potassium, barium, boron & strontium. Other water parameters included pH, electrical conductivity, and anions such as fluoride and chloride. The results showed different volcanic media had varying abilities to reduce the SAR. Blends of media showed mixed results for SAR reduction. The data showed that considerable gains in SAR reduction can be achieved by keeping the individual filter media divided and treating the water through a series of separate filter tubes each containing a specific type of cation exchanging volcanic rock.

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Mumpton, F. A. (1999). *La roca magica: Uses of natural zeolites in agriculture and industry*. *Proceedings National Academy Science U.S.A.*, 96, 3463-3470.

VanDeGraaff, R., & Patterson, R. A. (2001). *Explaining the Mysteries of Salinity, Sodcity, SAR and ESP in On-site Practice*. Paper presented at the On-site '01, University of New England Armidale.

id #2516

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### **Status of Water Management and Conservation in Urban Areas of Peshawar Pakistan**

**Muhammad Aslam Khan**<sup>1</sup>

1. *Gomal Damaan Area Water Partnership, Rawalpindi, PUNJAB, Pakistan*

Pakistan is one of the water scarce country and most vulnerable to climate change . Water wastage and its storage is another big issue. With this purpose in view the study was conducted in the populated urban areas of Peshawar which is the provincial capital of Khyber Pakhtoonkhawa (KPK) Pakistan. Study was conducted to acquire basic knowledge regarding the water management system in Urban Peshawar, information about common water conservation practices among population and build up strong grounds with social mobilization for water meter installation in University of Peshawar. The study areas included both commercial and residential areas; University of Peshawar, University Town, Hayatabad, Saddar, Cantt, Gulbahar, Baragate, Warsak, Kohati which are commercial and residential mix areas. A mixed method questionnaire with 43 questions was designed for the study for a sample size of 100 respondents. The data was statistically analyzed using SPSS software - Chi-Square Test. This study concluded that local community and residents of urban areas of Peshawar city have less information about the water distribution departments in their city. Ground water is being used as a primary source of drinking water which mostly people use directly without any purification but less number of people use different methods of water purification at household level. People have very limited knowledge about water quality and its parameters which put severe health risk to human health and natural ecology. Study suggested that there should be a strong cooperation among local community and government to assure the sustainability as well as revenue of water with its sufficient management & conservation at household level. Interesting finding would shared on the consumption of water with or without water meters. Billing system on per liter water consumption. The study would conclude by sharing useful suggestions and recommendations particularly for developing countries.

id #2220

### **Process Performance and Microbial Population Dynamics in Three ANAMMOX-Mediated Systems**

**Kiprotich Kosgey**<sup>1</sup>, **Oluyemi O Awolusi**<sup>1</sup>, **Sammy L Kiambi**<sup>1</sup>, **Faizal Bux**<sup>1</sup>, **Kartik Chandran**<sup>2</sup>, **Sheena K Kumari**<sup>1</sup>

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2. *Earth and Environmental Engineering, Columbia University, New York, USA*

Anaerobic ammonium oxidation (ANAMMOX) process represents an efficient nitrogen removal process. However, its widespread application is still being hindered by its sensitivity to operational conditions and other external factors. The objective of this study was 2-fold: to investigate the performance of ANAMMOX-mediated nitrogen removal over 10 months in three 5L reactors of different configurations i.e up-flow anaerobic sludge blanket reactor (UASB), continuously stirred tank reactor (CSTR) and gas-lift reactor (GLR); and (II) analyse the reactors' microbial community structure dynamics through shotgun sequencing. All the reactors were operated under similar conditions during the study. In each of the three reactors, effluent ammonium, nitrite and nitrate concentrations were analysed colorimetrically. Genomic DNA samples extracted from the inoculum and samples from each reactor (days 125, 192, 260 and 309) were sequenced and analysed to compare and uncover the taxonomic composition of bacterial communities in the samples. Over 10-fold gradual increases in the concentration of ANAMMOX bacteria was observed in UASB and GLR between days 125 and 260, before decreasing by ca. 10% and ca. 4% in UASB and GLR, respectively. In CSTR, fluctuations in the abundance of ANAMMOX bacteria were observed throughout the study period. However, a 5-fold increase in the abundance of nitrite oxidising bacteria (NOB) in the CSTR was observed, while fluctuations in the abundance of NOB were observed in both UASB and GLR during the study period. A 9-fold increase in the abundance of complete ammonia oxidising (COMAMMOX) bacteria was observed in CSTR between days 125-309, while the abundance of COMAMMOX bacteria increased 6-fold in GLR during the same period. In the UASB, the abundance of COMAMMOX bacteria fluctuated during the same period. Although the relative abundance of ammonia oxidising bacteria (AOB) was above 11% in all the reactors on the 192<sup>nd</sup> day, a drop to below 5% in all the reactors was observed on the 260<sup>th</sup> day. A shift from *Nitrosomonas europaea*-dominated AOB communities to *Nitrosospira multiformis*-dominated AOB communities was observed in all the reactors during the study period. Similarly, within the NOB and ANAMMOX bacterial communities, fluctuations in the abundance and the number of individual species was observed. In all the reactors, *Candidatus Nitrosospira inopinata* remained the only COMAMMOX bacterial species detected, while *Candidatus Kuenenia stuttgartiensis* were the dominant ANAMMOX bacterial species during the study period. Despite the observed fluctuations in bacterial populations during this study, an increase in nitrogen removal efficiencies was observed in all the reactors from 34.55±13.42%, 52.42±19.91% and 8.97±6.14% (days 125-192), to 93.78±3.38%, 73.50±19.53% and 68.59±23.87% (days 261-309) in the CSTR, UASB and GLR, respectively (ANOVA,  $p=3.52E-12$ ,  $F=29.49$ ). Overall, the CSTR had the highest microbial diversity (Shannon index) and evenness (Pielou's Evenness) compared to GLR and UASB. It was thus concluded that: (I) the prevailing operating conditions in the reactors influenced bacterial population dynamics, (II) nitrogen removal efficiency and stability correlated with high microbial diversity as observed in CSTR.

id #2502

### **Water services legislation, regulation and governance in Western Australia – an overview**

**Ursula Kretzer**<sup>1</sup>

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This talk will outline the legislative and regulatory framework for the water services industry in Western Australia. Providing water services in Western Australia – water supply, sewerage, drainage or irrigation – requires a licence or an exemption under the *Water Services Act 2012*. The aims of the Act are to protect water services customers; be fair to water service providers; ensure the safety, reliability, efficiency and quality of water services; as well as enabling an effective, competitive and sustainable water services industry. The Act established the Water Services Ombudsman Scheme, which assists water service customers to

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resolve disputes with their water service providers. The Act provides for the Minister to make codes and regulations, including the regulation of prices and a code on customer service standards.

Water services licences are granted by the water services regulator, the Economic Regulation Authority, subject to applicants demonstrating that the proposed services are technically feasible and financially viable. All licensed water service providers are subject to operational audits and asset management system reviews by the Authority at least every two years to ensure compliance with their licence and effective asset management systems. Licensed drinking water suppliers are required to have a memorandum of understanding with the Department of Health regarding the quality, monitoring, and management of drinking water supplies.

Although the regulatory framework is designed to allow for water services to be provided by public and private entities, the water services sector in Western Australia is still heavily dominated by Government-owned utilities. This raises questions as to whether the regulatory framework imposes unnecessary barriers to private sector entry. However, there are a wide range of factors that make it difficult for private providers to find a niche alongside established water services delivered through large, integrated networks.

**id #2298**

### **Increasing pollution in a tropical wetland: low cost technology in water quality improvement**

**Shadananan Nair Krishnapillai**<sup>1</sup>

*1. Centre for Earth Research and Environment Management, Kochi, KERALA, India*

Agricultural expansion, rising population and failure in development projects largely degrade the land and water in the Vembanad-Kol wetland, a designated Ramsar site in Kerala, India, resulting in serious environmental and health issues. Canals and rivers in the region have been polluted from the direct outflow of domestic waste, effluent from the local industries, outflow of contaminated water from rice fields, bathing of cattle, washing of vehicles etc. Entire wetland region has become inhospitable to several species of migratory birds and aquatic organisms. Failure in the project to multiply rice production, evacuate floodwater and prevent salinity intrusion in the wetland that lies below mean sea level affected the natural flushing and concentration of pollutants steadily increased over time. Amount of dissolved oxygen became so low that organisms such as fish and frog disappeared from most of the region. Vectors grew and spread fast in the water, inviting serious health issues. Deceases like Chikun Guinea, Japan Encephalitis, Dengue Fever, Diarrhoea and jaundice became common. Surface and groundwater resources in the region are far below safety limits. People still abstract the same water for non-cooking purpose, as there are no other alternatives. Skin deceases affect those who directly use the water for bathing. Recent survey indicates that around 10% of the people in a selected village has symptoms of cancer. Analysis of water sample from the sixteen locations along the canal showed that quality is much below safety limits and serious health hazards may be expected at any time. Ongoing projects for water diversion, tourism promotion and inland navigation worsen the environmental conditions. Failure in management and policy implementation, lack of finance, social issues and vested political interests make the conservation and management of water very complex. However, experiments in the test plot with local technology using locally available material like charcoal and lime shell, and locally made cheap aerators prove that condition can be made better without much financial expense. Deepening and cleaning of the canals to enhance water circulation and erosion control using local plants made a lot of changes. Public awareness on pollution issues and proper adaptation measures and wise management could much improve the situation. This study is a comprehensive analysis of the issues related to the pollution in the wetlands region and a critical review of the policies for environment and water and current strategies in management. Guidelines to control pollution and improve environmental conditions have been provided.

**id #1635**

### **Japan's Decentralized Domestic Wastewater Treatment System (Johkasou) and Its Application in Asia-Pacific Region**

**SHINHI KUMOKAWA**<sup>1</sup>

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In Japan, there are two major systems for domestic wastewater treatment, 'Sewerage system,' which is implemented in urban areas, and 'Johkasou system,' which is installed sub-urban areas and rural areas. Johkasou, which were developed as packaged plants to meet the needs of the flush toilets in unsewered areas in the early 1960s, has become a sound technology/system for decentralized domestic wastewater treatment in Japan. Johkasou system serves

Household johkasou, or small-scale johkasou in general are prefabricated products installed underground, by which domestic wastewater generated from flush toilets, kitchens, washing machines etc. is treated up to a high level of water quality and discharged into the surrounding water bodies.

Johkasou are designed for treating domestic wastewater biochemically utilizing the purifying function of microorganisms. Treatment processes based on biofilm method are adopted mainly in small/medium-scale johkasou, while treatment processes based on activated sludge method are adopted in large-scale johkasou.

In order to function as a wastewater treatment facility, johkasou products are regulated by laws, standards, etc. from the structure, the performance and the quality to maintenance and management.

Johkasou products should be approved by the ministry in charge after passing a test for treatment performance conducted by a designated third-party institute. Installation, operation and maintenance, desludging and legal inspection of johkasou should be carried out according to the related technical standards.

Private companies involved in johkasou businesses should be registered or approved by local governments. Requirements for the registration or the approval of johkasou businesses are stipulated by the laws and regulations. One of the requirements is that johkasou companies should employ certified technicians to engage in installation, operation and maintenance, desludging and inspection of johkasou. Johkasou technicians could obtain the certifications by completing a training course or an examination, which are conducted by the designated training/examination agency.

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Johkasou working as a system integrated both the technology and management have contributed greatly to sanitation improvement and water environment conservation in Japan.

The experiences of Japan in johkasou system has been introduced as a useful tool for solving wastewater treatment problems, especially in Asian countries, and some countries are developing and manufacturing johkasou locally. It is expected that this trend will be strengthened with the implementation of domestic wastewater treatment in developing countries.

**id #2732**

### **Impact of activated sludge based sewage treatment plant in the proliferation of antibiotic resistant bacteria**

**Jahnvi Kurasam<sup>1</sup>, Sudipta Sarkar<sup>1</sup>, Prabhat Kumar Mandal<sup>1</sup>**

*1. Indian Institute of Technology Roorkee, Roorkee, UTTARAKHAND, India*

Widespread use and significant availability of antibiotics in the environment led bacterial adaptability to antibiotics. Even at low concentrations (ng/L), long term exposure of antibiotics to the microbe rich environment could create a selection pressure on bacteria for resistance development. Sewage treatment plants (STP) are one of the places where favorable conditions like plentiful of oxygen and nutrients are made available for bacteria to grow and degrade the organic content at faster rates. Studies say around 60% of antibiotics used during therapy are excreted from the body in an un-metabolised state and ultimately found their way to STP's through wastewater. This could expose bacteria to sub inhibitory levels of antibiotics in the STP's and create a selection pressure on bacteria to become resistant and play a critical role in spreading resistant bacteria to the environment. This study focused on identification and fate of the flouoroquinolone (FQ) resistant bacteria in an activated sludge based STP. Samples were collected from different points of STP and analyzed for the presence of FQ resistant bacteria. FQ resistant bacteria ranged from  $5.4 \times 10^3$  to  $5.7 \times 10^3$  in the influent and  $2.5 \times 10^2$  to  $4 \times 10^2$  in the effluent stream. Compared to the inlet of the biological treatment, the relative abundance of FQ resistant bacteria in the total bacteria population within the treatment plant rose by two orders of magnitude indicating the presence of positive selection pressure within the biological treatment. The multi-antibiotic resistance index also significantly increased, indicating the growth and emergence of multidrug resistant bacteria within the STP. Furthermore, 16S rRNA gene sequencing revealed resistant isolates belonged to the family enterobacteriaceae of which *Escherichia*, *Salmonella* and *Shigella* were dominant species irrespective of the sampling point. The final disinfection step couldn't completely eliminate FQ resistant bacteria, FQ's and happen to release facultative human pathogens with multidrug resistance into the environment.

**id #2464**

### **Integrated Reverse Osmosis Module (iRO) with Energy Recovery for Seawater Desalination**

**Adrian Wing Keung Law<sup>1</sup>, Jie Song<sup>2</sup>**

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*2. School of Resources and Environmental Engineering, East China University of Science and Technology, Shanghai, China*

The development of an Integrated Reverse Osmosis (iRO) module with energy recovery shall be presented. The patented module design\* is intended to be a compact, energy efficient module to facilitate small scale seawater reverse osmosis (SWRO) applications of typically less than 100 m<sup>3</sup>/day. It includes an internal energy recovery system (ERS) which can significantly reduce the energy consumption for the desalination. The integration within a single module eliminates the capital cost of a separate ERS, as well as the need for skilled personnel for installation and maintenance of the high pressure piping connections. Additionally, the unique module design enables internal feed flow reversal on the membrane surface which reduces membrane scaling, and extends the operation time and life span of the module.

iRO combines the membrane filtration and energy recovery processes in a single module. The input to the module is low pressure seawater, and the output is pure water as well as low pressure brine which can be discharged directly to the sea. The technology is capable of providing affordable clean water to many communities and businesses around the world. They include the following:

- Provide drinking water to communities, resorts and hotels on islands
- Produce industrial waters to mining sites around the coast and offshore oilfields
- Supply onboard water for naval and civilian ships
- Act as terminal units in decentralised water supply schemes.

In this symposium, we shall present the background of the concept development, and the general potential applicability of the technology.

**id #2218**

### **Managing PFAS in Western Australia's biosolids and sludge**

**Elliot Lee<sup>1</sup>**

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Per- and poly-fluoroalkyl substances (PFAS) are a family of over 4000 fluorine-containing chemicals that have been used since the 1950's to make products that resist heat, stains, grease and water. In addition to their well-publicised use in certain types of firefighting foams, they have been used in a range of common household products, including non-stick cookware, fabric treatments, furniture and carpet stain protectors, food packaging, personal care products, paints and cleaning products. Many countries, including Australia, have been phasing out certain PFAS due to concerns about environmental persistence, bioaccumulation and toxicity.

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The Water Corporation has a long running and highly successful biosolids and sludge beneficial use program, to reuse their valuable nutrient content for soil ameliorants in agriculture, forestry and landscaping. PFAS has been detected in wastewater, biosolids and sludge samples in both large and small wastewater treatment plants from all over Australia (Gallen et al. 2018). The Corporation was therefore concerned about the risk from PFAS to public health and the environment from biosolids and sludge beneficial use applications.

It was hypothesised that there is a universal base load of PFAS entering wastewater treatment plants from domestic sources. In 2018, the Water Corporation commenced a research project to test this hypothesis by assessing the levels PFAS in wastewater, biosolids and sludge. This research was led by Royal Melbourne Institute of technology (RMIT), in partnership with Melbourne Water, and SA Water. It included monitoring of wastewater and biosolids at 15 of the Corporation's wastewater treatment plants (WWTPs) that were chosen as a representative of the Corporations 109 WWTPs across the State, based in treatment type, demographics and geographical locations.

Following the outcomes of this work, a follow up project commenced in 2019 to assess the environmental fate of PFAS from biosolids and sludge beneficial use in agriculture and composting. This research is being led by University of Newcastle and South East Water, in partnership with a wide range of industry participants.

This presentation will give an overview of the outcomes of research undertaken to date, and the subsequent management actions undertaken by the Corporation. It will include discussion of the risk assessment for public health, the legal implications of the findings, regulator and customer engagement, contingency planning, and ongoing monitoring and research projects.

Discussion will include the implications for management of biosolids and sludge from small wastewater systems, and management practices recommended for the protection of public health and the environment.

**id #2317**

### **Optimization of biological SBR process for treating domestic wastewater having low C/N ratio**

**Sunkung Lee<sup>1</sup>, Seungjae Yeon<sup>1</sup>, Munsik Park<sup>1</sup>, Seunghwan Jung<sup>1</sup>, Hyung-Keun Chung<sup>1</sup>, Donghee Park<sup>1</sup>**

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SBR is a type of EBPR. The common type of EBPR needs several reactors and recycle-lines for sludge and nutrient removal. In the case of SBR, it can treat wastewater with one reactor without any recycle line. Therefore, this process can be constructed in small area and be operated with low cost. Thus SBR is suitable for treating small amount of domestic wastewater generated in rural area. There have been operational problems with the removal of nitrogen and phosphorus, which cause the eutrophication of aquatic systems, including lakes and rivers. To identify and solve the causes, in this study, we operated SBR with real domestic wastewater.

Experiments of SBR operation were carried out under the four conditions: SBR operation time, reactor pH, organic carbon injection amount and temperature. Each batch operation of SBR consisted of anoxic (including filling), aerobic, settling, decanting, and idling steps. The process operation time was decreased from 12 h to 1.5 h in the same influent of wastewater. As the process operation time decreased, the nitrogen and carbon concentrations of the effluent decreased. However, the efficiency of the process was greatly influenced by the fluctuation of process circumstance at lower than 3 h of the operation time. In the pH experiment, the pH condition of the process was maintained at fixed pH for 3 days. Between the pH shifts, the process was stabilized for 4-8 days at pH 7. The pH experiment showed that nitrification rates were similar at pH 7, 8, and 9. At pH 6, however, nitrification rate seriously decreased due to the shortage of inorganic carbon source for nitrification. Denitrification rate increased with the increase of pH from 6 to 9. However, nitrite accumulation occurred at pH 9.

Due to the lack of organic carbon source in real domestic wastewater, the denitrification occurred a little without an external carbon source. Thus, in carbon experiments, organic carbon (acetate) was injected into the process along with the influent. Complete denitrification could be obtained with the injection of acetate above 50 mg-C/L. Short term operation of the process using 100, 150 and 200 mg-C/L of acetate resulted in the release and uptake of phosphate. However, when comparing the release and uptake of phosphate, no substantial phosphate removal occurred. Phosphate removal was satisfactorily obtained when even 100 mg-C/L of acetate was injected into the process over a long period of time. Complete removal of phosphate below 0.05 mg-P/L could be obtained by the injection of acetate above 300 mg-C/L. Nevertheless, nitrification rate decreased and nitrite accumulation was observed under the high acetate concentration condition. In SBR operation experiment at low temperature, ammonia removal rate was remarkably reduced and only a small amount of nitrate was produced at 10 °C. In order to solve this problem, the SBR operating conditions were modified so that anoxic reaction time was shorter and oxic reaction time was longer than those at the room temperature. In addition, the operating time of one batch cycle was shortened to reduce the load of ammonia.

**id #2305**

### **Plant- microbial and adsorption-desorption interactions in the combat against water pollution: new green infrastructure design for herbicide removal alongside stormwater pollutants.**

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Water sources are often contaminated with pesticides and herbicides. Of those, the second most commonly found in water wells is atrazine ([Perth, Gerritse et al. 2006](#), U.S Geological Survey, 2005). This herbicide disrupts the hormone system and might induce cancer (Hayes et al. 2010, Fan et al. 2007).

Such herbicides are being carried by stormwater into receiving water bodies. Thus it would be advantageous if can be removed by green infrastructures such as biofiltration system. To date, current biofilter designs are unable to promote consistent and effective removal of herbicides, e.g. atrazine and simazine were poorly removed (<20%) (Deletic et al., 2014).

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The main goal of this study is to extend the capacity of stormwater biofiltration technologies to effectively remove the herbicide atrazine from contaminated stormwater.

In the first stage of the study, we investigated atrazine removal by biodegradation and adsorption-desorption at the solid-liquid interface, using novel quartz crystal microbalance with a dissipation (QCM-D) technique (LeviRam et al., 2019). Unlike other methods, this technique enables analyzing in real-time the pollutant biodegradation by the sessile bacteria (rather than planktonic bacteria) simultaneously with adsorption-desorption (which often being neglected).

In the second stage of the study, the same atrazine removal mechanism concepts were implemented into a laboratory-scale biofiltration system. More specifically, we designed a prototype of a next-generation stormwater biofilter for enhanced atrazine removal, which includes the following modifications:

- **Comprising smart engineering choice for atrazine absorbing media of the biofilters' bed**

A confined layer of Granular Activated Carbon was incorporated into the biofilters' bed. It was selected based on essays testing the atrazine adsorption and the biofilm carrier capacities of a representative filter media. The typical biofilter media- sand compared to two filter media alternatives- Granular Activated Carbon and zeolite were characterized: biofilm-coated GAC provided atrazine adsorption capacities in one order of magnitude lower than pristine GAC. Yet, its adsorption capacities were 5-fold higher than biofilm-coated zeolite or biofilm-coated sand as well as their pristine formation. The GAC bed consisted 5% w/w of the total biofilter bed.

- **Bioaugmentation with an atrazine-degrading bacteria**

Inoculum of the previously characterized bacterial strain, *Arthrobacter aurescens* Phillips TC1 (Strong et al., 2002) was used to enrich biofilters' microbiota. Unlike another microorganism, *A. aurescens* TC1 rapidly consumes atrazine as its source of nitrogen, carbon, and energy. This makes it robust and attractive for removal of triazine herbicides by biofiltration.

- **Metagenomic based plant species selection**

For selecting plant species with potential for supporting microbial-mediated atrazine degradation; we performed a search of atrazine degrading genes *AtzABCDEF* and *TrzDEFN* (Udikovič-Kolić et al., 2012), in the biofilter metagenomic database of (Morse et al., 2018). We selected the plant species *Leptospermum continentale*, which has shown the highest copy number of *atzF,E* genes. This plant species was compared to a typical biofilter plant species: *Carex appressa* and non-vegetated control.

The prototype system was tested in comparison to the standard biofilter design using a long-term laboratory-scale biofilter column study, with promising initial results.

**id #2493**

### **Misinterpretations of Living Stream concepts and the problems they may lead to.**

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The way we manage stormwater today is vastly different from how we used to manage it before. Historically, stormwater was seen as a problem (waste, not resource), and the primary objective of stormwater management was conveyance and drainage, so as to protect, and conserve the asset from flood damage. There was little regard to the health of the receiving environment, or to water as a valuable resource.

Today, with reduced rainfall as a result of climate change, and increase in water demand through population growth, the need to improve water sensitivity and sustainability have changed our perception of stormwater from a problem, to a potential resource. The Water Sensitive Urban Design concept first provided practical initiatives through a series of environmental features to help improve outcomes, however this has continued to evolve such that stormwater is also now viewed as a valuable water source.

Living streams are becoming a common feature for replacing traditional concrete channels and trapezoidal drains, while embedding multi-functional benefits. They are technically designed systems that serve ecological and liveability functions. Living streams mimic the naturally occurring processes of actual streams to reap their water quality improvement benefits and create habitat for native flora and fauna species.

However, not all natural channel conveyance systems fit the multi-functionality required from living streams and there is a tendency to underestimate the complexity and land take required to design and deliver these successfully. Furthermore, individual communities have various expectations that may not be consistent with the true functional objectives and form of living streams, which can result in further compromises.

This talk discusses what Living streams actually are and compares them against these frequent misconceptions. Several cases studies will be used to examine the diverse range of challenges, expectations and community concerns encountered during living stream design and implementation projects. Possible ways to overcome these issues are also discussed.

**id #2546**

### **Achieving partial denitrification-anammox in biofilter for domestic wastewater tertiary treatment.**

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#### **Background**

Partial nitrification process has been studied for decade years, but it is still difficult to keep stable nitrite accumulation due to the growth of nitrite oxidation bacteria. The recently proposed partial denitrification process attracted wide attentions for its

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supplement of nitrite for anaerobic ammonium oxidation (anammox) technology. However, present investigations only focused on nitrate wastewater or simulate domestic wastewater treatment, and the sequencing batch reactor (SBR) was widely studied. The exploration of partial denitrification (PDN)-anammox (AMX) filter process for domestic wastewater tertiary treatment is never reported. Therefore, this study aimed to: (1) explore the performance of PDN-AMX filter treating secondary effluent, (2) analyze the nitrogen transformation in PDN-AMX filter, (3) reveal the variations of microbial community structure and functional gene abundance.

**Materials** and **methods**

A partial denitrification filter coupled with an anammox filter was set up. Domestic wastewater was first treated by two biological aeration filters (BAF) to remove COD and ammonium, respectively. In phase I synthetic wastewater was fed to PDN-AMX filter. In phase II and phase III, the mixture of BAF1 and BAF2 effluent was supplied, but different volume ratios were controlled to resist the fluctuation of domestic wastewater. Acetate sodium was added to PDN filter, and COD/NO<sub>3</sub>-N was controlled at 3. High-throughput sequencing was conducted to analyze microbial community structure, and real-time quantitative polymerase chain reaction (QPCR) was carried out to detect the nitrogen transformation functional gene abundances. Dissolved and gaseous nitrous oxide were also measured.

**Results** and **discussion**

Long-term and stable nitrogen removal performance was achieved in PDN-AMX filter process, effluent total inorganic nitrogen (TIN) was less than 15mg/L, and total inorganic nitrogen removal efficiency (TINRE) was higher than 70%. In PDN filter, comparing with synthetic wastewater was fed, when secondary effluent was fed nitrite accumulation ratio (NAR) obviously increased to 75%. The lower influent dissolved oxygen (DO) concentration and aerobic ammonium oxidation in PDN filter contributed to nitrite accumulation. In AMX filter, when synthetic wastewater or actual wastewater was supplied, excellent nitrogen removal performance was always kept. Anammox bacteria were enriched gradually with the operation of AMX filter, and dominant genus turned from *Candidatus Kuenenia* to *Candidatus Brocadia*. In PDN filter, *nirK* and *nirS* gene copy number were much less than that of conventional activated sludge (CAS) system, *narG*(*nirK*+*nirS*) at different phases were obviously higher than CAS system, indicating the great potentials of nitrite accumulation in PDN filter. Nitrous oxide produced from heterotrophic denitrification was detected in PDN filter. However, most of nitrogen was removed via anammox pathway, so it was obviously less than that of conventional denitrification system. Comparing with conventional denitrification filter for domestic wastewater tertiary treatment, the PDN-AMX filter process can save aeration 18.6%, save carbon source addition 60%, save sludge production and CO<sub>2</sub> emission.

id #2536

### Using Constructed Floating Wetlands to Enhance Treatment in Waste Stabilisation Ponds

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Constructed floating wetlands (CFWs) are an innovative water treatment technology that offers a means of reducing pollutants associated with urban, industrial, and agricultural land uses from entering downstream waters. They can also enhance the treatment function of existing sewage treatment processes, such as waste stabilisation ponds (WSPs). CFWs are a low-technology, nature-based treatment system comprising a buoyant structure that allows plant roots to grow into, and have direct contact with, the water column below. The CFW plant roots provide a substantial surface area for microbial biofilm growth, which enhances nutrient removal and reduces turbidity. The roots also reduce flow velocities which assists in the removal of suspended solids.

The plants and biofilm have a symbiotic relationship, where the plant roots exude photosynthates (i.e. sugars) as a nutrient source for bacteria and certain bacteria that are able to process nutrients in sewage, particularly nitrogen, into bio-available forms for plant uptake. In comparison to conventional WSP-based treatment systems, CFWs have significantly greater activated surface area available for biofilm growth as a consequence of the exposed plant roots. It is hypothesised that CFWs can provide an equivalent (or higher) level of treatment to existing systems within a smaller footprint.

This paper presents the research results of an innovative CFW project currently underway on a smaller decentralised WSP-based sewage treatment plant (STP) serving 350 equivalent people (EP) on the Sunshine Coast, Southeast Queensland, Australia. The project objectives are to assess:

- How nutrients are sequestered in a variety of plant species in a CFW system;
- How the CFW improves the water quality discharged from the WSP; and
- How different configurations of CFWs enhance various pollutant removal pathways (e.g. nitrification and denitrification).

The anticipated outcomes of this project should demonstrate how CFWs can be modularised to enhance performance of medium to large WSPs, and to help protect their downstream sensitive receiving environments.

id #2198

### Development of algal-bacterial consortia with aerobic granules in photo-sequencing batch reactors treating domestic wastewater

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In recent years, microalgae-bacteria consortia have been extensively studied, especially due to the possibility of less mechanical aeration needs since produced photosynthetic oxygen by microalgae can be used by heterotrophic bacteria for organics degradation. Besides, this treatment's units can be more compact, reducing the required construction area. Other important aspect is the capacity nutrient uptake for microalgae growth, increasing its efficiency removal and thus, with biomass recovery to produce bioenergy. Consequently, the algae-bacteria consortia can be a good alternative to conventional active sludge treatment, especially for small wastewater treatment plants. The performance of algal-bacterial aerobic granular sludge was investigated in two sequencing batch photoreactors (SBPRs) by treating synthetic domestic wastewater (COD=400 mg/L). The reactors were operated under an illuminance of  $140 \pm 20 \mu\text{mol}/\text{m}^2\text{-s}$ , at light/dark cycle of 12 h/12 h, and they were placed inside a cabinet to avoid natural sunlight penetration. Each cycle consisted of 40 min (R1) and 60 min (R2) anaerobic/anoxic feeding, 196 min (R1) and 176 min (R2) aeration, 3 min settling and 1 min discharging for both reactors, with a cycle duration of 4 h. The reactors were made of acrylic transparent plastic, with a 3.5-L working volume, H/D of 8, and volume exchange ratio of 45%. The sludge of the consortia was a mix of aerobic sludge from an extended aeration activated sludge plant (flocculent biomass, MLSS=4600 mg/L, SVI<sub>5</sub>=206 mL/g) and *Chlorella vulgaris* (cell density of  $10^6$  cell/mL and 103  $\mu\text{g}/\text{L}$  of chlorophyll *a*). Dissolved oxygen was maintained at 6.4 mg/L in R1 and 6.1 mg/L in R2. pH was maintained between 7.3 and 7.8 with sodium carbonate. The results showed an obvious decreased in MLSS during the first 3 day's operation (4600 mg/L on day 1 to 2430 mg/L on day 3) on both SBPRs due to the short settling time (3 min). Afterwards, the biomass concentration increased to 3200 mg/L in R1 and 3150 mg/L in R2 on day 22. The granulation was achieved 30 and 45 days after the start-up in R1 and R2, respectively, with a granules size distribution between 0.2 and 0.6 mm, and SVI<sub>5</sub>= 23 mL/g in R1 and SVI<sub>5</sub>= 15 mL/g in R2. This observation indicated that the longer anaerobic phase (R2) favored the granulation process and the rapidly increased of NH<sub>4</sub><sup>+</sup> removal efficiency (44±8 to 73±2%) in R2. The COD removal didn't show significantly changed before and after granulation, with removal efficiency of 73±7 % and 72±9% for R1 and R2, respectively. Due to small granules diameters (0.2 – 0.6 mm), there wasn't an anaerobic/anoxic zone the development of phosphorus accumulation organisms and denitrified bacteria were not observed. After 30 day's operation, chlorophyll-*a* concentration increased to 335 and 259  $\mu\text{g}/\text{L}$  in R1 and R2, respectively, indicating the growth of the microalga *Chlorella vulgaris* and favoring a possible symbiosis with the heterotrophic bacteria of the granule.

id #1649

### Domestic Reedbed System a Winner

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Constructed wetlands and reed bed filter systems have been used for water treatment in many applications worldwide for decades. They have been used for applications as diverse as household sewage treatment and stormwater remediation.

The Rootzone Wastewater Treatment System was initially developed in NSW and is now also being installed in Victoria and WA. This is an alternative septic system where effluent passes through a couple of reedbeds before recycled water is sent out to irrigate gardens. The advantage of the Rootzone system is that you get the effluent quality of an Aerated Wastewater Treatment System (AWTS), or as it is known in WA – an Aerobic Treatment Unit (ATU), without the high operational costs of frequent servicing, pumps and blowers running and replacing these on a regular basis.

While Rootzone is a little more expensive than traditional septic tank and leach drains, and even ATUs, it is a low maintenance, low energy consumption and environmentally-friendly system that treats all household wastewater to a secondary standard. Unlike septic tank systems, Rootzone cleans the wastewater by natural biological processes and pumps the treated effluent to dripline irrigation in gardens. All of the household wastewater is recycled and used.

The process relies on natural photosynthesis and biological degradation to achieve good quality effluent. Wastewater passes into a primary sedimentation tank before it enters a horizontal flow reed bed and then a vertical flow bed. Excess effluent is sent to either leach drains or conventional beds or pumped to dripline irrigation.

The Rootzone reed bed treatment systems contain special media and wetland plants (such as *Phragmites australis*) which provide sites for bacteria and other organisms which undertake the digestion of household wastes into simpler substances.

The main wetland plant used in the Western Australian installations is *Baumea articulata* (the Jointed Twig Rush or Jointed Rush). This is a WA macrophyte that can tolerate full inundation right through to moist soil. It grows to one and a half metres height and spreads via rhizomes.

Recent testing of incoming wastewater and outgoing treated effluent from the two installations so far in WA have yielded impressive results. Levels of nitrogen and phosphorus, as key indicators of effluent quality, have had significant reductions. Some of this reduction is due to plant uptake and some due to biological action in the substrate.

Rootzone is environmentally-friendly technology in wastewater and sludge treatment. With little or no electrical or mechanical parts, Rootzone systems are long lasting, wear free, self-regulating ecosystems that are simple to operate without complex controls and chemical additives. The maintenance requirement is relatively low and the system life is very long.

When good water is becoming scarce, even more so in our drying climate, being able to capture everything for toilets, laundry and bathrooms and the use it safely to maintain garden amenity is beneficial to people, the land and to the surrounding environment.

id #2690

### Integrated process design of WWTP and Coal power station effluents treatment coupled with Algae biomass production system, A waste to profit project.

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Supervisors: Navid Moheimani, Martin Anda

Decreasing the effect of global warming by using microalgae to bioremediate CO<sub>2</sub> and wastewater treatment is of growing interest. This project presents an integrated system to bioremediate Collie's WWTP and power plant effluent to produce a high-value algal

product and generate revenue for new economic growth. Microalgae have the potential to recycle and bioremediate the effluent nutrients of Nitrogen, Phosphorous and CO<sub>2</sub> to produce chemical energy in the form of biomass. Almost all mass algal cultures are nutritionally deficient, and the addition of nutrients can enhance biomass productivity by up to 80%. Direct injection of flue gas into microalgae culture improves the mass transfer of CO<sub>2</sub> and enables a better CO<sub>2</sub> fixation in general. All microalgae cultures can benefit from external nutrient sources and specific strains can be selected that are more adapt to the type of effluents.

Microalgae culture for CO<sub>2</sub> bioremediation is a viable methodology where techno-economic parameters are understood to ensure long-term operations. The microalgal biomass produced in this process can be used for making high-value products which include pigments, nutraceuticals, plastics or low-value commodities (e.g. food and biofuel). The potential valuable products make large scale microalgal cultivation an attractive application.

id #2212

### Electrochemical ferrate synthesis in neutral waters for decentralized water treatment applications

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Although a myriad of drinking water treatment technologies exist for even the most challenging raw waters, many complexities arise when implementing conventional processes for small and remote systems. A primary challenge includes the inaccessibility for supplying the chemicals (coagulants and oxidants/disinfectants) needed for treatment (Rupp, 2001). A burgeoning, yet currently under-utilized, treatment area is that of electrochemical water processes, which is receiving considerable research attention and innovation at present. In particular, through the advancement of efficient high oxygen overpotential electrodes, the ability to synthesise highly oxidative chemical species in neutral pH conditions has become possible. In this research, the generation of highly oxidative iron-based oxidants, namely ferrates (Fe<sup>6+</sup>), is being investigated. Ferrate has been shown previously to be an effective water treatment chemical, combining both oxidation and coagulation properties. The basis of the current research study is the possibility of utilizing the low ambient concentrations of dissolved iron (Fe<sup>2+</sup>), typically found in raw water, as the reactant source for ferrate generation, thereby eliminating the chemical supply chain required for conventional oxidation and disinfection processes. Electrochemical ferrate generation experiments were performed in batch-recycle mode, using a custom-made electrochemical cell with a boron-doped diamond coated monocrystalline silicon substrate anode and stainless-steel cathode. The anolyte and catholyte, composed of phosphate buffered ultra-pure water (pH 7.1) and FeCl<sub>2</sub> ([Fe<sup>2+</sup>] = 3 mg/L), were separated by a Nafion-324 perfluorinated membrane. The anolyte was well-stirred and temperature controlled using a thermoregulated glass vessel (20±1°C). The ferrate synthesis mechanism was found to be mass transfer limited, whereby the rate-limiting step was the diffusion of dissolved iron species from the bulk water solution, through the Nernst diffusion layer to the electrode surface. This was evidenced by the very little variation in ferrate generation observed with respect to varying operating current densities. From this, it was evident that the current efficiency of the system decreases with increasing current, due to the increase of parallel parasitic reactions, such as the generation of <sup>•</sup>OH, O<sub>2</sub> and other reactive oxygen species (O<sub>3</sub>, H<sub>2</sub>O<sub>2</sub>). Although the iron oxidation reaction from Fe<sup>2+</sup> to Fe<sup>6+</sup> is limited to the electrode surface, either by direct electron transfer at the electrode or indirectly by <sup>•</sup>OH absorbed to the electrode surface, the mass-transfer limitations are clearly highlighted by the minimal changes in generation with increased current. When methanol, an <sup>•</sup>OH scavenger, was added to the solution, ferrate generation substantially decreased and remained generally constant, without a statistically significant variation with changing current density. In the absence of <sup>•</sup>OH, ferrate generation was attributed to electron transfer directly at the electrode surface. The observed results provide one of the first examples of ferrate synthesis in neutral pH conditions from a dissolved Fe<sup>2+</sup> reactant and an in-depth investigation into the mechanism of generation.

1. Rupp, G.L., 2001. The challenges of installing innovative treatment in small water systems. J. Environ. Health 64, 1–22.

id #1953

### Decentral recovery of water and nutrients from wastewater: A case study in Flanders

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#### Introduction

In Flanders, as in many urbanized and industrialized regions, the water cycle is under pressure, resulting in periodical droughts and floods. There is a need for technological measures that can be taken on a decentral level. Buffering of rainwater for low-grade use (e.g., washing machines, toilet flushing) is already common practice. In densely urbanized regions, however, rainwater availability is limited. Greywater upgrading can be a valuable source of reusable water in cases where other water sources are unavailable or scarce.

Municipal wastewater can be source-separated into three fractions: greywater (showers, washing machines, dishwashers, sinks), blackwater (faeces and urine) and yellow water (urine). Source separation of wastewater allows a more efficient recovery of resources, since the 70% of the water volume and nearly all of the recoverable heat are present in the greywater. Macronutrients (80% of N, 53% of P, 70% of K) end up in the urine, and 47.5% chemical energy is concentrated in the faeces (Jönsson et al. 2005, STOWA 2012).

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Phosphorus is a crucial nutrient for the fertilization of crops, but natural reserves are limited, and the ores geographically restricted. When wastewater is separated at the source, the mineral struvite ( $\text{NH}_4\text{MgPO}_4 \cdot 6\text{H}_2\text{O}$ ) can be precipitated from the urine fraction before subsequent treatment. Struvite precipitation from urine has been investigated and demonstrated in practice (Dereze 2018, I-QUA 2019), but needs to overcome a number of challenges, both technologically and in terms of marketability.

### **Case study: De Kruitfabriek**

*De Kruitfabriek* (the Gunpowder Factory) is an event and business location in a former industrial building in Vilvoorde, Belgium. The site functions as a living lab where innovative concepts for urban housing projects can be tested. Four partners (city developer Matexi, sewage treatment company Aquafin, technology provider NuReSys, and the city of Vilvoorde) are currently running a research and demonstration project for decentral treatment of wastewater and recovery of resources. Wastewater is separated at the source into greywater, male urine, and blackwater. Greywater is treated in a constructed wetland and a nanofiltration unit, to remove bacteria, viruses, organic pollution, and divalent ions. Urine is treated in a struvite precipitation reactor. The installations produce approximately 1.5 m<sup>3</sup> clean water and 1 kg dry struvite per week. This project is unique in the sense that the recovered water and nutrients are re-applied locally, to create an effective short-loop circular economy.

This case study will present results of the research and demonstration project at *De Kruitfabriek*, which started operation in March 2019. It focuses on closing the water and nutrient cycle on a local scale, with special attention to dissemination and education: the +40.000 annual visitors experience from up close how their wastes are transformed into resources, which they are invited to reuse themselves. Results of this project will be used to demonstrate how the water and nutrient cycles can be made more sustainable at a localized urban scale, by allowing local reuse of resources and reducing the use of rainwater and tap water.

**id #2323**

## **DECENTRALISED WATER AND WASTEWATER SYSTEMS IN THE ALTERNATE ECONOMY—WHAT MIGHT THEY LOOK LIKE?**

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Decentralised approaches to water and wastewater have been around for centuries, however recently have found themselves at the centre of the emerging 'alternate economies' that favour smaller scale, low waste, at source and multi-benefit approaches to resource management. The push for a paradigm shift in our economic thinking has generated a plethora of terms that while are slightly different in scale and focus, provide new and similar approaches to the way we value and use our limited resources, which is based on capturing and maximising benefits and closing the loop to prevent resource wastage.

Within the 'blue-green economy', decentralised nature-based systems provide water supply, water management, biodiversity and health benefits among others as part of green infrastructure networks that add to the resilience and liveability of cities and augment conventional infrastructure. Within the 'circular economy', smaller localised systems can offer more efficient and appropriate approaches for limiting waste generation, enabling resource recovery and reducing life cycle costs. Within the 'new economy', a political vision for a just, sustainable, and democratic future, small systems can be renewable, recyclable, and repurposed and assist in equitable and sustainable water service provision. Regardless of the terminology, these alternate economies enable decentralised systems to be evaluated differently than the traditional linear evaluation methods which reward economies of scale and ignore indirect costs and benefits. This new world is however complex. It requires new (systems) thinking, multi-level governance and collaborative models to deliver change, and new tools to assist decision making and evaluation. This talk will discuss some Australian examples of where decentralised systems can or have enabled uncoupling of water and or wastewater from traditional linear networks, or have enabled augmenting conventional infrastructure networks. Whilst each of these examples are small in scale, these types of systems can conceivably be replicated and connected in larger networks, which could have large cumulative impacts on water supply, wastewater treatment and liveability.

**id #2542**

## **Challenges in Providing Water Services to a remote desert community, application of Innovations and Lessons learnt**

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TJ is one of the most remote aboriginal communities in the Great Victoria Desert in Western Australia. Challenges due to low and unreliable rainfall, high evaporation rate, hyper saline ground water and poor access limited the options available to improve the community's water and sanitation infrastructure. Some of the components of the project handled by DOC to be presented are as follows.

<b>Component</b>	<b>Challenges and Risks</b>	<b>Innovations and Methodology</b>	<b>Outcome and Lessons Learnt</b>
Feasibility study of the Integrated water management strategy	Limitation of professional capability to undertake full project due to the unique challenges such as shortage of fresh water, hyper saline ground water, remoteness of the site, aboriginal community specific needs and issues and the extreme urgency to deliver.	Invited over 15 consulting engineering companies to demonstrate specialised skills and experience to collaborate and deliver the project.	Experts in specific tasks selected from 8 consulting firms to work together. There were some initial communication issues but eventually worked well.

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Hydrogeological studies	The underlying aquifer has salinity over 60,000ppm. Limited quantity of fresh to mildly saline water is available in a perched aquifer (Donga Bore field) 4km away. Next available fresh water source is 90km away.	To maximise the chances of successful drilling for fresh water, Housing commissioned a TEM (Transient Electromagnetic) survey to map out the electrical conductivity of the strata in and around the Donga bore field. Drilled 8 exploratory holes in areas showing the least conductivity.	Exploratory drilling based on the outcome of TEM survey resulted in limited success. Converted 6 bores into monitoring bores and equipped 2 of them as production bores. Water Quality of these bores being monitored.
Provision of a dual pipe water network, both of potable quality, but different levels of salinity.	Modification to internal plumbing in existing houses and institutions to service with two types of water, both potable quality as per ADWG water quality criteria.	Used two bores in the Donga borefield producing high quality water to bypass the main water supply system into the Class 1 drinking water network. Class 2 water is a blend of RO permeate with water from lower quality Donga bores.	Construction of this part of the project is still in progress. Expected completion will be in September.
Improvement of Personal Hygiene	Community members previously did not use much water for personal hygiene.	Community education of effective water use was launched.	New sanitary appliances are being used and improvements monitored
Equip bores and monitoring	Drawing water without adversely impacting on the limited freshwater lens.	Air pump technology to reduce the risk of over abstraction	Performance is monitored remotely with water level and EC probes

id #1903

### Determination of iron form in sludge accumulated in small-scale wastewater treatment plants for phosphorus removal

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This study focuses on small-scale wastewater treatment plants (SWTPs) referred to as Johkasou systems, which are decentralized in sparsely populated areas of Japan. Phosphorus removal from wastewater treatment plants is imperative for controlling eutrophication, even in SWTPs. An iron electrolysis system, which can be classified as an electrocoagulation technology, is installed in SWTPs for phosphorus removal. Ferrous ions are released from the anode of the iron electrodes and oxidized into ferric ions by the dissolved oxygen. Phosphorus can be removed via the formation of an insoluble compound containing phosphate and iron, such as  $\text{FePO}_4$ . In our previous study, the amount of  $\text{PO}_4\text{-P}$  in the filtrate in both anoxic and aerobic tanks decreased with an increase in the iron content in the sludge samples. Phosphorus release to the bulk phase was prevented by the accumulated iron in SWTPs, resulting in stable phosphorus removal. However, it was necessary to determine the conditions under which phosphorus can be effectively and stably removed in actual SWTPs. In particular, it is important to clarify the chemical form of iron that accumulates in the tank during electrolysis.

The present study targeted 3 existing SWTPs that had an iron electrolysis system for phosphorus removal in Saitama prefecture, Japan. Each plant has two anoxic tanks and one aerobic tank. Four iron electrodes (two units) were installed in the aerobic tank, with continuous aeration. The wastewater in the aerobic tank was returned to the first anoxic tank as recirculation for the denitrification of nitrogen. The effluent was periodically collected, and its water quality was measured. Sludge samples were also collected from the aerobic tanks at the three plants. X-ray fluorescence spectrometry (XRF) was performed for elemental analysis of the samples. X-ray diffraction (XRD) analysis was also performed on the sludge samples for determining their crystallinity. XAFS measurements were conducted at the Synchrotron Radiation Center of Ritsumeikan University, Japan. XAFS analysis was performed to characterize the structure of iron in the sludge. Fe K-edge XAFS spectra were measured using BL-3. Mossbauer spectrometry analysis was performed at the Reactor Institute Delft of the Delft University of Technology.

There were large differences in the iron contents of the samples, with the highest value being about 80%, as revealed by XRF analysis. A crystallographic structural peak was occasionally observed; however, this peak was not observed in the XRD spectra of most of the samples, implying that the samples were mostly amorphous. Pattern fitting was conducted between the spectra of the sludge samples and the standard reference materials of  $\text{FeCO}_3$ ,  $\text{Fe}_3\text{O}_4$ ,  $\alpha\text{FeOOH}$ ,  $\alpha\text{Fe}_2\text{O}_3$ , and  $\text{FePO}_4$  from XAFS analysis. The  $\text{FePO}_4$  ratio was the highest among the standard reference materials, and the  $\text{FeCO}_3$  ratio was low in the samples. The ferrous iron ratio was calculated by fitting of the Mossbauer spectrometry analysis, and the results agreed with those of the XAFS analysis.

id #1819

### Nitrification in Fixed-Bed-Sequencing Bio-Reactor for Seafood Processing Wastewater Treatment

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Seafood consumption has high food demand especially in Malaysia as its contain 15% of the protein from food dietary hierarchy. According to the Fisheries Department of Malaysia, the fisheries production is increasing about 5% for each of the year since 2013. The increase of the seafood production led the high pollution effluent load in the water body. Seafood processing wastewater contain intestinal organs, bloods, fins, gill and the outer skin which it contains high amount of ammonia and nitrogen. Therefore, the study was aimed to treat seafood processing wastewater by using jute fiber with the modification of the sequencing batch biofilm reactor (SBBR). Samples were collected from the local seafood processing stall located at Parit Samijan, Parit Raja, Johor. Jute Fibre- Sequencing Batch-Reactor (JF-SBR) was operated by mixing the seafood processing wastewater with activated sludge and jute fiber. The efficiency of the JF-SBR was compared with the traditional SBR by controlling the aeration time and aeration rate suggested from the Response Surface Methodology (RSM) design software. The result illustrated that JF-SBR have higher efficiency compared to the traditional SBR by 66.86% vs 53.52% for BOD, 95.65% vs 78.26% for TSS, 66.86% vs 53.52% for COD, 68.75% vs 50.86% for AN, 91.67% vs 83.33% for Nitrate and 100% vs. 50% for Nitrite, respectively. Therefore, the JF-SBR is proven as one of the best alternative to be used in treating the seafood processing wastewater.

id #2654

### THE FEASIBILITY OF USING TiO<sub>2</sub> NANOTUBES FOR PHOTOCATALYTIC DEGRADATION IN LAUNDRY GREYWATER

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Laundry greywater is a wastewater that generate from domestic household, hotel, school as well as cloths industries. Concerns exist in relation to the presence of pollutant compound in Laundry Greywater (LGW) into the water body from the untreated discharge of greywater. Therefore, the aim of this study was to identify the chemical that absent in LGW and the effectiveness of TiO<sub>2</sub> nanotubes that act in photocatalyst treatment for LGW treatment. The presence of physiochemical were measured for Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Dissolved Oxygen (DO), pH, total suspended solid (TSS), temperature and turbidity by using the TiO<sub>2</sub> nanotubes as catalyst in photocatalyst process. Photocatalyst treatment was designed and developed using titanium oxide (TiO<sub>2</sub>) nanotubes which were in the foil form. TiO<sub>2</sub> was divided into three sample which is each of sample produce with different voltage that are 10 V, 40 V and 60 V to present with different pattern of TiO<sub>2</sub> nanotubes. Results exhibit the effectiveness of TiO<sub>2</sub> nanotubes for photocatalyst degradation in greywater by reducing the BOD to 89.7%, COD to 52.1%, TSS to 34.2% and turbidity to 34.3%. Moreover, the characteristic and crystallinity of TiO<sub>2</sub> nanotubes was determined by using X-ray Diffractometry (XRD) and Field Emission-Scanning Electron Microscopy (FESEM) where nanotubes structure of 40v pattern was appropriate to increase the efficiency of the photocatalytic treatment process. It is found that the use TiO<sub>2</sub> nanotubes in photocatalyst degradation treatment provide great opportunity for laundry greywater management.

id #2689

### Algal culture to treat anaerobic digestates

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The overwhelming interest in the use of algae to handle associated nutrient surge from anaerobic digestion technologies for the treatment of wastewater, is driven by the need for efficient nutrient recovery, greenhouse gas mitigation, wastewater treatment and biomass reuse. In a series of studies, we tested the feasibility of growth and ammonium nitrogen removal rate of microalgae and macroalgae cultures for treating sand-filtered, undiluted anaerobic digestion piggery effluent (ADPE) under Perth, Western Australia outdoor climatic conditions. Microalgae were grown using paddle wheel driven raceway ponds and tubular photobioreactors. Macroalgae cultures were maintained as biofilm using an algal turf systems.

Initial ammonium nitrogen concentration in the Biocoil and raceway pond was 893.03±17.0 mg NH<sub>4</sub><sup>+</sup>-N L<sup>-1</sup>. The microalgal consortium in both cultivation systems was dominated by *Chlorella* and *Scenedesmus*. Overall, similar average ammonium nitrogen removal rate in Biocoil (24.6±7.18 mg NH<sub>4</sub><sup>+</sup>-N L<sup>-1</sup>d<sup>-1</sup>) and raceway pond (25.9±8.6 mg NH<sub>4</sub><sup>+</sup>-N.L<sup>-1</sup>d<sup>-1</sup>) was achieved. However, the average volumetric biomass productivity of microalgae grown in the Biocoil (25.03±0.24 mg AFDW L<sup>-1</sup>.d<sup>-1</sup>) was 2.1 times higher than in raceway pond. This microalgal consortium could be maintained in semi-continuous culture for more than three months without changes in the algal composition.

A consortium of two macroalgae could efficiently grow in the ADPE. Maximum ammonium removal rate (30.6 ± 6.50 mg NH<sub>4</sub><sup>+</sup>-NL<sup>-1</sup>d<sup>-1</sup>) was achieved at ADPE concentration equivalent to 248 mgNH<sub>4</sub><sup>+</sup>-N L<sup>-1</sup>. Mean biomass productivity of 31.1 ± 1.14 g ash-free dry weight (AFDW) m<sup>-2</sup>d<sup>-1</sup> was achieved.

Results of our studies indicated that microalgae consortium is suitable for simultaneous nutrient removal and biomass production from undiluted anaerobic digestion piggery effluent. We also found the potential of use macroalgal consortium for treating diluted ADPE. Produced algal biomass can be used as a source of animal feed or biomethane production.

id #2512

### A Smart Grid for Micro-trading Rainwater

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Urban water management is challenged across the globe, due to limited resources, development of urban demands, and climate change. Novel water markets and water supply paradigms have emerged, including fit-for-purpose water reuse that delivers water treated to certain quality standards for appropriate end uses and on-site rainwater harvesting to meet non-potable household

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demands. In this study, we propose a peer-to-peer non-potable water market that allows households to capture, use, sell, and buy rainwater within a network of water users. This framework proposes that a peer-to-peer non-potable water market can be enabled by existing and emerging technologies, including household rainwater harvesting cisterns, a dual reticulation network, Advanced Metering Infrastructure (AMI), and blockchain. Many households have the infrastructure to collect rainwater from rooftop runoff. A community pipe network is needed to serve as the backbone for the water trading network by receiving water from rainwater harvesting tanks and distributing water at households. The dual reticulation system should be dedicated to circulating non-potable water and augmented by a base flow of reclaimed water. AMI is needed to sense and record water contributed to and withdrawn from the water network at each household on sub-hourly time steps, and blockchain technologies can be applied to create a ledger to record transactions between peers. This manuscript describes the peer-to-peer non-potable water market and explores the climate characteristics and demand profiles that would create a viable market. An all-pipe hydraulic model is constructed for a hypothetical community to simulate the storage dynamics in household-level tanks, demands exerted for non-potable uses at households, and hydraulics in the dual reticulation network. The simulation is applied for climates at locations in the United States and Australia to explore the feasibility of a system. Simulations explore infrastructure components, network flows, and the mix of buyers and sellers that are required to maintain nodal pressures and flows in the network. Scenarios are simulated to explore the tradeoffs between energy and water savings. An agent-based modeling concept is proposed to capture interplay among demands, climate, trading adaptations, and infrastructure performance. Implications for infrastructure investment, water quality, health risks, and decentralized energy are explored.

**id #2273**

### **Adaptable constructed wetlands for on-demand greywater treatment in Brazil and Germany**

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Strengthening urban blue-green infrastructure is a prerequisite for mitigating climate change-associated effects, e.g. flooding and drought, and could considerably contribute to regulating urban microclimate, mainly through cooling by evapotranspiration and shading. Invariably, however, it implies increased water demand for irrigation, which is further aggravated by rising water scarcity worldwide, wherefore alternative urban water resources must be made available. Typically, the sole use of stored rainwater is inadequate in densely populated urban areas due to high storage requirements, whereas greywater is generated continuously, yet it requires handling for safe reuse. Centralized constructed wetlands (CW) are a consolidated technology that have not been broadly applied in urban centers due to large area requirements. For decentralized urban units, however, adaptable CW may be suitable for greywater treatment, as they might require less area. In order to elaborate suitable dimensioning parameters and supply urban greens with sufficient irrigation water and nutrients, characteristics of light greywater in Brazil and Germany were investigated as a basis for developing adaptable CW for greywater treatment specifically tailored to urban requirements and green infrastructure needs (e.g. trees, green roofs etc.) in terms of water flow and nutrient loads. Data for light greywater from different sources was analysed in Brazil and Germany to allow for a comparative analysis. In both countries treatment requirements were assessed considering varying seasonal needs of urban greens and water/nutrient availability in greywater. The effectiveness of modified CW was evaluated for on-demand greywater treatment. Despite low nutrient concentrations in light greywater in Brazil (TN=4.2–8.8 mg/l; TP=0.2–5.6 mg/l), nutrient loads of 0.4–1 g N/(PE·d) and 0.2–0.4 g P/(PE·d) could be determined; volume flows amounted to 70–85 L/(PE·d). In Germany, shower greywater entailed 0.9 g N/(PE·d), 0.1 g P/(PE·d) and 44 L/(PE·d). Considering nutrient requirements of 5–30 gN/(m<sup>2</sup>·yr) and 0.5–5 gP/(m<sup>2</sup>·yr) for max. urban green yields, recycled light greywater was shown to be an adequate source for water and nutrients, if no significant nutrient removal takes place in the long-term. In Brazil, depending on the region, one inhabitant's light greywater could provide up to 8 m<sup>2</sup> (N-limiting) to 31 m<sup>2</sup> (flow-limiting) urban greeneries with sufficient nutrients and water, whereas in Germany up to 5 m<sup>2</sup> (P-limiting) to 16 m<sup>2</sup> (flow-limiting) greens would be possible. In Germany, due to well defined seasonal and vegetation periods and varying water and nutrient needs of plants throughout the year, it is however necessary to adjust treatment periodically and achieve nutrient removal from October to February. The addition of a P adsorbing layer and controlled on-demand denitrification through partial saturation in vertical flow CW could be suitable for that purpose. In sum, this study showed that both constructive modifications and different operation modes could significantly flexibilise CW. Mass and flow balances provide evidence that on-demand water reclamation and nutrient removal may promote blue-green infrastructures in two different urban contexts, thus helping to relief future water and climate-related challenges. However, further investigation is required to provide better insights into the large-scale viability of the proposed technological innovations.

**id #1719**

### **Silos to systems - Taking a circular economy approach to service provision**

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Global drivers such as climate change, increasing population, stricter environmental regulation, and resource scarcity and together with local liveability considerations and rising energy costs, mean that water and sewage service provision is expanding beyond health and environmental protection to include the recovery of valuable resources. The focus is the win-win-win for utilities, their customers, and the environment, associated with diverting waste streams from sewerage outfalls and landfill to recovery and beneficial reuse instead. Resource recovery strategies in the Australian water sector have historically focused on water and biosolids, albeit to a limited extent, other resources are now under consideration. The IWA (2016) framework, using a circular economy approach, encourages utilities to consider recycled water, energy generation and nutrient recovery as a business-as-usual approach.

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In order to truly drive an integrated water management approach or One Water approach, we need to ask the question: Can we go beyond reducing ecological damage and seek to design infrastructure that actually improves the local economy, environment and society? To do this we need to start to think differently about the recovery of valuable and dangerous materials; acceptable levels of risk, security and price; and a more expansive approach to externalities.

Our research has identified a range of factors prevents the development of institutional changes that would allow a shift to a circular economy or One Water approach. Foremost of these is the inertia associated with the dominant paradigm of centralised and siloed systems. This, together with the complex structure of regulations that currently exist for water supply, wastewater and stormwater management, poses significant obstacles to a fully integrated approach.

The regulatory patchwork environment, with overlapping responsibilities and jurisdictions, particularly with respect to the need for management of both public health and environmental risks, currently hinders system integration. Further, there is a lack of appropriate economic tools to value integrated water services, including the ability to monetise indirect costs, understand and account for cross-subsidies, and evaluate short-term versus long-term costs.

Within the water industry, the rigid cultural norms of organisations, professionals and academics, and a lack of incentives, reward systems and capacity development, are barriers to integrated and innovative water management. In addition to understanding the cultural nuances that influence change in the water industry it is also important to understand the cultural issues that influence the behaviour of customers and the community.

A number of examples of how these challenges could be overcome will be presented, drawing on work focused on One Water approaches, circular economy projects with Hunter water and Sydney Water.

**id #1768**

### **Application of Membrane Distillation for Water Reuse from Wastewater Concentrate**

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The interest towards zero liquid discharge in water reclamation plants (WRP) led to this study in evaluating the suitability of membrane distillation (MD) technology for treating wastewater reverse osmosis (RO) concentrate. Sydney Olympic Park Authority's (SOPA) WRP uses a combination treatment operation, followed by RO. One of the major limitations of adopting RO in SOPA's WRP is the production of substantially large volume of wastewater RO concentrate, generally comprising 20–25% of the feed stream volume.

The aim of this study was to evaluate the performance of membrane distillation (MD) for treating wastewater RO concentrate to achieve near zero waste discharge. The results of this study showed that a direct contact MD, at obtaining 85% water recovery of wastewater RO concentrate showed only 13–15% flux decline and produced good quality permeate (10–15 µS/cm, 99% ion rejection) at moderate feed temperature of 55 °C. Granular activated carbon pretreatment helped in reducing organic contents of wastewater RO concentrate and adsorbed a range of micropollutants. This ensured high quality water production by MD (micropollutants-free) and enhanced its reuse potential, promising a near zero waste discharge in WRPs.

Further, the role of 3D printed spacers for organic fouling mitigation in DCMD was evaluated. Compared to a commercial spacer, the design of 3D printed triply periodic minimal surfaces spacers (Gyroid and tCLP) - varying filament thickness and smaller hydraulic diameter enhanced DCMD fluxes by 50-65%. In MD, high organic contents minimally affected MD fluxes but reduced membrane hydrophobicity. Repeated DCMD cycles showed that organic pre-treatment as well as cleaning-in-place of membrane and spacer are essential for achieving high recovery rate while maintaining a stable long-term DCMD operation with wastewater concentrate.

**id #2643**

### **The criticality of policy and institutional issues to the attainment of SDG6 on sanitation in Sub-Saharan Africa**

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Several studies have been done to identify the reasons for poor sanitation performance and determinants of sanitation success. While literature findings provide critical information that could help address the underlying causes of poor sanitation coverage in sub-Saharan Africa (SSA), the focus was mainly on socio-economic, environmental, socio-cultural, political and technological factors, without recognising the critical role of policy and institutional factors as key enablers of success. The enabling environment comprises of a set of related functions that help governments, public and private partners to collaborate in effective and sustainable service delivery. Policy-making and regulation is typically a function of government. Governments have tried to develop policies/laws that specifically address access to adequate sanitation. Aspects addressed at national level include public services regulation, water quality management, the quality of water and sanitation service provisions, service standards, recognition and entitlements, allocation and availability, physical accessibility, non-discrimination and attention to marginalized and vulnerable groups, participation and access to information, monitoring and complaints procedures, and definition of the broad institutional framework for service delivery. In order to understand the lack of progress in sanitation, research needs to investigate governance challenges bedeviling the sector. These include weak institutional and management frameworks, lack of proper sanitation regulatory controls, lack of clarity of roles/responsibilities, lack of implementation of policies, corruption and lack of transparency, inadequate capacity and spending in the sector.

This study collected sanitation policies and strategies from 26 countries from SSA and analysed them based on a set criteria defining the enabling environment. These are sector policy and strategy; institutional arrangements; planning, monitoring and review; budgeting and financing; and sector capacity development. A scoring system was developed to assess status and correlate this to the sanitation achievements of the different countries. The sources of policy and strategy data included the UN-Water Global Analysis and Assessment of Sanitation and Drinking-Water reports, African Ministerial Council on Water reports

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and other internationally recognized reports and country official reports. The sanitation coverage data was obtained from the WHO/UNICEF monitoring data.

The study demonstrated that only 26 countries in SSA have sanitation and hygiene policies. About 31% of the nations do not have a dedicated institution regulating sanitation across the service chain, whilst 69% mention regulatory institutions in various agencies. About 73% of the policies do not describe the sources of capital costs for the sanitation service chains - (sewered/non-sewered; household, public, private). Only 27% have described financing and cost recovery. Other challenges noted include no clear mention of sanitation technologies that support safely managed sanitation, and lack of clear definition of sanitation service levels. Most of the available policies talk to the MDG era and only a few countries such as Rwanda and South Africa revised their policies after 2016. This study shows compelling evidence of the need for a consistent policy framework to guide reforms in Africa for sanitation improvements in line with the SDGs. It also shows that most countries that made significant progress in meeting the MDGs had guiding documents to define their institutional arrangements.

id #1621

### **Aerobic biodegradation of butyric acid by *Achromobacter animicus* B1a for potential pit latrine deodorization: Effects of medium agitation rate and temperature**

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Access to effective sanitation is of paramount importance to reduction of health risks associated with poor sanitation. A simple pit latrine is the most affordable and common means of human excreta disposal. It is currently used by about 1.8 billion people globally particularly in the emerging economies of Africa and India. However, bad smell from pit latrines is one of the major nuisances that discourage their use over the world. This is because of many social, aesthetic and disease related concerns the smell represents. Butyric acid has been identified as one of the organic compounds released from pit latrines responsible for odour nuisances. Effective methods for preventing and eliminating odour causing compounds such as butyric acid is required for increased investment in, adoption and consistent use of pit latrines in the developing countries to meet SDG 6 sanitation target. The objective of this work was to isolate highly efficient butyric acid degrading bacteria from pit latrine fecal sludge. Further, the effect of agitation rate and temperature on the bacterial growth and butyric acid degradation was elucidated. By enrichment culturing of the fecal sludge collected from pit latrines *Achromobacter animicus* B1a was isolated. In liquid medium, *Achromobacter animicus* B1a grows using butyric acid as the sole source of carbon and energy. With the initial concentration of 1000 mgL<sup>-1</sup>, the bacterium achieved 100% butyric acid degradation in 24 h. The bacterium was capable of degrading butyric acid at a wide range of agitation rate of 0 (without agitation) to 200 rpm and temperature of 20 to 45 °C to the bacterium optimally degraded butyric acid at the temperature of 30 °C and agitation rate of 110 rpm. The present work confirms that the use of obligate aerobic bacterium, *Achromobacter animicus* B1a for deodourisation of pit latrine malodours as a result of butyric acid is possible. The exploitation of *Achromobacter animicus* B1a would be helpful for development of an efficient technology for the removal of odour-causing compounds using bacterial species

id #2297

### **Evaluation of a Human-associated Genetic Marker for *Escherichia coli* (H8) for Fecal Source Tracking in Thailand**

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Fecal contamination by water discharged from point sources and non-point sources causes waterborne diseases. This is a major concern in many countries, especially in developing countries. Fecal contamination becomes difficult to implement a management plan without the identification of their source. Therefore, fecal source tracking becomes an important method for understanding the source of fecal contamination and for decreasing the hazard of waterborne diseases that occur in the environment. *E. coli* can be used as an indicator organism of fecal pollution in freshwater. Recently, a human-associated genetic marker for *Escherichia coli* (H8) has been developed and successfully used it to check the proportion of human-associated *E. coli* in wastewater and drinking water. However, this H8 marker method has not been widely applied to investigate the fecal pollution in water environment for fecal source tracking in Thailand. Thus, the H8 marker required further investigation into its the applicability and performance in identifying fecal contamination sources in Thailand. This study was conducted with the objectives: (1) to evaluate the performance of H8 marker in Thailand; (2) to compare the performance of H8 marker with other countries. In this study, influent and effluent from a wastewater treatment plant and septage samples (target host groups) were collected for evaluation of the sensitivity of H8 marker. In addition, animal feces samples including cattle, buffalo, chicken, duck, and pig (non-target host groups) were also collected for testing the specificity of this marker. To check the performance, SYBR Green based Real-time PCR assays were performed with this marker for 150 isolates collected from target host groups and 250 isolates from non-target host groups. Sensitivity was calculated by using true positives and false negatives of the target host samples. Furthermore, specificity was calculated by using true negatives and false positives of the non-target host samples. The results showed that the sensitivity and specificity of H8 marker to human-associated *E. coli* strains in Thailand were 36% and 96%, respectively. All of the non-target host groups were found that they were significant differences with a positive proportion from the target host group ( $p \leq 0.01$ ). This performance of H8 marker would be similar compared to the three previous studies carried out in Japan (sensitivity: 30%, specificity: 99%), Australia (sensitivity: 45% and specificity: 94%) and Bangladesh (sensitivity: 16%, not confirmed). From these results, the performance of the H8 marker in Thailand was projecting a similar trend as compared with other countries. Thus, we considered that H8 marker can be used as a human-associated *E. coli* genetic marker for fecal source tracking in water environment in Thailand.

id #2215

### **Potentials of *Chlorella* species in the Remediation of Crude Polluted Water**

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The use of microalga in the remediation of crude oil polluted water was assessed using *Chlorella* species. Crude polluted water sample was collected from Agip exploration site at Njaba River basin, Izombe, Oguta Local Government Area of Imo State, while microalga was for the study was collected from a drainage system within Abakaliki metropolis, Ebonyi State, both in Southeast Nigeria. The microalga sample collected was isolated, identified morphologically and cultivated in the laboratory using BBM media. The cultivated microalga was introduced into the polluted water samples in conical flasks for one week. Thereafter, the mixture was transferred into another closed bioreactor designed to filter the sample after digestion by the microalga. Some water quality parameters which include pH, chemical oxygen demand (COD), conductivity, total dissolved solids (TDS) and dissolved oxygen were measured for the crude oil polluted water before, during and after treatment with *Chlorella* species. The results showed that mean pH varied from 6.20 in the crude polluted sample to 6.80 in the filtered sample. Mean chemical oxygen demand decreased from 3.68 mg/L to 3.52 mg/L in the polluted and filtered samples, respectively. Mean conductivity (1,843.33  $\mu$ S/cm) and Total dissolved solids (910.67 mg/L) were higher in the filtered samples. Mean dissolved oxygen (6.93 mg/L) was also higher in the filtered samples. Differences in the parameters measured in the polluted, treated and filtered were significant ( $p < 0.05$ ). Higher pH value was in indication of reduction in organic acid content while reduction in COD showed that the filtered water had more dissolved oxygen. On the other hand, higher conductivity and TDS recorded in the filtered sample indicated the presence of more ions in the treated and filtered samples due to the activity of the microalga in the breakdown of the complex crude hydrocarbon molecules. Hence, the study revealed that *Chlorella* species have the potential for remediation of crude oil from water if utilized.

**id #2214**

### **LOW COST-LOW TECHNOLOGY HOUSEHOLD WATER COLLECTION AND TREATMENT SYSTEM**

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Globally, water is the major driver of socio-economic activities of man and it is at the centre of development and poverty eradication. However, more than 40% of the world population (mostly from Africa) lack access to adequate sanitation and safe portable water. The problem is anticipated to worsen in the near future due to projected rise in human population and attendant increase in water demand. For Instance, in 2018, Nigerian and African populations were estimated at 200 million and 1.3 billion, respectively, these populations are correspondingly projected to reach 410 million and 2.5 billion in 2050. The rise in population implies increased demand for water, food and social amenities. Furthermore, projected increase in industrialization and urbanization will also increase water demand and pollution. The situation is obfuscated by lack of municipal water treatment facilities and proper reticulations in most tropical African cities. Residents are therefore forced to rely on streams, groundwater and rainwater to meet their water needs. Unfortunately, in cities like Abakaliki, the groundwater is contaminated with hardness causing carbonates, heavy metals and pathogenic organisms, that make the water unfit for human consumption. Rainwater though relatively clean and free from the aforementioned contaminants is available in only six months (May-October) of the year. In this study, we designed a low budget and low technology household water treatment system. The system collects and treats groundwater in three plastic tanks during the dry season (November-April). In the first tank, sodium hydroxide is added to remove hardness, the water is aerated naturally and allowed to stand for two days, thereafter Alum is added to aid flocculation and settling for three days. Afterwards, the water is transferred by gravity to the second tank where it is chlorinated to kill microorganism before pumping into the third tank (overhead tank). The water is then reticulated through gravity to the household, passing through a filter and reverse osmosis system. During the raining season, rainwater is collected from aluminum roof, filtered into the second tank, where it is treated with chlorine and then pumped into the overhead tank. This simple technology and low cost water treatment system eliminates water hardness and over 99.5% of heavy metals and microorganism, thus reducing water shortage and increasing the availability of portable water to the household throughout the year.

**id #2667**

### **Distributed Systems for Space Age**

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Growth and development in technology has assisted humans to dream of interplanetary travel and possible habitation. Availability of water is key for survival of earth-based life forms anywhere in the universe. On celestial bodies that lack the abundance of water that we experience on planet Earth, this may pose an impediment. The organic nature of life forms as we know it, requires organic supplements, which require organic management of resources and waste. Development of innovative solutions are not only useful for space age travel, however many of the appliances and technologies that we use in our day-to-day existence had been developed from innovative technologies originally intended/developed for space technology. While the space war between US and USSR has definitely helped in indirectly driving innovation in many sectors of technological advancement, there is no real need for competition to organically grow innovative options in re-inventing old methods for new requirements. Meeting the basic human needs for wastewater treatment and reuse, access to safe potable water and growing food would be paramount whether one is on Earth, Moon or Mars.

Composting or vermicomposting may offer a possible option to treat organic solid and liquid waste that is an unavoidable component of life. This paper would primarily focus on one low technology option that had been researched for use in remote communities that would be a contender for use in space travel and habitation if and when that eventuates. Different aspects of the innovation, including technological know-how, preliminary cost considerations, fail-safe options and ongoing maintenance will

be discussed. The possibility of collaboration across different areas, such as academic research, space research, social research and water servicing sectors would be key. The paper would also look into existing research and the need for further work in this area to investigate real world scenarios.

id #2308

### INTEGRATED, GREEN INFRASTRUCTURE-BASED SOLUTIONS FOR RESTORATION OF SUSTAINABLE AND RESILIENT URBAN LAKES

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Urban lakes play a pivotal role in the functioning and liveability of our cities, being a vital part of stormwater management and the invaluable assets and services that underpin resilient, connected, and sustainable communities. The roles and expectations associated with these purpose built or modified wetlands, many of which were originally stormwater and groundwater 'sumps' have evolved over time in response to increased awareness and perception of their values (e.g. urban biodiversity, public health, historic & cultural benefits).

However, population growth, urbanisation and climate change are posing an ever-increasing threat to urban lake systems, causing degradation of water quality and deterioration of the overall ecological health, which is often manifested via phytoplankton and harmful algal blooms (HABs). The negative impacts of these blooms, and in particular cyanobacterial blooms, are multiple as they may represent a threat to human and animal health due to toxin production, and can greatly reduce the value of lakes as recreation and aesthetic assets causing broader negative economic and social impacts.

Commonly, the need to come up with a solution for HAB management and restoration of urban lakes is urgent, driven by incidents and/or community concern, and the decision process is based on and hence limited by personal opinions, the knowledge and experience of managers or operators, and is driven primarily by cost. As a result, applied management approaches and technologies are neither sustainable nor feasible solutions as they often generate an array of secondary issues that more serious and harder and more expensive to manage.

In this paper we present a case study for an approach for creating effective, sustainable and resilient lake remediation systems, based on Green Infrastructure principles and delivered using a decision-making process that draws from the local context and broader project objectives. The case study is an urban lake in the City of South Perth (Neil McDougall Park Lake) for which an on-site, integrated system was developed. This integrated system predominantly focuses on i) biological/microbiological nutrient management and ii) improvements in lake circulation, specifically targeting the key underlying causes of algae blooms in the lake. This was found to be a more sustainable and feasible solution compared to conventionally used mechanical or chemical approaches, as it provides a range of additional benefits such as biodiversity enhancement, landscape improvements, improvement in community value. Whilst the approach is not reliant on longer term catchment interventions, it complements these, offers a more immediate management response and is a progressive, longer lasting intervention that is easily integrated within the wider green network solutions.

id #2189

### A Study on Crystal Growth Characteristics to Decide Recovery Criteria of Struvite

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Struvite ( $\text{MgNH}_4\text{PO}_4 \cdot 6\text{H}_2\text{O}$ ) crystallization process is one of the methods in recovering ammonium nitrogen (N) and phosphate phosphorus (P) from wastewater containing high N, P. The process can recover phosphorus and ammonium resources as valuable slow-release fertilizers. For struvite crystallization in side stream of wastewater treatment plants, it is necessary to adjust pH 8 – 10 and add magnesium source.

The struvite crystallization process consists of 2 steps: crystal nucleation and crystal growth. Seed material improves the nucleation rate by decreasing necessary energy. The crystal growth is self-catalyzed reaction that is affected by fluid-shear and contact between particulate crystals. In this study, a struvite crystallization plant was operated by using recycled struvite as seed material. The aim of this study was to demonstrate crystal growth characteristics and determine the optimal recovery criteria in the struvite crystallization plant.

The struvite crystallization plant (capacity of 10 m<sup>3</sup>/d) utilizes a feeding system of MgO, a pH controller, and a hydrocyclone. The pH controller maintains the value of pH around 8.2 – 8.5 constantly by controlling the feeding flowrate of MgO slurry. The hydrocyclone is operated to separate and recycle struvite crystal as both seed material and product of fertilizer every 6 hours. The influent was digested sludge filtrate containing 98.3 – 123.9 mg/L of PO<sub>4</sub>-P and 251.4 – 315.1 mg/L of NH<sub>4</sub>-N typically. Residual Mg<sup>2+</sup> concentrations of effluent were 28.4 – 60.9 mg/L. The average removal efficiencies of PO<sub>4</sub>-P and NH<sub>4</sub>-N reached to 87.5%, 17.0% respectively.

To recycle struvite crystal, the hydrocyclone was operated for 2 minutes each time; the bottom effluent of hydrocyclone was returned to crystallization reactor as the seeds of struvite; and some of them were sifted and recovered as fertilizer by standard sieves with mesh size of 75, 150, 300, 600 and 1200 μm. The dry weight fractions by particle size were measured. The weight fractions of 300 – 600 μm increased from 7.3 to 73.7% within 18 hours and maintained around 70% consistently. Those of 75 – 150 μm and 150 – 300 μm maintained under 10%, 20% after 18 hours.

Recovered crystal of 75 – 150 μm, 150 – 300 μm, and 300 – 600 μm was analyzed by SEM-EDX and XRD. As a result of analyses, those of 150 – 600 μm showed orthorhombic crystalline structures of struvite, and average content of struvite was about 60%. However, those of 75 – 150 μm showed most amorphous structures; this suggested that those of 75 – 150 μm would

be immature. When the size of crystal grows larger than 150  $\mu\text{m}$ , the crystal with clear struvite structure becomes major constituent considerably. After 18 hours, the portion of 300 – 600  $\mu\text{m}$  crystal occupied dominant proportion higher than 70%. As a result, this investigation has indicated that when struvite crystal larger than 300  $\mu\text{m}$  is recovered, high-purity fertilizer can be achievable. In order to meet this criteria, it takes longer than 18 hours in this operation condition. Further research for determining recovery criteria in different conditions could be needed.

id #2303

### FROM WASTE TO BIOENERGY: ENHANCING THE RECOVERY OF ENERGY AND NUTRIENTS FROM SMALL-SCALE FOOD WASTE TREATMENT SYSTEMS

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**Introduction.** Each year, nearly 1.3 billion tons of food waste (FW) is generated in the world (FAO<sup>1</sup>). Anaerobic digestion can be an alternative for treating FW and recover high-value byproducts, mainly biogas and nutrients in biomass. Currently, there is a FW methanization platform in operation at the Federal University of Minas Gerais. It receives 0.5 Tn-week<sup>-1</sup> of FW from a university restaurant and it comprises a manual sorting unit, a grinder, an anaerobic digester (CSTR  $V=18.8\text{ m}^3$ ) followed by an up-flow anaerobic sludge blanket (UASB) reactor ( $V=1.8\text{ m}^3$ ) and solid-liquids separators. Part of the liquid digestate is treated in a high-rate algal pond (HRAP) ( $V=1.25\text{ m}^3$ ). pMethar facilities also include units for biogas storage and upgrading, and an adapted internal combustion engine that runs on biogas and generates energy.

**Material and Methods.** The operation of the pMethar started in 2013. Data from the operational phase 2017-2018 are presented in this abstract. During this phase, the anaerobic digestion was performed in two stages, the first took place in the CSTR, operated in environmental conditions (22 to 30°C) with an HRT of 100 days. FW was diluted with tap water for maintaining total solids (TS) concentration at 5%. The second stage took place in the UASB reactor, operated at room temperature and HRT of 10 days. The HRAP was fed with 150 L/d (HRT=10d) of diluted FW digestate. pH, alkalinity, COD, volatile solids (VS), volatile fatty acids (VFA), and biogas production and composition were monitored periodically in the CSTR and UASB reactors. For the HRAP, pH, dissolved oxygen (DO), COD, ammonia (N-NH<sub>3</sub>), total nitrogen (TN) and total phosphorus (TP) were analyzed periodically. A Biomethane production (BMP) test was performed for the harvested biomass. All analyses were carried out according to the standard procedures (APHA, 2012).

**Results and conclusions.** Since 2013, approximately 150 - 480 Tn of FW were treated producing 400 - 20.000 m<sup>3</sup> CH<sub>4</sub>. The higher energy efficiency was measured during 2013-2014, with a net value of 36 kWh d<sup>-1</sup> (Ferreira, 2014). Due to space limitations, the parameters monitored for the CRTS+UASB during 2017-2018 will be presented in the full paper. The system was fed at an organic loading rate (OLR) of 0.4±0.3 kg VS·m<sup>-3</sup>·d<sup>-1</sup> and yielded an average of 450 m<sup>3</sup>CH<sub>4</sub>·kgVS<sup>-1</sup> (CSTR+UASB). In a preliminary energy assessment study, these values were enough to cover the energy requirements of the pilot system. In relation to the HRAP (operated at a digestate concentration of 50% v/v), COD, NH<sub>4</sub>-N, TN and TP removal efficiencies of 66±11%, 96±2%, 66±20% and 62±8% were measured. Also, BMP test shows a biogas yield of 128.6 mL·gVS<sup>-1</sup> for the harvested biomass (1.64g VS·L<sup>-1</sup>). Further operational steps will include the co-digestion of harvested microalgae biomass with FW in the CSTR, seeking to enhance biogas production and reduce the use of tap water. Operational constraints regarding the sustainability of FW transportation and market opportunities for by-products were also evidenced as critical factors to achieve sustainability. Results suggest that pMethar is an alternative for a decentralized-low carbon footprint FW treatment.

id #2452

### SUSTAINABLE PRETREATMENT ALTERNATIVES TO ENHANCE METHANE RECOVERY FROM ANAEROBIC DIGESTION OF MICROALGAL BIOMASS GROWN IN WWTP

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**Introduction.** Several pretreatments technics have been extensively investigated to enhance the hydrolysis of microalgal biomass to increase both bioavailability and biodegradability of macromolecules for anaerobic digestion (AD). However, the application of some pretreatments entails high costs and energy consumption to large scale application, for example, the use of commercial enzymes in biological pretreatment and the energy used for heating in thermal pretreatment (Passos & Ferrer, 2014; Saratale *et al.* 2018). Therefore, this study aimed to assess the use of two low-cost alternative pretreatments: a solar heating system as a thermal pretreatment; and ruminal content as a source of hydrolytic microorganisms for biological pretreatment of microalgae grown in a high rate algae pond treating food waste digestate.

**Material and Methods.** For both pretreatments, microalgal biomass was harvested in a lamellar settler (1,25m<sup>3</sup>). For thermal pretreatment, the biomass was transferred into three vacuum tube solar collectors, disposed at a slope of 20° south relative to magnetic north, for taking advantage of the greatest solar radiation throughout the day. Different exposure times were evaluated (4, 7 and 10 hours). At the end of the exposure time, the tube was emptied for sample collection. The temperature was measured inside the tubes at 30-minute intervals. TS, VS, COD and sCOD were analyzed in the initial sample and after each exposure time following standard procedures (APHA, 2012). BMP tests were conducted with the samples from each pretreatment exposure time and non-pretreated biomass to evaluate the biogas production.

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For the biological pretreatment, the microalgal biomass was stored for 24 hours in a cold room at 4°C for sedimentation and concentration. Then, it was inoculated with ruminal content from a fistulated cow for another BMP test with different microalgae/ruminal content ratios (0.5, 1, 3 and 5). Additionally, controls containing only ruminal content or microalgae were used.

The AD inoculum for both BMP tests was collected from an UASB reactor and added to the glass serum bottles at a proportion of 0.5 g VS/g VS of  $S_0/X_0$  ratio. To this aim, 180 mL of working volume was established, leaving 90 mL as headspace. The headspace was purged with  $N_2$  gas for 60s, and then the bottles were incubated at 37 °C with constant mixing at 100 rpm. Tests were performed in triplicate. Blanks containing only inoculum were used for quantifying endogenous respiration.

**Results and conclusions.** In terms of thermal pretreatment, the initial temperature of the biomass was 16°C and the peak temperature was 93°C, reached after 4 hours of pretreatment. The COD solubilization attained was 17%, 22% and 24% after 4, 7 and 10 hours of pretreatment, respectively. The BMP result showed the highest biogas production after 10 hours of pretreatment (210,2 mL $gVS^{-1}$ ). This value corresponded to an increase of 63% in relation to the non-pretreated biomass. Regarding to biological pretreatment, the bottles with microalgal/ruminal content ratios of 0.5 showed the highest methane yield (224,6 mL $CH_4gVS^{-1}$ ) corresponding to a 19% increment when compared with microalgae and ruminal content controls. When compared to previous literature, both pretreatments show promising results.

**id #1668**

### **USE OF CONSTRUCTED WETLAND ECOSYSTEMS TO TREAT DOMESTIC WASTEWATER BEFORE DISCHARGE TO THE RIVER HIRNO IN ABBOTTABAD, PAKISTAN — PILOT STUDY**

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Sustainable development contributes for the welfare of human communities and the natural environment. Pivotal to the sustainable development is the conservation and protection of water bodies, which requires the treatment of wastewater of various sources, and the improvements of the purification efficiency of treatment technologies and processes. This research considers the use of constructed wetland ecosystem in wastewater treatment on pilot-scale and how it may be exploited for the treatment of wastewater from the local community. Since 2001 experiments have been carried out on a pilot scale on polishing of the domestic wastewater of district Abbottabad (Pakistan), in a constructed wetland system, a combination of locally available macrophytes and substratum. The treatment included the constructed wetlands with *Phragmites*, constructed wetlands with *Typha*, constructed wetlands with *Phragmites* and *Typha*. These were compared to control. The hydraulic retention time has been 7 days. Wastewater was treated in a set of 70 dm<sup>3</sup> pilot-scale vertical flow constructed wetlands. Wastewater was supplied at a rate of 23 l m<sup>-2</sup> day<sup>-1</sup> over the whole the year. Different systems tested and were compared to the control. Results of initial 12 months of data reveal that all constructed wetland cells were very effective and stable in COD elimination (90%), BOD (93%) and PO<sub>4</sub>-P removal (69%), whereas NH<sub>4</sub>-N elimination have improved markedly from around 55% to 75%. Elimination of total coliform, faecal coliform and coliphage is between 58 to 95%.

The purpose of the research is to understand the treatment processes and to find out the appropriate role of each component in simulated wetlands. Only on this basis it will be possible to establish and calibrate a model on large-scale for the local community, district Abbottabad, a city with over population 0.05m resident in order to treat domestic wastewater before discharge into the river Hirno that passes through many villages. Water of this river is used for purpose of drinking, agriculture and livestock. Small pilot studies seem to act a forecast and design tool for the applied research on large-scale.

**id #2262**

### **Roof harvesting- Rainwater harvesting formalization in rural Cambodia**

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Around the world, 663 million people still lack access to improved drinking water sources. Water is fundamental for human life and thus access to clean water is a basic human right. At the very least, one should have daily access to a minimum of 20 litres of clean water for basic needs.. Both the quality and quantity of water supply must be ensured to meet people's basic needs for drinking and cooking.

Cambodia Sustainable Development Goals #06 aims to increase national access to improved water supply to 100% by 2025. In 2016, 61% of Cambodians had access to improved water supply of which 53% lived in rural areas. In order to achieve the goal, the Cambodian Ministry of Rural Development (MRD) has established the National Action Plan (NAP) to be implemented from national to sub-national levels. Under the NAP, the MRD and WASH sector have jointly developed either a provincial action plan or a district action plan for a more specific implementation in these areas.

Rainwater is in abundance in Cambodia: there is enough annual rainfall to cover both domestic water supply and irrigation needs. But for rainwater systems to be considered an improved source, the water must be stored in a single tank with a capacity of at least 3,000 litres. It also requires certain types of roofing and storage to ensure the water is clean enough to drink at all times. Rainwater systems are ideal for Cambodia, where many people already have the right types of roofing installed. However, current systems are too small to store water for the dry season and do not store the water in a safe manner. RainWater Cambodia (RWC) has designed and implemented risk managed rainwater harvesting systems which are designed to capture the large rainfall in Cambodia and store enough water to last through the dry season. The risk management approach prevents contamination during storage ensuring the water stays safe to drink

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This paper combines a literature review, experience and the findings of studies undertaken by RainWater Cambodia (RWC). The first step is to examine the community's perception on traditional rainwater harvesting in rural Cambodia, and the second step is describe how rainwater harvesting with risk managed model promoted by RainWater Cambodia contribute to the change in term of health, environmental and society. And third step is to investigate the sustainability of using risk-managed rainwater harvesting systems promoted by RWC in terms of physical condition, ability to maintain and user perceptions in rural Cambodia with the objective of improving access to water and make drinking water affordable, convenience and realizable in Cambodia.

**id #1905**

### **Water In Kathmandu: "The Scarcity in an area of abundance"**

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The Human body is 72% of Water; our body is the product of the Earth, which is also 72% water. Not only the amount of water we drink but also how we handle the water and what's the qualities of water this all can make a difference for our total wellbeing. This research has reviewed existing water quality management frameworks and spatial relationships between land use and urban water quality in Kathmandu Valley. Rivers in Nepal have been depleted by 70%. Primary data on water quality has been collected through the sampling of river water from various locations within the Kathmandu valley. Similarly, review of secondary data and related literature from various sources, field observation, interaction and discussion with concerned stakeholders of various governments and non-governmental line agencies were carried out to perceive the existing water environment situation of the valley. All these data and study indicates that urban water quality in the Kathmandu valley is not good enough to sustain a healthy water ecosystem. The lack of Infrastructures and the high level of pollution due to the pesticides, fertilizers and waste water are the main causes of the problem of lack of water. Retrogression quality of river water has caused frequent cases of water-borne diseases such as Typhoid fever, Amoebiasis, Constipation, Naegleriasis, Cryptosporidiosis, dysentery, cholera, and skin diseases among people living in riverside areas. It has also reduced the religious, recreational and aesthetic value of rivers. Conservation, efficient use of water in agriculture is important. We should Act now to bring back 15% of rivers in 10-15 years. Efforts to save Nepal water supply have to focus on the rivers and the agriculture that depends on them. We should Increase trees and vegetation to save rivers, it's called for reimagining the irrigation systems by setting up organizations that bring together farmers and the corporate sector for efficient management. We should advocates planting trees for a width of half km on either side of rivers because they can help conserve water while increasing rainfall. They also help to filter and regulate water, preventing flooding and protecting watersheds.

**id #2249**

### **The intangible amenity benefits of small stormwater management systems: A case study of living streams**

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Water Sensitive Urban Design (WSUD) is an approach that allows achieving better water management outcomes in urban settings. WSUD has different elements with varying objectives from managing the urban water quality and hydrology to urban amenity improvement.

Living streams are small stormwater management systems within WSUD approach. They offer an alternative to traditional stormwater management conveyance but also generates a variety of other benefits such as water quality, biodiversity, aesthetics, and amenity. Making decisions about investment in living streams by local governments or private developers requires information about the economic value of all benefits generated by such projects.

Estimating economic values, however, is not straightforward due to the non-market nature of the benefits generated by living streams. Environmental economists have used various non-market valuation methods to estimate the values of these benefits. Previous studies found a positive economic impact of restoring urban drains to living streams in established suburbs, but these results might not be applicable for valuation of living streams created in new suburbs. This study attempts to fill this gap.

We use hedonic pricing method to estimate the capitalised amenity value of living streams established in two greenfield suburbs, Harrisdale and Piara Waters, located at 20 km south-east of the City of Perth, Western Australia. These suburbs were developed from 2007 over the last 12 years. For the analysis, we obtained property sales data from a commercial provider. The living streams and other public open spaces were digitised using aerial images. We used a hedonic model with log-log functional form and spatial and temporal fixed effects.

We found that most value is captured by the residents of houses immediately adjacent (within 50 m) to living streams and the value sharply declines with distance. We also found that living streams generate greater value than other types of public open space. Finally, we found that the future benefits of living streams are capitalised in the values of vacant residential lots. This information is useful for making smart decisions and to help policymakers and constructors making better decisions about investment in small stormwater management systems as part of water sensitive urban infrastructure.

**id #2028**

### **Risk assessment of the treated greywater reused for irrigation**

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The study area was set in Ban Laloomma community in Thailand. The aim of this study was to assess the risk of the treated greywater reused for irrigation. Risk assessment consisted of 4 steps. Firstly, the hazard identification involved analysis of the characteristics of untreated and treated greywater. After the treatment dissolved oxygen increased, in contrast with a decrease in the other parameters such as BOD, COD, Zn and Pb which dropped to 35.63 mg/L, 9.95 mg/L, 0.011 mg/L and 0.001 mg/L, respectively. Total coliforms and fecal coliforms were also decreased to 23417 and 5666 MPN/100 ml. Secondly, the hazard characterization also involved comparison of the treated greywater quality with Thailand's standard and World Health Organization guidelines. Almost all detected contaminants were minimized and did not exceed the standard. Thirdly, the exposure assessment was the treated greywater reused for the irrigation of 7 edible plants. Plants were 4 leafy vegetables and 3 fruiting vegetables. There were 3 vegetable plots; the treated greywater reuse (TGW), the tap water with fertilizer (TWF) as a comparative sample, and the tap water (TW) for control. Zn, Pb, Cd, Cu and Hg were detected in all irrigation plots depending on kind of plants; for example, the maximum concentration was found in leafy vegetables. Zn and Cu accumulated in all plants and their maximum concentrations were found in parsley types. The maximum concentration of Pb was also found in parsley types whereas the minimum was detected in all fruiting vegetables, especially in winged bean. However, the concentrations of these contaminants were close to the Codex standard for contaminants and toxins in foods and TACFS Thailand's standard. Finally, the risk characterization showed no impact on plant growth; all kinds of plants grew very rapidly and perfectly when irrigated with TGW, similar to when irrigated with TWF. Moreover, the optimum and most concentrations of nutrients in soil after cultivation, especially nitrogen, were found in the TGW irrigation plot that promoted rapid growth of plant. In addition, the risk results showed no impact on consumer health when compared with these standards.

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**id #2240**

### **Optimization of permeate backwashing on ceramic membrane fouling control in Anaerobic Membrane Bioreactor**

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Permeate backwashing is a widely administered physical cleaning method for amelioration of membrane fouling in Membrane Bioreactors (MBR). The backwashing frequency plays a key role in maintaining stable higher flux and ameliorating membrane fouling. The effect of permeate backwashing frequency (without backwashing, 60s/day= x/day and 120s/day=2x/day) on fouling amelioration in an external side-stream cross flow microfiltration anaerobic ceramic membrane bioreactor (AnMBR) for the treatment of domestic wastewater was investigated in this study. The reactor was operated for 60 days at the ambient temperature (26.68 ± 4.0 °C). The automatic control strategy of the membrane filtration included 55 minutes membrane filtration and 5 minutes relaxation in all backwashing scenarios. The fouling behavior of the membrane filtration was analyzed in terms of the consequential increase in trans-membrane pressure, total membrane resistance, permeability and flux decline co-efficient. The bio polymeric composition was analyzed using the three-dimensional excitation emission matrix fluorescence spectroscopy analysis (3D-EEM) of the anaerobic sludge, permeate, backwashing solutions. The results without backwashing indicated a rapid flux decline and related increase of the transmembrane pressure and the permeability deviated more from linearity,

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indicating a higher degree of fouling. The Pearson correlation analysis indicated strong negative correlation between the flux decline coefficient and the total membrane resistance in all scenarios. The correlation between transmembrane pressure and flux during 60s/d backwashing showed a slightly positive correlation (0.641). The 3D -EEM results inferred that membrane fouling was more likely to be due to protein during this study and backwashing has the ability to remove most foulants deposited on the membrane surface. Both 60s/day and 120s/ day backwashing were effective in maintaining membrane flux in a stable level. However, 120s/d backwashing was able to maintain slightly higher flux ( $39.81 \pm 1.70 \text{ LMH}$ ) than 60s/day ( $38.78 \pm 5.76 \text{ LMH}$ ) backwashing. The long-term studies are recommended for better clarification of the results.

**Keywords** : Permeate backwashing, Ceramic membrane fouling, Transmembrane Pressure, Flux

**id #1849**

### **ANALYSIS OF THE PERFORMANCE OF THE PRE-TREATMENTS OF THE WWTP SYSTEMS IN CANTON CUENCA-ECUADOR**

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The increase in the demand for water due to population growth and extensive human activity have led to high production of wastewater that exceeds the purification capacity of nature. This is why the importance of implementing a treatment plant, before of pouring them into the effluent. ETAPA EP is responsible for providing potable water and sanitation services in the city of Cuenca, with the aim of providing these basic services with the best quality and to the entire satisfaction of the population. In Ecuador, due to insufficient infrastructure, high costs, lack of maintenance and trained personnel, only 36% of the wastewater generated is treated, which creates the need to develop technologies for their purification by constantly developing and innovating. In recent years, the monitoring of the drinking water and sanitation systems of ETAPA EP has grown considerably. The research has been carried out in the 21 Wastewater treatment systems plants of the surroundings of Cuenca City, with a sewerage coverage of approximately 60 % of the rural population. This work presents a summary of the work carried out by the Drinking Water and Sanitation Management, through the Operations Sub-Directorate, to evaluate the status and performance of the pre-treatment of wastewater treatment plant systems in the rural sector.

**id #1632**

### **Advancing Regulatory Compliance of Recycled Water Schemes in Western Australia through Cooperation**

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Since the release of the Guidelines for the non-potable use of recycled water in Western Australia (WA) in 2011, there has been significant progress in the implementation of a structured risk-based approach for recycled water management.

The Guidelines are based on the 12-Element Framework for the management of recycled water quality and use of the Australian Guidelines for Water Recycling (2006). Therefore, compliance is demonstrated by developing and implementing a risk-based recycled water management system.

The Water Corporation is the main wastewater service provider in WA. The Corporation own and operate 11 schemes and supply recycled water to 64 recipients most of them for municipal irrigation of public open spaces.

A Water Recycled Assessment Report was conducted by the Water Corporation (2012 – 2014) to determine the level of compliance of each recycled water scheme with the Guidelines. An assessment of assets, water quality data, existing documentation and inspection of irrigated areas was conducted. These reports were submitted to the DoH for assessment and were the first step for the update of approval conditions. Recycled water managers and operators were also able to identify actions to be implemented to improve compliance.

The Water Corporation also checked currency of Recycled Water Supply Agreements with recycled water recipients and where required the agreements amended to ensure to each party was aware of their roles and responsibilities.

After the first reports, a series of activities have been implemented with the support/participation of Water Corporation staff. Of significance is the increased percentage of schemes submitting annual reports, the number of schemes with Recycled Water Quality Management Plans and the completion of the first internal audit report for all recycled water schemes.

The presentation will discuss outcomes of the risk-based approach implementation and the importance of maintaining a cooperative approach to achieve the best possible outcomes to ensure adequate public health protection.

**id #2287**

### **The FairCap project – an collaborative approach to water supply in emergencies**

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Around the globe, two billion people do not have access to safe drinking water [WHO, 2019] and about 70 million [UNHCR, 21019] are refugees forced to leave their homestead. The FairCap project aims on improving water quality for those on the move as well as for more permanent situations. Since 2015, an ultrafiltration product using a polysulfone membrane has been developed in an open access approach, including the use of 3D printing and collaboration with various partners from universities to designers. The filter should be easy to handle and transported and eventually be produced at a cost of 1 € (capacity 1000 l) thus being an alternative to the various existing products on the market. Quality parameters to be achieved are based on the recommendation by the WHO regarding water quality in emergency settings including a turbidity below 5 NTU and E. coli concentrations of 0 per 100 ml. Two different core products have been designed; the FairCap Mini for individual use (operated by suction, about 1000 l capacity) and the FairCap Family (operated by pumping, at least 2000 l capacity) to supply small groups.

In a pilot test, the FairCap Mini and Family filters were operated with surface water from the Panke river in Berlin. This waterbody partially receives the discharge of a wastewater treatment plant and is highly urbanized resulting in considerable E. coli concentrations. Two filters have been operated from March to April 2019 with E. coli inlet concentrations between 1000 CFU/100 ml to 6000 CFU/100 ml. Analysis of E. coli has been done according to the DIN EN ISO 9308-01. The results show, that a complete removal of bacteria was ensured by the UF membrane. Laboratory tests in Barcelona also showed a complete removal of bacteria. Since spring 2019, the FairCap Mini and Family are being tested in different field settings, focusing rather on difficulties in handling and implementation than on water quality. Tests in North-East-Syria and Lebanon did show, that the Family filter has more potential for further use in the humanitarian context. Currently an optimized pumping system is designed to operate the filter efficiently and prototypes are deployed in various settings to learn more about the demands by potential users.

**id #2461**

### **Wall vertical constructed wetland system for household and small sources wastewater treatment – results of two years long operation and testing**

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The paper will present the results of the research focused on the development and testing of wall (facade) vertical flow constructed wetland system aimed to the treatment and transpiration of mechanically pre-treated wastewater of household, offices and small settlements producers. The paper and presentation include description of the following phases: i) system development and construction, planting by selected wetland species, including ornamental plants; ii) first year (2018) of operation focused on the searching of the optimal hydraulic and mass loading; iii) winter season without wastewater loading; iv) spring start-up period and iv) treatment efficiency during second year (2019) of operation of the fully developed system and plant cover. The CW system was built as a group of four separate channels with the length 2 meters, surface area 0.40 m<sup>2</sup> and filtration volume 112 litres. The channels were filled by different mixtures of filtration materials (sand, gravel, lightweight material). Each channel had separate inflow and outflow.

The system was connected to the source of real wastewater, what was pre-treated by multi-section compact settling tank (analogous to a septic tank). The wastewater source was a combined sewer system of a small settlement in the South Moravia Region of the Czech Republic. The paper includes description of the composition of wastewater at the inflow and the outflow sections of the settling tank.

During both years, there were monitored basic characteristics of the wastewater at the above mentioned profiles and at the outflow points of all channels including water temperature, dissolved oxygen, pH, electrical conductivity, turbidity. The water flow and balance were measured. Forms of nutrients (N, P), organic pollution (BOD, COD, TOC, TC, DOC), microbial contamination indicators and selected ions (Cl, SO<sub>4</sub>) were measured in the Institute labs. Inflow / outflow concentration changes and treatment efficiencies were calculated and they would be presented at the conference.

We analysed the structure of microbial community, especially the ratio of nitrifying bacteria during the operation of the system.

There were also monitored climate characteristics at the site by a meteorological station and shading during the days by a photo trap.

The results of analyses and field measurements allow find optimal hydraulic loading of the particular CW system channels with regard to used filtration medium, identified important design parameters to achieve best treatment efficiency and provide recommendations for the similar systems implementation within the climate conditions of the Central Europe and other regions with appropriate climate. It was approved that such treatment system based on the water irrigation principles can be successfully used as a part of decentralised wastewater treatment.

The paper was financially supported by the research project TH02030583 „Optimization of automatic irrigation system for pre-treated wastewater land application - the measure for decreasing risk of drought and surface waters eutrophication “

**id #2460**

### **Metagenomic Analysis of Bacteria, Bacteriophages, and Antibiotic Resistance in Slow Sand Filters for Drinking Water Treatment**

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Slow sand filtration (SSF) is the most common treatment technology for drinking water in small communities (less than 10,000 residents), especially in low- and middle-income countries, due to its low capital and operational costs and maintenance. The biological function of SSF is instrumental for the removal of contaminants such as organic carbon, nutrients, and heavy metals. SSF has also been shown to remove contaminants of emerging concern such as antibiotic resistance genes, which contribute to

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the spread of antibiotic resistance in waterborne pathogens. As such, understanding the complete microbial community of biofilters is instrumental in managing the final water quality of drinking water treatment facilities.

Recent studies have used next-generation sequencing (NGS) technology to characterize the bacterial community of SSF. However, very little is known about the composition and contribution of bacteriophages in biofilters. Bacteriophages are the most abundant organism-like particles, with an estimated population of  $10^{31}$  on earth. They are ubiquitous in both natural and built environments. The two main types of bacteriophages, lytic and lysogenic phages, have different yet substantial effects on their hosts. Lytic phages contribute to the predation of bacteria through infection and lysis, acting as a bottom-up control of microbial populations. They also contribute to the release of nutrients to the environment via bacterial death, affecting biogeochemical cycles. Lysogenic phages contribute to the horizontal gene transfer of genetic material by the process of transduction. This affects the evolution and diversity of bacteria, as well as the fate and transport of genetic material, including antibiotic resistance genes.

The study of bacteriophages in bioactive sand filters has important implications for their management and operation for drinking water quality. The metagenomic analysis of biofilter bacteriophages can determine the relative abundance of viral pathogens in relation to other phages. This study also illuminates a potential mechanism for biomass loss in bioactive sand filters by lytic bacteriophages. The bacterial cell death by bacteriophages edifies their contribution to the release of contaminants, as well as the fate and transport of genetic elements associated with virulence and antibiotic resistance. The objectives of this study were to determine the composition and quantity of bacteriophages found in bioactive sand filters, to determine the contribution of bacteriophages to the horizontal gene transfer of genetic material, and to determine if bacteriophages that infect nutrient removing bacteria contribute to the release of contaminants through lysis.

Biomass samples were collected from three drinking water treatment facilities that have chemically and biologically different source waters. Water samples taken before and after filtration were collected for chemical and biological analysis. Bacteriophages and bacteria were isolated through physical filtration, and DNA extracted. High-throughput metagenomic sequencing was performed on bacterial and bacteriophages DNA at a standard sequencing core facility, using Illumina HiSeq technology. Raw reads from bacterial and phage metagenomes were processed on a CLC Genomic bench station. The viral metagenome was analyzed against several ARG databases, including CARD, ARDB, and ResFinder. A cluster analysis of the relative abundance of bacteria, bacteriophage, and associated ARGs was visualized using Cytoscape software.

id #2456

### Comparison of two operational strategies on aerobic granular sludge development

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Aerobic granular sludge (AGS) has been extensively investigated in the last decades due to the potential to remove organics matters and nutrients in one single compartment. Compared to activated sludge, this system is more compact, thus the implementation requires less construction area. From this point of view, it is an attractive alternative for place with increasing urbanization or for those unavailability of large areas. However, operational success depends on granular formation and stability, which is related to treatment conditions and sludge aspects. In this study, two strategies were applied in sequential batch reactors bench scale (SBR1 and SBR2) inoculated with activated sludge (flocculent biomass, MLSS=4.6g/L, SVI<sub>5</sub>= 206mL/g) from a WWTP in Pernambuco, Brazil. The reactors were made of acrylic transparent plastic, 3.5L working volume, a height to diameter ratio (H/D) of 8:1 and volumetric exchange ratio of 45%. The reactors were fed with a synthetic wastewater (COD= 400 mg/L; NH<sub>4</sub><sup>+</sup>= 100 mg/L). Each cycle consisted of non-aerated feeding phase, 60 min (SBR1) and 40min (SBR2), followed by aeration, 196 min (SBR1) and 176 min (SBR2), 3 min settling and 1min effluent discharge. The reactors were operated at room temperature (26 °C), and 6mg/L of dissolved oxygen. After 22 days of operation, COD and nitrogen removals from both reactors were very similar, 77±45% and 78±10% for COD efficiency removal, and 41±16% and 40±16% for nitrogen removal, on SBR1 and SBR2, respectively. On the 24<sup>th</sup> day of operation, the formation of granules in both reactors was observed. The LGA formed in SBR1 (MLSS = 3.7 g/L, IVL<sub>5</sub> = 32 mL/g) and SBR2 (MLSS = 3.8 mg/L; IVL<sub>5</sub> = 24 mL/g) was light brown in color, presenting good sedimentability. The COD removal efficiency increased to 86 ± 4% and 86 ± 3%, and removal of NH<sub>4</sub><sup>+</sup> showed a significant increase of 70 ± 4% and 71 ± 6% in SBR1 and SBR2 respectively. In SBR1 the granules formed had a diameter between 0.2mm and 0.6mm, representing 75% of the total biomass, whereas in SBR2 bigger granules was observed ranged between 0.2 and 1mm, representing 84% of the sludge. From 46 days of operation, filamentous bacteria appeared in SBR1, without interfering on COD and nitrogen removal. On the other hand, filamentous overgrowth should reduce the cohesion of the biomass, and is often regarded as the cause of granular disintegration. The results revealed that with short anaerobic phase (SBR2), non-aerated phase of 40 min, it is possible to obtain aerobic granules with less tendency of disintegration by development of filamentous bacteria, with the establishment of stable sludge for a longer period of operation.

id #2610

### INTEGRATED PROCESS DESIGN OF PALM OIL MILL EFFLUENT (POME) TREATMENT COUPLED WITH ALGAE BIOMASS PRODUCTION SYSTEM

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For over a decade, Indonesia has been the world's largest palm oil producer with over 900 of palm oil mill, owned by public and private companies. Every year, the production of palm oil in Indonesia increases, ergo produces more waste such as empty fruit bunch (EFB) and effluents. Big amount of water needed for the sterilization process for the fresh fruit bunch (FFB), but almost 70% of the water from the sterilization process become Palm Oil Mill Effluent (POME) and go to an effluent pond. Palm Oil Mill Effluent (POME) is a harmful waste because it is high in COD and BOD, organic compounds and greenhouse gases (GHG) emission and needs to be treated before it can be discarded into the environment, but the treatment for POME in Indonesia is

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currently not fully utilized. To fully utilize the produced POME, several ways can be conducted and those are using green algae such as *Chlorella sp.*, *Botryococcus braunii* and *Nannochloropsis sp.* to produce Algal Oil using organic compounds in POME and to substitute additional nitrogen and phosphate as its nutrients, treating POME in a biorefinery plant, and to study whether it will be profitable to build a biorefinery in every palm oil mill in Indonesia. Sample and data of POME is obtained from 2 palm oil mill specifically from PT. Perkebunan Nusantara VIII, Cikasungka and Kertajaya plant, and the whole process is simulated using Aspen Plus software.

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id #2582

### Fertilizer effect of vertical flow constructed wetland effluent on development of *Leucaena leucocephala*

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Wastewater reuse in agriculture has become a growing practice, which represents savings in the consumption of treated water, reduced fertilizer costs and increased productivity and quality of agricultural crops. The objective of this study was to evaluate the reuse of domestic sewage effluent treated by vertical flow constructed wetlands (VF-CW) in leucena cultivation. The VF-CW has 80 cm, being 5 cm of free layer, 5 cm of gravel, 60 cm of sand, 5 cm of gravel 2 and 5 cm of bottom gravel, with application rate of 160 mm.d<sup>-1</sup>. The agronomic experimental design was a randomized block design in a 3x3 factorial scheme, with 3 irrigation effluents, (water, effluent after septic tank treated by VF-CW (1), stabilization pond effluent treated by VF-CW (2) and 3 substrate types (pine bark, sand and soil). The efficiency of the VF-CW was evaluated through physicochemical and microbiological parameters and to evaluate the leucena seedlings: height, stem diameter, dry mass, root length and root volume. Regarding the efficiency of VF-CW, these achieved the following removals for VF-CW (1) and VF-CW (2) respectively: Turbidity 85.83% and 75.29%, COD 73.47% and 65.85 %, Phosphorus 94.14% and 90.76%, Total Nitrogen 95.79% and 96.16%, Total Solids 47.41% and 55.61% and in the removal of pathogens, a decay of 2 to 3 logarithmic. Regarding the growth of leucena seedlings, for height, there was a statistical difference when using substrate composed of pine bark and as irrigation the effluent (2), reaching 14.84 cm in length. It was concluded that the VF-CW showed efficiency in the treatment, also acting as fertilizers for the production of leucena seedlings, in which the commercial substrate composed of pine bark in most parameters, allowed the greater initial development of the seedlings.

id #2511

### Simultaneous nitrification and denitrification in anaerobic-aerobic sequential reactor treating domestic sewage

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Simultaneous nitrification and denitrification (SND) process was studied in reactor system, in order to remove organic matter and nitrogen from synthetic domestic sewage containing 420 mg COD.L<sup>-1</sup> and 37 mg TN-N.L<sup>-1</sup>. The treatment system was constituted by sequential anaerobic and aerobic reactors with support medium. Each reactor was operated with a 4.7 L working volume and a 10 h hydraulic retention time. The system performance was evaluated in three phases (F) of 48, 50 and 52 days, respectively. Different dissolved oxygen concentrations were applied in the aerobic reactor, 3.0 mg.L<sup>-1</sup> in FI and 1.7 mg.L<sup>-1</sup> in FII and FIII. In FIII, the system was operated with recirculation of the aerobic reactor effluent to the anaerobic reactor in a 0.25 ratio. Final COD concentrations of the treatment system were 28.3 ± 3.9 mg.L<sup>-1</sup> (FI), 24.6 ± 1.8 mg.L<sup>-1</sup> (FII) and 26.5 ± 5.1 mg.L<sup>-1</sup> (FIII), with significant differences among the treatments (p<0.05). In FIII, higher accumulation of nitrite of 9.8 ± 1.3 mg NO<sub>2</sub>-N.L<sup>-1</sup> was observed in the aerobic reactor. Significant differences (p<0.05) were also observed in the three phases regarding nitrogen removal and mean effluent concentration. The removal efficiencies were of 61, 63 and 65% and effluent concentrations were 14.2 ± 1.4, 13.4 ± 0.9 and 12.9 ± 0.5 mg TN-N.L<sup>-1</sup>, respectively. Denitrifying bacteria and ammonia oxidants were always present in adhered biomass of the aerobic reactor in all the three phases, as confirmed by specific analyses of polymerase chain reaction. Massive sequencing analyses indicated that *Rhodococcus* microorganism had a 70% prevalence in the biomass samples. This microorganism genus can oxidize ammonia by heterotrophic nitrification and denitrify via nitrite in aerobic systems. It was concluded that the operation in FIII was the most favorable since nitrite accumulation in the aerobic reactor corroborated with the increase of relative abundance of that genus; and that the 0.25 recirculation ratio increased the biomass-substrate contact, contributing to the organic and nitrogenous matter good removal efficiencies.

id #2507

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### **On-Site Sewage Management for Isolated, Remote or Challenging Access Locations: Applying Flexibility in Design, Management and Operation**

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On-site wastewater management in the urban and peri-urban setting remains relatively straightforward, with standard design guidance and sustainable solutions readily available in most Australian jurisdictions. In many cases, considerations of power availability and reliability; construction access and practicality, and operational robustness are negligible.

In atypical locations such as isolated off-shore islands, remote campsites and wilderness areas, such considerations are forefront; presenting a unique set of circumstances that will not always fit the standard design approach. In these settings, the designer is required to more closely match the wastewater system and effluent land application design to the complex, and sometimes conflicting, constraints of the location.

This paper presents Case Study examples and learnings from six (6) such on-site sewage management designs at Broughton Island and South Solitary Island NSW, Gabo Island VIC, Cradle Mountain TAS and Lake Catani and Yarra State Forest VIC.

The work demonstrates the need for, and importance of, flexibility in the application of first-principle design to reliably and sustainably address identified Site limitations while achieving Client specific goals and operational capabilities.

**id #2487**

### **Role of Alternative Water Systems in Urban Water Servicing**

**Ashok A/ Prof. Sharma<sup>1</sup>**

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Urban water, stormwater and wastewater municipal services have been provided through centralised systems for over 100 years as a common practice. These systems centre around providing reliable and safe water supply, human health protection, and flood management. The sustainability of current urban water systems is under pressure from a range of challenges including: fast population growth and resulting urbanisation, climate change impacts, system capacity constraints and aging infrastructure. Globally, centralised water systems and services are under pressure to respond environmental, social and economic challenges. The current level of urban water services can't be provided within the existing centralised system approach without significant increase in investment to enhance system capacity, improve level of treatment, and rehabilitate the existing centralised systems. To address these issues, urban water services are now being implemented with Integrated Urban Water Management (IUWM) approaches. IUWM considers all parts of water cycle, which can be natural or man-made, surface or sub-surface within an integrated system based on fit for purpose concept. Under IUWM approaches, decentralised and distributed water, wastewater and stormwater are being promoted either in combination with centralised systems; or alone as the sustainable solution for urban water servicing. These systems can deliver multiple benefits including water conservation, stormwater quality improvement, flood control, landscape amenity and a healthy living environment.

Current urban water systems are beginning to undergo a transition, where decentralised systems will play a major role in the long-term sustainability of these systems to meet the above mentioned challenges. However, these decentralised systems are relatively new and involve increased complexity and thus, there are wide knowledge gaps in their planning, design, implementation, operation and management, integration with existing centralised systems, which are impeding their uptake.

The paper would summarise the role of decentralised systems in the transitioning of centralised systems to a more sustainable state and discusses some of the complexities in the implementation of decentralised systems.

**id #2561**

### **ASSESSMENT OF RISKS FROM ON-SITE WASTEWATER SYSTEMS UTILISING FIELD VALIDATED GIS FRAMEWORK**

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#### **INTRODUCTION**

Decentralised Water Consulting (DWC) have spent the last four years developing and refining a risk based GIS Framework for assessing on-site wastewater management risks and prioritising investment in improved management. The Framework was initially developed to support Yarra Valley Water's Community Sewerage Program. This Framework methodology has since been expanded to more broad-scale, higher level assessment of shires / municipalities across Victoria. Importantly, the GIS Framework has been extensively field validated, for both input parameters and data, along with refinement of the scale-based methodology.

#### **METHODOLOGY / PROCESS**

The methodology can be summarised into two key stages. Stage 1 involves desktop (GIS) analysis in which a number of land capability constraints (i.e. likelihood of system failure) are analysed, including soil, climate, drainage and slope. In addition, environmental receptors (i.e. consequence of system failure) are also factored in including watercourses / bodies, groundwater resources, potable catchments and sensitive ecological communities. This includes both proximity and relative sensitivity of receptors from properties. This may be confirmed via Google Street View™ depending on the scale of the assessment.

Stage 2 involves groundtruthing and field validation of the Stage 1 analysis. A specific application (app) has been developed for this field data collection and assessment. This is focused on both ensuring both data accuracy is validated (to be refined where

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possible) and confirming that assigned hazard parameters are representative of the 'real world'. The refined methodology is dependent on the study area and the degree of investigation is scaled accordingly, for example soil data for key landscape facets collected as a minimum.

### **RESULTS / OUTCOMES**

The risk-based Framework has been applied across both Victoria and NSW with a high level of accuracy and consistency. Extensive field validation of the Framework has helped to refine the methodology and utilisation of available data sets for a range of sources. Existing on-site system performance / maintenance data (availability is highly variable) has also been incorporated into the risk assessment to provide a means of prioritising areas (and funding) based on known issues as part of Domestic Wastewater Management Plan risk assessments. Risk classifications have also been used to inform multi Criteria Assessment processes that aim to prioritise investment in improved wastewater management.

### **CONCLUSION**

Based on this risk-based GIS Framework, the potential risks associated with on-site systems can be consistently assessed for properties within study areas at a range of scales (suburb through to full local government area). The developed methodology allows for efficient field validation via an app, which can be scaled up or down depending on data availability and the level of assessment required. The strong alignment of the Framework with regulatory instruments, state government Codes and relevant Australian Standards also assists in its effectiveness.

**id #2565**

## **Parameterisation and Calibration of Pollutant Export Models for Decentralised Water Systems with Field Data**

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Decentralised Water Consulting (DWC) and Yarra Valley Water (YVW) are undertaking comprehensive baseline and verification monitoring of existing and upgraded on-site systems and receiving environments under a Before/After/Control/Impact (BACI) study design. Monitoring has included broader catchment inputs such as climate, hydrology and receiving water quality in addition to detailed monitoring of a sample of individual on-site systems. This detailed on-site monitoring has included soil moisture monitoring and water quality analysis of effluent plumes in addition to effluent quality.

This paper will present the data and outcomes of the baseline monitoring along with early insights from the verification monitoring. It will then discuss how data collected for the Trial monitoring program was utilised specifically to parameterise and calibrate models developed as part of the project. These included MUSIC (for long-term, continuous stormwater modelling of 'background' flows and loads) and Decentralised Sewage Model (for modelling of on-site systems and wastewater flows and loads transported off-site).

DWC has since applied learnings from this project to the application of numerical models to the assessment of off-site impacts from existing and proposed decentralised water and wastewater systems. This paper will also outline a recommended modelling methodology and framework for on-site and decentralised systems based on these learnings.

**id #2771**

## **The effect of pH control through CO<sub>2</sub> addition on microalgae growth in undiluted anaerobic digestate abattoir effluent (ADAE) under the outdoor condition**

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The continuous surge in the human population coupled together with the growing demand for food and animal-based protein has significantly increased the number of abattoirs around the world and volume of wastewater generated in these facilities. Abattoir wastewater is restricted by high quantities of inorganic, organic matters as well as a large concentration of toxicants and solids (suspended and dissolved). Although anaerobic digestion (AD) can be employed as a primary biological treatment for reducing the concentration of organics in abattoir wastewater, it is inefficient for the removal of inorganic nutrients (e.g. phosphorus and nitrogen). As AD treated effluent cannot be directly released into natural water bodies due to the remaining phosphorus and nitrogen content which at times may not satisfy environmental discharge regulations, there is a great need for additional treatment steps which are not only efficient but cost-effective.

Algal-based systems offer an elegant solution and cost-effective treatment option for various wastewater. Cultivation of microalgae on undiluted anaerobic digestate abattoir effluent (ADAE) requires minimal to no freshwater which is important especially in regions of water scarcity. Microalgae can efficiently assimilate various forms of nutrients for the production of valuable biomass, representing the conversion of waste-to-profit. Moreover, nutrient-depleted water effluent after algal cultivation can be safe for discharge or reuse within the abattoir's operations. The generated biomass can be used for other purposes like animal and aquaculture feed, and bio-fertilizer.

The efficient growth of microalgae in wastewater depends on key growth parameters such as pH and CO<sub>2</sub>. The pH of an algal culture can determine the solubility and availability of dissolved CO<sub>2</sub> and can influence many cellular processes such as photosynthesis in microalgae cells. The aim of this outdoor study is to identify the optimum pH for the growth and nutrient removal efficiency of microalgae cultivated in raw ADAE. Four different pH values (5.5, 6.5, 7.5 and 8.5) will be evaluated and regulated through the addition of CO<sub>2</sub>, and their impact on microalgae productivity and nutrient removal rate will be investigated by measuring biomass concentration and water chemistry analysis during the cultivation period. The results of such study will be valuable in optimization microalgae cultivation in anaerobically digested abattoir effluent (ADAE) in outdoor conditions.

## Why do we need the Government Sewerage Policy in Western Australia?

**Natalia Shishkina<sup>1</sup>**

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With significant increases in urban populations and the geographic spread of Western Australia (WA), both low and high-density development environments can become increasingly unhealthy if town planning rules are not appropriately applied. This understanding is particularly important for those undertaking Health Impact Assessment (HIA) of developments and subdivisions applications – from single sites to entire neighbourhoods and regions.

Sewage contains pathogens and bacteria which can cause harm to public health, the environment and impact on amenity. It is therefore critical that these risks be managed appropriately. The treatment and disposal of sewage in WA at each stage of the planning process is subject to a range of planning, health, environmental and economic regulation.

The Government Sewerage Policies (*Perth Metropolitan Region and draft Country Sewerage Policy*) were first established in 1981 to set out the wastewater disposal requirements for new subdivisions and developments in WA. Since the introduction of the sewerage policies, the Department of Health (DOH) has taken on prominent role in the planning assessment process, primarily to ensure that public health and environmental issues do not arise due to inappropriate location and/or density of the proposed development. The mandatory and discretionary provisions within the policies set out the subdivision and development of areas without reticulated sewerage to ensure that public health and environmental issues are addressed and managed.

In 2010 Government identified the need to undertake the policies review in light of the age of the policies and the need to develop evidence-based policy that was consistent with the Australian/New Zealand Standard 1547:2012 *On-site domestic wastewater management* (AS/NZS 1547). The review reflects changes in on-site sewage treatment, disposal technologies and management, and with our traditional water resources in WA dwindling the need for total water cycle management is becoming increasingly necessary to sustain our growing population. The review has been based on the best available practices and scientific evidence, and has been conducted with the participation of different government departments and agencies in order to provide evidence-based decision making advice.

The new Government Sewerage Policy 2018 (the Policy) has been developed by an inter-agency committee consisting of representatives from the Department of Planning, Lands and Heritage, Department of Health, Department of Water and Environmental Regulation and other government agencies.

The policy incorporates the principles of risk management as a fundamental component for both reticulated sewerage and onsite sewage disposal to address potential public health and environmental concerns. The policy takes a risk management approach to sewerage servicing relevant to planning and development of land.

This paper describes the purpose of the policies review, its challenges, the benefit of having a State-wide Government Sewerage Policy and the importance of the key agencies to work collectively and collaboratively to develop, implement and manage the new Government Sewerage Policy. The paper also provides an overview of how the development of land in areas of WA not serviced with a reticulated sewerage system occurs and how it can present potential environmental and public health risks as a result of inadequate on-site disposal of effluent. The paper presents some case studies of inadequate on-site disposal of effluent resulted from poor planning decision making and discusses how it can be prevented and improved in the future.

## Smart City Application in Overcoming the Quantity and Quality of Groundwater Problems in Jakarta Groundwater Basin

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The research area is located in Jakarta Groundwater Basin which is consisting of 3 Provinces that are DKI Jakarta, West Java, and Banten. As the primary needs, clean water quantity and quality is the major factor for being a SMART CITY. The affordable clean water also is the important thing to achieve the Sustainable Development Goals (SDGs) 2030, such as SDG 3: Good Health and Well-Being; SDG 6: Clean Water and Sanitation; SDG 9: Industry, Innovation, and Infrastructure; and SDG 11: Sustainable Cities and Communities. However, Jakarta Groundwater Basin is still classified into the region that has a complex problem in clean water quantity and quality. The rapidly growing infrastructure in the industry, public facility, and urban stuff enhances the clean water demand.

The study about Jakarta Groundwater Basin is classified into quantity and quality aspects. As the quantity aspect, the maximum amount of shallow groundwater that can be abstracted is only 36.17 million m<sup>3</sup>/year. This is not as equal as the total of water abstraction in 2015 that is 13.75 m<sup>3</sup>/s or 433.62 million m<sup>3</sup>/year. The exceeding of groundwater abstraction causes the land subsidence in some areas with the rate of subsidence 0-12 cm/year. The highest rate of subsidence value is in Ancol, Pademangan, and Muara Baru, North Jakarta. Based on the groundwater sample analysis, regarding the drinking water standard from Ministry of Health (492/MENKES/PER/IV/2010), there are only 16 observation wells that fulfill the requirement of drinking water standard, which is only about 17% from the total 94 wells. As well as in the deep groundwater, there are only 13 observation wells that fulfill the requirement, which is only about 18.6% of the total 70 wells. Adding this problem is the indication of seawater intrusion shows from the several data such as the distance of sampling water from the shore, salinity rate (from TDS value), hydrochemical facies, Cl/HCO<sub>3</sub> and Na/Cl ratios, and the rate of seawater mixing from <sup>18</sup>O and <sup>2</sup>H isotope analysis.

Based on the complex problems, the water technologies based on IoT (Internet of Things) that is Smart Well to monitor and control the fluctuate of water level in the elected borehole to monitor and control the water level and quality in real-time data. There is also another solution to conserve the groundwater resources such as widening the groundwater discharge area; limiting the infrastructure development in Bogor and Tangerang Regency; building the emergency well (water storage) to keep up the water reserve; building the artificial lake as the surface water keeper; optimizing and recycling the water use; enacting the rules

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of economical water technology; limiting the amount of water consumption for the industry, hotel, and company; and socializing the society about the water-conservation way. As the conclusion, the author believes that by implementing this solution can give significant improvement of groundwater conservation in Jakarta Groundwater Basin. The synergy between the government, the private sector, and society were also needed to succeed this program progressively and measurable to be the Smart City and achieve the SGDs 2030.

**id #2719**

### **Glycogen accumulating organisms (GAO) attached growth with passive aeration a sustainable way of wastewater treatment.**

**Sukhbir Singh**<sup>1</sup>

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#### **Glycogen accumulating organisms (GAO) attached growth with passive aeration a sustainable way of wastewater treatment.**

Historically, wastewater produced was used on land for many centuries as an irrigation option. With time, as the population growth and industrial revolution took place, the municipal and industrial wastewater increased exponentially inhibiting its land applications. Therefore, the wastewater treatment processes were originated and went through different reforms to tackle the quality and quantity of wastewater produced. Waste in the water includes organic and inorganic components which lead to water-borne diseases. The organic waste can be microorganisms such as bacteria, virus, protozoa, fungi and organic carbons present in the water, which usually comes from human and animal faeces. On the other hand, two major inorganic chemical pollutants are nitrogen and phosphorus.

Carbon and nitrogen in the wastewater can only be efficiently removed by a biological process based on the microbial metabolism and nitrogen cycle. phosphorus is usually easier to eliminate from wastewater via biological and physiochemical treatment. There has been a lot of research work in the recent past to optimise the biological processes for wastewater treatment to make it more sustainable. The conventional treatment process demands intensive energy input especially for pumping air in the reactors. Larger footprint due to higher hydraulic retention time and excessive sludge yield are also the drivers instrumental in the development of novel processes.

A noble process for treating wastewater has been tested for sustainability in the lab by Sukhbir Singh and Md Iqbal. After successful results from the lab, the same process is now under testing on the pilot scale. Attached growth retains more mlss and vlss to reduce hydraulic retention time hence, reduces the footprint of the plan]. Anaerobic intercellular COD uptake as polyhydroxyalkanoates (PHA) reduces the sludge yield and passive aeration helps to reduce the power consumption by 35 to 45% in comparison to activated sludge process. From results, it was evident that carbon uptake of 23 mM/hr was achieved which is four folds higher than the conventional process..

**id #2483**

### **RESULTS OBTAINED FOR AGROCHEMICALS ANALYZED IN WATER SAMPLES COLLECTED IN SANT'ANA DO LIVRAMENTO/RS/BRAZIL**

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The results obtained from the analysis toxic substances of 27 parameters are presented in the Consolidation Ordinance n° 5 in XX Attachment of the Health Ministry (2017) and 46 parameters of Ordinance n ° 320 of the State Secretary Health/Rio Grande do Sul/Brazil (2014). The samples were collected by technical from the Department of Water and Sewage, and sent to the laboratory, duly accredited for analysis of samples, as requested by the aforementioned Ordinances. The results were satisfactory for the analyzed periods (year 2017 and half 2018), no substance was detected above the maximum permissible values, reason for great relief for the Water and Sewage Department of Sant'Ana do Livramento City, due to the same area of recharge of the Guarani Aquifer, by the type of soil present and also by the population as a whole to be supplied by groundwater from the Aquifer.

**id #2004**

### **The application of waterless composting toilets in meeting various requirements demonstrated through case studies**

**Anthony Mr Smith**<sup>1</sup>

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Composting toilets decompose waste by design, allowing for the aerobic conditions required for healthy bacteria and other macro and micro-organisms to thrive. The objective is to destroy harmful pathogens, eliminate the risk to human health and the environment, and to transform the nutrients from waste into a safe, easy to manage end product.

A composting toilet will not smell if used and maintained correctly. The aerobic conditions created within the composting chamber means that there are no anaerobic gases produced which are responsible for the smells commonly associated with sewerage waste and other 'pit toilets' commonly found in National Parks and remote public places such as roadside stops. The ventilation system draws any smells down through the composting chambers, and out of the external vent pipe leaving the toilet odour free.

There is growing momentum in the use of composting toilets all over the world and in particular in areas where water is in short supply. Some examples of the wider use and applications of composting toilets include; residential homes, schools, eco retreats,

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remote public places, holiday homes, temporary emergency relief solutions and other environmentally sustainable public amenities.

### Case Study 1

BHP was looking to provide toilet facilities at some remote locations along a railway network running between Port Hedland and Newman in the Pilbara region. The introduction of the amenities was an important cultural step to provide basic facilities and promote inclusion and diversity for BHP rail workers.

The provision of a modular building unit with 'batch' type composting toilets. The complete building and toilets supplied as a modular unit to be transported and placed on-site. 3 units installed for this project are to act as a trial for additional facilities to be added in the future.

### Case study 2

Dambimangari Corporation is creating opportunities for its members to return to country in the Dambimangari Native Title Determination area north of Derby. One of the key objectives of the group's work is the development of a new generation of leaders to preserve their language and culture. Dambimangari were needing some basic toilet and shower facilities for a remote coastal site in the northern Kimberly which has cultural and potential tourism significance.

Partially assembled buildings were barged onto the site and erected on site. 'Continuous' type composting toilets were installed and greywater from the shower is filtered and pumped to irrigate existing gardens at the site.

### Case Study 3

Nature's Atelier Childcare Centre, Vasse. Several 'continuous' type composting toilets were installed throughout the facility and surrounding grounds. The toilets with the greatest expected usage, and hence the greatest capacity, were installed in the main building and similar 'satellite' toilets were used in locations around the grounds of the property. The buildings and architecture around the toilet facilities were in keeping with the centre's quirky/fun vibe.

**id #2294**

## **Effects of Rainwater Harvesting on Urban Runoff, Drainage and Potable Water Use: High Temporal Resolution Stochastic Model**

**Ofer Snir<sup>1</sup>, Eran Friedler<sup>1</sup>, Manfred Schuetze<sup>2</sup>**

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As trends of urbanization and population growth continue to stress local hydrological systems, the need for sustainable management of existing water sources and utilization of alternative sources is gaining interest from both stakeholders of urban water systems and research community. Rainwater harvesting has a promising potential as an alternative water source, which could also carry positive impacts on urban drainage infrastructure (Campisano et al., 2017).

Rainfall and domestic water consumption consist of sporadic events which could be difficult to predict, hence, we suggest a short time-step stochastic model. The high-temporal resolution is necessary to assess RWH effects on the urban drainage (Campisano&Modica, 2014). The model draws data from real time series of rainfall and relevant domestic water uses. The data is sampled with replacement in several time cycles, thus following real-life periodicity of rainfall and water consumption. The stochastic process is able to represent the erratic nature of water demands in short time intervals, and the dynamic modelling approach enables important insights such as overflow patterns during rain events and the effects of consumption on the available tank volume.

Besides rainwater harvesting, the model also incorporates real-time control of water level in the rainfall collection tank to reduce peak-flows in the urban drainage system (Xu et al., 2018) and harvesting of air-conditioning condensation water in summer.

The model could be used for optimizing RWH systems, assessing the long-term efficiency of installed systems, or incorporated in a drainage model (SWMM or Simba) to estimate the effects of RWH implementation on a catchment scale drainage system. To achieve this, the model framework is built to simulate datasets from a single rain-event up to multi-year timescales.

By setting up a model with short time steps, we hope to generate accurate estimations of the benefits of rainwater harvesting: reduction of potable water demand and urban stormwater flows.

**id #2243**

## **Faecal sludge and wastewater treatment technologies in practice: a case study review across four countries**

**Simone Soeters<sup>1</sup>, Pierre Mukheibir<sup>1</sup>, Juliet Willetts<sup>1</sup>, Freya Mills<sup>1</sup>, Antoinette Kome<sup>2</sup>, Rajeev Munankami<sup>2</sup>**

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This research outlines the practices of the real-world implementation and use of selected faecal sludge and wastewater treatment, disposal and reuse technologies in Bangladesh, Indonesia, Kenya and Zambia. Low-resource setting countries face unique challenges in meeting their faecal sludge and wastewater management needs. The purpose of this research is to make accessible the experiences, operational realities and decisions in treatment and disposal options, such that this information can facilitate improved informed choice of treatment technologies.

Eight treatment technologies across the four countries were investigated based on a literature review of the treatment technologies currently in use in these countries and semi-structured qualitative interviews with operators and designers. These

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technologies range from decentralised treatment systems in Indonesia (both mechanised and non-mechanised) to innovative reuse and disposal options such as briquettes in Kenya. Led by the Institute for Sustainable Futures- University of Technology Sydney, the research was designed and conducted in partnership with the SNV Netherlands Development Organisation and the SNV in-country project teams.

We present how the selected treatment, disposal and reuse technologies are being operationalised at the selected sites and why the design was selected. For the eight case studies, key construction and operational factors, financing arrangements, occupational health and safety situation are highlighted, as well as the daily practices of the operator of the technology. The focus is on field experience rather than a purely technical view, since technologies are rarely employed in reality exactly as they were intended. In this way, the research has the objective to support improved understanding of treatment, disposal and reuse options in low- and middle-income countries supporting better informed choice of those technologies most suited to a given context at hand.

**id #2250**

### **Infrastructure services in Brazil: a new regulatory framework in the water and sewage sector**

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The Brazilian Federal Constitution, enacted in 1988 has established that health is a fundamental right for all the citizens. Since the absence of basic sanitation, such as water supply and sewage systems, affects the population health, the access to those services is one of the fundamental rights enshrined in that Constitution. The Brazilian Institute of Geography and Statistics estimated for 2017 a population of 209.3 million inhabitants, distributed in the North (8.7%), Northeast (27.2), Midwest (7.7%), Southeast (42.1%) and South (14.3%) regions. In Brazil, there are about 5570 municipalities, of which 90% are considered as small communities (population <50,000 inhabitants); 40.8% of those communities are located in the North and Northeast. The municipalities are responsible for the basic sanitation services. However, most of them left the responsibility to the state sanitation companies that have as policy, the transfer of subsidies from more profitable municipalities to less favoured municipalities. The aim is to reduce the regional and local socio-economical differences. According to the latest report of the National Sanitation Information System (SNIS, 2017), more than 35 million inhabitants do not have access to safe drinking water. Concerning the sanitary sewage, the situation is even more alarming, since more than 100 million inhabitants are not provided by such services. The lack of appropriated collection and treatment of sewage is even more severe in the poorest regions of the North and Northeast, where 90% and 73% of the population, respectively, do not have any access to wastewater collection. In addition, only 23% and 35% of the collected sewage have an adequate treatment. The National Congress is currently discussing a new law (Nº 3261, 2019), which is aimed to give a new regulatory framework for basic sanitation, pretending to update the current Federal Basic Sanitation Law from 2007. However, the new draft law so far does not take into account the interdependence between sanitation, health and environment. The proposed changes are claimed to increase the low levels service offered to the population by the public sanitation companies. They have not been able to provide the universalization of the sanitation services and therefore, it is necessary to create new conditions by increasing the participation of the private capital. The new law estates that for an efficiency achievement of complying with the standards defined in the environmental legislation, will be conditioned to the payment capacity of the customers. The Brazilian Northeast is the poorest region of the country. Additionally, that region has severe water scarcity, with the largest deficit in the country, besides being the municipalities mostly of small communities. These aspects may lead to a low interest from the private sector to invest in the region. Consequently, other financial approach might be included in the new law. To accomplish the intended objectives, it is necessary to consider the financial conditions of each municipalities that need subsidy and aid. Proposals for a unique regulatory framework for the whole country with huge regional differences, will have no effect on expanding services or improving the environment conditions.

**id #1662**

### **Comprehensive Evaluation of Decentralized Wastewater Treatment Plant Performance In India**

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Inadequate sanitation is amongst the causes of escalating pollution problems in developing countries, as municipal wastewater treatment systems remove only a fraction of pollutants that could be removed. This presentation will report results of a comprehensive evaluation of decentralized wastewater treatment plants (STPs) that was carried out in India. An initial survey of 1517 STPs in India was conducted on the basis of official reports and inquiries to producers and operators. Of them, a sample of 58 STPs was drawn across the country. The case study selection focused on promising technologies for combined-flow WWT (greywater plus black water), using technologies that were representative for India. Only apparently well-managed STPs were chosen. This was later confirmed by measurements of pollution reduction and a qualitative assessment of O&M (operation and management, including maintenance). As land-use requirements could impede the implementation of certain technologies, the study aimed to investigate for each type of land-use at least one suitable technology. The evaluation included environmental, health and cost aspects. Based on the results of the evaluation, suggestions for how to improve decentralized wastewater treatment plants in developing countries such as India will be elaborated and selected case studies presented.

**id #2532**

### **Electrochemical Technique for Removal of Emerging Per- and Polyfluoroalkyl Substances (PFASs) in Water using Boron-Doped Diamond and Titanium Electrode**

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Per- and polyfluoroalkyl substances (PFASs) are a group of synthetic organic compounds. Numerous products containing PFASs contribute to environmental contamination through groundwater [1], surface water [2] and tap water [3] as major sources for drinking water production. Conventional techniques have failed to eliminate PFASs [4] due to their stable molecular structures. Advanced oxidation processes have attempted to reduce PFASs including membrane filtration, photochemical oxidation, sonochemical methods and ozonation. Electrochemical technology (EC) for PFASs degradation [5] occurs at the electrode surface where hydroxyl radicals ( $\text{OH}^\cdot$ ) are formed via oxidation [6]. Consequently, electrode type is a necessary factor for the EC technique. For example, a  $\text{Ti/SnO}_2$  electrode was doped with antimony (Sb) for high conductivity and successfully removed more than 83% [7], however, Sb is a toxic substance. Guidelines for drinking water quality issued by USEPA have an Sb limit of  $6 \mu\text{gL}^{-1}$  [8].  $\text{PbO}_2$  electrodes release lead ions and hydrogen fluoride which adversely impact the environment [9]. A boron-doped diamond (BDD) electrode contributes higher efficiency degradation for perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) [10], with no appearance of toxic ions after the reaction. The cathode site is also an essential degradation parameter but contains weaknesses such as fragility and low stability. Research has been conducted on EC techniques but few studies have focused on suitable electrodes which can eliminate both short-chain and long-chain PFASs. BDD and titanium electrodes were selected to improve degradation performance and solve the problem of metal ion release. Hence, this research investigated the efficiency of an electrochemical oxidation technique to remove PFASs using BDD and titanium electrode. PFOS and PFOA were selected as representatives of long-chain and perfluorohexane sulfonate (PFHxS) was selected as a representative of short-chain PFASs. Furthermore, this research aimed to determine a technique to decrease toxic ion release from the electrode.

All experiments were performed in a batch reactor using a polypropylene vessel containing 350 mL of Milli-Q water spiked with PFOA, PFHxS, and PFOS at concentrations of  $3 \text{ mgL}^{-1}$ . Two types of electrolyte as  $\text{Na}_2\text{SO}_4$  and  $\text{NaCl}$  were admixed in solution. Reactions were performed with a BDD anode (NeoCoat, Switzerland) as a working electrode and a titanium cathode. The electrode surface area was  $78.5 \text{ cm}^2$  with plate distance of 3 cm. For the pre-treatment step, electrochemical samples were filtered through syringe filters and the filtrates were loaded directly into preconditioned cartridges using column conditioning with methanol 10 ml followed by MilliQ water 5 ml. All samples were analyzed using high-performance liquid chromatography with tandem mass spectrometry (HPLC-MS/MS). Results showed that PFAS degradation efficiency reached 91.34% PFOA removal, 92.57% PFOS removal and 92.78% PFHxS removal which increased as reaction time increased. Challenges facing EC techniques include the removal of toxic titanium ions which adversely impact on HPLC-MS/MS as well as presenting a danger to human health.

**id #1703**

### **Automated algal system for wastewater recovery: A Review**

**Batsuren Sundui<sup>1</sup>**

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Publish consent withheld

**id #2319**

### **Experimental Studies on and Numerical Simulation of Batch Operated Constructed Wetlands in Wastewater Treatment**

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Development of small decentralized wastewater treatment system is a necessity in small villages and towns. Constructed wetlands are a good choice as a low-cost decentralized wastewater treatment technology. In this study, the performance of a batch operated constructed wetland with and without vegetation in removing nutrients from wastewater was compared and the applicability of HYDRUS 2D model in simulating batch operated constructed wetland was studied. The experimental wetland unit was of size 1.8m x 1.2m x 1.2m. The main treatment layer consisted of 50 cm thick river sand of 1-4mm size. Euphorbia Milii was used as the vegetation in the wetland unit. The influent was supplied for a period of 12hrs a day and thereafter the supply was stopped for next 12hrs. This was continued until the top level of the treatment layer became saturated. A hydraulic loading rate of  $100 \text{ l/m}^2/\text{day}$  was maintained throughout the loading period. After loading, the influent was retained in the wetland unit for 6 days and the effluent was collected and analysed for quality parameters such as ammonia nitrogen, nitrite nitrogen, nitrate nitrogen and phosphorus. The experimental results were compared and it confirmed that the batch operated constructed wetlands are highly effective in treating nutrient contaminated water. Also, the presence of vegetation enhanced ammonia removal efficiency and nitrification. Numerical simulation of wetland unit without vegetation was performed using the HYDRUS wetland module and its results were compared with the experimental observations. The water flow simulation was performed using the single porosity van Genuchten-Mualem hydraulic model. CW2D multicomponent reactive transport module implemented in HYDRUS 2D was adopted for solute transport modelling. A reasonably good fit between the measured and computed effluent concentrations could be achieved after adjustment of some of the default parameters in the model.

**id #2481**

### **Monitoring and managing the safety of small (decentralised) public drinking water systems in Western Australia**

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Western Australia (WA) is the second largest administrative territory in the world. The state is divided into 138 local government (LG) districts where the LG is responsible for the administration of the relevant health legislation related to drinking water supplies that are not connected to a reticulated scheme. Although majority of the population in WA has access to reticulated drinking water supplies, there are areas serviced by onsite drinking water systems. Water for decentralised systems are usually sourced onsite (or carted in), treated and plumbed to the premises located on the lot. In most instances, these small decentralised drinking water systems are operated by the owner of the premises. The public health risks associated with these systems becomes significant for premises that are accessible to members of public, such as food premises, roadhouses (general stores), caravan parks, camp sites, public meeting places, education facilities and accommodation facilities. Every LG in WA keeps a register of such premises and ensures that drinking water supplied to members of public is safe for consumption.

In order to verify that the drinking water at these premises is safe, the WA Department of Health (DOH) works together with LGs to implement a state funded drinking water quality monitoring program. The drinking water supplies at premises that operate their own drinking water system and provide drinking water to members of the public are sampled on a monthly basis. Every sampling location captured by this program is assigned a unique code (sitecode) that can be immediately identified to a specific LG. The drinking water samples are collected by the LG and couriered to the laboratory with 24 hours of collection. At the completion of the analysis, the results are emailed to the LG and transferred to DOH water sampling results databases via electronic File Transfer Protocol (FTP). For example in the 2018-2019 financial year, 654 unique sampling locations were sampled across 43 local government districts in WA.

This presentation discusses the type of parameters tested, the non-compliant notification process and the corrective actions implemented. The presentation also discusses case studies of site inspections conducted by LG to investigate into the source of contamination and the operation and design of the drinking water treatment system.

**id #2255**

## **Compliance versus risk based management of water quality for small water supply systems**

**Andrew G Telfer**

Management of water quality in supply systems is critical to ensuring the safety of consumers. Not adequately managing water quality risks can have significant impacts to the health of consumers and therefore needs to be carefully considered in all water supply systems. Water quality is often regulated with set compliance requirements. However, water quality management must also include a risk based approach as prescribed by water quality management guidelines such as the World Health Organisation (WHO) Guidelines for Drinking Water Quality (GDWQ) and Australian Drinking Water Guidelines (ADWG), to ensure water quality risks are adequately identified, assessed and mitigated. Both compliance and risk-based management of water quality are important and need to be considered when developing water quality management strategies for water systems. However, understanding the difference is important when compliance places a significant burden in terms of resources which is not warranted, or complying with the set rules does not adequately mitigate risks. This may be particularly critical for small water systems where available resources are more limited. This paper will explore the differences between compliance and risk-based management, the place of each in development of water quality management strategies, and how you might apply these strategies in management of specific water quality risks.

**id #2509**

## **OPERATIONAL PRACTICES TO IMPROVE BIO-P AND N REMOVAL IN A SMALL WASTEWATER TREATMENT PLANT**

**Isabel Telles Silveira<sup>1</sup>, Wayne Bagg<sup>1</sup>**

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Mundaring WWTP is the first UCT-MBR plant installed by the Water Corporation in Western Australia; it is fully automated and runs as a remote site. Treated effluent (0.14 MLD) is reused for irrigation in local areas therefore it demands high treatment efficiency. To improve treatment performance a process model was developed and tested against different operational settings; this tool was key to evaluate process alterations without risking environmental compliance. This paper outlines the findings of the assessment and the proposed operating strategy. The three main outcomes were optimization of (a) A and R recycles; (b) MLSS targets and (c) DO settings. All have a direct impact on treatment performance and energy demand.

The model revealed that increasing WAS extraction rate and targeting MLSS can help to lower treated water TP and TN concentrations. The WWTP capacity is 0.24 MLD and was designed to operate with aerobic MLSS of 8,000 mg/L. Current SRT is 30 days and aerobic MLSS has been maintained up to 6,000 mg/L. By reducing it to 4,000 mg/L, the final effluent TP decreased from around 5 to 3 mg/L. The raw influent is variable and weak and changes in F/M ratio benefits the PAOs at the head of the plant. On the other hand, denitrification cannot be improved since there is insufficient carbon available to the NOBs in the anoxic tank. The model has also shown that is possible to operate the plant at very low MLSS, maintaining high SRT, without compromising nitrification.

To better understand the limitations of the treatment, COD and phosphate profiles were verified against *A recycle* rates. As previously hypothesized, the carbon is primarily consumed in the anaerobic reactor and favours PAOs growth. The remaining COD is oxidized almost anoxically, meaning that phosphorous has been taken up by dPAOs in the anoxic reactor to the detriment of the denitrifiers. The whole treatment process is carbon limited. The balance between optimizing the removal of nitrates and phosphates is influenced by TKN/COD ratio, VFAs available in the raw influent and adequate TP/COD ratio.

Another setting of significance is DO in the aeration tank. By maintaining the current operation and reducing the DO from 1.2 mg/L to 0.5 mg/L, TP decreases to 2.8 mg/L in the final effluent. Despite the resistance of operating the aerobic tank at such low levels of oxygen, gradual changes in DO settings should be tested. Reduced DO might encourage the growing of SNDs and improve denitrification.

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This process modelling assessment showed that simple adjustments of MLSS and DO concentrations could be effectively used to enhance biological nutrient removal especially when treating weak effluents.

**id #2453**

### **Study Tour to Queensland Water Utilities - Key learnings and opportunities for Regional Wastewater Asset Planning Group**

**Sasi Thamrongvoraporn<sup>1</sup>**

*1. Water Corporation of WA, Perth, WA, Australia*

The Water Corporation provides wastewater services for the metropolitan & regional towns of Western Australia (WA) to ensure that public health and the environment is protected. In line with our Corporate objectives, as a Corporation we are striving to achieve the lowest environmental impact with an appropriate level of investment.

In WA, the management of wastewater is regulated under the *Environmental Protection Act, 1986* (EP Act, 1986) through licencing by the Department of Environmental Regulation (DWER). The Corporation is required to apply for a licence to operate a wastewater treatment plant and disposal of treated wastewater. Currently, there are no guidelines on treatment and disposal of treated wastewater on land or to waterways. This presents challenges, for both the proponents and regulator in assessing environmental impacts of treated wastewater to the receiving environment. The current regulatory framework as well as the lack of State-wide Guidelines means that the assessment is constrained to a site specific assessment. As a result, the assessment is subjective and does not encompass overarching environmental outcomes at a regional scale. This often results in a higher level of investment for smaller towns to achieve positive environmental outcomes.

The Water Corporation undertook a desktop review of regulations of wastewater nationwide to compare environmental licencing requirements with the view to improve environmental risk assessment process and management of wastewater in WA. In May 2019, the Corporation undertook a field based tour of various Queensland Water Utilities to exchange information on planning, technologies and regulation frameworks.

The key learnings are (a) Queensland has an overarching State-wide environmental policy which sets out clear environmental outcomes. This provides a regulatory framework for regulator and proponents to work toward achieving common environmental outcomes. (b) Queensland has a catchment water quality improvement policy which is developed based on mature water quality monitoring data that sets water quality targets for each catchment. (c) Environmental risk assessment process is robust and scientifically assessed by proponent and regulator (d) Licencing process is streamlined with outcomes focussed on licencing conditions.

Various opportunities to improve environmental risk assessment process and licencing process in WA were identified from the study tour. These include (a) Working collaboratively with the regulator on developing guidelines for wastewater treatment and discharge to land and water in which environmental risk assessment and overarching environmental outcomes are the foundations (b) Embedding the environmental risk assessment framework within the planning process (c) Building site specific / or catchment based targets for a water quality monitoring database to enhance the understating of environmental conditions in the catchment.

**id #1712**

### **Why Small and decentralized systems are of importance**

**JOSEPH THANIKAL<sup>1</sup>**

*1. RICS School of Built Environment, Noida, UP, India*

It is estimated that the wastewater generated by almost half of the population of the United States is treated by small or decentralized systems. Decentralized management of wastewater, which has been defined as the collection, treatment, and reuse of wastewater at or near the point of generation (Crites et al., 1998), currently serves almost one-quarter of the population. Most of this wastewater is treated at the household, although small systems that serve clusters or housing developments are becoming more common. Another quarter of the population lives in urban areas with less than 50,000 inhabitants. The wastewater generated by this population is usually collected and treated in small, centralized treatment plants.

The goal of this paper is to review the technologies that are used for the collection and treatment of wastewater from individual households and small communities, highlighting the important differences from the technologies that are used to treat larger flows. About one-third of new homes rely on onsite systems. Unfortunately, many onsite wastewater systems are failing, due to inappropriate siting, design, or maintenance (USEPA, 2002). Failing onsite systems are recognized as sources of both groundwater and surface water contamination, posing a risk to public health (due to the presence of pathogens and nitrate) and the ecological health of lakes, rivers, and estuaries (due to nutrients that cause eutrophication). The regulation of onsite systems is currently undergoing important changes, and stricter and more uniform design and performance standards are expected in the future. Many existing systems will likely be required to upgrade. Small and decentralized wastewater treatment presents unique opportunities for reuse. The important characteristic that distinguishes this type of wastewater management from larger systems is that there is a much greater potential for the treated wastewater to be generated closer to the potential reuse sites. With currently available technology, the capability exists to produce wastewater at the quality that is appropriate for the specific type of reuse, ranging from irrigation of low-value crops to toilet flushing. Decentralized wastewater management, if viewed as an alternative to larger, centralized systems, presents perhaps the greatest opportunity for wastewater reclamation and reuse. For example, landscape irrigation of public areas, industrial reuse, or reuse in buildings creates a distributed demand for wastewater. If the production of reclaimed wastewater can be coordinated with the demand, facilities can be constructed close to the site of demand. In small communities, often located in agricultural regions, there is a large potential for reusing wastewater for

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agricultural irrigation. Ironically, much of the wastewater currently generated by small communities is currently disposed of on land (spray irrigation, infiltration basins, or overland flow), but no crop is harvested. As water becomes scarcer in many regions of the country, it is likely that land disposal will be converted to planned reuse.

**id #2680**

### **Concept Paper for the conference, Dec. 1 to 5, Murdoch University, Australia Experience in Implementing Small Scale Rural Water Supply Schemes, Including Rooftop Rainwater Harvesting, and Ensuring Sustainability 'A Parathode Village Experience'**

**Peter Thettavil<sup>1</sup>**

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The State of Kerala, Which is situated at the south west end of India, is rich in rainfall with more than 3000 mm annual rainfall!! The state has three distinct geographical areas of habitat, Viz, The seashore, the plains and the hills. Water availability in the hills during the summer months from mid-February to the mid-May is very very scarce. As the state has the rain in 7 month starting from mid-May to mid- November, wells in each family will have enough water during those months. the water in the wells will be there for another two months after the rains. after mid-February the acute water storage starts till mid-May. the women folk wail long distance during these three months to the valley to collect water from ponds and small canals. this problem exists for decades and the People are suffering. the only temporary solution is to supply water in lorries by the village authorities. but still, the problem of cleanliness of that water remains?

'JALA NIDHI' (Water - The Treasure) project was brought in to solve this grave problem. In 2015, our NGO- The Andhyodaya took up this project in Parathode Grama panchayat. the main features of the GP are:

**Area:** 53.49Km<sup>2</sup>                      **Location:** 9°53'39.6"N 77°05'51.0"E, 9.894320, 77.097500  
**Population:** 33402                      **Male:** 16557    **Female:** 16815                      **Families:** 11693  
**Literacy:** 98.50%                      **Water Coverage:** 43.8%

The project has 4 stakeholders – The World bank, The State Government, The local self government body (Grama Panchayat) and the People. The people are the main stakeholder. People can find a solution to their drinking water issue without any limitation to funds. Sharing of cost of project is as follows:

World Bank – 75%; Grama Panchayat – 15% and the People – 10%

Our role is to co-ordinate all activities of the project both physical and financial. We need to ensure the timely implementation of the project and documentation related to it.

Beneficiaries of the project are selected by voluntary participation mode. Once clusters of beneficiary families come forward, then they are formed into a registered beneficiaries group (BG)

In parathode GP, we could form 49 beneficiary groups (BGs) covering 3,247 families. The project cost is RS. 14.5 Crore (about USD 2.5 million)! For the 49 BGs sources of water supply are as follows:-

- |                                   |                 |               |
|-----------------------------------|-----------------|---------------|
| 1. Rooftop Rainwater Harvesting : | 9 BGs Covering  | 641 families  |
| 2. Open wells/ Tube Wells :       | 38 BGs Covering | 2446 families |
| 3. Gravitational flow of water :  | 2 BGs Covering  | 160 families  |

During the past 4 years of our involvement in the project, we could transform parathode GP from a water scarce village to a water rich village reaching drinking water to every family of the village. The solutions adopted for the problem are sustainable and so the village people will not have to run for water in year to come.

**id #2320**

### **Evaluation of biosolid quality from innovative decentralised fecal sludge treatment technologies in rural and urban Tanzania**

**Emmanuel Mrimi<sup>1</sup>, Beda Levira<sup>1</sup>, Alfred Lazaro<sup>1</sup>, Fatuma Matwewe<sup>1</sup>, Jacqueline Thomas<sup>2</sup>**

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*2. The University of Sydney, Darlington, NSW, Australia*

**Introduction:**

On-site sanitation includes, pit-latrines, septic tank or simple vaults. In Sub-Saharan Africa (SSA) these types of latrines are used by 84 % of the urban households [1] and the majority of rural households. Tanzania is typical of other countries in SSA, that despite high rates of on-site sanitation usage, there is a lack of safe emptying and treatment practices [2]. Sustainable Development Goals 6.2 (SDG) has a target of increase increasing access to a safely managed sanitation service and SDG 6.3 to halve the quantity of untreated excreta being discharged [3]. A review of decentralized treatment systems in SSA found a number of promising technologies [4]. Especially, as there is also growing demand for the resources that can be recovered from faecal sludge including bio-solids as a soil conditioner for agriculture [5].

**Aim:**

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The aim of this research was to evaluate the bio-solids quality produced by two different decentralised faecal sludge treatment technologies, serving dissimilar rural and urban households in Tanzania.

### **Methods:**

The first system consisted of a 4 m<sup>3</sup> dome anaerobic digester, with anaerobic baffled reactors and sludge drying beds [6]. The plants served ~ 1000 urban households in Dar es Salaam. The second system consisted of faecal sludge drying beds and an innovative rocket stove design to treat faecal sludge leachate. The system had the capacity to serve ~ 300 rural households in Ifakara, Morogoro District.

Samples were taken from both systems during wet and dry seasons over a period of one year. Raw faecal sludge entering the system and bio-solids produced were sampled in 100 g quantities. Samples were analysed for pH, total solids (TS) and total volatile solids (TVS) using standard methods [7]. Faecal indicator bacteria (*Escherichia coli*) density was determined per g of sludge using membrane filtration methods [8].

### **Results and Discussion:**

Raw faecal sludge samples from urban households had a lower TS value and higher volumes were collected after rainfall events. Rural raw faecal sludge had a higher TS with an average of 688 g/kg at a depth of 1 m across 22 pit latrines emptied. TVS also halved between the top and bottom of the pit latrines, indicating the on-going digestion within the rural pit latrines.

The treated bio-solids from both the rural and urban system had maximum *E.coli* densities of  $1 \times 10^7$  cfu/ 100 mL. These values are above the recommended guidelines for safe use in agriculture of  $1 \times 10^3$  cfu/100 mL [9]. The urban drying beds and rural system heat sterilisation step did have minimum results that were within the guidelines values.

In both systems overloading and reduced drying times for bio-solids resulted in unsafe *E.coli* densities in the bio-solids. Despite very different systems and raw sludge, both treatment systems were capable of producing safe bio-solids, however, it required careful operational and monitoring. To safely reuse of bio-solids from faecal sludge treatment systems in Tanzania, there needs to be more robust technologies along with operational and monitoring plans.

**id #2204**

## **Low cost gravity enabled filtration microfilters**

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A novel configured microfiltration membrane filter (polyacrylic needlefelt) pilot plant was developed and tested for solving the energy demand, fouling and low flux challenges experienced with membrane bioreactors (Ersahin et al., 2012). Needlefelt microfilters that consist of needled or locked fibres with a typical hairy surface was used in these tests. These membranes displayed robustness as they were exposed to weeks of sunlight and periods of being submerged in effluent prior to a continuous operation. The *E.coli* levels in the filtrate were decreased to levels within the discharge parameters. Needlefelts functions as a type of dynamic membrane which is formed on a supporting material layer that may consist of a woven and or non-woven filter. The surface of this cloth entraps suspended solids in the influent and forms a secondary biomass filtration layer on top. This is in contrast to the colloidal particles, microbial cells and flocs that adhere to the filters pores and clog it. The expected low cost of the membrane material together with high chemical resistance should provide an easily disposable membrane filter with extended lifetimes.

**id #2257**

## **What water treatment lessons can remote Australia learn from the Middle East?**

**Eric Vanweydeveld<sup>1</sup>**

1. Power and Water Corporation, Alice Springs, NT, Australia

Conventional and advanced water supply systems currently used in Australia have been developed for large cities. Typically these systems have very high capital and operating costs, require a regular supply of various chemicals and daily intervention by experienced and well-trained operators.

In contrast, water supply systems in small regional and remote communities are relatively simple, often providing only basic disinfection; biological and mineral impurities with potential health impacts frequently remain untreated.

Conventional and advanced water treatment solutions, designed for larger cities, are not an economically viable solution for replication across Australia's hundreds of remote communities and small regional centres. The resultant technological gap between urban and remote systems is considerable, with consequent social and economic inequity and disadvantage.

The significant differences between urban and remote systems (scale, budget, availability of skilled operators etc) limit the transfer of innovation from urban systems to remote systems. There is potential for new insights applicable to regional and remote Australia to be gained from small scale systems overseas.

Alice Springs-based Power and Water Engineer and Senior Project Manager Eric Vanweydeveld was awarded a 2018 Churchill Fellowship. In March 2019, Eric spent eight weeks in the United Arab Emirates, Israel and Oman investigating innovative and emerging water treatment solutions and technologies appropriate for small, decentralised water supply systems. Eric also investigated the way in which water management and innovation is included in regional development policies in Israel, UAE and Oman, and assessed the socio-economic impact of innovative water solutions.

Eric is now sharing the key findings and insights from the Middle East to address similar water scarcity challenges faced by regional and remote Australia, and importantly, sharing knowledge about these new approaches to assist the broader Australian water industry to advance the United Nations' Sustainable Development Goal 6: ensure access to water and sanitation for all.

**id #2466**

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### **Borrooloola water treatment system upgrade - An innovative approach to public participation in remote indigenous communities**

**Eric Vanweydevel**<sup>1</sup>

*1. Power and Water Corporation, Alice Springs, NT, Australia*

Borrooloola is one of the most remote communities in Australia, located in the Gulf of Carpentaria of the Northern Territory. To address water quality issues and to ensure long term security of water supply, major infrastructure upgrades were undertaken by Power and Water Corporation. The project dealt with various levels of complexity (technical, social, geographical and logistical) as well as a wide range of challenges including a high level of political and social influence and a large number of stakeholders involved in different phases of the project with various interests. To ensure communication and public participation were actively promoted and managed in a meaningful way, giving consideration to local characteristics (i.e. language, cultural and social context, and local sensitivities), an extensive communication and stakeholder engagement strategy was developed and updated throughout the project. Applying rigour to the public participation process facilitated the establishment of strong relationships between the community and the project team. In addition to using "tried and tested" engagement strategies, the project also featured new and innovative approaches to engagement that advanced the field of public participation in remote Indigenous communities. These included:

- Engagement of school students and local artists in an artwork project to create a link between the benefits of the project and the local Aboriginal culture. The artwork created local pride in the facility and provided an avenue for the project team to engage with the school about the water supply and share messages about saving water.
- Development of key messages in local languages in the form of water stories and image-based factsheets. Messages were developed in partnership with local community members to ensure the messaging was culturally relevant and meaningful to the targeted audience.
- Creation of a series of radio stories (in language) that were broadcast throughout the project duration. Radio stories were developed in accordance with the stage of the project and the key messages that needed to be conveyed.

This project was considered very successful because of the high level of engagement of the community and the social outcomes that were achieved.

**id #2223**

### **Can High Rate Algal Ponds be used as post-treatment of UASB reactors to remove micropollutants and nutrients?**

**Lucas Vassalle**<sup>1,2</sup>, **Alcino Trindade**<sup>1</sup>, **Camila C Moreira**<sup>1</sup>, **Matheus P Freitas**<sup>1</sup>, **Andrés Felipe T Franco**<sup>1,3</sup>, **Fabiana R Passos**<sup>1</sup>, **Cesar R Mota Filho**<sup>1</sup>

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The widespread presence of micropollutants in the environment is currently one of the most pressing environmental issues worldwide (1). Their incomplete removal after conventional wastewater treatment makes the search for alternative, more efficient treatments a priority concern. In Brazil and other world places, Upflow Anaerobic Sludge Blanket reactors (UASB) are extensively used for domestic sewage treatment, in small and big scale systems (2). The main advantages of UASB technology are the low cost of organic matter removal and the possibility to recover bioenergy with reduced space. However, UASB effluent usually require post-treatment for the removal of soluble organic matter and nutrients. In this context, if followed-up by microalgae-based treatments (especially high-rate algal ponds – HRAP) to perform the post-treatment of UASB effluents and remove soluble organic matter and nutrients, this treatment system becomes a highly low-cost, sustainable anaerobic-aerobic technology when compared to conventional activated sludge treatments, the technology most commonly used to treat domestic wastewater worldwide. The current study evaluated the removal capacity of a UASB-HRAP treatment system for eleven micropollutants present in raw sewage, Ibuprofen, Diclofenac, Naproxen, Paracetamol, Estron, 17 $\beta$ -estradiol, 17 $\alpha$ -ethynynestradiol, Estriol, 4-nonylphenol, Bisphenol A and Gemfibrozil. In addition, analyzes were carried out to verify the removal of nitrogen and phosphorus in the system. The UASB reactor and the HRAP were operated at a hydraulic retention time (HRT) of 7 hours and 8 days, respectively. Samples were collected periodically from the influent (raw sewage), UASB reactor effluent (to evaluate anaerobic performance) and HRAP effluent (to evaluate the aerobic performance of the pond and the global performance UASB-HRAP). All the studied compounds were found in raw sewage, with an occurrence ranging from 70 to 100%. Removal in the UASB reactor was incomplete, but the overall performance of the UASB+HRAP system was highly efficient for most of the compounds, with removal rates ranging from 39 to 95%. Hormones were the compounds best removed in the system. About the nutrients in the UASB reactor, no nitrogen removal is observed, occurring an intense mineralization of organic nitrogen. For this parameter, the mean value of concentration observed in the raw sewage was 25 mg.N-NH<sub>4</sub>.L<sup>-1</sup> already for the UASB this average up to 34 mg.N-NH<sub>4</sub>.L<sup>-1</sup>. There is a mean removal of 44% of this compound in the evaluated ponds, leaving the final effluent with 14mg.N-NH<sub>4</sub>.L<sup>-1</sup> on average. To phosphorus we found an average of 6 mg.L<sup>-1</sup> in the raw sewage with a reduction in UASB to 4 mg.L<sup>-1</sup> and less than 1 mg.L<sup>-1</sup> in the ponds. The UASB-HRAP system has proved promising to be applied in sewage treatment systems, even in small systems.

**id #2274**

### **Recovery of micro algae from high-rate algal ponds to increase the production of biogas from UASB reactor in a treatment system for domestic effluents**

**Lucas Vassalle**<sup>2,1</sup>, **Alcino Trindade**<sup>2</sup>, **Camila C Moreira**<sup>2</sup>, **Matheus P Freitas**<sup>2</sup>, **Andrés Felipe T Franco**<sup>2,3</sup>, **Fabiana R Passos**<sup>2</sup>, **Cesar R Mota Filho**<sup>2</sup>

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The use of upflow anaerobic sludge blanket (UASB) reactors allows a lower cost of operation and in a smaller space to treat the domestic effluent in removal of carbonaceous organic matter suspended or dissolved in wastewater (1). Usually, it is necessary post treatment to improve the treated effluent quality. Priming sustainability scenario in the sewage treatment process, based on the concepts of the circular economy, a technology indicated for the UASB post treatment would be the High Rate Algal Ponds (HRAP). These units are considered low cost and when compared to conventional units they use infinitely smaller spaces. In addition, microalgae produced in HRAP systems can be co-digested in UASB reactor, together with anaerobic sludge and increase methane production in biogas by up to 108% (with pretreatment), improving the energy potential of this by-product (2), (3). However, pilot scale studies that use real domestic effluent and UASB+ HARP flowchart are still incipient in the literature and require further clarification. Based on the assumptions presented , the aim of this research is proposing to monitor a sewage treatment system, composed of UASB reactor, treating real domestic effluent, followed by HRAP, evaluating the biogas production from the anaerobic co-digestion of the algal biomass produced in the ponds and recirculated into the UASB reactor, and analyse the physical chemical parameters. Were performed tests in a system comprised by a two pilot-scale UASB reactors (340 L) followed by two high rate algal pond (204 L), operating with an 8 day HRT and volumetric organic load of 25gCOD/m<sup>3</sup>.d. To fulfill the proposed objectives, one UASB, without a algae biomass recirculation was used for control. Samples were taken in the liquid, solid and gaseous phases of the system. PH, solids and COD were analyzed in the system. In the gas phase, the biogas production of UASB reactors with Ritter meters was analyzed. In order to know the biogas composition of each reactor, the Geotech brand analyzer was used. It was observed that during the monitoring time of the system that the average biogas production in terms of L.CH<sub>4</sub>.Kg.COD<sup>-1</sup>.day<sup>-1</sup> in the UASB reactor that received the algae biomass from the ponds was on average 47% higher than in the UASB control reactor. It is important to note in this case that the increase of COD in the UASB to which the codigestion of algal biomass was made was 10% in relation to the control reactor. In this way, it can be concluded that, even without a pretreatment, due to the increase of the organic load inside the reactor, there is an increase in both biogas production and methane production.

**id #2300**

### **Removal of pharmaceuticals and personal care products in constructed wetlands**

**Jan J Vymazal<sup>1</sup>**

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#### **Removal of pharmaceuticals and personal care products in constructed wetlands**

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Introduction

The term Emerging Pollutants primarily refers to those for which no regulations currently require monitoring or public reporting of their presence in our water supply or wastewater discharges. Many constituents described as emerging pollutants are pharmaceuticals and personal care products (PPCPs) that may enter the environment through excretion in human and animal urine and feces, through flushing of unused medications, household uses, or bathing, and result in ng/L to µg/L concentrations in the environment. Emerging pollutants have the potential to enter the environment and cause known or suspected adverse ecological and (or) human health effects. In some cases, release of emerging pollutants to the environment has likely occurred for a long time, but may not have been recognized until new detection methods were developed in the late 1990s. The most targeted pharmaceuticals belong to several groups of substances, namely pain relievers, antibiotics, antiepileptics, antiphlogistics (NSAID), antibacterial agents, anticoagulants, beta blockers, anticoagulants, diuretics, fibrates (lipid regulators), psychoactive drugs (stimulants) and most recently also antidepressants.

Removal of PPCPs in constructed wetlands

The first attempts to evaluate constructed wetlands (CWs) with respect to removal of pharmaceuticals from wastewaters were carried out in USA and Spain. According to the Web of Sciences, 175 research papers dealing with removal of PPCPs in constructed wetlands were published until the end of 2018. The experiments dealt with the total of 206 compounds and 47 metabolites. The most frequently studied pharmaceuticals were carbamazepine (antiepileptic drug, 75 papers), ibuprofen (NSAID, 70 papers) diclofenac and naproxene (both NSAID, 62 and 52 papers) caffeine (psychoactive drug, 49 papers) and sulfametaxazole (antibiotics, 47 papers). The most frequently studied personal care products were musks tonalide (24 papers), galaxolide (21 paper) and methyl dihydrojasmonate (17) and oxybenzone (13 papers) a synthetic UV filter. Most studied groups of compounds were antibiotics (45 compounds), personal care products (16), beta-blockers, antidepressants and NSAIDs (all 12). Most studies were carried out in micro/mesocosms (109) while only 49 studies were done in full-scale operational constructed wetlands. The available results indicate that the removal efficiencies are highly variable among studies and there is a wide array of parameters that can influence the removal efficiency. These parameters include chemical structure and physical-chemical properties of the compounds, redox conditions in the wetlands, temperature, filtration material or inflow loading among others. There are many processes which are responsible for PPCP removal in constructed wetlands, however, biodegradation, plant uptake, sorption and photodegradation are the most important. The removal efficiency of constructed wetlands varied widely but it apparent that some compounds are removed very well (e.g., paracetamol, triclocarban, furosemide) while removal of other compounds is very limited (gabapentin). The treatment efficiencies of constructed wetlands reported in the literature for various pharmaceuticals are unanimous, however it seems that the efficiency of constructed wetlands is comparable with conventional activated sludge systems.

**id #2592**

### **Disaster relief water treatment in Indonesia: A solar powered solution.**

# **SWWS2019 Abstracts**

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Throughout Indonesia the incidence of natural disasters has been increasing in frequency for the last twenty years. In 1999 there were 56 natural disasters recorded, this increased to 3397 natural disasters in 2018. An average of 70% of these natural disasters were the direct result of water related issues. The provision of water after these disasters is of paramount importance to reduce the health impacts associated with the contamination of drinking water, such as diarrhoea, cholera, dysentery and typhoid.

The method that will be used for provision of potable water in an emergency situation is the design of a solar PV-powered portable water treatment unit that is able to treat polluted, brackish and saline waters into water suitable for potable use. This is achieved using a variety of techniques, including desalination by reverse osmosis membrane and UV disinfection, dependent on the source of the feed water.

In this study a water treatment unit is designed that is portable, easy to use, fully self-contained and able to be fully powered off grid, without the use of fossil fuels. A computer model will also be created to show the output of potable water, the energy required and the TDS of the permeate water for all feed water types. The model will also show how the unit is expected to operate under various other situations that may arise out in the field, including any warnings that may arise.

**id #2242**

## **Vanuatu's Failing Solar Water Pump Systems**

**Jake Ward<sup>1</sup>**

1. UNICEF, Pacific

According to manufacturers, suppliers and marketing information at large, solar water pump (SWP) systems should have a lifespan of **20+ years**, requiring little if any maintenance aside from a potential pump or controller change-out near the system's mid-life. Recent assessments in other parts of the globe found that, in practice, SWP systems have an average lifespan of **10+ years**<sup>[1]</sup>. Contrarily, the average lifespan of community and household-scale SWP systems in Vanuatu is **1 to 2 years**, with some failing within a matter of months, or even weeks. This lifespan disparity makes lifecycle cost, design and performance comparisons among water pumping options (e.g. solar vs. diesel) mostly impractical.

Drawing from data collected from key stakeholders and site inspections, this presentation reveals categorised causality of solar water pump system failures in Vanuatu. Failures are typically technical, design, systemic or user-related, and often a combination of two, three or all four. Options to rectify the situation will be explored.

Breakdowns due to technical issues (such as pump, cabling, controller, panel or piping failure) and system design (sizing, siting, and configuration) will be assessed in comparison to findings from other countries. Appropriate supply-side mitigation measures that could be contextualised and applied will be identified.

Technical and design issues aside, the majority of failures were caused, in full or in part, to systemic bottlenecks. Whilst Vanuatu's National Energy Roadmap (NERM 2016 – 2030) Green Growth Objective #4 aims to “*improve access to and the quality and reliability of water services through the use of renewable energy and energy efficiency technologies*”, the government currently lacks the capacity to enforce compliance (let alone establish standards and compliance protocol) among system designers, installers, operators and users. No warranty agreements, for example, are required to be signed by installation contractors to overcome design, siting and installation issues commonly prevalent during what has been coined as the 2-year “*mortality period*”<sup>[2]</sup>, beyond which the likelihood of system functionality increases significantly.

This presentation will explore the two contrasting schools of thought in Vanuatu with regards to improving operation and maintenance by either strengthening installer liability or user capacity, concluding with applicable domestic and international best practice guidance for solar water pumping practitioners.

**id #1882**

## **“Innovations in Acid-Iron Water Groundwater in Remote Tourism Cottages, Nannup, WA”.**

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1. Westerlund Eco Services, Nannup, WA, Australia

### **Abstract:**

Remote country based private resorts are under review to be more water sustainable.

The BRC's, Nannup, water systems were reviewed in May 2019, based on Leslie Westerlund's principles of a “Sustainable Water Management Regime for a Remote Homestead”.

Rainfall and underground water is precious. This is complemented by the energy integrated system that use high priced electricity and bores to pump underground water to the house irrigation tanks; Calcite to neutralise the acid; settling tanks to remove some iron sediments; gravity to supply rain water to the house; inline filters; UV light; and electric pumps to water the house and garden. The Resort is also on 3phase 240v; with plans for solar backup.

### **Conclusion**

The new systems were installed from 2013 and reviewed 2017-9.

The rain water from land and 4 cottages overflows into the dam.

The local Blackwood River shallow underground water is limited and good quality. Pumped into a 100,000 litre tank. Gravity

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fed, and the extra filters and UV lights help maintain better drinking water quality and self-cleaning for 4 cottages and laundry use.

The deep underground acidic water is treated with calcite: then aerated and then filtered off the Fe precipitated; and good water stored in 100, 000 l tank: Ready for tree and lawn watering.

**id #2278**

### **Mains Water Reduction Strategies: Analysis of their Effectiveness in a Medium Density Residential Development**

**Tom Wheeler<sup>1</sup>, Mark Taylor<sup>2</sup>, Stewart Dallas<sup>1</sup>, Martin Anda<sup>1</sup>, Josh Byrne<sup>3</sup>**

1. School of Engineering & Information Technology, Murdoch University, Perth, WA, Australia

2. Josh Byrne & Associates, Fremantle, Western Australia, Australia

3. School of Design and the Built Environment, Curtin university, Perth, Western Australia, Australia

#### **KEY HIGHLIGHTS**

- Analysis of mains water reduction strategies in a medium density residential development.
- Identifies policy implications for future developments.

Climate change combined with rapid urbanisation in Perth has resulted in an emphasis on investigating mains water reduction strategies. *WGV by LandCorp* is a 2.2ha infill development in the Fremantle suburb of White Gum Valley, Western Australia. It integrates a unique set of leading-edge water reduction strategies with climate sensitive considerations, and creative urban greening. The *WGV Waterwise Development Exemplar* aims at reducing mains water consumption by 60 – 70% compared to the Perth average mains water consumption through various water reduction strategies including efficiency measures, water conservation, rainwater harvesting, and community bore irrigation supply for both residential and public open space.

This paper integrates smart metering and data analytics for a detailed analysis on the effectiveness of mains water reduction strategies for a medium density residential development. *WGV by LandCorp* is analysed as a case study to identify mains water consumption data as a result of the water reduction strategies implemented within the precinct. The mains water consumption data collected, is compared to the typical water consumption for Perth residents as well as the *WGV* project modelling estimates provided by the initial design panel consultants. There are policy implications from this investigation to guide the implementation of water reduction strategies for future projects.

**id #2268**

### **Responding to the challenges of designing non-domestic on-site wastewater management systems.**

**Joe Whitehead<sup>1</sup>, Helen Tunks<sup>2</sup>**

1. Whitehead & Associates Environmental Consultants Pty Ltd, CARDIFF, NSW, Australia

2. HMC Environmental Consulting Pty Ltd, Tweed Heads, NSW, Australia

*Australian/New Zealand Standards and Australian State Government Codes and Guidelines are primarily written to cover domestic on-site wastewater management systems. Whilst they are to some degree relevant to the design of mostly larger, non-domestic on-site wastewater systems, there remain a range of information gaps and challenges which the established guidelines do not cover.*

*This paper explores the challenges in obtaining the necessary information for appropriate design and sizing of a wide range of non-domestic on-site wastewater management systems and illustrates some means by which these challenges can be overcome. Case studies drawn from the collective experience of two established design consultancies are used to illustrate the range of regulatory and technical information required to design sustainable on-site wastewater treatment and land application systems for a variety of non-standard, non-domestic facilities.*

**id #2270**

### **25 years of professional short course training in on-site wastewater management in Australasia – how far have we come and where are we heading?**

**Joe Whitehead<sup>1</sup>**

1. Centre for Environmental Training, Cardiff, NSW, Australia

*The Centre for Environmental Training (CET) has been the major provider of professional short course training in on-site and decentralised wastewater management in the Australasian Pacific Region for more than two decades. In that time, some 4,000 on-site wastewater professionals from both the Government and private sectors have attended a wide range of short courses on on-site and decentralised wastewater subjects. The range, content and depth of the courses has evolved as the industry has grown and developed.*

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*This paper documents the changing training needs and the demographic and geographic distribution of course participants, the development and content of courses and the links with evolving regulations, technologies and management approaches. It identifies trends in the training and professional development requirements of the industry and flags opportunities for the future.*

id #2506

### Private service provision in Viet Nam: investigating key sustainability and equity considerations

**Juliet Willetts<sup>1</sup>, Melita Grant<sup>1</sup>, Naomi Carrard<sup>1</sup>, Ben Madden<sup>1</sup>, Ly Ha<sup>2</sup>, Tuyen Nghiem<sup>2</sup>, Dao Van Dinh<sup>3</sup>, Tim Foster<sup>1</sup>, Georgia Davis<sup>4</sup>**

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2. *Vietnam National University, Hanoi*

3. *Institute for Water Resources Economics, Hanoi*

4. *Independent, Canberra*

Small-scale private service provision is an emerging model for water services in rural areas, however associated equity outcomes and service sustainability require attention, including in the context of Viet Nam. For the last decade, the Government of Viet Nam has incentivised private sector involvement through subsidies and tax benefits as a model of service provision alongside other models of community management, cooperatives, commune-level management and state-owned enterprises. This research examined both the life cycle costs of selected rural piped water schemes and the extent to which this service model was reaching poor households.

We assessed the cost structures of fourteen water schemes in Viet Nam managed by private enterprises, and through associated research, examined the extent to which the poor were or were not being systematically excluded from service provision. We also conducted semi-structured interviews with 443 householders, 35 private enterprises and 61 government representatives to understand tariff-related decision-making processes, key priorities and experiences. Lastly, we undertook GPS mapping of 800 registered poor households across six case study communes served by private enterprises and other providers. This research was conducted by the Institute for Sustainable Futures at the University of Technology Sydney in partnership with the East Meets West Foundation (EMWF), the Centre for Natural Resources, Environmental Studies, Vietnam National University (CRES) and the Institute for Water Resources Economics (IWEM).

Results concerning life-cycle costs showed that both capital and operational expenditures varied widely. Cumulative investment in new and expanded systems averaged approximately USD324 per connection and operating expenditure averaged USD25 (USD14-48) per connection per year or USD0.22 (USD0.09-0.34) per cubic meter. Twelve of the fourteen schemes generated an operating profit in the most recent calendar year. However, taking into account depreciation as well as historical subsidies and connection fee payments, only four of the schemes were profitable based on a 20-year design life assumption, raising questions about long-term sustainability.

Interviews revealed that a desire to provide access to piped water services to the poor was not a key driver for private enterprises' decision-making. They generally did not keep consistent records of who was poor (or where they lived) in their service areas and most did not view providing services to low-income households as an important factor in determining where a system was placed. While private enterprises reported offering case-by-case concessions more often than other types of service providers, overall their median connection fees and tariffs were higher than those charged by other service provider types. Meanwhile, householders confirmed that connection fees being unaffordable was the primary reason for not connecting to a piped water system. Lastly, GPS mapping showed that in four of the six case studies, poor households were statistically less likely to be connected within water service areas.

This study provides an important and robust evidence base for determining the appropriate policy settings to support and regulate sustainable and affordable rural water services in the Viet Nam context, as well as findings relevant to other country contexts where private providers are emerging actors contributing to service delivery.

id #2550

### Establishing a co-management approach for community-scale sanitation in Indonesia

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Community scale sanitation has rapidly expanded in Indonesia, with more than 25,000 systems built to date, typically in low-income, urban and peri-urban areas. Government of Indonesia has targeted 7.5% urban areas to be served by these systems. Since the first systems were built in the year 2000, they have evolved from communal toilets and a community empowerment focus, to implementation of small-scale simplified sewerage serving 50-100 households, which are more complex to operate and maintain. A previous three-year research by UTS institute for Sustainable Futures in community sanitation governance found that the current institutional arrangements which prescribe sole responsibility to a community group were unsustainable, particularly financially (Mitchell et al., 2016). In contrast, the slightly larger decentralised wastewater systems serving 200 households are fully managed and financed by local government.

This paper describes findings of a follow-up research project that worked with two cities to test the feasibility of a formalised co-management approach and reviewed national guidelines to identify opportunities to shift the overarching framework for implementation of community-scale systems. The co-management approach involved four minimum local government responsibilities to provide institutional, technical and financial support, given their legal mandate to provide services, while communities remained responsible for day-to-day management. In parallel, the research project worked with national ministries to review how the national guidelines could better incorporate local government responsibilities and clarify post-construction financing, asset ownership and community management groups' legal status.

The research illustrated that it was appropriate, acceptable and feasible for local governments to take on the proposed minimum responsibilities in a co-management approach and the case studies provide other local governments in Indonesia with examples how to enact the minimum responsibilities.

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This research highlighted that while these systems are community scale, the local government should and could fulfill their legal mandate and support the community to ensure ongoing sustainability of these sanitation investments. The research holds wider implications for sanitation services in urban areas throughout developing country contexts, and provides a potential way forward to improve these services and their sustainability.

id #2563

### Preliminary design of sanitary systems with a new tool (SAmpSONS) for the comparison of the efficiency and sustainability of sanitary systems

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New and Alternative Sanitation Systems (NASS) are based on the paradigm change of turning end-of-pipe systems into resource-oriented sanitation systems. NASS have become more and more the subject of considerations of urban water management in view of the scarcity of resources, decreasing water consumption and associated hydraulic problems in our sewers as well as constantly changing boundary conditions due to demographic and climatic change. Despite successful testing of the NASS technologies, their equal use alongside conventional methods has not yet been achieved. Often these are small and decentralized sewage systems, as well.

In a two-year project, the simulation tool "SAmpSONS" was developed for visualization of NASS technologies and provide a tool for decision makers to compare different alternatives in the pre-planning phase in terms of sustainability criteria. SAmpSONS is a universal software system that can perform static and dynamic simulations. It includes functions for MFA, LCA and LCC and is equipped with a visualization capability for these calculations. Functional values of the considered technologies can be specified for the considered scenarios. If no performance data are available, the SAmpSONS library contains default values which can be used for the considerations and if necessary modified. The scenarios are constructed from collection, drainage, treatment and recovery and disposal components or modules.

In order to introduce the functionality of SAmpSONS, in the context of this paper, two scenarios of conventional and alternative source separation sanitation system for a 5,000 population site were simulated. Within this tool, mass balance of nutrient, energy and cost is evaluated. In addition, the environmental indicator (including Green House Gas (GHG) emission, eutrophication potential), balance of micro-pollutant (organic trace substance) and social acceptance as a results of the tool is provided.

When comparing the different variants, it is noticeable that the alternative systems score particularly well in reuse. But these are the results that are expected anyway, as NASS focus primarily on reuse. The evaluation further shows that, compared to conventional sanitary systems, NASS has a particularly positive effect energetically. The ecological aspects (emissions of GHG and nitrous oxide) are better taken into account. Due to the current market availability and prices, NASS are not yet economically competitive. In the overall analysis of all evaluated factors, this example for the construction of a new settlement shows clear indications of more sustainable wastewater management with a NASS system. The full paper will present more detailed evaluations.

id #2290

### Effect of inoculum on microbial electrolysis cells anode biofilm and Hydrogen production

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The limited source and environmental damage by the combustion of fossil fuels, forced the modern science to move on renewable energy. Hydrogen is considered a clean renewable energy that can be generated biologically (photosynthesis, fermentation and electrohydrogenesis). Microbial electrolysis cells (MECs) became a promising technology for hydrogen production by converting the organic wastes to renewable energy (hydrogen), which basically attributed from electroactive microorganisms. In this study, we investigated the effect of two different kinds of inocula (Domestic wastewater (M<sub>1</sub>) or glucose-fed MxCs effluent (M<sub>2</sub>)) on single-chamber MECs performance, including hydrogen production, overall energy recovery (based on both electricity and substrate) and microbial community with Pt/C as cathode. Acetate was used as electron donor for enrichment of both MECs (M<sub>1</sub> and M<sub>2</sub>). After the performance of MECs (current density and Hydrogen production) reached to steady state, substrate changed to 10% hydrolysate. During acetate as electron donor, the dominant anode microbial species in M<sub>1</sub> were 69.42% exoelectrogens (*Geobacter* sp.) while M<sub>2</sub> accumulate 22.42% exoelectrogens (*Klebsiella* sp.) and 45.52% fermentative bacteria (*Enterococcus* sp.). Which caused lower current density (465±30 A/m<sup>3</sup>) in M<sub>2</sub> than M<sub>1</sub> (600±30 A/m<sup>3</sup>). Similarly, COD removal, hydrogen production rate, and overall energy recovery were 95±2%, 44.68 mmol/H<sub>2</sub>/L/D and 99.43%, respectively in M<sub>1</sub> that were higher than M<sub>2</sub> (94±1%, 39.22 mmol/H<sub>2</sub>/L/D and 71.88%, respectively). After the substrate changed to hydrolysate, current density was still lower in M<sub>2</sub> than M<sub>1</sub>. Unlikely, M<sub>2</sub> got higher COD removal (84±2%) than M<sub>1</sub> (79±1%), hydrogen production rate and overall energy recovery increased 1.2 times and 1.4 times higher than M<sub>1</sub>. The COG functional category verified the biofilms community by quantities of signal transduction gene and carbohydrate transport/metabolite genes. These results shown the same electron donor can enrich different microbial community based on inoculum. Second, the fermentative and exoelectrogenic bacteria enhanced the MEC performance against complex organic compound as electron donor. It contributes to understand the nature of anode enrichment and microbial composition on anode for better utilization of complex organic compounds in MECs for hydrogen production.

id #2566

### Predicting wastewater treatment and biomass production in a high rate algal pond

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High rate algal ponds (HRAP) have been independently validated and accepted as alternate wastewater treatment systems for rural South Australian Community Wastewater Management Schemes. This paper identifies the operational and environmental parameters affecting HRAP performance using novel statistical analysis.

Wastewater from the rural community of Kingston on Murray (34°14'34.1"S 140°19'48.7"E; population 300) was treated in a 200 m<sup>2</sup>, single loop, continuously mixed HRAP. The effluent supplied to the HRAP had already undergone pre-treatment in on-site septic tanks. The final HRAP treated effluent was recycled for on-site irrigation. Over the study the HRAP was operated at 4.5, 6.4 and 9.1 d theoretical hydraulic retention times (THRT). An on-site weather station recorded, total solar and UV irradiation and air temperature. HRAP dissolved oxygen (DO), pH and water temperature were measured and logged continuously. The chemical composition of the inlet and treated wastewater was determined (n>120) using methods described in *Standard Methods for the Analysis of Water and Wastewater*.

Regression tree analysis (*rpart*, *R statistical package*) with additional boot-strap analysis (*Random Forrest*), was used to model HRAP performance. Regression tree modelling sub-divides, or partitions, the complex data space into smaller regions, where the interactions are more manageable. The technique was applied to determine the factors influencing BOD<sub>5</sub> and NH<sub>4</sub>-N removal, log<sub>10</sub> removal value (LRV) of *Escherichia coli* and biomass production following treatment in the HRAP.

BOD<sub>5</sub> removal was >90% following HRAP treatment. BOD<sub>5</sub> loading both areal (g m<sup>-2</sup> d<sup>-1</sup>) and volumetric (g m<sup>3</sup> d<sup>-1</sup>), season and THRT explained 56% of the variance in BOD<sub>5</sub> removal efficiency. In comparison 90% of the variance in NH<sub>4</sub>-N removal efficiency was explained by chlorophyll *a* concentration, daily variation in DO and 5-day average water temperature. The relationship with, chlorophyll *a* was indicative of the uptake of ammonium by algae, whereas the relationship between DO and temperature was likely associated with 'removal' of NH<sub>4</sub>-N via the processes of volatilisation and nitrification respectively. As might be expected given the foregoing, biomass production was strongly related to NH<sub>4</sub>-N concentration, THRT, 5-day average total solar radiation and maximum water temperature. The variance in *E. coli* LRV was largely explained by the THRT. This implies longer THRT increases exposure to the prevailing conditions of pH, DO and sunlight which adversely affect *E. coli* survival. The average water temperature over the 5 days preceding measurement of *E. coli* removal was a better predictor than the water temperature on the day of measurement. The paper will further discuss the outcome and interpretation of regression tree analysis and nuances within the data.

**id #2301**

### **Perspectives on Regional WQ Management in Western Australia**

#### **Luca (Luke) R Zappia**

The Water Corporation of Western Australia is the principle supplier of water, waste water and associated scheme services throughout the state of Western Australia. Our offices are located in each of 5 regions and our operations span more than 2.6 square million kilometres. We employ approximately 2900 people and our asset base is estimated at 42 billion dollars in water supply, waste water, drainage infrastructure and bulk water for irrigation. The Corporation is owned by the Western Australian government and is accountable to its sole shareholder, the minister for water. Most of the Corporations surplus is returned to the government as a dividend to contribute to the development of the state, with the remainder invested in capital projects.

In 2017/2018, our Integrated Water Supply Scheme (IWSS) delivered 363 ML to over 1.5 million people in Perth. The bulk of water supply is derived from a range of sources:

- 10% surface
- 2% ground water replenishment
- 40% ground Water Corporation
- 8% desalination

Water quality management is fundamentally governed by the Water Corporations' Accountability Framework, which is underpinned by policies, standards and guidelines. Arguably the greatest challenge is the delivery and provision of services, in keeping with the Framework, to regional and remote communities across Western Australia.

In addition to this, since the late 1990s, the Federal government provided custodial water services to remote aboriginal communities across Western Australia. However, in 2015 the state government initiated the Reform Unit. And in December 2016 the Essential Municipal Services Upgrade Program (EMSUP) was announced and ratified, effectively reinstating the management of water services across the state back under the control of the State Government of Western Australia. The decision to reinstate Corporation involvement in remote aboriginal support services and infrastructure effectively will increase the Corporations treatment related asset base from 370 to 644 sites.

This presentation will provide insight into how the Water Corporation manages one of the world's largest fleet of technologically diverse treatment assets across the largest demographic compared to any other utility in the world. With specific focus on:

1. Current state and issues providing safe and reliable drinking water into remote areas
2. Collaborative approaches to WQ management.
3. Gaps and challenges in the provision of water services to remote communities in Western Australia.

**id #2315**

### **Comprehensive evaluation of an integrated wastewater reclamation system combining ozonation, ceramic membrane filtration and biological activated carbon: removal of contaminants, and membrane fouling control**

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id #2213

## Biomimetic Dynamic Membrane for the Advanced Treatment of Micro-polluted Water

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This study utilized physical adsorption, and filtration of carbon nanotubes (CNTs) and laccases, to fabricate biomimetic dynamic membrane (BDM) for the advanced treatment of micro-polluted Water wastewater. In BDM, the adsorption, enzymatic degradation and membrane separation demonstrated a synergism effect on pollutant removal. At first, the fabrication methods of BDM were investigated, and the mixed filtration for laccases and CNTs showed a better performance than the stepwise filtration. Furthermore, the operation parameters of BDM, including CNTs and laccase loading amounts, micro-pollutant concentration, agitation speed and transmembrane pressure (TMP), were studied. Suitable CNTs and laccase amounts could reduce filtration resistance and increase catalysis efficiency, while moderate TMP and agitation speed were in favor of boosting the BDM structure for catalysis and permeability. Optimized operation parameters (CNT loading amount = 20 g m<sup>-2</sup>, laccase loading amount = 74.6 g m<sup>-2</sup>, agitation speed = 100 rpm, and TMP = 1.0 bar) sustained a high removal rate, and the flux was over 120 L m<sup>-2</sup> h<sup>-1</sup>, even for 7 operation cycle tests. BDM exhibited an excellent micro-pollutant removal rate, stable flux and great antifouling capacity, on the ground that adsorption saturation and foulant may be alleviated "online and in-situ" by the enzymatic degradation. Afterwards, the bionic layer on BDM, after absorption saturation and catalyst deactivation, could be eliminated rapidly by carrying out a simple backwash cleaning operation, then a new one could be fabricated immediately. Therefore, BDM is a good candidate for functional membrane materials in future water treatment.

id #2327

## The toilet flush dilemma: rural toilet revolution in northwest China

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The rural toilet revolution has been highly valued by Chinese leaders and farmers since 2017. However, the northwest region has encountered a typical "water flushing toilet dilemma". There are seven common characteristics in rural areas in the northwest China: the cold long weather, water shortage problem, the scattered residence and the courtyard area is large, complex topography; the residents are accustomed to using outdoor dry toilets (single household or public). It is not acceptable in local tradition to have toilets in courtyards, especially in rooms; the habit of using manure from dry toilets; and there are an elderly and seasonal fluctuations in population problem. Thus, there are three types of water flush toilet dilemmas. Primarily, if the method of "water flushing toilet--sewage pipe--small centralized sewage treatment facility" is adopted, the following problems will occur: (1) Water flushing toilets will waste clean water resources (6-12L/time), it is unbearable in arid areas; (2) The challenge brought by the cold climate is that the water pipes and the household pipes are prone to be frozen and cracked. The sewer pipes must be installed under the permafrost layer (generally 1.5 to 2 meters deep). Considering the scattered residential and complex terrain, the construction cost is extremely high; (3) Simultaneously, the decentralized sewage treatment facilities generally adopt biological methods, it is difficult for microorganisms to grow in winter. However, the amount of sewage treatment will increase in winter, measures such as heat preservation of sewage treatment facilities will greatly increase the operation cost. Secondly, if adopt the way of "water flushing toilet--septic tank", the septic tank clearing will become a new problem. Farmers are reluctant to use the septic tank manure to the field because of the dilution of water. The third point is easily overlooked, for the popularity and monopoly of water flushing toilets, people are less satisfied with other types like ecological toilets. People yearn for a convenient, clean and comfortable toilet experience which are similar as flush toilet. It will bring heavy economic burden and long-term operation and supervision problems to the local government while most rural northwest areas are relatively underdeveloped in economic.

Therefore, this paper proposes technical and management methods to break the water flushing toilet dilemma in rural northwest China. Technically, the use of waterless toilets should be encouraged, meanwhile, the comfort and convenience should be better designed; in the process of collection and utilization of excreta and urine, give priority to resource-oriented and local utilization of resources, and greywater should be treated and discharged separately. Vacuum toilet and others are recommended. In terms of management, it is necessary to increase the financial subsidy for rural toilets and put forward the policy of encouraging innovative toilet design and research based on the characteristics of northwest China to break the monopoly of water flush toilet. The rural toilets and sewage treatment departments must coordinate, and fully mobilize the masses to participate in the construction and operation of toilets is crucial.

id #2060

## The present situation, problems and technical development trend of rural sewage treatment in north China --- A Case in Tianjin, China

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Rural residents in north China are relatively concentrated with a population of hundreds to thousands in each village. In the past, dry toilets were used in most rural areas and there was no concern of centralized sewage treatment. Farmers have gradually switched to water toilets in recent years, followed by the establishment of drainage pipe networks. Rural sewage has become a critical task in controlling basin water pollution in China. this study mainly introduced the water quality characteristics of rural

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sewage in north China (High nitrogen concentration and the concentration of organic matter varies greatly), development of rural sewage drainage standards, guiding ideology changing from the simple emphasis on strict pollution control to encouraging ecological utilization and adaptation to local conditions. The treatment efficiency, existing problems and adaptability of several common technologies and equipment used in rural sewage treatment such as MBR, AAO and rotating biological contactor were analyzed. The engineering application effects of sewage treatment devices including intermittent biofilm and spiral carrier biofilm floating bed developed by Tianjin university were introduced in this study. Finally, useful development strategies were proposed facing the existing problems of rural sewage management, system construction and facility operation in north China.

**Keywords:** Rural wastewater; Current situation; Discharge standards; Development strategies; North China

**id #2573**

### **Groundwater level calculation for managing urban water systems**

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One of the key requirements in planning and design of many small scale water and wastewater systems especially in shallow groundwater areas is to determine groundwater levels. For example, changes in groundwater levels are important in the design of water, wastewater and stormwater systems, as well as discharge volume of small community groundwater supply systems. Moreover, an understanding of the groundwater level is crucial to identify the key issues associated with the management of groundwater quality and quantity for constructed wetland systems, rain gardens and stormwater detention systems. In addition, groundwater levels affect all design elements of subsoil drainage systems such as materials, depth, sizing, spacing, volume and method of dewatering, managing quality and quantity of discharge and drainage infrastructure maintenance which affect the cost of projects significantly.

Uncertainty in determining groundwater levels poses significant challenges in urban water management and causes difficulties for engineers, designers, building developers and management authorities. Failure to identify appropriate separation distance between groundwater levels and urban structures could cause damage and risks such as inundation of road surfaces, reduced efficiency of stormwater infiltration systems and quality issues which result in economic losses.

As groundwater head distribution depends on many different factors, numerical groundwater flow models provide a dominant tool for assessing different parameters that impact groundwater level and can help to calculate groundwater levels more accurately. A new approach of groundwater modelling is used which aimed at using a combination of accurate estimates of groundwater levels at monitoring locations by using analytical methods and simulation of physical processes through numerical modelling combined with model-independent parameter estimation (PEST) as an interpolation tool.

In order to determine spatial changes in groundwater levels, a case study is selected which is related to the largest road construction project conducted ever in Perth, Western Australia. The entire study area is located within the Swan Coastal Plain comprising a multilayered unconfined aquifer and covers an area of 185 Km<sup>2</sup>.

In order to assess the accuracy of the groundwater level prediction by using the new approach, a simplified groundwater flow model of the area is created by the Visual MODFLOW Flex package. Recharge zones are identified and features that mainly impact groundwater levels (e.g. drainage systems) are included in the model. The model is calibrated by trial and error and PEST is used as an interpolation tool.

The outcome elucidates the changes in the accuracy of groundwater level prediction by using the numerical model and automatic calibration (PEST) compared with groundwater level prediction by using interpolation. The efficiency of current methods is assessed and a blueprint for future direction is proposed.

This study can provide guidance for urban designers, engineers and management authorities and can be helpful to develop the fit-for-purpose strategies. It can pave the way to achieve a water sensitive urban design and sustainable development.

**id #2285**

### **OTUKPO MUNICIPAL WATER SUPPLY SYSTEM DESIGN NIGERIA**

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Otukpo township water supply has been a serious problem and this has led to so many water borne diseases .The present population has really outgrown the water design system of the community and this has led to serious scarcity and affecting commercial activities. According to the 2006 National Population Census,Otukpo township has risen to 328,798 and the water system was provided when the population was far lesser than the present population and these facilities and designs can no longer meet the water requirement of the residents of the town.In order to solve these problems ,the paper has come up with a design which is based on the projected population using a growth rate of 2.5% for Otukpo township. So this design can accommodate even a sudden population increase which could be as a result of even migration to Otukpo township.The design covers even the facilities from the intake pipe to the supply systems and this design would certainly solve water scarcity problems if the relevant water agencies use it as a guide.

**Keywords:** Water supply, design, projected population, facilities, township

**id #2235**

## Sludge reduction system with high density ozone using ozone adsorption and concentration technology

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The activated sludge process has been widely applied to treat many types of wastewater in wastewater treatment plants. In this process, excess sludge is produced and is required to be safely disposed of. However, the amount of excess sludge has been increasing worldwide, which causes a significant increase in the total plant operating costs and poses a great threat to both human health and the environment.

In order to solve this problem, we have developed a sludge reduction system with high density ozone using ozone adsorption and concentration technology. In the technology, a selective ozone adsorption characteristic of silica-gel is applied to generate high density ozone such as over 50 vol% gaseous concentration. Our developed system has two advantages. First, sludge ozonation using high density ozone allows a decrease in the amount of ozone required for sludge reduction. Second, unreacted oxygen can be reused as source gas for ozone production. Therefore, sludge can be reduced at lower cost by the technology.

In this research, the sludge reduction performance of a pilot-scale wastewater treatment system (anaerobic/anoxic/aerobic process) coupled with sludge ozonation with our developed system was investigated. In the system, the sludge was withdrawn from the aerobic tank, ozonated, returned to the anaerobic tank and digested by microorganisms. During ozonation, the organic substances were released from disintegrated microorganisms in the sludge. In order to investigate the amount of ozone required to sufficiently disintegrate the sludge, the relationship between the mass ratio of mineralized sludge to ozonated sludge ( $k_d$ ) and the elution amount of organic substances from ozonated sludge ( $C_v$ ) was analyzed. Mineralized sludge means sludge converted into carbon dioxide gas by catabolism.

There was a positive correlation between  $k_d$  and  $C_v$ . Sludge production in the system significantly decreased and  $k_d$  became the maximum value of about 0.50 under the condition that the value of  $C_v$  was more than 90 mg-COD/g-VSS (COD: Chemical Oxygen Demand, VSS: Volatile Suspended Solids). It is suggested that the reaction of ozone and sludge has sufficiently progressed at more than 90 mg-COD/g-VSS. In fact, viable cells in the sludge decreased sharply until 90-100 mg-COD/g-VSS, but the decrease of viable cells was almost completely stopped when  $C_v$  exceeded 100 mg-COD/g-VSS. Sludge ozonation by high density ozone using our developed technology allowed a significant decrease in the amount of ozone required for making  $C_v$  more than 90 mg-COD/g-VSS. Additionally, 84% of unreacted oxygen could be reused as source gas of ozone production.

This technology, which can reduce the amount of excess sludge at lower cost, is expected to contribute to solving the problem of a significant increase in excess sludge worldwide.

id #2552

## Institutionalisation of IWRM through strengthening local regulatory systems

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The Institutionalisation of IWRM in the Barind Project was initiated in 2014 with a goal that “*competent LGIs contribute to increase the availability of water for disadvantaged people in the Barind area through sustainable, effective, inclusive management and use of water resources*”.

In the first phase of the IWRM project the Swiss Red Cross (SRC) and Development Association for Self-reliance Communication and Health (DASCOH) have tested a range of regulatory licensing, economic, technical, social and arbitration instruments to strengthen integrated water resources management at the citizen and local government level. Through strategic engagement with the national component of this project, SRC / DASCOH with the support of SDC has brought the experience of citizens and local governments into the drafting of the Water Rules (2018) and UP Guidelines (2018) by WARPO.

In the context of a considerable deterioration in the downward accountability of local governments in Bangladesh, the local component has shown that it is still possible to strengthen integrated water resources management at the local level. This has been achieved primarily through the strength of the engagement with local civil society institutions to collectively assess, plan, implement and monitor their own activities to reduce the overexploitation of water resources. By bringing the integrated water resources management plans of these local collectives into the local government planning and budgeting cycle it has been possible for the project to institutionally and financially link civil society with local government to regulate (4R - reduce, reuse, recycle and restore) water resources in their jurisdiction.

This presentation will share the experiences in the testing of integrated water resources management instruments (i.e. licensing, economic, technical, social and arbitration instruments) with local government institutions. It will also share the experience in the extension of those instruments that have proven to be effective.

- From the bottom-up, this has pivoted around the federation of civil society IWRM institutions at the union parishad level.
- From the top-down this was anchored through the official gazetting of the IWRM Rules and the IWRM Guidelines for union parishads and the integration of IWRM training within the national curricula of the National Institute of Local Government.
- Horizontally, this explored the win/win opportunities to improve water resources management with agencies that include the Civil Administration at the district and upazila (sub-district) level, the Barind Multipurpose Development Authority (BMDA), the Agricultural Extension Office, the Local Government Engineering Department (LGED) and Department of Public Health Engineering (DPHE).

The paper will briefly highlight the regulatory system adopted and applied in the IWRM Project, its successes and challenges.

id #2547

### Analysis of the characteristics of Poultry Slaughterhouse Wastewater (PSW)

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The first step towards selecting a suitable treatment option for poultry slaughterhouse treatment is to characterize it. Various parameters such as the pH, tCOD, BOD<sub>5</sub>, TSS, FOG, turbidity, salinity or conductivity were analyzed in this study and provided values significantly higher than discharge limits imposed by various countries. Furthermore, the biodegradability index (BOD<sub>5</sub>/COD) of PSW was determined and averaged a value of 0.61, which translated to a good biological decomposition potential. Moreover, since PSW is known for its high FOG concentration, a correlation was established between FOG and tCOD and resulted in an average ratio of 0,2 between the two parameters. These correlations can be used to determine the value of BOD<sub>5</sub> and FOG of PSW without analysis, or the other way around.

id #2238

### Study of the Brazilian energy efficiency scenario in the basic sanitation

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Energy efficiency is made up of systemic activities that together aim to bring improvements and optimize the use of non-renewable energy sources of our environment. Intelligent use aims to use less to provide the same amount of energy, the concept of energy efficiency is considered as a pillar of sustainable energy policy. (Pereira, Mario, 2009).

Basic sanitation has a great impact on the quality of life, work and environment. According to Brazilian law 11.445 / 2007, the basic sanitation service must meet all of the requirements of access to quality water supply and in sufficient quantities for the consumption, collection and treatment of sewage and garbage and the correct management of rainwater. In Brazil, according to Gonçalves; 2009, about 3% of the total energy consumed in the country goes to basic sanitation, within that 90 to 95% for powering pumps and electric motors.

In the water supply system, in order to ensure a quality service under the law, it is necessary to use a lot of energy for the generation and distribution of water. In this way the water utilities need studies and technologies to improve their processes aiming at energy efficiency in the supply system that feeds the city.

In this work, actions, technologies used and improvements made at a national level at energy efficiency were identified. It was pointed out that actions such as pressure control, reduction of losses and reduction of maintenance in the distribution networks can lead to continuous process improvement, minimization of future failures, environmental and financial problems for the institutions responsible for water supply and sewage activities

id #2531

### The Good of Standards - Accelerating Innovation of Emerging Decentralised, Resource Recovery Faecal Sludge Treatment Units (FSTU)

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#### Introduction

While many different regulations, guidelines, and standards exist for water and wastewater treatment technologies and systems, there is no international standard that exists for decentralised, resource recovery and energy independent sanitation treatment systems that evaluate and benchmark their performance.

As technologies advance through innovations, standards are required to ensure performance, conformity and safety of new products and process. Innovative, energy independent, resource recovery faecal sludge treatment units (FSTU) are designed to play a vital role in managing and treating waste 'off-grid' from on-plot and on-site sanitation systems. However, the development of such systems faces problems with buyer acceptance because of a lack of known guidelines and standards.

To address this gap, an ISO standard is currently being developed to provide baseline performance to ensure human health and environmental safety is met to accelerate innovation and acceptance of this new, decentralised, technology. Scope development, stakeholder analysis, technology and standards landscaping, as well as leveraging on industrial best practice tools such as risk assessments were employed to develop the standard. The standard has the capability to achieve increased adoption and accelerated permitting of these novel technologies, paving the way for a sustainable circular economy driven sanitation value chain.

#### Methods

##### Criteria development

This standard would apply to treatment units that (a) primarily treat human excreta, (b) can operate in non-sewered and off-grid environments, and (c) are prefabricated. Additionally, treatment units to which this standard applies exhibit resource recovery capability (e.g., energy, drinking water, fertiliser) and are capable of being energy neutral or energy net positive.

##### Technology & standards landscaping

Based on the established criteria, identification of currently available, and potential systems through desktop review and site visits were conducted. At the same time, a review of existing standards and tools to establish baseline safety and performance guidelines was conducted.

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### Proactive standards development

Continual development of the draft through seeking consensus amongst a group of stakeholders from various fields of expertise and sectors (government bodies, regulators, academia, commercial and industrial), gathered as an expert advisory group, to discuss the development of the documents on the document criteria, technical requirements, test methods and threshold levels.

### Risk assessments

Working together with the identified technology partners, a technical risk assessment using established standards such as ISO 12100, was performed based on the framework requirements to ensure that the standard develops requirements that meet baseline safety and performance guidelines.

### Conclusion

While there is no way to predict the market response to emerging technologies in the non-sewered sanitation treatment industry, based on existing best available technologies and test methods, these technologies can be tested against the consensus-driven standards to verify that the product is robust, safe, and fit for purpose.

- Sustained positive impact of new sanitation models can be ensured through actionable standards
- Standardization is a powerful tool to facilitate the introduction of innovative technologies into the market and expedite implementation.
- Adoption of non-traditional sanitation technologies, with their risk of human, environmental impact, could benefit from a standard driven approach to gain user acceptance.

**id #2622**

### **Energy-Water-Waste Nexus; Hydrogen Economy**

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Poster

**id #2209**

### **SIMULTANEOUS REMOVAL OF ORGANIC MATTER AND NITROGEN COMPOUNDS FROM LANDFILL LEACHATE BY AEROBIC GRANULAR SLUDGE**

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The aim of this study was investigating the treatment of landfill leachate using the aerobic granular sludge process in a pilot scale sequential batch reactor (SBR-AGS). The leachate from a giant sanitary landfill localized in the State of São Paulo (Brazil) exhibited high concentration of COD  $5,300 \pm 78 \text{ mg L}^{-1}$  and TKN  $2,630 \pm 355 \text{ mg L}^{-1}$ . Comparatively, the leachate was added to wastewater in three different volumetric ratios (5, 10 and 20%) and the mixtures were characterized over treatment time. The results indicated that there were no significant changes in the behavior of the biological process even at the highest leachate ratio. Granulation of the aerobic sludge occurred around 90 days of operation and the granules had a diameter of 485 to 1585  $\mu\text{m}$ . SBR-AGS exhibited efficiency in the removal of 87 to 89% organic matter and at least 98% total nitrogen, regardless of the leachate ratio. The treated effluent that received 20% of leachate showed  $2.7 \text{ mg L}^{-1}$  ammonia and  $1.1 \text{ mg L}^{-1}$  nitrate. This study shows that SBR-AGS was able to form large granules promoting a SND process. We highlighted that SND occurred in low dissolved oxygen concentrations ( $< 1.5 \text{ mg L}^{-1}$ ) for 120 days, *without compromising aerobic granule integrity*. These results suggest that the aerobic granular sludge process is a promising alternative for the treatment of landfill leachate and its use should be encouraged. **Performance:** The SBR-AGS was operated under aerobic granular sludge conditions for a period of 120 days, with a total of 360 cycles, receiving leachate in different concentrations (5, 10 and 20% v/v) in 3 distinct phases, from 0 to 40 days (phase 1), 40 to 80 days (phase 2) and 80 to 120 days (phase 3). The VSS concentrations in the biological sludge were  $2,468 \pm 139 \text{ mg L}^{-1}$  (phase 1),  $2,319 \pm 186 \text{ mg L}^{-1}$  (phase 2) and  $2,085 \pm 173 \text{ mg L}^{-1}$  (phase 3), while the F/M ratios were  $0.34 \text{ g d}^{-1}$  (phase 1),  $0.49 \text{ g d}^{-1}$  (phase 2) and  $0.80 \text{ g d}^{-1}$  (phase 3). The maintenance of the aerobic granules in the system was stable during all experiment time, except at short periods of the phase changes. The granulation was partially affected during the leachate increment, resulting in a decrease in the proportion of granules versus flocculent sludge and increase of the solids concentration in the effluent. This effect was observed only in the first days after phase change and the treatment process was not significantly damaged. The results showed an excellent removal of TKN and  $\text{N-NO}_3^-$  (efficiencies  $> 98\%$ ), resulting in low concentrations of  $\text{N-NO}_3^-$  in the effluents as  $0.9 \text{ mg L}^{-1}$  (phase 1),  $1.0 \text{ mg L}^{-1}$  (phase 2) and  $1.1 \text{ mg L}^{-1}$  (phase 3). These values indicated that nitrification in sewage occurred efficiently, but not completely. The mean concentrations of TKN in the effluent were  $0.5 \text{ mg L}^{-1}$  (phase 1),  $1.6 \text{ mg L}^{-1}$  (phase 2) and  $4.5 \text{ mg L}^{-1}$  (phase 3), while ammoniacal nitrogen concentrations were  $0.1 \text{ mg L}^{-1}$  (phase 1),  $0.6 \text{ mg L}^{-1}$  (phase 2) and  $2.7 \text{ mg L}^{-1}$  (phase 3).

**id #2000**

### **Household scale greywater treatment and potential use for hydroponic system**

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Household greywater includes wastewater from bathroom, wash basin and laundry (excluding kitchen and toilet). It has been accounted for 60-80% of total wastewater. The surprising fact is that we are using high quality water for these purposes and it is a waste of water resource. This study focus on recycling greywater from washing machine and reuse it for irrigation. The specific objectives are (1) to create a small scale, user-friendly, simple and low cost recycle system and (2) to assess potential effects of recycled water on plants in order to justify its potential for irrigation purpose. In phase 1 of the project, we determined activated carbon and sand as the efficient filter materials for the recycle system. An experiment using laboratory columns (30 cm long, 3 cm diameter, flowrate of 500 mL/h) showed high removal ability of activated carbon and sand. There was a 80% reduction of COD index for artificial greywater (AGW). Going on to the second phase of the project, we enlarged the filter system to the tank of 10 L, adding gravel layer under sand and activated carbon layer and the efficiency of the filter tank increase to 80-95% in reducing greywater COD at flowrate of 4 L/h.

To evaluate the safe use of the treated greywater, we started growing red leaf lettuce (*Lactuca sativa*) and Sweet Basil (*Genovese basil*) in deep water culture hydroponic system. The lettuce seeds were germinated and grown in nutrient solution in 6 weeks before starting the experiment. Lettuce and basil irrigated with laundry AGW and surfactant solutions to separate the effects of detergent surfactants alone on plant from surfactants combined with other pollutants in laundry greywater. The plants were randomly placed in 4 different benches in 4 plastic tanks (6 replicates each tank). The irrigation water includes tap water (control sample), artificial greywater, and the water with low-concentration (20 mg/L) and high-concentration (50 mg/L) of surfactant (SDS), respectively. The same quantity of hydroponic nutrient solution was added to all tanks. During the next 5 weeks, we observed and recorded the root length, canopy diameter, the number of leaves, the largest leaf diameter, and the unusual colour changes or pigment on leaf. A statistical analysis using Student's *t*-test was performed on the collected data to detect abnormal differences between the control and intervened samples. Visual inspection showed a healthy growing of plants in the low concentration SDS water and the treated greywater. Statistically, the root growth in the intervened samples was not different from the control sample (*p*-value 0.78 and 0.43, respectively). However, plants showed slightly lower growth (*p*-value 0.02) in the water sample with high concentration SDS. In case of AGW, significant damages in the plant roots were observed. High concentration of surfactants inhibited the development of root hairs and lateral roots and therefore, depressed the water and nutrient uptakes. Further ongoing experiments will clarify the chemical characteristics of treated artificial greywater and the potential uptake of plants, irrigated by treated greywater.

**id #2302**

### **Evaluation of human enteric viruses and coliphages in small- and medium-sized wastewater treatment plants**

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Human enteric viruses are a major cause of waterborne diseases globally. In addition to having long-term persistence in environmental waters and strong resistance to disinfection, they generally have a low infectious dose (Prevost et al., 2015). A recent study from the Global Water Pathogen Project revealed a lack of reliable information on removal efficiency of viruses in technologies commonly used in small- and medium-sized wastewater treatment plants (Verbyla et al., 2017). On the other hand, the reduction of fecal indicator bacteria has been well documented, but they are less resistant to treatment processes than enteric viruses. Coliphages (viruses that infect *E. coli*) have been used as surrogates for studying the reduction of enteric viruses in sewage treatment systems because they have similar structure and persistence in the environment compared to enteric viruses (Grabow, 2001). We quantified the reduction of human adenovirus as well as somatic and F specific coliphages in the following three small- and medium-sized wastewater treatment plants located in southeast Brazil: a UASB reactor followed by a high rate algae pond, a vertical constructed wetland and an activated sludge system followed by UV disinfection. We used real-time (quantitative) PCR to quantify human adenovirus and the double agar layer plaque assay to quantify coliphages. The results obtained provide us with a better understanding of virus removal in the different treatment units and will help validate discharge standards for small- and medium-sized systems.

**id #2535**

### **Annual Greenhouse Gas Emission estimate from Pernambuco state sewage treatment plants: Understanding and proposing process improvements**

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The waste sector is responsible for 3% of the total emissions of greenhouse gases from anthropogenic sources in 2010, 54% accounting from the wastewater handling (Blanco et al., 2014). Considering the many possibilities of emissions mitigation in the wastewater sector, broadening the studies spectrum in this is needed. In this way, direct emissions from Sewage Treatment Plants (WWTP) were estimated in the state of Pernambuco, Brazil.

This research analyzed data from 86 Sewage Treatment units operated by Pernambuco Sanitation Company (COMPESA) serving from 600 to 300,000 people and its data provided by National Water Agency (ANA) of Brazil. Most of the treatments combine anaerobic with aerobic reactors, but stabilization ponds is the most used treatment unit in the state. The direct emissions of methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O) from the biological treatment, as well as from treated effluent discharge in rivers, were analyzed based on the Intergovernmental Panel on Climate Change (IPCC) in 2006 methodology, refined in 2019. The carbon dioxide (CO<sub>2</sub>) emissions were not included, since they are derived from biogenic (organic) matter (IPCC, 2019). Furthermore, the

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IPCC methodology was adapted to include treatment systems adopted in the region and to adjust to the available data. The Global Warming Potential for a horizon of 100 years ( $GWP_{100}$ ) was adopted to compare different gases, with the values from the IPCC (2014).

A total of 293,881 tCO<sub>2</sub>eq/year was found - 81% from STP's CH<sub>4</sub> emissions, 10% from CH<sub>4</sub> emissions derived of effluent discharge into water bodies, with corresponding values of 4% and 5% from N<sub>2</sub>O emissions. The major uncertainty in the estimates are from the stabilization ponds, which is used in 49% of the STP and a lack of emission knowledge is reported. 65% of total methane comes from direct emissions of Upflow Anaerobic Sludge Blanket (UASB) reactors, with huge potential of reduction through flaring or energy generation. UASB are already designed to collect the gases, however the majority of the units, currently, releases biogas into atmosphere. As for the nitrous oxide, most of research efforts to reduce this emission are focused in avoiding its production (Law *et al.*, 2012), but there is also the possibility of use for improve methane combustion (Zhao *et al.*, 2016).

id #2475

### Upgrading biogas into biomethane by a novel ex-situ bioelectrochemical process

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Recently bioelectrochemical system (BES) has been considered as an emerging technology to be integrated in-situ into anaerobic digesters for increasing methane content of biogas. However, no study has described the use of BES as an ex-situ step for improving biogas quality. To explore this possibility, we placed the BES in-line at the exit gas from an anaerobic digester for it to function as a biofilter converting carbon dioxide in the biogas into methane. Further we investigated the performance of BES biofilter on the methane enrichment under thermophilic conditions. The energy efficiency of the biofilter was also analysed. The results indicated that when applying working electrode potential at -1.1 V vs. Ag/AgCl the ex-situ biofilter increased the methane content of inflowing gas from 50% to 85%. Analysis of the cathodic microbial community showed that the biocathode of the BES biofilter was dominated by *Methanothermobacter* (an obligate hydrogen consumer) as the key methanogen converting of carbon dioxide to methane. Initial comparative energy input and output analysis suggested that the energy efficiency was 76%. Overall, this study suggests that a bioelectrochemical system used as an ex-situ biofilter can enrich methane content of biogas. In order to apply this technology at an industrial-scale, optimisation of energy efficiency is an area for further investigation.

id #2244

### Field applications of innovative SeDAF (sedimentation & dissolved air flotation) process for advanced treatment of wastewater effluent

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The needs of advanced wastewater treatment have increased in Korea due to the severe algal blooms of lakes and rivers by the effluent from wastewater treatment plants. The conventional advanced phosphorus treatment processes for wastewater treatment in Korea include filtration, dissolved air flotation (DAF), and sedimentation. The advanced wastewater treatment should achieve stable removal efficiencies in spite of influent's fluctuations, but the conventional processes in small wastewater treatment plants have many difficulties to reach the goals. It is important to develop the alternative process suitable for small scale treatment plants that is more economical and efficient than existing processes, while meeting effluent water quality criteria. In this study, SeDAF process, the integrated technology of sedimentation and DAF, has been developed and its operation results have been presented.

The SeDAF process has aimed to remove phosphorus and SS (suspended solid) especially through two ways; After injection of coagulant, coagulation and flocculation occurred. Heavy flocs are removed by sedimentation and then residual lighter flocs are additionally removed by flotation. The hydraulic retention time (HRT) of process is within 1 hr. The treatment flow of the pilot plant is in the order of influent - coagulation and flocculation (rapid & slow mixing with HRT 20 min) - sedimentation (HRT 20 min) - flotation (DAF) (HRT 20 min) - effluent. Poly aluminium chloride (PAC) (10% as Al<sub>2</sub>O<sub>3</sub>) was used as coagulant. The previous sedimentation process with inclined plates and forward flow direction is located at under zone, and DAF process with reverse flow direction takes upper zone in a single basin of SeDAF plant. It is important for this process to optimize two units simultaneously and to integrate each operation parameters comprehensively.

The operation conditions were in the range of 100 m<sup>3</sup>/d of influent, 15 m<sup>3</sup>/d of microbubble flow rate, and 3.0 to 20.0 mg/L (as Al<sub>2</sub>O<sub>3</sub>) of coagulant dose (n=17). Influent of the plant was secondary settlement basin effluent and water quality conditions were analyzed as 0.24 - 0.46 mg/L of T-P, 3.0 - 20.0 mg/L of SS, 1.98 - 4.64 NTU of turbidity, and 34.0 - 64.0 mg/L of COD. The treated water qualities of each parameter were analyzed to be 0.01 - 0.11 mg/L of T-P (average removal efficiency: 84.6%), 0 - 1 mg/L of SS (95.4%), 0.46 - 1.20 mg/L of turbidity (72.4%), and 12.0 - 27.9 mg/L of COD (59.4%). The operation results revealed that treated water quality parameters have shown quite stable removal efficiencies, even with the fluctuation of influent conditions.

The operation results showed stable efficiency regardless of small coagulant dosage through proper interaction of coagulation, sedimentation and flotation. Therefore, SeDAF process is expected as an alternative technology of advanced wastewater treatment plant.

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id #2549

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### **Study on the kinetic characteristic of Pre-denitrification biological filter for domestic sewage treatment**

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The kinetics model of organic, ammonia and nitrate nitrogen removal by pre-denitrification biological aerated filter process for domestic sewage treatment were established, and studied the mechanism of organic removal and denitrification removal efficiency by the process. The pre-denitrification biological aerated filter filled with lava filter has good treatment effect on domestic sewage, and the average removal rates of COD, NH<sub>4</sub><sup>+</sup>-N and TN can reach 85.1%, 97.0%, 63.8%, respectively.

**id #2562**

### **New concept of biological SBR process operation for municipal wastewater treatment**

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Nitrogen and phosphorus is known to cause eutrophication. Therefore, almost all wastewater treatment plants have adopted advanced wastewater treatment to remove these elements. Biological nutrient removal (BNR) is one of the most effective and economical processes in advanced wastewater treatment. However, the efficiency of BNR is influenced by operational conditions, organic substrate concentration, pH, dissolved oxygen concentration, and hydraulic retention time. Many researchers have performed studies to optimize operating conditions.

Sequencing batch reactor (SBR) process is a type of enhanced biological phosphorus removal (EBPR). The common type of EBPR needs several reactors and recycle-lines for sludge and nutrient removal. In the case of SBR, it can treat wastewater with one reactor without any recycle line. Therefore, this process can be constructed in small area and be operated with low cost. Thus SBR is suitable for treating small amount of municipal wastewater generated in rural area.

In this study, we operated a lab-scale SBR process for treating real municipal wastewater. Each batch operation of SBR consisted of anoxic (including filling), aerobic, settling, decanting and idling steps. In addition to the influent parameters including nutrients concentration and flow rate, process operation parameters such as recharge ratio and cycle time are also important. To optimize the process operation parameters, the cycle time was decreased from 6 h to 0.5 h in the same influent of wastewater. As the cycle time decreased, the nitrogen and carbon concentrations of the effluent decreased. There was an optimal condition for nutrient removal efficiency. To investigate the maximum performance of the optimized process, the recharge ratio was increased. The results could be explained by the microbial activity, *i.e.*, specific nitrification and denitrification rates. Based on these results, a new concept of SBR process operation was further examined. This process consisted of an intermittent influent input and cross operation of nitrification and denitrification. In conclusion, we could suggest new concept of SBR process operation for nutrients removal in municipal wastewater.

**id #2064**

### **Sustainable resource recovery sanitation system for small and medium sized cities in India**

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With increasing population, rapid urbanization and limited fresh water resources, wastewater management has received utmost importance over the years. This abstract focuses on resource recovery from sludge produced through wastewater treatment as well as faecal waste produced in urban areas and strategies to valorize and safely re-use them. Especially the Southeast Asian countries which have high dependency on on-site sanitation (OSS) systems are heavily tasked with management of accumulated and highly contaminated faecal sludge. In India, where only about 34% of the urban households are connected with sewers and rest of the country depends on various on-site sanitation systems, faecal sludge treatment and safe disposal has become evidently important for protecting the public health. While 80% of the supplied domestic water returns to system as wastewater, it is majorly used to recharge the water bodies in India and concept of domestic reuse has always been minimal due to multiple challenges. Along with the on-site sanitation systems, existing operational sewage treatment plants (STPs) also generate significant amount of digested sludge which also needs to be safely managed. The Indian Faecal Sludge Management (FSM) policy came into existence in early 2017, since then there has been a constant need for innovation and research to identify a viable resource efficient solutions that can address such large-scale issues. Centre for Policy Research has been working in the city of Udaipur, Rajasthan to improvise the non-sewered urban sanitation in partnership with Udaipur Municipal Corporation (UMC).

As per the on going urban infrastructure development scheme, the city sewer coverage will increase up to 63% from existing 20% by end of 2021. However, the remaining 37% of the urban areas would be still dependent on the OSS systems. Also, the merger of nearby rural and peri urban areas into city's core urban areas ultimately lead to establishment of a standalone FSTP. The city has operational sewage Treatment Plants (STPs) with a cumulative treatment capacity of 60 MLD, but these are specifically designed for treatment of domestic waste water and not for faecal sludge having significantly varied characteristics. Hence, the faecal sludge is being dumped into fresh water bodies and on open grounds post emptying, causing an extensive environmental pollution. In order to holistically address this issue, a comprehensive FSM plan has been made and being implemented. As part of the planning, a standalone faecal sludge treatment plant (FSTP) of 15 KLD capacity is designed and planned to be commissioned to cater the demand of FSM services in the city. In order to optimize the operations, a site within STP has been identified and FSTP will be co-located along with STP. Resource recovery is one of the major outcomes of the planned, adopting a circular sanitation economy model. The Omni processor based thermo mechanical FSTP treats the faecal and STP sludge and converts it into distilled water and non-hazardous fly ash which can be used for cement/brick manufacturing and also used as soil conditioner.

### THE PROBLEMATIC OF WATERS REGULATIONS IN THE REPUBLIC DEMOCRATIC OF CONGO

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The Democratic Republic of Congo has several natural rivers and lakes, small waters all are connecting to the Atlantic Ocean. Despite this extensive network of rivers, lakes, small water and wastewater unfortunately about 70% of the population does not have access to clean drinking water, while this country might be among the first country of Africa to get a lot of resources of water.

As we know, this country had its independence from Belgium in 1960, its population that time was around 10 million, so today is around 80 million. Since then the Government has slightly undertaken the regulation initiative to promoting these different kinds of water. But this regulation is not good enough to respond to the needs of the population and to contribute to protecting the environment.

The government company called Regideso, which is dealing throughout with waters issues does have a good vision for changing the old regulation left by Belgium. While the environment law, especially the international right of water is updating daily. That why the wastewater and small water management systems should be considering these innovations and integrate them into its regulation. Nonetheless, a few efforts are being done by the Government but are not efficient due to the political problem and corruption affected this country. This situation cannot afford the innovation funding to be managed rationally.

However, these types of waters some had been made by people (wastewater and the small water) others are natural.

No one ignores that the Republic Democratic of Congo has around half mining companies established in the world, the most common are owned by Australia, USA, Canada, U.K and China.

These Mining companies are pouring the wastewaters after be using for its works in the small waters which the local population is using it for the housing issues.

1. For example, recently, the population of Kambove village in the province of Katanga had suffered the different diseases and others died just for using the small water which mixing with wastewaters pouring by the mining companies, and had polluted the environment. This shows that the managing policy by the government of Congo DR of small waters and wastewaters systems does not exist. In other words, its regulation does not prevent this violation of environmental law and human rights.

IN CONCLUSION

The Democratic Republic of Congo does not have an efficient regulation of managing wastewater small water systems. Despite has an abundance of types of waters but the population several need it. never plans to privatize the managing of water.

Recommendations

- update its water regulations by including wastewaters and small waters according to the International Right of water.
- Inspire to other countries the wastewater management system.
- Decentralize the waters management to its province.
- Privatize the water management area.
- Review the mining companies' agreement regarding the protection of the environment.
- Get a fund to developpe waters issues.
- Promoting affairs climate for attracting the investors.

### Hahndorf AS 1546.3:2017 Compliance Testing Facility for On-site Domestic Wastewater Treatment Units Secondary Treatment Systems

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Manufacturers of all existing and new domestic Secondary Treatment Systems (STS) are required to test and accredit their systems against the Australian Standard 1546.3: 2017 in order to sell them in the majority of Australian States and Territories from the end of 2020. The STS classification includes all types of aerated wastewater systems, reed beds and aerated sand filters. The focus is on domestic units and the Standard details a range of hydraulic flows between 1200 L/day and up to 5000 L/day. The inflow wastewater must be within a set range of chemical parameters and allowances have been made within the Standard for different climatic zones within Australia. Arris has completed construction work on a compliance testing facility for the new Australian Standard for on-site domestic wastewater treatment units, located at the Hahndorf wastewater treatment plant in South Australia. The STS units are supplied with macerated raw sewage (allowed by AS 1536.3:2017) from a 5,000 L balance tank which receives unscreened sewage from the Ambleside sewer main at the head of the wastewater treatment plant. Control systems for sewage dosing and influent plus effluent sampling are housed in sheds installed adjacent the STS bunker. Fully automated refrigerated autosamplers are also housed in the control sheds, allowing for programmable and automated grab and

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composite sampling from influent and effluent lines as per the requirements of AS 1546.3:2017. With a nominal depth of 2.1 m, the bunkered bay allows STS systems to be installed and backfilled with sand to simulate fully underground, *in situ* operating conditions. The accreditation facility has been fully operational since March 2019, with wastewater supply to the facility within specification as per the standard. Seven STS systems are installed, five of which are currently underway for 2019 compliance testing, with these units producing compliant results for their target effluent quality. Installed systems are targeting a range of effluent water qualities, from basic secondary to advanced secondary with nutrient reduction, and include both advanced AWTs' and passive treatment systems. Intensive testing of the influent wastewater so far has given us good insights into the variations in sewage strength during the 24 hour daily cycle, as well as weekly and seasonally. This paper will detail the design and testing regime of the compliance facility at Hahndorf in South Australia. It will also discuss the feedback provided to Australian Standards on the practical application and installation of the compliance testing facility as per the requirements set in AS 1546.3:2017.

**id #2196**

### **Development background & Forces at work for Small Packaged Wastewater Treatment System**

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1. Patentee Introduction

2. WWTP Technology and Portfolio

To Explain the surviving technology trend in Korea which has got through a compression growth period for the last only one generation to reach the rank of advanced countries for 100 years.

3. Medium / Large Scale Technology; CSBR

Basic process technology of the subjected theme Packaged CSBR System

4. Small Package CSBR with Corrugated Pipes and/or Plates

Background of development history and era

5. Forces at Work of Packaged CSBR System

Major characteristics different from the conventional system and indicative unit processes for reclamation

**id #1620**

### **Research on pollution characteristics, migration and transformation mechanism of Cr(VI) in a typical chromium contaminated area**

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The Cr(VI) pollution characteristics in soil of different land use types (industry, agriculture and residential area) were investigated by selecting a typical chromium contaminated area around an enterprise in Xiangxiang, Hunan. The accumulation and transformation characteristics of chromium from three common vegetables in the study area, namely, celery *Apium graveolens*, Brassica *compestris* Lsp. *pekinensis* Lour and *Lactuca sativa* L, were analyzed. The migration mechanism of Cr(VI) in soil was studied and a model suitable for this region was established. The results showed that the average chromium concentration in the soil of industrial, agricultural and residential area were 1910, 986 and 105mg/kg, respectively. The content of water soluble Cr(VI) in the industrial area is 115 times as much as that in the residential area. Only Cr(III) was detected in vegetable samples, but Cr(VI) was not detected, indicating that vegetables had the ability to convert toxic Cr(VI) into non-toxic Cr(III). The total chromium content in vegetables was more than three times the allowable value of food. The enrichment ability and health risk of Chinese cabbage to chromium were the highest among several common vegetables. The transport laws of Cr(VI) in soil were researched by a column dynamic simulation experiment. The results showed that the transfer of Cr(VI) was obviously delayed in soil comparing to that of the conservative matter (Cl<sup>-</sup>). The soil conductivity, fluid dynamic dispersivity, adsorption distribution coefficient and retardation factor of Cr(VI) in soil were also estimated. The correlation coefficient between the simulated and measured results was 0.9986. The method and results of this study can provide the theoretical and technical support for the prevention and control of chromium pollution in soil.

**id #1994**

### **Adsorptive Removal of Tetracycline Using Modified Mesoporous Silica**

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Publish consent withheld

**id #2224**

### **Microbial dynamics during remediation of aviation kerosene-contaminated soil**

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Nowadays, air transportation has been worldwide practiced for moving people and cargo as quickly as well efficiently. According to recent studies, the global aviation kerosene (jet fuel) consumption by commercial airlines has increased each year since 2009 and is predicted to reach an all-time high of 97 billion gallons in 2019. Therefore, jet fuel has been the cause of environmental contamination around airport areas, such as forests, bays, lakes and beaches. Among several remediation technologies available for petroleum hydrocarbons removal from the soil, groundwater and seawater, bioremediation technology is gaining prominence due to its simplicity, environmental friendliness, higher efficiency, and cost-effectiveness in comparison to other technologies. The purpose of the present study was to investigate the behavior of microbial populations in clay soils contaminated with 1, 5 and 10% (v/w) of jet fuel kerosene. In parallel, uncontaminated soil was used as control in all experiments. Along 60 days of experiments, total heterotrophic bacteria (BHT), total fungi (TF) and oil-degrading microorganisms (ODM) were numerically monitored using culture-based methods in appropriated media and incubation time. Additionally, microbial community was analyzed by molecular method applying PCR-DGGE fingerprint and total bacteria quantification by real-time PCR. Results revealed that there was a counting increase of indigenous microorganisms (BHT, TF and ODM) after kerosene-contamination soil, however, the microbial diversity was reduced. Probably, there was a selection of microorganisms resistant to kerosene, which grew up exponentially in favorable conditions of carbon source. The highest hydrocarbon removal was in the soil contaminated with 10% kerosene, reaching 18 and 25% at 30 and 60 days of experiments, respectively. These soil samples showed unique bands in the DGGE, suggesting specific oil-degrading microbial strains, which could have improved the hydrocarbon removal.

**id #2282**

### **Study on Energy Saving Technologies for Oxidation Ditch Process**

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#### **1. Power consumption by OD process**

Power consumption of OD process which is divided into 4 divisions shown in Fig. 1. From this figures, energy saving measures for wastewater treatment facilities are important. For this reason, energy saving measures of wastewater treatment facilities in OD process was examined in this study.

#### **2. Energy saving technologies for OD process**

##### **1) Energy saving type aerators**

In OD process, vertical axis aerators and horizontal axis aerators were generally adopted. Recently, energy saving type aerators described below have been development and applied in OD process. The vertical axis aerator with a lifting device, which has five functions, circulation, pumping, mixing aeration, spiral flow, and anoxic mixing, enables high-performance and stable operation. The aeration device which consists of diffusers and submerged propeller is composed of submerged propeller mixers that generates circulating wastewater flow and membrane diffusers with high oxygen transfer efficiency, and enables appropriate air flow rate control in combination with a DO controller.

In addition, the aeration device which consists of diffusers and vertical axis wastewater flow generator is composed of vertical axis wastewater flow generation apparatus with low power and membrane diffusers with high oxygen transfer efficiency. An aerobic zone and an anoxic zone can be formed to enable appropriate air flow rate control.

##### **2) Energy saving technology for operation/control**

In the operation/control of OD process, optimization of air flow rate and mixing is required. For this issue, operation/control method using ammonia sensors and using automatic control were studied.

In operation/control method using ammonia sensors, the daily variation of inflow ammonia concentration is measured using a portable ammonia sensors. Based on the daily variation inflow ammonia concentration, the on / off of the aerator timer is set to optimize the aeration time. Because daily inflow pattern is almost same every day in small scale WWTPs, it is not necessary to install ammonia sensors in WWTPs

Automatic control system is mainly consists of water quality sensors including ammonia sensors and automatic control system. Major functions of automatic control system are to control aerators by OR control, to control return sludge flow rate, and to control dewatering machines based on MLSS concentration and ASRT.

#### **3. Effect of energy saving technologies (Introduction effect of operation/control using ammonia sensor and automatic control)**

Daily fluctuation of the inflow ammonia concentration was measured by portable ammonia sensors in 3 WWTPs. Based on the daily fluctuation of inflow ammonia concentration, the on/off timers of aerator were set to optimize the aeration time. As a result, the power consumption by aerators was reduced 8 to 35% (average 25%) as shown in Fig. 2. In addition, effluent quality was stabilized to reduce fluctuation of ammonia concentration in effluent. And in 9 WWTPs, with the introduction automatic control system, 9 to 24% (average 14%) reduction of power consumption was observed. The introduction of automatic control system led to optimization of aeration, mixing, and MLSS concentration; as a result, power consumption was thought to be reduced. Also, these optimization resulted to better effluent quality.

**id #2316**

### **AMMONIUM REMOVAL FROM WASTEWATER EFFLUENT USING NATURAL ZEOLITE: NON-LINEAR MODELS FOR ADSORPTION KINETIC STUDY**

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## SWWS2019 Abstracts

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Two-thirds of world population have experienced rigorous blue water scarcity at least a month per year and unfortunately, millions even faced water shortage for a year-round. Reusing, recycling and reclaiming wastewater discharge are among strategies for encouraging water-use efficiencies. Recovering polluted water can be performed by utilizing natural zeolites acting as ion exchangers. This technique favors an alternative in recovering polluted water. Natural zeolites exhibit excellent selectivity for cations and provide inexpensive maintenance for up-scale application with relatively low-energy cost. In this study, we completed batch tests for ammonium removal from synthetic ammonium solutions and wastewater effluent with natural zeolites as adsorbents. X-Ray diffraction analysis implied the studied Korean natural zeolites contained heulandite, clinoptilolite, mordenite, and quartz. Silica was found 74.3% and  $Al_2O_3$  was 14.6%. We evaluated the adsorption kinetic fitness using three most common models (PFO; pseudo-first order, PSO; pseudo-second order, and intra-particle diffusion model). Adsorption kinetic was determined by monitoring the amount of adsorbates in synthetic ammonium solutions around 50 mg/L and wastewater effluent for 720 minutes. Both PFO ( $0.90 < R^2 < 0.97$ ;  $0.31 < SSE < 0.38$ ) and PSO models ( $R^2 > 0.97$ ;  $SSE < 0.18$ ) fitted the experimental data well however PSO model provided closer  $q_e$  values (6.91 and 3.87 mg/g for wastewater effluent and synthetic ammonium solution, respectively) to the experimental ones (6.60 and 3.99 mg/g zeolites) than those of PFO (6.12 and 3.54 mg/gr zeolites). Multiple linear regions from experimental data plots confirmed that intra-particle diffusion model described adsorption of ammonium onto zeolites was governed by multistep mechanisms including external surface adsorption and slow diffusion onto internal surface. Regeneration efficiency was higher in 1 M NaCl regenerant (89%) as compared to those from 0.1 M NaCl (62%) and 0.5 M NaCl (81%). Several cations were exchanged during batch tests of wastewater effluent by which concentrations of Na, K, and Ca ions were evidently increased in final solutions. Natural zeolites enable significant ammonium removal from heavily contaminated wastewater, thus, strategies for its optimization in larger scale are necessary for future study.

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id #1655

### New Wastewater Courses in Western Australia

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Change is coming. Recent reviews by the Department of Health and the Department of Commerce's call for submissions on the Regulatory Impact Statement for Reform of the Plumbing Regulations in Western Australia highlighted the current lack of suitable training for plumbers and other personnel working in the wastewater and greywater industries.

One of the key issues is that the TAFE system does not provide any training on Aerobic Treatment Units (ATU's) – also known as Aerated Wastewater Treatment Systems – in any of the apprenticeship and trade and licensing plumbing courses, and this sector of the wastewater industry is rapidly growing.

Up to now, anyone who wanted to undertake training in this area had to travel to Queensland or NSW and enrol in courses delivered there. Unfortunately, many plumbers and others who work in wastewater, either servicing, installing or designing systems, do not see the need to undertake training and there is no legal requirement for this to be so. But, the cogs of government is slowly turning and the writing is on the wall. Anyone who wishes to move into this specialist area will need to be qualified in some way.

Two courses have now been developed and delivered in WA. Both are one-week courses, based on accredited training units in either the National Water or the Construction, Plumbing and Services Training Packages.

The Aerobic Treatment Unit (ATU) Service Technician Course is a mixture of classroom theory, practical skills tasks and site visits to ensure participants can achieve competencies in servicing wastewater treatment plants, as well as basic understanding of the biology and chemistry of On-site Treatment Plants.

Assessment tasks for the units NWPTRT061 Operate and control wastewater processes and NWPGEN008 Sample and test wastewater are undertaken during the week.

The Site and Soil Evaluation for On-site Wastewater Systems Course covers two nationally accredited units as part of CIV Plumbing. This course specialises in designing wastewater treatment plants, as well as developing skills in soil assessment, sizing land application areas for effluent disposal and reuse, and drawing and interpreting maps and plans. The units CPCPCM4014A Prepare simple sketches and drawings and CPCPDR4013B Design and size domestic treatment plant disposal systems are covered, both with an emphasis for wastewater sizing and specifications.

This paper outlines more details about the learning outcomes of these courses and the need for industry to embrace education and training as a way to make it more professional. To be effective and relevant, the courses need to undergo industry appraisal and withstand scientific rigour, so that what is presented is accepted by government, manufacturers, installers and service technicians, and becomes the minimal qualifications of all in the wastewater industry.

id #2480

### Biological treatment of 2,4-diaminoanisoic acid (DAAN), a biotransformation product of a high explosive compound, under different redox conditions

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Recently, insensitive munitions compounds (IMC), such as 2,4-dinitroanisole, began to be applied for explosives production, due to their higher stability compared to conventional explosives. Environmental contamination by IMC can occur via undetonated pieces on the soil or industrial wastewater release into waterbodies. IMC and their biotransformation products are known to be toxic, mutagenic and carcinogenic. One of the most important IMC is 2,4-dinitroanisole (DNAN), given that it is a major replacer of 2,4,6-trinitrotoluene (TNT). DNAN is anaerobically reduced to 2,4-diaminoanisole (DAAN), a toxic aromatic amine. DAAN can undergo different abiotic reactions: autoxidation, incorporation into natural organic matter, and coupling reaction with other DNAN intermediates. Nevertheless, how different electron acceptors in sludge affect DAAN consumption and whether biodegradation can still take place, discounting all abiotic reactions DAAN can undergo, are still open questions. The present study aimed to quantify DAAN consumption by biotic and abiotic pathways in biological sludge under different electron-accepting conditions, and to assess how DAAN exposure affected the microbial community. We tested different electron acceptors in sludge microcosms (in triplicate at  $27 \pm 2$  °C): no electron acceptor (with and without pyruvate addition), sulfate, nitrate, and oxygen. The inoculum was a 1:2 mixture of anaerobic sludges from textile wastewater treatment and petrochemical wastewater treatment, respectively. We also tested abiotic conditions without sludge, with heat-killed sludge, and with humic or fulvic acids extracted from sludge. Oxygen exposure was the only abiotic condition in which DAAN concentration significantly decreased due to autoxidation, forming an azo dimer. We observed that heat-killed sludge became saturated of DAAN after 53 days, with a total consumption of 67.4  $\mu\text{mol DAAN} \cdot (\text{g SSV heat-killed sludge})^{-1}$ . However, DAAN concentration decreased only 20.2 and 12.3 % when incubated with fulvic and humic acids, respectively, for 76 days. DAAN was completely consumed in all treatments with live sludge in different rates even when injected 3 times. The conditions with no electron acceptor (with and without pyruvate) and with sulfate were the slowest ones. Even so, the parcel of DAAN that could have been biodegraded varied from 89.9 (without electron acceptor, second spike of DAAN) to 99.8% (with sulfate, third spike of DAAN). The condition with nitrate was faster than the other anaerobic conditions in the first time DAAN was injected, but it became slower as DAAN was reinjected for more two times. Even so, biodegradation could have accounted for 79.8% of DAAN consumption rate after the third injection. Aerobic was the fastest condition and biodegradation may have accounted for 80.8 and 70.4 % of DAAN consumption rate after the second and third spiked of DAAN, respectively. Microbial communities sequencing results show the similarity between the communities in the microcosms with no electron acceptor (with or without pyruvate) and with sulfate. The results also evidence that the communities of the microcosms with nitrate and with oxygen changed the most. Several microorganisms related to the degradation of aromatic compounds were identified (e.g. genera *Clostridium*, *Bacteroides*, *Parabacteroides*, *Desulfotomaculum*, and *Rhodococcus*) and could have their changes in relative abundance assessed.

id #2236

### Assessment of Waste Water Effluent Quality at Dandora Estate Treatment Plant.

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Assessment of effluent quality of dandora estate treatment plant.

#### Abstract

The aim of the study was to examine effluent quality of dandora treatment works (DESTW) to demonstrate its compliance with regulations of the NEMA. Waste water samples were obtained from influent and effluent from the plant and analyzed for some heavy metals, COD, BOD, TSS, Electric conductivity, PH, and chloride. The values obtained for TSS,  $\text{Cl}^-$ , BOD and COD in the effluents were 76, 95, 125, 273 in mg/l respectively, removal efficiency for TSS, BOD, COD exceeds 70% in the effluent indicating high performance of DESTW.

Key words effluents, resource, re-use

#### INTRODUCTION.

Waste water flowing in open channels is used to irrigate land, trees, fodder, flowers and vegetables. According to (Huertasa et al., 2008) waste water reuse for agriculture practices depends mainly on the quality of wastewater effluent which has to be sufficiently to protect environment and human health and also be suitable for soil and plants. DESTW is the second treatment plant in Africa. It treat combined domestic and industrial waste water. It uses natural method of treatment. The plant has a design capacity of 160,000 M3. The influent waste water is preliminary treated by mechanical bar screens and grit removal then biological treatment follows.

Heavy metals such as cadmium (Cd), lead (Pb) zinc (Zn) and Nickel (Ni) are measured in waste water as an indicator for effluent quality (Mensah et al., 2009). Other paramount wastewater criteria affecting plant growth and soil properties depend on specific ion concentration in particular sodium, calcium magnesium and chloride.

#### Objectives.

- To determine some heavy metals in influent and effluent water.
- To determine physiochemical parameters.
- To analyze biochemical parameters.

#### Materials and methods.

Sampling: Grab samples of influent and effluent were collected.

#### Results and discussion.

parameter	Influent	Effluent	Effluent NEMA standards in (mg/l) except PH	Reduction percentage
BOD	620	125	30	80%
COD	971	273	50	72%
Chloride	88	95	250	

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PH	7.73	8.41	6.5-8.5	
Conductivity	922	963		
TSS	688	76	30	89%
Cu	0.0783	0.0112		86%
Cr	0.4615	0.0647		86%
Zn	0.1624	0.0341		79%
Fe	2.0978	0.2175		90%

### Discussion

It was noticed that effluent waste water contains contaminates. Pollution reduction is taking place although the parameters don't meet the required NEMA (National Environment Management Authority) standards. This shows that the treatment process is not efficient enough. This could be attributed to industries discharging their effluent to the main trunk sewage without pre-treating.

Presence of heavy metal ions can be toxic to plants and animals. They can also be carcinogenic. Industries have become ignorant and don't treat their waste water before discharging to the main sewage trunk sewage hence government should put policies in place to ensure it is done to improve the treatment process.

### Recommendations.

Construction of settlement tanks to receive effluent for more UV radiation treatment.

Sand filtration of effluent water could also be done

Construction of wet land

id #2307

### Analysis of initiatives and technologies of the Non-Revenue Water Reduction Program: A study case in the city of Ivoti – RS, Brazil.

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This paper aims to describe the actions to reduce losses in the municipality of Ivoti and the importance of applied technologies for water management in small distribution systems. Ivoti is a 23.800 inhabitants and approximately 7000 water connections that presented a reduction in its Non Revenue water index from 57,4% in December 2016 to 47% in the first half of 2019.

For this, after a small bibliographical review on the subject, the water balance of the system of each period was elaborated according to the methodology of the International Water Association. The data obtained with evaluation of the real losses through the method of Minimum Night Flows were compared, calibrating the results initially obtained on the balance sheet.

From this, the importance of the technologies used to monitor these indices was evaluated, and recommendations were made about other technologies that could have boosted the work. The results obtained from the water balance indicate a reduction of more than 10% in the unbilled water index from the actions carried out between the years 2016 and the first half of 2019. Among them, the one that obtained the greatest impact was the research and repair of invisible leaks with execution oriented by the levels of pressure in the water network and of reservoirs monitored by telemetry. It was concluded that the most important technologies for loss reduction achieved in this system were the supervisory control and data acquisition system for real-time monitoring of pressures and reservoir levels, invisible leakage detection with an electronic geophone and pressure management with valves reducers.

id #2321

### Biodegradation ability of fungi *Trametes versicolor* and *Trichoderma harzianum* isolated in Thailand for removal of antibiotics in water

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Antibiotics are any compounds with biological activity to inhibit living organisms. Nowadays the present of antibiotic can be detected in the various water bodies (Kümmerer, 2009a). Antibiotics like Sulfamethoxazole (SMX) are widely used and cannot be completely metabolized in the body. Their chemical property makes it difficult to be removed by the current wastewater treatment processes (Yang *et al.*, 2013, Sinthuchai *et al.*, 2016). So, SMX and its metabolite had become the emerging and widespread contaminant that causes concern in the aquatic environment. The contamination raises the concern over the antibiotic resistance gene in bacteria which can induce a similar effect on human health and the environment (Suhartono *et al.*, 2016, Ben *et al.*, 2017). The physicochemical methods used in the removal of SMX present higher toxicity after degradation process due to the transformation of byproducts, or due to remnants of the parent compound remaining after the degradation process (Noguera-Oviedo and Aga, 2016). Hence, alternative SMX treatment such as biodegradation is required. Ligninolytic enzyme-producing

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fungi can produce intracellular and extracellular enzyme, as well as inducing adsorption ability that can degrade a wide range of pollutants such as pharmaceutical and personal care products (PPCPs), including antibiotics. This study aims to isolate and analyze the ability of locally-obtained ligninolytic enzyme-producing fungi for the degradation of antibiotics. In this study, SMX was selected as the target antibiotic and the potential fungi were isolated from Central Thailand. Guaiacol and ABTS oxidation were used to determine the potentiality to produce laccase enzyme. The selected strain with the ability to produce laccase enzyme was classified type, species, and strain by analyzing the nucleotide sequence. BLAST program and MEGA software were used to construct a phylogenetic tree of the selected strain. Suitable conditions, such as pH and temperature, were determined. The fungal resistance to the concentration of SMX was monitored. Lastly, in vitro biodegradation of SMX by the screened fungi were performed. From this study, it is determined that the fungal strain BGP115 demonstrate the highest scale in the screening. The selected fungus was analyzed by the BLAST program using the GenBank database of the National Center for Biotechnology Information (NCBI) which identified the strain as *Trichoderma harzianum* with 97% similarity (Accession no. MH707098.1). The suitable condition for culturing *T. harzianum* BGP115 was determined to be at pH 4 and 25°C. Furthermore, this study finds that *T. harzianum* BGP115 (the screened strain) has more tolerance towards SMX as compared to *Trametes versicolor* (the reference strain), when assaying the fungal growth with SMX concentrations of 10 mg/L. This concentration was selected for the in vitro degradation assay. The percentage of SMX degradation by *T. harzianum* BGP115 was at 71% after 7 days while the percentage of degradation by white rot fungi, *T. versicolor* was at 90% after 10 days. This study could successfully screen and isolate ligninolytic enzyme-producing fungi. The screened fungi isolated in Thailand demonstrated the ability to biodegradation of SMX and the potential to adapt to tolerant to the concentration of SMX.

id #2557

### Old HSSF constructed wetland WWTP intensification and purified wastewater reuse by drop irrigation systems as a part of the Nexus approach

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The paper and presentation are focused on the sharing of experience from the small village wastewater treatment plants built in the Czech Republic during the period 1990 – 2000 with horizontal subsurface flow constructed wetlands and waste stabilization ponds intensification, including implementation of drop irrigation wastewater reuse semi-operated systems. The aim of the work is to include procedures of the Nexus approach to the village wastewater treatment & reuse, extensive dewatering of produced sludges, their composting & reuse as a fertilizer with regard to the emerging pollutant contamination.

The paper include results and experience from two case studies of the small WWTP for approx. 250 and 800 p.e. reconstructions, intensification and semi-operated testing of water, sludge and biomass recycling.

First part of the paper deals with the description of intensification and the results of the treatment efficiency changes after its. The reconstruction and intensification of these WWTP were based on the design and building of new vertical flow filters with pulse filling at the place of old HSSF CW, on the changes in the design of pre-treatment facilities and on the changes in the waste stabilization ponds used as a final purification step.

The second part brings pieces of knowledge from the semi-operated testing of purified water and pre-treatment sludge reuse. Constructed wetlands have a low impact on the environment which could be lowered even more if the treated water could be used in cropland irrigation. Although national regulations restrict the wastewater reuse in farmland irrigation, the treated wastewater could decrease the pressure over other freshwater sources. Moreover, due to residual concentration of nutrients, it has the potential to serve as fertilizer and satisfy part of the plants' needed nutrients. Our team built two semi-operated drop irrigation systems to studying their potential asset to the decreasing impact of outflow water on the receiving freshwater body ecosystems and to studying potential threats to soil under the local climate conditions when the irrigation is used only during period May – October (vegetation season). We study changes in soil characteristics not only during irrigation period, but also during the non-vegetation period with more rain events and snow cover. In case of sludge reuse, sludges were sampled in the period 2016 – 2019. In the samples, there were analysed nutrients, macroelements, heavy metals, microbial contamination parameters and is some of the samples AOX and some emerging pollutants. The last part of the presented research work has been focused on verifying the possibility of composting of selected (mentioned) waste materials by composting. In the period 2016 – 2019 were prepared series of experimental composts and during the composting process were taken samples for the analysis of microbial contamination, nutrients and heavy metals content.

The work was financially supported by the research project TH02030583 (Czech Technology Agency) „Optimization of automatic irrigation system for pre-treated wastewater land application - the measure for decreasing risk of drought and surface waters eutrophication“.

id #2556

### Purification of Contaminated Tannery Wastewater with a Locally Available Bio-adsorbents

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This experiment was carried out to observe the efficiency of two bio-adsorbents for removal of Chromium (Cr) and Copper (Cu) from tannery effluent. The tannery effluent contains huge amounts Cr and Cu which has huge negative impacts on environment. The removal efficiency was also investigated for standard solution in batch processes for different contact time with same dose. The effluent was treated with water hyacinth (WH) and Arum shoots (AS). The bio adsorbents were collected from locally available place. For tannery waste, the WH removed about 87.5% Cr at 180 min, but for AS the value was about 77.08% at 180 min. The WH showed the highest Cu ions removal efficiency at 120 min which was about 83.3%. In case of AS, the highest removal efficiency was about 75% at 180 min. For standard solution, the WH removed about 85.29% Cr from solution at 180 min but for AS, the value was 79.46 for the same. The WH removed about 87.96% Cu from standard solution at

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180 min. For AS the value was 78.57% for the same. Our result clearly indicated that the efficiency of WH was higher than the AS.

Key Words: Bhairab river, Adsorbents, Cu (II), Cr (VI), Removal Efficiency, Tannery Effluents

**id #2269**

### **Removal of metal ions in water by rice hull magnetic activated carbon and a rotary drum type high gradient magnetic separator**

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We have developed rice hull magnetic activated carbon (RH-MAC) and studied its adsorption properties for heavy and valuable metal ions in water and magnetic separation properties using a rotary drum type high gradient magnetic separator. RH-MAC was synthesized by impregnating rice hull with an iron nitrate solution and heat-treatments in nitrogen and carbon dioxide atmosphere. In those processes, a lot of meso-pores and nano-size magnetite were generated inside the activated carbon. The magnetization of RH-MAC increased with increasing concentration of iron nitrate solution. The maximum magnetization of RH-MAC3 made from 1.6 mol/L iron nitrate solution reached 22.2 Am<sup>2</sup>/kg at 1 T. The adsorption properties of several kinds of RH-MAC for heavy metal ions (Hg, Cd, Pb, As) and valuable metal ions (Sr, Rb, Li) were investigated. Especially for Cd and Rb, RH-MAC shows excellent adsorption properties and the removal rate from 0.03 ppm Cd solution for RH-MAC of 50 mg and 0.12 ppm Rb solution for RH-MAC 30 mg achieved 99.0 and 60.5% respectively. For magnetic separation the multiple magnetic mesh filtering system wound around the permanent magnet drum was used. We simulated magnetic particle trajectory by finite element method for magnetic separation. RH-MAC3 was captured at 99.2% by using double magnetic mesh filter with 0.5 T at the flow rates of 250 mL/min.

**id #1936**

### **Treatment of food wastewater using an anaerobic membrane bioreactor**

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Food wastewater showed the most rapid growth in the organic waste resources, the need for the processing technology is increasing. Nowadays food wastewater treatment has emerged as a social issue in Korea. Every year, about 4 million tons of food waste is discharged across the country, and about 1 million ton of food wastewater had been sent out to the sea, but the discharge to the sea was banned by the law in 2013. Though some local governments have treatment facilities, their capacity is not enough to treat all the wastewater that had been discharged to the sea. Therefore, a more effective and reliable food wastewater treatment process should be provided. In this respect, anaerobic membrane bioreactor (AnMBR) would be an alternative food wastewater treatment process. Therefore, in this study, we attempted to treat food wastewater blended with sewage by using AnMBR. For this purpose, we developed a submerged AnMBR, in which the membrane fouling was controlled by scouring with media induced by rotary disk. Two rotary disks connected to the motor via a shaft were installed in the anaerobic MBR, and a submerged flat sheet of membrane module was located between the rotary disks. The reactors were filled with fibrous ball media made of polypropylene and suspended anaerobic sludge. The circulation flow generated by the rotation of the rotary disks made the media circulating so that the media swept out foulants on membrane surface. The AnMBRs operated for long-term with three different organic loading rates (OLRs) (1.5, 3 and 6 kg COD m<sup>-3</sup>d<sup>-1</sup>, respectively) to examine the effects of the different OLRs on food wastewater treatment, methane production, membrane fouling. As a results, the average COD removal efficiency was 98~99%, regardless of different OLRs. The methane production tends to increase with increase in OLR. Although the TMP increase slightly for the operation days, it was kept below 30 kPa. Consequently, the anaerobic MBR could achieve excellent treatment performance in terms of COD removal and biogas production.

**id #2520**

### **An Intelligent Supervision Platform for Operation and Maintenance of Decentralized Domestic Sewage Treatment Facilities**

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#### **Introduction**

More than 530,000 of decentralized domestic sewage treatment facilities have been built in China. How to supervise the operation and maintenance (O&M) of these facilities has become an urgent problem because of the huge number while an extensive dispersion. Zhejiang province tried three stages in a few areas. The first stage focuses on the establishment of information platform to solve the problems of long distance and information collection. In the second stage, the information platform with only safety monitoring and manual inspection can't meet the improved management requirements, especially the pollutant removal efficiency has decreased with the prolongation of the operation time of treatment facilities. Therefore, this paper discusses the construction of intelligent supervision platform, and integrates the intelligent concept into the whole construction process for realizing the supervision of long-term O&M of treatment facilities.

#### **Operation and Maintenance supervision problems with an information platform**

According to the operation state and water quality of treatment facilities with an information platform, it is found there are O&M supervision problems as follows:

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(1) Large investment, low inspection efficiency, high missed detection rate, and delayed fault diagnosis. Online monitoring is mainly based on safety monitoring. The normal operation of the facility is judged mainly by the start-stop of the pump, fan and personnel inspection.

(2) Lack of early warning and prediction of operating state, timely response and treatment of anomalies and faults, and efficient adjustment of the key process parameters such as dissolved oxygen and influent load in time.

(3) Lack of centralized data source and corresponding data integration, mining and analysis, leading to low supervision efficiency.

Design and realization of intelligent supervision platform

Based on the basic advantages of information platform, the construction of intelligent supervision platform is guided by the demand and problems for excavating the new potential of process management, data value and application service, supported with Internet of things, big data and cloud computing. It has software running mode of B/S architecture and adopts standard intelligent solution with four levels of intelligent perception, intelligent interconnection, intelligent calculation, application service mode. The whole platform establishes a standardized system which integrates informatization, intelligence and specialization.

Optimization of process management

The intelligent model has many advantages over traditional manual model on optimizing process management, the former can realize the full-process tracking and self-optimization with a modified PDCA cycle model, in which "personnel" refers to how to arrange personnel, "process" to standardize the work flow, "technology" to improve work efficiency, and "resource" to ensure the work results.

The main thinking

The establishment of intelligent supervision platform is the better realization of "wisdom" in management and "good" in service. It should take the practical application as the guide, consider the major adjustment of policy, management mode and service demand diversity. It's hoped some thoughts and experiences in this paper provide reference for the construction, management and service of treatment facilities in other regions.

Acknowledgement

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**id #1813**

### **Wastewater treatment, renovation and reuse for agricultural irrigation in small communities**

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The need for water and the risks associated with inadequate wastewater treatment have stimulated attempts to reuse domestic wastewater for various purposes, mainly for agricultural irrigation. This strategy has now become practical. The use of wastewater in small communities depends on a range of factors, such as community size, socio-economic aspects, relative location to other communities, and land availability for the community. Reuse of effluents European erosion is the subject of in-depth study of integrated methods and looks promising: among these, erosion control is part of a larger effort to improve the productivity of agriculture and agriculture. Preserve natural resources, while giving farmers the opportunity to participate in the organization, development of technologies and the management of natural resources at a local level. Currently, on the contrary, population pressure and the need for food self-sufficiency are forcing many governors to undertake the creation of large artificial water schemes and hydraulic equipment for large agricultural areas. Legislation to secure land use rights could reinforce this approach. The adverse impact of the poor quality of water in the Third World is such that in 1980 the United Nations opened the Water Decade with the aim of "providing safe drinking water for all." To do this, considerable work, especially concerning sanitation in third world countries that still pay a heavy price for biological, microbial and parasitic pollution of water. For in the developed countries the situation, formerly so worrying, has fortunately been transformed by the work undertaken, as we have said, by the fear of cholera and other water-borne diseases. A significant financial commitment to the program at the national policy level is essential for the program to be accomplished in a long-term framework. The management, operation and maintenance of a water supply are issues that politicians and design engineers have been concerned with since the early stages of planning. It is necessary, in some cases, to treat the water so that it can be suitable for drinking and domestic purposes. Any form of treatment in a water supply system leads to an expense that can be relatively high. In addition, the problems of maintenance of the water supply system, and the risks of failure, are considerably increased. Some water treatment processes are easier for others to maintain, but they all require regular monitoring and attention. When designing water treatment plant, operating and maintenance requirements are key factors to pay close attention to. The goal of water treatment is to transform surface water, raw water, into drinking water suitable for domestic use. Two main types of small isolated communities can be identified. One of them has limited water and water resources and their main problems are related to the treatment and disposal of wastewater. The second has sufficient land for the reuse of effluents, but lacks additional quantities needed for cultivation. Additional quantities of effluent can be obtained from an adjacent municipality of the first type which, for its part, must solve problems of sewage disposal.

**id #2482**

### **A new risk-based drinking water and wastewater regulatory framework in Western Australia**

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*Health (Miscellaneous Provisions) Act 1911 (Health (MP) Act)* is the principal legislation in place in Western Australia (WA) that prescribes the requirements associated with safe provision of drinking water and wastewater management. This includes small privately-operated drinking water systems and onsite wastewater systems contained within a lot.

The Health (MP) Act is currently being repealed and replaced with the *Public Health Act 2016* (Public Health Act). Unlike the prescriptive nature of the Health (MP) Act, the Public Health Act provides a risk-based regulatory framework for the management of public health risks. The main regulatory mechanism in the Public Health Act that will be used to manage the public health risks

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associated with drinking water and wastewater in WA is the registration and licensing public health risk activities. The Public Health Act enables specified activities to be declared a public health risk activity that is either registrable and/or licensable. Once formally declared a public health risk activity, the Public Health Act provides the necessary powers and mechanisms to manage the public health risks.

It is proposed that the supply of drinking water to members of the public via an onsite drinking water system will be declared a public health risk activity. Premises that supplies drinking water to members of the public via a small (decentralised) drinking water system will be required to be registered with the local government. As part of the proposed requirements, these drinking water suppliers will need to establish a drinking water risk management plan (DWRMP) that addresses the key elements of the Australian Drinking Water Guidelines (ADWG). The scope and detail required in their DWRMP will be proportionate to the drinking water system's risk. A state funded drinking water quality monitoring program will continue to be implemented to ensure that the drinking water supplied at these premises is safe for consumption.

It is proposed for the use of onsite wastewater systems (OWWS) and servicing of specific types of OWWS will be declared public health risk activities. Prior to the installation of OWWS, an application to install standard pre-approved systems will need to be lodged with the Local Government (LG) or the Chief Health Officer (CHO) if it is a non-standard system. Site and soil evaluation will need to be undertaken and the OWWS must comply with a prescribed code of practice. After the installation approval is granted, the OWWS can then be installed. Prior to the registration of the premises, which allows the OWWS to be used; the LG will inspect the installation to ensure that it has been installed in accordance with the installation approval. As the servicing of OWWS has been identified as a key factor that is required for the adequate treatment and disposal of wastewater onsite, service technicians will need to be licensed by the CHO to service specific types of OWWS.

In this presentation the development of the discussion papers and the comments received so far to draft the new legislation will be discussed.

**id #2544**

### **An Automated Blending Device for Brackish Water Desalination:Upscaling the Laboratory-Scale Device for Standardised Water Supply on Farms**

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Farmers in many places across Australia are facing drought and dryland salinity in Western Australia is the biggest concern in the rural Wheatbelt farming industry. This project deals with the salinity issue and how to reduce energy consumption while providing suitable quality water for diverse farming needs. The method used to investigate and solve this issue is the automation of a blending device for solar PV-powered brackish water desalination by reverse osmosis membrane (PVRO). The plant will use brackish water provided from the borewell on the farm at Muresk Institute near the Wheatbelt town of Northam, and permeate water from the PVRO device. The selection switch can be used to blend different concentrations of total dissolved solids (TDS) to suit different requirements. Different TDS concentrations in the water can be used to either water the crops, distribute to the cattle or use it for the potable drinking source. In this study, data will be presented to show that Solar PVRO permeate and brackish water can be automatically blended and remotely controlled and monitored via the Arduino IDE and Supervisory Control and Data Acquisition (SCADA) system. This will allow for the off-site user to monitor and adjust any parameters needed, also inform the user on the site if anything is wrong and what needs to be repaired on the system. The processed system data will give the user at the site, information about the unit and the achieved TDS levels, the amount of water that will be distributed, choice of selecting different water quality levels so that system operation and maintenance costs can be reduced and savings made on good quality water. By assisting the user in controlling the quality, the system can reduce the energy required in running the PVRO module, as well as provide more opportunities on what the water can be used for.

**id #2258**

### **Borrooloola Water Treatment System Upgrade - The containerised story**

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The project delivered a sustainable and effective water treatment solution through an innovative modular approach to address public health risks for one of the most remote communities in Australia (1000 km from the nearest major town).

The project dealt with various levels of complexity (technical, social and environmental) as well as a wide range of challenges.

To overcome the geographical and logistical challenges associated with the delivery of a complex system in such a remote location, the water treatment system was delivered through an unique containerised solution.

The 'plug and produce' system provided rapid installation with only minimal disruption to the existing plant operations and mitigated risk and uncertainty associated with Borrooloola's remote location.

The design phase was managed entirely through a 3D modelling representation and was reviewed and assessed through a series of "walk through" workshops.

Majority of the treatment plant equipment is fitted inside a number of 20 and 40 foot shipping containers which were fabricated in Brisbane and Melbourne. The filters were made in India and are fixed inside a transportable filter skid structure to minimize work during integration. The gas chlorination system, which was built in Sydney, is entirely fitted in a transportable concrete building and incorporates a number of features that provide a high level of safety to the operators and the community. The 6 metre degassing tower was fabricated in France and was selected for its proven performance, high CO<sub>2</sub> removal efficiency and robustness.

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All components were assembled, connected and pre-tested in Darwin in a controlled environment before being dispatched to Borroloola for final integration and commissioning.

To reduce risks of vandalism and increase community understanding of the benefits of the project, the local Aboriginal art centre and school were involved in an artwork project. Eighteen paintings designed by school students were printed on large steel sheets and are displayed around the compound.

The project contributed to achieving the UN Sustainable Development Goals no.6: clean water and sanitation and no.9: build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.

**id #2310**

### **Study of Macro and Micro Elements Contamination in Selected freshwater Macrophytes of Raigadh Tank, Gujarat, India.**

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The Present study deals with Raigadh tank (lake) waters were analyzed for macro and micro contaminations. The results values of the metals estimated through lake during -2014. Their ranges of concentration were comparing to permissible limit of WHO, ICMR. Based on the concentration and toxicity status observed in the lake vegetation, the six element are arranged in the following descending order; Na >K>Mn>Fe>Zn>Cu compared with the standard, normal and critical toxicity range in plants.

**id #1900**

### **Optimization of anoxic-oxic process for the treatment of domestic wastewater with low C/N/P ratio**

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Anoxic-oxic (AO) process can treat domestic wastewater by consecutive biological reactions. Ammonia is oxidized into nitrate by nitrifiers under oxic condition and nitrate is reduced to nitrogen gas by denitrifiers under anoxic condition. Phosphate accumulating organisms (PAOs) can remove phosphate through phosphate release under anaerobic condition and excessive phosphate uptake under oxic condition. Carbon compounds are removed by being used as carbon source for denitrifiers and PAOs. In Korea, however, there have been serious operational problems in nitrogen and phosphorus removals in the AO process when treating domestic wastewater with low C/N/P ratio. Thus the objective of this study is to find the strategy for the stable and satisfactory operation of the AO process even under low C/N/P condition.

AO process reactor consisted of two rectangular tanks for anoxic/anaerobic reactions and oxic reactions. Working volume of each tank was 4 L and hydraulic retention time was 3h, respectively. To mimic real process, AO reactor was continuously operated with real domestic wastewater containing ~ 30 mg-C/L, ~ 45 mg-N/L and ~ 5 mg-P/L. Due to the low content of organic carbon, denitrification performance of the AO process was lower than 30% and sludge flock was unstable and floatable. Phosphate release and uptake were negligible due to the same reason. To supply deficient organic carbon for nitrogen and phosphorus removals, external organic carbon was added into the anoxic tank with fresh wastewater. The effects of acetate concentration on the carbon, nitrogen and phosphorus removal in the AO process were examined. Complete denitrification occurred above 100 mg-C/L of acetate and no inhibition of nitrification was observed below 300 mg-C/L of acetate. Biological phosphorus removal occurred above 200 mg-C/L of acetate. Although effluent concentration of phosphate reached to below 0.5 mg-P/L by adding 300 mg-C/L of acetate, too much amount of acetate was required. Thus it was considered to be non-economical to supply additional 200 mg-C/L of acetate for only phosphorus removal. To overcome the low efficiency of biological phosphorus removal, a chemical method using Fe(III) was used. 10 mg/L of Fe(III) showed similar performance in phosphorus removal by 300 mg-C/L of acetate. In conclusion, optimum condition of AO process for the treatment of domestic wastewater with low C/N/P ratio was determined to be 100 mg-C/L of acetate and 10 mg/L of Fe(III).

**id #2505**

### **Electrical conductivity as an indication for ammonia concentration and a feedforward control parameter in rural domestic sewage treatment facilities**

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Introduction

More than 60, 000 rural domestic sewage treatment facilities have been constructed in Zhejiang province, China since 2014. However, lots of them cannot work with an appropriate pollutant load and gradually becomes inoperable. In this study, the correlation between Electrical conductivity (EC) and ammonium nitrogen (NH<sub>3</sub>-N) concentrations in rural domestic sewage were investigated, thereby providing a fast and economical alternative method for pollutant indication and an effective water quality index for the pollutant load adjustment.

#### **Materials and Methods**

177 rural domestic sewage samples were collected from 3 City (Jiaxing, Huzhou, Jinhua) in Zhejiang province. Representative facilities with different treatment scales (1-5, 5-20 and >20 t/d) and unit processes (A/A/O, SBR and constructed wetlands) were selected. COD, TN, NH<sub>3</sub>-N, TP and suspended solid (SS) analyses of wastewater were performed in accordance with the American Public Health Association (APHA) Standard.

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### Results and discussion

Five pollutant indices (TN, NH<sub>3</sub>-N, TP, COD and SS), pH and EC of influents of rural domestic sewage treatment facilities in Jiaxing, Huzhou and Jinhua City were determined and listed in Table 1. The average values of influent NH<sub>3</sub>-N and EC in the three cities were 31.6 mg/L and 929.3 μS/cm, 52.5 mg/L and 879.5 μS/cm, 15.8 mg/L and 485.4 μS/cm respectively.

Fig. 1 depicted the correlations between influent NH<sub>3</sub>-N and EC in the rural sewage treatment facilities of Jiaxing City (a), Huzhou City(b) and Jinhua City(c). NH<sub>3</sub>-N of the three cities all demonstrated good correlations with EC, and the related R<sup>2</sup> were as high as 0.7850, 0.6697 and 0.7957, respectively. Evidently, the influent NH<sub>3</sub>-N concentrations of rural domestic sewage in these cities can be expressed by an easily detected EC index.

The above study not only provided an efficient and comparatively accurate method for estimating NH<sub>3</sub>-N concentration, but also the possibility of remotely feedforward optimization for rural domestic sewage treatment facilities in a fast and low-cost way which was based on online EC. EC metres (Fig. 2a, b) were installed in regulating pond before A<sup>2</sup>O treatment facility. In addition, the inflow durations of A<sup>2</sup>O was calculated according to its relationships with EC as follows:  $t = L_{\text{NH}_3\text{-N}} \times V_{\text{eff}} / (n \times (ax + b) \times q)$ , where  $L_{\text{NH}_3\text{-N}}$  (g/ m<sup>3</sup> d) was the NH<sub>3</sub>-N load capacity of facility,  $V_{\text{eff}}$  (m<sup>3</sup>) was the effective volume of facility,  $n$  was the feed frequency,  $x$  (μS/cm) was the influent EC, and  $a/b$  were fitting coefficients,  $q$  (m<sup>3</sup>/h) was the rated flow of feed pump. As shown in Fig. 2c, the removal rate of NH<sub>3</sub>-N in A<sup>2</sup>O based on EC feedforward optimization was about 2.9 time compared with control which was fixed inflow and stopping duration both at 4h.

### Conclusions

In this study, positive correlation was found between influent NH<sub>3</sub>-N and EC in the rural sewage treatment facilities in Zhejiang province. In addition, not only the concentration of NH<sub>3</sub>-N in rural domestic sewage can be determined by installing a conductivity metre in the facility, but also the influent load can be feedforward optimized online in real time according to the EC value.

id #2048

## The Tridimensional Microbial Responses to Rural Wastewater with Different Salinity in a Sequencing Batch Biofilm Reactor

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To overcome the limits of traditional biological processes in treating saline and arbitrary-discharged rural wastewater, a spiral fiber based Sequencing Biofilm Batch Reactor (SBBR) was operated to explore the pollutants removal behavior as well as the tridimensional (suspended sludge, exterior biofilm and interior biofilm) microbial diversity with varying salinity (0.0 - 10.0 g/L of NaCl). Results indicated that a quick start-up could be achieved in 15 days, along with sufficient biomass up to 4365 gVSS/m<sup>3</sup>. The simultaneous nitrification and denitrification process and denitrifying phosphorus removal process were observed in this SBBR system. The SBBR showed better adaptation to low salinity (≤7.5 g/L) with the removal efficiency of total nitrogen and phosphorus up to 85% and 80%. The abundance of *Zoogloea* decreased sharply to 5.0% with the salt concentration increasing to 10.0 g/L, and this was consistent with the low phosphorus removal efficiency (40%). The abundance of microorganisms in suspended sludge, exterior biofilm and interior biofilm were different, indicating the different oxygen demand of the microorganisms. The interior biofilm (DO ≤ 0.5 mg/L) tends to favor the growth of *Thauera*, while the exterior biofilm interior biofilm (DO ≥ 5.0 mg/L) and suspended sludge (DO ≥ 6.0 mg/L) were more suitable for *Nitrospiraceae*, *Zoogloea* and *Kineosphaera* to live in. This study will provide theoretical foundation and guidance for application of SBBR in saline rural wastewater treatment.

**Keywords:** Rural wastewater; High salinity; Sequencing Batch Biofilm Reactor; Microbial Responses; Nitrogen removal

id #2756

## Energy recovery devices for small brackish water desalination units Case study: Economical feasibility analysis for brackish water desalination plants.

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id

## Improving sanitation programmes through nurturing a culture where we admit to our failures

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Water, sanitation and hygiene (WASH) endeavours regularly fail. Sometimes this means that programmes do not achieve their stated aims; other times these failures are setbacks that can be rectified with sufficient reflection and action. In the worst cases, the purported 'beneficiaries' of sanitation projects are harmed— sometimes even killed— through the unintended consequences

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borne of admirable intentions. These tales of failure are rarely shared with the wider sector, in part due to a culture of covering up things that go wrong. This presentation will report on a recent initiative, “WASH Failures”, which has included participatory research where local WASH staff in four sub-Saharan countries are sharing their own stories of failed programmes, a series of “Blunders, Bloopers and Foul-Ups” game shows at WASH conferences, and the development of “The Nakuru Accord: Failing Better in the WASH Sector,” a statement of best practice that has been signed by over 180 WASH professionals globally. The WASH Failures initiative will result in more successful WASH programmes as sector actors learn from one another and gain insights from the experiences of their colleagues.

**id #2757**

### **ALTERNATIVE WATER SOURCE INVESTIGATIONS FOR OUTER URBAN AREAS OF PERTH**

**Nick Turner**

*Water Corporation, Perth.*

Perth continues to experience the impacts of a drying climate. The North East corridor of Perth (NE corridor) is experiencing significant growth; while at the same time, not having enough groundwater to sustainably meet demand including non-potable water for amenity and irrigation of Public Open Space (POS). An additional four gegalitres of water will be needed by 2040 to service this demand. This paper compares some of the options which could potentially service this demand, and focusses on reuse of subsoil drainage as a specific opportunity.

#### **INTRODUCTION**

Water Corporation is committed to supporting the transition of Perth into a leading waterwise city by 2030 and improving liveability for communities, including access to public open space that delivers health and environmental benefits. The North East corridor of Perth (NE corridor) is experiencing significant growth; while at the same time, not having enough groundwater to sustainably meet demand including non-potable water for amenity and irrigation of Public Open Space (POS). An additional four gegalitres of water will be needed by 2040 to service this demand. A variety of sources could potentially meet this demand, including sewer mining, harvesting of subsoil drainage (also termed rejected recharge), improved efficiency of private water use with subsequent water trading and repurposing of existing Water Corporation assets.

As part of a masterplanning exercise, Water Corporation has used the NE corridor to assess and compare the various options, and identified that rejected recharge has potential to be a cost effective, sustainable alternative source. The Water Corporation are assessing the feasibility of undertaking a trial of harvesting, treatment, storage and use of rejected recharge with a view to delivering the technical specifications, regulatory guidelines and operating model to undertake this anywhere in the Perth metropolitan area.

#### **HIGHLIGHTS**

- A total of nine source opportunities were identified for the area
- These were compared for complexity, core business alignment, unit cost and yield availability
- rejected recharge suits local conditions and is potentially cost effective
- Subject to feasibility being demonstrated, a trial will proceed of the source
- This will deliver the regulatory instruments, design and operating standards for other schemes

#### **PROCESS**

The physical context of the local area was analysed, taking account of existing water use, hydrogeological conditions, existing and planned assets, projected urban development and associated water requirements.

The nine source options identified for the area were compared within the local context using a “2X2” mapping approach (refer Figure 1) to identify which sources were most prospective for the area. Rejected recharge was identified as a prospective source, this involves the collection and reuse of subsoil drainage water for non-potable reuse (see Figure 2).

Water Corporation are assessing the feasibility of undertaking a trial of the approach, with a view to delivering the necessary guidelines and technical specifications for this to be a future source for the whole Perth metropolitan area.

The criteria for assessing whether to proceed with a trial are:

- Unit cost in comparison to scheme water

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- Definition of a design standard and availability of the scheme (given that this is NOT a drinking water supply)
- Level of confidence that a trial would deliver the necessary regulatory instruments to allow assessment and regulation across the Perth metro area
- Level of water sensitive benefits delivered, in particular enhanced local community amenity
- Agreement on an operating model that would be a demonstration of how schemes would be operated and maintained in the future at larger scale. From findings elsewhere, local councils will play a significant role
- Clarity of funding, both for the trial, and for future schemes

Other potential source opportunities in the area include increased efficiency in private water usage with trading of water delivered by these efficiencies, and potentially repurposing of existing Water Corporation assets for provision of non-potable supply.

### **RESULTS**

The assessment is still under water so results are not yet available

### **CONCLUSION**

There are a number of alternative water source opportunities available for the NE corridor of Perth, and this paper demonstrates a transparent approach whereby these can be compared for the local environment to identify the most prospective sources.

**id #2838**

## **Microfibre Technology – Mitigating Risks Related to Health while Improving Asset Performance**

**John Coetzee**  
**Amiad Water Systems.**

It is universally accepted that turbidity is a good indicator of overall water treatment plant performance. This is further evident in the *Australian Drinking Water Guidelines: Draft Framework on Microbial Health Based Targets (HBT)*, where default recommended LRVs (Log Reduction Values) for Bacteria, Virus and Cryptosporidium are attributed to water treatment processes based on the plant's performance, in terms of turbidity. For example, a conventional water treatment plant will have 3.5 LRV for Cryptosporidium, provided the individual filter turbidity is less than 0.2 NTU for 95% of the month, and not greater than 0.5 NTU for more than 15 consecutive minutes. Operating a regional water treatment plant consistently below 0.2 NTU may be difficult during times of flooding rains, process upsets or component failure.

With the increased use of HBT to provide a quantitative definition of the microbiological safety of water, and the growing global awareness of HBT for drinking water (following the example of the USEPA, World Health Organization - WHO and Health Canada guidelines for drinking water), maintaining overall plant performance in terms of turbidity, will be increasingly important to ensure the minimal acceptable risk of microbial infection – one  $\mu$ DALY. One  $\mu$ DALY is approximately equal to 1 case per year of mild diarrhoea (lasting 3 days), for every 1000 people.

How do you effectively mitigate the risks related to health, during extreme weather or inconsistent performance of water treatment assets? Reducing the flow rate, optimising coagulant dosing, investing in additional disinfection (e.g. UV) or additional filtration are some of the options available to treatment plant operators. However, the ideal solution will be one that offers turbidity reduction and additional disinfection (i.e. LRV for Cryptosporidium) in a small foot print with a high efficiency (recovery) and a low operating cost.

This paper will look at real life examples where the Amiad Automatic Microfiber (AMF) filter, has been used to:

- assist water treatment asset performance following the Great Alpine Bushfires of 2006-07, in Australia;
- improve the drinking water turbidity through the monsoon season, by 90% to <1 NTU, for a remote village in India through Water4India (Water4India is co-funded by the European Union within the 7<sup>th</sup> Programme Framework – FP7);
- remove 4 kg of iron per day from a large distribution network in Australia (the equivalent of 1.4 tonne per year), while reducing chemical consumption; and

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- protect the injection bore from clogging in ASR (Aquifer Storage and Recovery) or SAT (Soil Aquifer Treatment).

These examples are in addition to the more than 70 municipal installations in the last 20-years. Since the AMF filter is essentially a self-cleaning cartridge filter, the applications are endless, especially in remote sites where water quality, access and labour, preclude the use of manual cartridges.

**id #**

### **Integrated water systems for water conservation and livability: precinct-scale case studies from Perth, Western Australia**

**Josh Byrne**

*Josh Byrne & Associates, Fremantle, W.A.*

**id #2839**

### **Building water security through complementary supplies**

**Mike Rowe**

*Director General, Department of Water and Environmental Regulation*

The Waterwise Perth Action Plan launched in October this year is the McGowan Government's coordinated response to the impacts of climate change on water resources and liveability in Perth and Peel, which is home to 80 per cent of Western Australia's population.

Climate change is making our urban areas hotter and drier, as well as reducing the amount of groundwater that can be taken in a sustainable way.

Lower average annual rainfall is markedly reducing the amount of water in collected dams and, less obviously, over several decades, has caused groundwater levels to decline.

Without changes in the way we approach water use and water supply, there could be a 100 GL/yr shortfall in the amount of water we need for public water supply and other non-drinking water needs by 2030.

To complicate this, over 80 per cent of new urban developments planned for the next five to 10 years are in places with no allocable groundwater.

As part of the Waterwise Perth Action Plan new alternatives to using groundwater alongside water sensitive urban design, will help address this shortfall and keep communities cool and liveable.

Our target is that 45 per cent of the projected shortfall will be met through recycled and alternative water supplies.

There is no one-size-fits-all solution to building water security. Managing the natural water resources and building large-scale solutions such as new desalination plants and groundwater replenishment schemes will be complemented by smaller-scale water supply and wastewater systems.

We will encourage the multi-solution thinking by revising our urban water cycle policies to make them more integrated and easier to navigate.

This will remove administrative barriers to waterwise development and raise the standard of urban design in relation to drainage and water efficiency.

Achieving improvements in waterwise urban planning will also contribute to reducing the urban heat island effect, improve our waterways and wetlands and ultimately improve public health through access to high value and biodiverse recreational spaces and parks.

**id #**

### **A new method to determine assimilable organic carbon for drinking water treatment performance optimization**

**Xingding Zhou**

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Assimilable organic carbon (AOC) refers to a fraction of "labile" or "bio-available" dissolved organic carbon (DOC) that is readily assimilated and utilized by microorganisms resulting in an increase of biomass. The AOC is comprised of a wide variety of low-molecular-weight organic carbon molecules such as sugar, organic acids and amino acids and represents only a small fraction (< 10%) of the total organic carbon (TOC). The AOC is usually considered as one of the main indicators of biological water stability and is a critical parameter for drinking water treatment and distribution processes. Recently,

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the AOC concept has also been extended to measure microbial growth potential for environmental samples such as soil water extracts, seawater and reclaimed water.

Conventional standard AOC assay is laborious and time-consuming. This includes stage I, 9 days of cell growth of two test strains (*Pseudomonas fluorescens* P-17 and *Spirillum* sp. NOX) and stage II, 3-5 more days for cell enumeration by plating counting. Here we developed a rapid method to detect AOC in water samples. For phase I, *Pseudomonas fluorescens* P-17 is replaced by a Green Fluorescence Protein (GFP) tagged mutant (GFP-P17) which was created by Tn-5 transposon mutagenesis from the wild type strain *Pseudomonas fluorescens* P-17. For phase II, cell enumeration for both GFP-P17 and *Spirillum* sp. NOX is simultaneously obtained by flow cytometry. We have demonstrated that this new method only need 3 days to determine AOC for real water samples from various stages of a local waterworks. It can also provide cell growth data starting from day 2 of incubation. More importantly, our data shows this new method maintains the same reliability and accuracy of the conventional AOC measurement method. Besides, we have found that our mutant GFP-P17 strain keeps the same or even better merits such as higher growth rate and wider carbon utilization spectrum in comparison with wild type strain. Implementation of this new AOC testing method will significantly improve the efficiency in monitoring and optimizing of water treatment processes (such as GAC/BAC monitoring through quick AOC determination).