The 17th IWA Leading Edge Conference on Water and Wastewater Technologies

the international water association

Latest Innovations, Technologies and Solutions for Water & Wastewater Management

Conference Programme

28 MARCH — 1 APRIL 2022
RENO, NEVADA | UNITED STATES
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Welcome to Reno

& The IWA Leading Edge Conference on Water and Wastewater Technologies 2022, from the IWA President

Dear colleagues and friends,

I am delighted to extend a welcome to you for what is IWA's 17th Leading Edge Conference on Water and Wastewater Technologies. This inspiring event provides a great opportunity to again network and share innovative ideas with colleagues.

We are at a crossroads for the future of water. We have the opportunity to choose a new path, connecting with the 'build back better' and climate adaptation agendas. Now is the time to provide innovative and dramatic solutions that can change the future of water for good and rise to the most pressing global challenges.

There are enormous opportunities for improvement and innovation, especially with water and wastewater technologies. For example, digitalisation can drastically improve water asset management and reduce inefficiencies, while technology can play a critical role in improving access to sanitation in non-sewered systems. Also, there are great opportunities to pursue a circular economy approach with water and the energy and other resources contained in used water.

The trending themes in the programme show the extent of these opportunities. As well as the core programme, posters and technical visits will add further coverage of research and insights into water technologies and innovations in the industry, all complemented by the various networking activities.

I would like to take this opportunity thank all the many people involved with the preparations for this event, especially our organising partner, University of Reno, Nevada, the organising and programme committees, and the supporting partners and sponsors. On behalf of IWA, I wish you all a successful time during your visit to Reno.

Tom Mollenkopf, *IWA President*

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Welcome

from the Conference President

The IWA Leading Edge Conference on Water and Wastewater Technologies (LET) has built a world-class reputation as the forum for leading researchers to share and debate pioneering science, technological innovation and leading practices that will provide solutions to emerging and persistent water challenges.

Water challenges are intensifying, day after day. Fast growing demand for clean and accessible water is being driven by an increasing global population and industrial needs. New approaches are challenging the status-quo of centralised water infrastructure systems; water scarcity and diminishing groundwater levels are spurring new research into the circular economy of water, with wastewater and resource recovery playing a pivotal role.

The pandemic has shined light on the essential role played by the water and wastewater sector. For example, Wastewater-based epidemiology, wastewater monitoring, microbial source tracking and resource recovery are areas of increasing research activity. The innovation agenda around sewage and wastewater treatment spans opportunities that are ready for implementation and those where considerably more research and development is needed.

The conference programme clearly reflects all of these leading-edge themes. LET provides the ideal space for sharing practical knowledge and stimulating further research and innovation for a sustainable, water-wise future. I look forward to seeing you there.

Professor Bruce Rittmann, *Arizona State University, LET Conference President*

Welcome

from the Programme Committee

In its 17th edition, the Leading-Edge Conference on Water and Wastewater Technologies (LET) conference has grown into a top-notch forum of significant importance in the global water and wastewater sector. Here, we will present and discuss the most significant global technology developments in the industry.

Novel and much-needed water technology developments are emerging continuously in response to the global water and climate crisis and LET provides the ideal forum for discussion and exchange on the latest research as well as implementation by industry.

The 2022 edition provides us with a platform to share our latest advancements and pioneering solutions for a water-wise future. LET represents the first post-covid large IWA conference, and we are thrilled about finally being able to meet in person and benefit from direct knowledge-sharing and networking. Throughout the days together here in Nevada, we look forward to hearing from our great panellists, speakers and fellow IWA members about innovations, technological research, and practical, leading-edge applications from across the industry.

In the past months, we have worked hard to focus on the issues which are of highest importance at a global and regional level. We have produced a rich programme which includes extremely trending topics, ranging from water reuse, wastewater-based epidemiology and anti-microbial resistance to digital water and sustainable wastewater treatment solutions. We hope that you will find the conference enriching and stimulating, and we very much look forward to seeing these lively discussions turn into actual impact in our industry and beyond, helping the world to bounce back after the pandemic and fight the climate crisis at the same time.

The impact of this conference also depends on your commitment and active engagement. As Chairs of the 17th Leading Edge Conference on Water and Wastewater Technologies (LET) Programme Committee, we are very excited to hear more about your innovative ideas. We would like to officially welcome you to the 17th LET conference in Reno, Nevada, United States!

Jonathan Clement *(Ramboll , The Netherlands)*
Ana Soares *(Cranfield Water Science Institute, Cranfield University, United Kingdom)*

from the Chair of the Organising Committee

As Chair of the organising committee, is my pleasure to welcome you to the 17th IWA Leading Edge Conference on Water and Wastewater Technologies that is taking place in the beautiful Truckee Meadows region in Nevada, United States. The region provides many opportunities to learn about water from mountains to alpine rivers to terminal lakes.

The US water industry market offers many opportunities for improvement and innovations. There are many issues that need to be addressed, such as ageing infrastructure, access to quality water, anthropogenic chemicals in water bodies, building sustainable water infrastructure, and issues exacerbated by climate change such as water scarcity and urban flooding. We need to develop smart, sustainable solutions to tackle these water problems, for both remote communities and fast-growing big cities. We need to address the deterioration of drinking water quality in light of emerging contaminants, and we need to come up with innovative ways to reclaim clean water for reuse from traditional and alternative sources. The extreme water challenges that we have faced here in Nevada in the past few years, ranging from prolonged drought to severe flooding show exactly how much is at stake if we don't find solutions to manage water responsibly.

The University of Nevada, Reno, is the lead LET2022 organiser and has partnered with founding members of the Nevada Water Innovation Institute including Truckee Meadows Water Authority, Truckee Meadows Water Reclamation Facility, Cities of Reno and Sparks, Washoe County, and local engineering companies to provide a memorable experience to the delegates of LET2022.

The 'Silver State' offers incredible natural sceneries, including high desert and mountain landscapes. While in region, you can explore the beautiful Lake Tahoe and serene Pyramid Lake, go hiking or skiing in the Sierra Nevada mountains, check out Black Rock Desert (the home of Burning Man festival), or visit various national parks, forests, and recreational areas. On behalf of the local organising committee, it's a pleasure to welcome you to Reno, Sparks, and to the entire state of Nevada!

Krishna Pagilla *(University of Nevada – Reno, United States)*

Programme Committee

Ana Soares, *Professor of Biotechnology Engineering | Cranfield University, United Kingdom*
Mark van Loosdrecht, *Professor in Environmental Biotechnology | TUDelft, The Netherlands*
Jonathan Clement, *Ramboll, The Netherlands*
Bruce Rittman, *Conference President | Arizona State University, United States*
Sunil Sinha, *Professor & Director SWIM Center of Excellence | Virginia Tech, United States*
Beverley Stinson, *Executive Vice-President, Global Water Business Line Leader | AECOM, United States*
Lydia Teel, *Emerging Resources Program Administrator | Truckee Meadows Water Authority, United States*
Megan Plumlee, *Director of Research and Development | Orange County Water District, United States*
Stewart Sutherland, *Water Asset Capability Team Lead | Scottish Water, United Kingdom*
Chris Dermody, *Jacobs (formerly Denver Water), United States*
Shane Trussel, *TrusselTech, United States*
Marc Deshusses, *Professor, Civil and Environmental Engineering and Global Health | Duke University, United States*
Gary Amy, *Dean Distinguished Professor | Clemson University, United States*
Joan B. Rose, *Professor and Homer Nowlin Chair in Water Research | Michigan State University, United States*
Ian Law, *Principal, IBL Solutions and Adjunct Professor | University of Queensland, Australia*
Shaily Mahendra, *Professor and Samueli Fellow | UCLA, United States*
Jeff Yarne, *Yarne & Associates, United States*
Daniel Gerrity, *Southern Nevada Water Authority, United States*
Jörg Drewes, *Technical University of Munich, Germany*
Nikolay Voutchkov, *Water Globe Consultants, United States*

Organisers

the international water association

The International Water Association (IWA) is a global network of water professionals, spanning the continuum between research and practice and covering all facets of the water cycle. Through IWA, members collaborate to promote the development and implementation of innovative and effective approaches to water management.

The strength of IWA lies in the professional and geographic diversity of its membership – a global mosaic of member communities, including academic researchers and research centers, utilities, consultants, regulators, industrial water users, and water equipment manufacturers. IWA members from each of these communities represent the leading edge in their fields of expertise; together they are building new frontiers in the research and implementation of water and wastewater treatment technologies within the framework of the total water cycle.

www.iwa-network.org

Organising Committee

Krishna Pagilla *(Chair), University of Nevada, United States*
Laura Haak, *University of Nevada, United States*
David Hanigan, *University of Nevada, United States*
Angelica Lacroix, *Truckee Meadows Water Authority, United States*
Nikita Lingenfelter, *Nevada Division of Environmental Protection, United States*
Casey Mentzer, *Truckee Meadows Water Reclamation Facility, United States*
Vijay Sundaram, *AECOM, United States*
Rick Warner, *Warner and Associates, LLC, United States*

University of Nevada, Reno

The University of Nevada, Reno, is a public research university that is committed to the promise of a future powered by knowledge. Nevada's historic land-grant university founded in 1874, the University serves 20,000 students. The University is a comprehensive, doctoral university, classified as an R1 institution with very high research activity by the Carnegie Classification of Institutions of Higher Education. UNR also earned the Carnegie Community Engagement classification. More than $800 million in advanced labs, residence halls and facilities has been invested on campus since 2009.

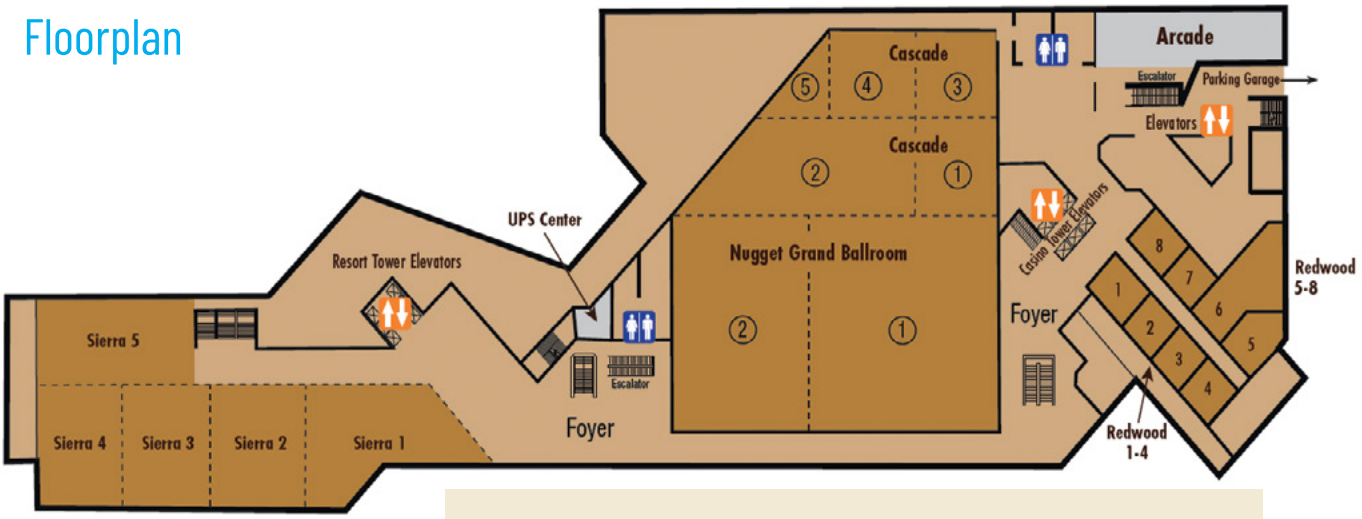
Inspired by its land-grant foundation, the University of Nevada, Reno provides outstanding learning, discovery, and engagement programs that serve the economic, social, environmental, and cultural needs of the citizens of Nevada, the nation, and the world. The University recognizes and embraces the critical importance of diversity in preparing students for global citizenship and is committed to a culture of excellence, inclusion, and accessibility.

Today, the University delivers on its land-grant mission of access to education and knowledge by investing in academics, facilities, support engagement, and vibrant campus life that promote UNR's diverse students' cognitive growth and academic achievement — all while remaining one of the best values in American higher education, according to both Forbes and Money magazines (2018). The University is ranked in the top tier of National Universities by U.S. News & World Report and in the top tier of the WSJ/Times Higher Education World University Rankings.

www.unr.edu

Practical Information

Floorplan



SECOND FLOOR — LOCATION GUIDE

1. **Nugget 1 Foyer** — Registration
2. **Cascade 1** — Water Workshops and Sessions
3. **Cascade 3** — Wastewater Workshops and Sessions, Closing Ceremony
4. **Nugget 1 Ballroom** — Welcome Reception, Plenary Session, Gala Dinner
5. **Nugget 2 Ballroom** — Poster Display and Breakfast/Lunch/Coffee Breaks

Useful Information

REGISTRATION DESK

Nugget 1 Foyer

The registration desk will be open from:

Sunday 27.03 — 16:00 until 18:00
Monday 28.03 — 07:00 until 17:15
Tuesday 29.03 — 07:00 until 17:15
Wednesday 30.03 — 08:15 until 17:15
Thursday 31.03 — 08:15 until 16:00

WI-FI

Network: Hotel network
Password: To be provided on site

SOCIAL MEDIA

Planning to use social media while at the conference?
Join the conversation:

#iwaLET @IWAhq
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www.linkedin.com/company/international-water-association
@iwa_network

TOGETHER, TOWARDS A WATER-WISE WORLD!

As an IWA member you can contribute towards a better water future.

Join IWA and get access to a network of thought leaders, exclusive content and professional development.

Meet us at the IWA Registration and discover a world of opportunities!

Special **20% DISCOUNT** on IWA membership if you decide to **JOIN** or **RENEW** until 30 April 2022 with the code: **IWA22LET**.

DISCLAIMER

The information contained in this programme guide is believed to be correct at time of publication. The organisers reserve the right to alter or remove from the programme as circumstances dictate. The organisers take no responsibility for any errors, omissions or changes. The organisers assume no responsibility for opinions or facts expressed by contributors to the programme. Any late changes to the programme will be made available on the conference programme online.

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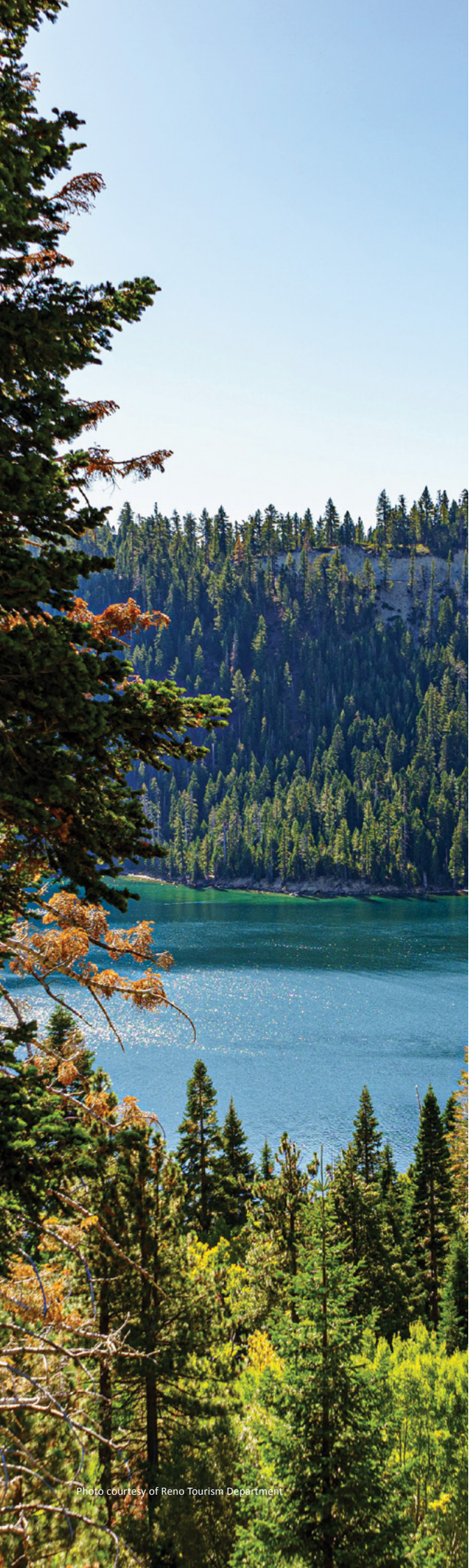

Photo courtesy of Reno Tourism Department

Programme Overview

	Monday 28 March	
7:30 — 9:00	**BREAKFAST**	
09:00 —12:15	**WORKSHOP 1** Aerobic Granular Sludge Biomass Development for WWTPs: Connecting Possibilities with Opportunities	**WORKSHOP 2** Bringing Leading Edge Technology to Market — A Path of Innovation ** until 11.45*
12:15 — 13:00	**LUNCH BREAK**	
13:00 — 17:00	**WORKSHOP 3** Raw and Treated Water Augmentation (aka Direct Potable Reuse) – the Time has Come	
17:30 — 19:30	**WELCOME RECEPTION** *(Sponsored by Nanostone)*	
	Tuesday 29 March	
7:30 — 9:00	**BREAKFAST**	
09:30 — 12:15	**PLENARY SESSIONS** Bruce Rittmann, Ana Deletic, Pete Vale	
12:15 — 13:15	**LUNCH BREAK**	
13:15 — 17:00	**PLENARY SESSIONS** Beverley Stinson, Steve Kloos, Rick Warner, Megan Plumlee.	
	Wednesday 30 March	
7:30 — 9:00	**BREAKFAST**	
9:00 — 12:45	**TECHNICAL SESSION 1** Emerging Technologies for Drinking Water ** until 11:45*	**TECHNICAL SESSION 2** Emerging Technologies the Enable High Effluent Quality and Resource Recovery
12:45 — 14:00	**LUNCH BREAK**	
14:00 — 17:45	**TECHNICAL SESSION 3** Potable Water Reuse and Alternative Treatment Technologies	**TECHNICAL SESSION 4** Emerging Contaminants: Microplastics, Pharmaceuticals and Personal Care Products (PPCP) and Antibiotic Resistance
	Thursday 31 March	
7:30 — 9:00	**BREAKFAST**	
9:00 — 12:45	**TECHNICAL SESSION 5** Adapting Water Supply Systems for Climate Resilience	**TECHNICAL SESSION 6** Wastewater Based Epidemiology
12:45 — 14:00	**LUNCH BREAK**	
14:00 — 17:45	**TECHNICAL SESSION 7** Sustainable Desalination ** until 16:45*	**TECHNICAL SESSION 8** Treatment of Complex and High Strength Wastewater
17:45 — 18:00	**CLOSING CEREMONY**	
19:00	**GALA DINNER** *(Sponsored by Ramboll)*	
	Friday 1 April	
9:00 — 14:00	**TECHNICAL TOUR** Truckee Meadows Water Authority's Water Supply System – From Lake Tahoe to Chalk Bluff Water Treatment Plant	**TECHNICAL TOUR** Truckee Meadows Water Reclamation Facility ** until 12:30*

Photo courtesy of Reno Tourism Department

Monday 28 March

LET 2022 | Morning | Workshop 1

Room: Cascade 3

AEROBIC GRANULAR SLUDGE BIOMASS DEVELOPMENT FOR WWTPS: CONNECTING POSSIBILITIES WITH OPPORTUNITIES

Organisers: **Bryce Figdore** *(HDR, United States)* *and* **Terry Reid** *(Aqua-Aerobic Systems, United States)*

This workshop brings together researchers, engineers and early adopters who have contributed towards advancing the understanding and application of densified and granular biomass in nutrient removal. Presenters will share experiences and lessons-learned to elucidate the current state of the technologies. The workshop will address both research and practical implementation while previewing granular sludge development to enhance flow-through activated sludge.

TOPICS

1. Latest Developments in Global Aerobic Granular Activated Sludge Implementation
This presentation will update the global AGS installation experience while highlighting recent start-ups at several US Facilities in Alabama, Idaho, Hawaii, Kansas, Colorado and Montana.

2. Assessing the integration of waste activated granular sludge (WAGS) to intensify conventional activated sludge processes
The addition of waste aerobic granular sludge to conventional WAS will be reviewed and the impacts on settling, nitrification rates, clarifier operation and pumping equipment will be discussed.

3. Case Study – Long term performance of Pilot-Scale Aerobic Granular Sludge at the Truckee Meadows Water Reclamation Facility
This discussion will share findings from a 1-year pilot study which conducted a side-by-side evaluation of the AGS technology on primary influent and primary effluent at the TMWRF. Findings on granular development and morphology will be presented along with live demonstration of AGS settling from the pilot plant.

4. Achieving Low Nutrient Limits using Densified and Aerobic Granular Sludge
Biological nutrient removal in a full-scale densified activated sludge system and a pilot AGS plant will be reviewed. The discussion will address impacts of maximum loadings, diurnal variations, wet weather, incineration scrubber returns and variable clarifier performance. Findings from a 1-year study of a full-scale DAS system will discuss elevated MLSS concentrations up to 5.5 g/L and peak solids loading rate in excess of 50 lb/ft2-day

5. Assessing the role of DNA Amplicon Sequencing of the 16S rRNA Gene to Characterize Biomass Development in Nutrient Removal Systems
Advancements in molecular methods (i.e., DNA analysis) have opened a new window to the understanding practical methods to characterize wastewater treatment. This discussion presents tools for identification and quantification of important bacteria, archaea and eukaryotic organisms using 16S rRNA amplicon sequencing and qPCR and its potential importance to operating wastewater treatment facilities.

Programme

9:00 - 9:10	Welcome & Introduction – Review of Goals, Objectives, and Outcomes **Terence Reid** *(Aqua-Aerobic Systems, United States)*
9:10 - 9:35	Latest Developments in Global Aerobic Granular Activated Sludge Implementation **Joseph Tardio** *(Aqua-Aerobic Systems, United States)*
9:35 - 10:00	Assessing the integration of waste activated granular sludge (WAGS) to intensify the conventional activated sludge processes **Eric Redmond** *(Black & Veatch, United States)*
10:00 - 10:15	Q&A Session with Presenters
10:15 - 10:45	**Coffee Break** *(Nugget 2 Ballroom)*
10:45 - 11:10	Case Study – Long term performance of Pilot-Scale Aerobic Granular Sludge at the Truckee Meadows Water Reclamation Facility **Bryce Figdore** *(HDR, Inc., United States)*
11:10 - 11:35	Achieving Low Nutrient Limits using Densified and Aerobic Granular Sludge **Wendell Khunjar** *and* **Ron Latimer** *(Hazen and Sawyer United States)*
11:35 - 12:00	Assessing the role of DNA Amplicon Sequencing of the 16S rRNA Gene to Characterize Biomass Development in Nutrient Removal Systems **Trevor Ghylin** *(Jacobs, United States)* *and* **John Tillotson** *(Water Trust, United States)*
12:00 - 12:15	Panel Discussion

Monday 28 March

LET 2022 | Morning | Workshop 2

Room: Cascade 1	Programme	
BRINGING LEADING EDGE TECHNOLOGY TO MARKET - A PATH OF INNOVATION **Organisers**: **Jonathan Clement** *(Ramboll, The Netherlands)* and **Krishna Pagilla** *(University of Nevada – Reno, United States)* *TIt is well recognised in the water industry that it takes considerable time to bring a new idea into a working practice.* *Further the timeline can be so long that by the time it gets implemented it is no longer novel. The challenge to the water industry is how we can accelerate this process. For that we need to have dialogue across, academicians, industry, and utilities.* *The workshop will bring panellists together from universities, industry (technology developers and consultants) and utilities, with the aim of discussing how we can accelerate this process.*	9:00 - 9:10	Opening Remarks **Jonathan Clement** *(Ramboll, The Netherlands)*
	9:10 - 10:15	Panel Perspectives each panellist will give a short perspective on what in their opinion are the biggest problems and potential solutions Academic Panel **Bruce Rittmann** *(ASU, United States)* **Ana Soares** *(Cranfield University, United Kingdom)* **Jörg E. Drewes** *(Technical University Munich, Germany)* Industry Panel **Jeff Yarne** *(JLY Associates, United States)* **Jonathan Pressdee** *(Nanostone, United States)* **Beverly Stinson** *(AECOM, United States)* Utility Panel **Charles Bott** *(Hampton Roads Sanitation District, United States)* **Gurdev Singh** *(PUB, Singapore)*
	10:15 - 10:45	**Coffee Break** *(Nugget 2 Ballroom)*
	10:45 - 11:45	Open discussion with panellists

Monday 28 March

LET 2022 | Afternoon | Workshop 3

Room: Cascade 1

RAW AND TREATED WATER AUGMENTATION (AKA DIRECT POTABLE REUSE) — THE TIME HAS COME

Organisers: **Jörg Drewes** *(Technical University Munich, Germany)* and **Ian Law** *(IBL Solutions, Australia)*

This Workshop will bring together six speakers who will draw on their international experience to lead the discussion on important factors that should be considered for any Direct Potable Reuse Scheme.

TOPICS

1. The evolution of direct potable reuse schemes and requirements for design and operation
Overview talk on the different 'philosophies' being implemented or being proposed how DPR should be conducted. This will start with Windhoek, considers WHO Guidelines Guidelines from Australia and developments in individual U.S. states (Texas, Colorado) and ends with the very advanced considerations of California's proposed DPR regulations.

2. Advances in technologies including membrane and non-membrane-based systems including the rise of Ozone/BAC/GAC treatment trains in inland areas
The topic of alternative schemes considering MF-RO-AOP and ozone/BAC/GAC/AOP will be addressed in particular under Triple Bottom Line perspectives.

3. Identifying and managing the microbial risk in DPR
This talk will report on recent developments regarding a better database of pathogen occurrences in raw sewage and using QMRA to more appropriately address microbial risk in DPR applications in California.

4. Management of chemical risk in DPR
This talk will give an overview on different strategies to mitigate the risk from chemicals in various DPR applications

5. Microcontaminants — have we identified methods and tools to manage the risks to human health in these advanced forms of potable reuse
This talk will provide insights on the efficacy of different DPR treatment schemes regarding trace organic chemicals together with state-of-the-art monitoring approaches.

6. The importance of source control programs in potable water reuse
The importance of the first two barriers in any potable reuse application – the Source Control Program and the format of the WWTP. Steps to be taken to enhance the SCP including methods to assess and manage risks of the various trade waste discharges in the catchment (sewer-shed), to set acceptance standards for trade waste discharges, at-premises and in-sewer monitoring systems to act as 'early warning systems' and to optimize the quality of water produced by the WWTP.

Programme	
13:00 - 13:30	The Evolution of direct potable reuse schemes and requirements for design and operation **Jörg E. Drewes** *(Technical University Munich, Germany)*
13:30 - 14:00	Advances in technologies including membrane and non-membrane-based systems including the rise of Ozone/BAC/GAC treatment trains in inland areas **Tyler Nading** *(Jacobs, United States)* and **Germano Salazar-Benites** *(HRSD, United States)*
14:00 - 14:30	Identifying and managing the microbial risk in DPR **Brian Pecson** *(Trussell Technologies Inc, United States)*
14:30 - 15:00	Management of chemical risk in DPR **Eva Steinle-Darling** *(Carollo Engineers, United States)*
15:00 - 15:30	**Coffee Break** *(Nugget 2 Ballroom)*
15:30 - 16:00	Microcontaminants – have we identified methods and tools to manage the risks to human health in these advanced forms of potable reuse **Shane Snyder** *(Nanyang Technological University, Singapore)*
16:00 - 17:00	Panel Discussion
17:30 - 19:30	**Welcome Reception** *(Sponsored by Nanostone)*

Photo courtesy of Reno Tourism Department

Tuesday 29 March

LET 2022 | Plenary Sessions

Room: Nugget 1 Ballroom

7:30 - 9:00	**BREAKFAST RECEPTION** *(Nugget 2 Ballroom)*
9:00 - 9:30	**WELCOME ADDRESSES** *(Nugget 1 Ballroom)* **Kala Vairavamoorthy,** *IWA Executive Director* **Bruce Rittmann,** *Conference President* **Krishna Pagilla,** *Chair of Organising Committee*
	Morning Session Chair **Jonathan Clement** *(Ramboll , The Netherlands)*
9:30 - 10:15	**THE PARTNERING COMMUNITIES OF LET: PEOPLE AND MICROORGANISMS** **Bruce Rittmann**, *Arizona State University, United States*  Dr. Bruce E. Rittmann is Regents' Professor of Environmental Engineering and Director of the Biodesign Swette Center for Environmental Biotechnology at Arizona State University. His research focuses on the science and engineering needed to "manage microbial communities to provide services to society." Services include generating renewable energy, cleaning water and soil, and improving human health. Dr. Rittmann is a member of the National Academy of Engineering; a Fellow of AAAS, WEF, IWA, and NAI; and a Distinguished Member of ASCE. **ABSTRACT:** The key to advancing water technology is forming partnerships. The 17th Leading Edge Technology Conference highlights and enables partnerships among researchers, technology developers, technology users, and policy makers. Like the previous 16 LETs, this LET features technical sessions, workshops, field trips, and many informal get-together opportunities – the ingredients needed to form and sustain the people partnerships essential for advancing technology to address the continually expanding needs to protect human and ecosystem health. Another essential partnership is with communities of microorganisms. Environmental Biotechnology is defined as "forming partnerships with microorganisms that provide sustainability services to human society." Environmental Biotechnology is my field, and I share insights into why partnering with microorganisms is so powerful. In short, it is the perfect synergy of humans' vast intellect with microorganisms' nearly infinite metabolic capacity. I provide a few examples of leading-edge environmental biotechnologies that exemplify the synergistic power of partnering with microbial communities.
10:15 - 10:45	**Coffee Break** *(Nugget 2 Ballroom)*
10:45 - 11:30	**WATER SENSITIVE URBAN DESIGN FOR WASTEWATER TREATMENT** **Ana Deletic**, *University of New South Wales, Australia*  Professor Ana Deletic is Executive Dean of the Faculty of Engineering at Queensland University of Technology, Brisbane Queensland (QUT). Previously, Ana held roles as the Pro Vice-Chancellor (Research) at the University of New South Wales and Associate Dean of Research Engineering Faculty and the Founding Director of Monash Infrastructure research institute at Monash University. Ana is an urban water researcher, focusing on stormwater management and socio-technical modelling. She led the development of several green nature-based water treatment systems which are now widely adopted in Australia and abroad. Ana is an Honorary Fellow of Engineers Australia, a Fellow of Australian Academy of Technological Sciences and Engineering (ATSE), and Editor of Water Research. In 2012, the Victorian State Government awarded Ana the Victoria Prize for Science and Innovation (Physical Sciences) for her lifelong achievements in stormwater research. **ABSTRACT:** Water sensitive urban design (WSUD) systems are designed to harness natural processes to manage and treat stormwater runoff from paved urbans surfaces. They come in different shapes and forms, for example: raingardens, stormwater swales, and bio-retentions – vegetated sand filters; constructed wetlands – shallow marshlands; and green roofs and green walls. They can help us manage urban floods, as well as protect aquatic ecosystems from pollution. They promote urban greening, which means reduce local temperatures, increasing biodiversity and amenity value of urban areas. However, they are rarely used for treatment of wastewater. The latest research into design of green walls for greywater treatment and bio-retentions for pre-treated wastewater show how we can safely and effectively integrate wastewater treatment into WSUD. These novel designs can also be used in a mixed mode - designed to treat stormwater when it rains and wastewater on a daily basis. These systems, although in their infancy, could become a valuable tool in our straggle to manage water resources in changing climates.

Tuesday 29 March

LET 2022 | Plenary Sessions

Room: Nugget 1 Ballroom

11:30 - 12:15

TRANSITIONING TO A CIRCULAR AND LOW CARBON FUTURE IN A LARGE WATER UTILITY

Pete Vale, *Severn Trent, United Kingdom*

Pete is the Carbon and Circular Economy Architect in Severn Trent's Innovation Team. He has worked in innovation in the water industry for the last 20 years and has played a key role in developing and implementing Severn Trent's wastewater treatment strategy. He has worked extensively on nutrient removal and recovery processes, removal of emerging contaminants and low energy processes, a number of which have now been implemented at full scale. His current area of focus is on developing and evaluating technologies that will deliver low carbon, low energy, material recovery treatment flowsheets that will help Severn Trent deliver its net zero commitment.

ABSTRACT: The English Water Companies have made a commitment to achieve net zero carbon emissions by 2030. This session will outline how Severn Trent (one of the largest water and wastewater utility companies in England) are developing, testing, validating and implementing circular economy, low carbon technologies and processes to achieve this challenging target. The paper will cover activities at the Resource Recovery and Innovation Centre at Spernal WwTP; where full scale trials to test the feasibility, viability and desirability of membrane aerated biofilm reactor and on-line nitrous oxide monitoring have been undertaken alongside Europe's largest mainstream Anaerobic Membrane bioreactor demonstration trial and cellulose recovery trial. The sludge to fertiliser demonstration trial at Minworth WwTP will also be discussed together with thoughts on how these various processes can be best integrated to achieve net zero treatment plants and net zero full operations.

12:15 - 13:15

Lunch *(Nugget 2 Ballroom)*

Afternoon Session Chair

Ana Soares *(Cranfield Water Science Institute, Cranfield University, United Kingdom)*

13:15 - 14:00

GLOBAL WATER MEGATRENDS, CHALLENGES AND OPPORTUNITIES IN A CARBON ZERO WORLD

Beverley Stinson, *AECOM, United States*

Dr. Beverley Stinson is the Global Water Chief Executive at AECOM (NYSE:ACM), the world's premier infrastructure consulting firm, delivering professional services across the project lifecycle – from planning, design and engineering to consulting and construction management.

A longstanding member of the AECOM team, Beverley has worked with cities and communities across the globe to develop progressive and sustainable solutions that address some of our most challenging water issues. She leads more than 6,000 professionals in AECOM's global Water business, overseeing the development, financing, delivery and operations of major water infrastructure globally.

Over a career spanning more than 30 years, Beverley is widely recognized as an industry leader and champion for applied research and innovation. She has focused her career to developing cutting-edge technologies and identifying novel solutions for addressing emerging issues like energy neutrality and Net Zero GHG emissions, cost effective solutions for space-constrained sites, water reuse, and PFAS. She brings this passion into AECOM's technical excellence program, ensuring delivery of the best technical solutions for our clients.

Beverley is widely published, the recipient of several national and international awards and has filed and contributed to numerous technological patents. She serves on the boards for several water institutions, including the Water Research Foundation.

ABSTRACT: Water and wastewater treatment has traditionally focussed on protecting human health by providing functional treatment systems based on standard cost benefit decision making. Given what we know today about our environment, and the profound impact that today's decisions have on the future, our social responsibilities are driving the water industry in a new direction, with a goal of improving the health of our communities. Creating a sustainable legacy requires emerging technologies to advance, and to be implemented by innovative utilities that recognize their environmental and social role in the community. This presentation will highlight global environmental challenges, the progress we've made towards community improvement, and discuss some of the utilities that have shown a commitment to driving technology forward.

Tuesday 29 March

LET 2022 | Plenary Sessions

Room: Nugget 1 Ballroom

14:00 - 14:45

RESHAPING WATER THROUGH DISRUPTIVE INNOVATION

Steve Kloos, *True North Venture Partners, United States*

Steve Kloos is a Partner with True North Venture Partners and is CEO of their portfolio company AquaHydrex. He was the founding board chair of Current, a Chicago-based water non-profit, is an ImagineH_2O Advisory Board member, and advised Singapore on advancing the water sector.

Steve held leadership roles at General Electric, including as Advanced Technology Leader for GE Water, as a member of GE's venture capital team, founding GE's Singapore Water Technology Centre and leading GE's water R&D team in Shanghai. Steve started at Osmonics doing membrane R&D and has a PhD in Chemistry from North Dakota State University.

ABSTRACT: The water industry is slowly changing to provide better overall treatment and to be more efficient and equitable. But because of climate change and the need to achieve Net Zero, water needs to be reshaped more radically and on an accelerated timeline.

Disruptive Innovation is a term that's frequently used but not well understood, and in practice disruptive innovation is very hard whereas incremental innovation is typically how progress is made.

This talk will discuss the roots of disruptive innovation and the dilemma of incumbents who want to radically change but find it difficult to do so. It will break down why disruptive innovation is so hard and will give a framework for innovators of all types to drive towards the radical changes that we need in the sector. Steve will give some examples of his experience driving radical changes and he'll share views of megatrends that demand disruptive change.

14:45 - 15:15

Coffee Break *(Nugget 2 Ballroom)*

15:15 - 16:00

TECHNOLOGY AND LEADERSHIP: INSPIRING OPTIMISM

Rick Warner, *Warner & Associates, United States*

Rick Warner, President of Warner and Associates, helps communities solve complex water challenges. Rick has served in U.S. national water leadership positions as an enthusiastic water leader, including the Water Environment Federation president and Water Research Foundation director. Mr. Warner's expertise focuses on policy development, strategic planning, and program management. Mr. Warner received B.S. and M.S. degrees in civil engineering from the University of Nevada, Reno, and is the recipient of the James G. Scrugham Medal, recognizing distinguished alumni of the College of Engineering. Rick is also a recipient of the National Advocacy Achievement Award from the WateReuse Association.

ABSTRACT: WTechnical water scarcity and security challenges in the arid southwestern United States drive leading-edge advanced treatment technology developments and pioneering operational methods. Technological advances enable communities to achieve visionary water management initiatives, including advanced potable reuse programs and climate resiliency strategies. However, implementing an innovative water solution is often an extensive journey navigated through formidable technical and social challenges. By necessity and desire, water agencies are increasingly bringing value to society at a critical time, offering enriching stakeholder engagements reflecting the local cultures, norms, and equitably maximizing the resultant economic and social welfare without compromising the sustainability of vital ecosystems. The intersection of leading-edge treatment technologies and community-based program implementation strategies offers optimism for a sustainable and resilient water future.

Tuesday 29 March

LET 2022 | Plenary Sessions

Room: Nugget 1 Ballroom	
16:00 - 16:45	**RESTORING DRINKING WATER SUPPLY IN ORANGE COUNTY, CALIFORNIA: IMPACT OF PFAS AND INSPIRATION FOR CURRENT RESEARCH PROGRAM AT THE ORANGE COUNTY WATER DISTRICT** **Megan Plumlee**, *OCWD, United States*  Dr. Megan Plumlee is the Director of Research and Development (R&D) for the Orange County Water District (OCWD), where she oversees a team of scientists and engineers who conduct applied research that supports the District's core operational needs. The R&D Department evaluates promising new technologies to improve water quality and increase the efficiency of OCWD's recycled water treatment and groundwater recharge operations. Megan's current work includes oversight of OCWD's PFAS pilot study, which is testing various treatment options for removing PFAS from groundwater to restore local drinking water supply. **ABSTRACT:** The Orange County Water District (OCWD) is a groundwater wholesaler serving 19 major retail water agencies or City water departments in north and central Orange County in Southern California. OCWD manages the 350-square-mile local groundwater aquifer that is a key drinking water resource for more than 2.5 million residents. OCWD replenishes the aquifer via managed aquifer recharge (MAR). Per- and polyfluoroalkyl substances (PFAS) have been detected in the groundwater system at certain locations. While sources are under investigation, PFAS may be introduced to groundwater via the Santa Ana River (SAR) whose flows infiltrate into the aquifer during MAR operations. PFAS inputs to the SAR include treated wastewater discharges and stormwater runoff. This presentation will provide an overview of OCWD's PFAS treatment study that supported ongoing design and construction of 35 treatment facilities to restore the local drinking water supply, as well as other studies featured in the current PFAS research program at OCWD.
16:45 - 17:00	**OPEN DISCUSSION**

Photo courtesy of Reno Tourism Department

Wednesday 30 March

LET 2022 | Morning | Technical Sessions

	Room: Cascade 1	Room: Cascade 3
	DRINKING WATER TRACK / SESSION 1 **EMERGING TECHNOLOGIES FOR DIGITAL WATER** Co-chairs: **Chris Dermody, Sunil Sinha**	**WASTEWATER TRACK / SESSION 2** **EMERGING TECHNOLOGIES THE ENABLE HIGH EFFLUENT QUALITY AND RESOURCE RECOVERY** Co-chairs: **Ana Soares, Beverley Stinson**
9:00 - 9:30	**Keynote (1)** Pure Water San Diego's implementation of a digital twin to improve system understanding and support commissioning **Tyler Nading,** *Jacobs (United States)*	**Keynote (1)** State-of-the-art granular sludge technology **Mari Winkler,** *University of Washington (United States)*
9:30 - 9:45	Development of an intelligent system at sewershed scale with big data management and Artificial Intelligence application **Kenneth Thompson,** *Jacobs (United States)*	Application of partial nitrification, denitrification — anaerobic ammonia oxidation for nitrogen removal at WRRFs **Wendell Khunjar,** *Hazen and Sawyer (United States)*
9:45 - 10:00	A dive into Machine Learning in the water industry **Derya Dursun,** *Hazen & Sawyer (United States)*	A novel photo-biorefinery concept based on purple phototrophic bacteria for mixed urban bio-waste treatment **Patricia Zamora,** *FCC AQUALIA (Spain)*
10:00 - 10:30	**Discussions**	
10:30 - 11:00	**Coffee Break** *(Nugget 2 Ballroom)*	
11:00 - 11:30	**Keynote (2)** Findings from National Science Foundation Engineering Research Center planning grant for development of Smart One Water **Sunil Sinha,** *Virginia Tech (United States)*	**Keynote (2)** State-of-the-art on resource recovery from municipal wastewater **Ana Soares,** *Cranfield University (United Kingdom)*
11:30 - 11:45	Third party validation of Artificial Intelligence for water reuse **Elise Moore,** *Carollo Engineers, Inc.* and **Eva Steinle-Darling,** *Carollo Engineers, Inc. (United States)*	Using a novel anaerobic technology to treat hydrothermal liquefaction aqueous by-product **Xavier Fonoll Almansa,** *Great Lakes Water Authority (United States)*
11:45 - 12:00		Incorporating anammox into SND and EBPR process for efficient nutrient removal of low-strength municipal wastewater **Helen Littleton,** *LX Environmental LLC (United States)*
12:00 - 12:30	**Discussions**	
		Poster Pitch Session 2
12:30 - 12:35		Mainstream anaerobic technologies for carbon redirection and nitrogen removal from wastewater **Carolyn Coffey,** *Colorado School of Mines (United States)*
12:35 - 12:40		Mainstream anammox in action! Implementation of full-scale Partial Denitrification-Anammox (PdNA) **Stephanie Klaus,** *Hampton Roads Sanitation District (United States)*
12:40 - 12:45		Intensive microalgal cultivation for phosphorus and nitrogen removal from wastewaters **Hannah Molitor,** *University of Illinois at Urbana-Champaign (United States)*
12:45 - 14:00	**Lunch** *(Nugget 2 Ballroom)*	

Wednesday 30 March

LET 2022 | Afternoon | Technical Sessions

	Room: Cascade 1	Room: Cascade 3
	DRINKING WATER TRACK / SESSION 3 **POTABLE WATER REUSE AND ALTERNATIVE TREATMENT TECHNOLOGIES** Co-chairs: **Jörg Drewes**	**WASTEWATER TRACK / SESSION 4** **EMERGING CONTAMINANTS: MICROPLASTICS, PHARMACEUTICALS AND PERSONAL CARE PRODUCT (PPCP) AND ANTIBIOTIC RESISTANCE** Co-chairs: **Bruce Rittmann, Shaily Mahendra**
14:00 - 14:30	**Keynote (1)** Strategies for cost-effective potable reuse project implementation **Vijay Sundaram,** *AECOM (United States)*	**Keynote (1)** Developing a holistic approach to monitor ARG and ARB in the effluent of an ultrafiltration membrane **Laura Orschler,** *Technical University of Darmstadt (Germany)*
14:30 - 14:45	Digging deeper: uncovering the makeup of pathogen removal mechanisms in membrane bioreactors **Larry Morris,** *Kubota Membrane (United States)*	Removal of a C16-alkyl quaternary ammonium compound via microbial peroxide production cell and UV-light **Yen Jung Sean Lai,** *Biodesign Swette Center for Environmental Biotechnology (United States)*
14:45 - 15:00	Reverse osmosis with flow reversal (FR-RO) to minimise concentrate discharge in drinking water treatment **Nico Wolthek,** *Vitens (The Netherlands)*	Effects of non-antibiotic and antibiotic co-exposure on the development of antibiotic resistance in *E. Coli* Populations **Yujie Men,** *University of California, Riverside (United States)*
15:00 - 15:30	**Discussions**	
15:30 - 16:00	**Coffee Break** *(Nugget 2 Ballroom)*	
16:00 - 16:30	**Keynote (2)** Free two birds with one key: coupling biological iron and nitrate removal in anoxic groundwater filters **Francesc Corbera Rubio,** *TU Delft (The Netherlands)*	**Keynote (2)** Supercritical water oxidation for on-site biosolids and emerging contaminants elimination **Marc Deshusses,** *Duke University (United States)*
16:30 - 16:45	Comparison of oxidants used in advanced oxidation processes with non-target analysis and bioassays **Mingrui Song,** *University of Nevada, Reno (United States)*	Optimization of pilot-scale membrane processes hybridized with inline dosed powdered activated carbon Or pre-ozonation **Christoph Schwaller,** *Technical University of Munich (Germany)*
16:45 - 17:00	Pilot testing for validation of log removal credit for reverse osmosis and nanofiltration membranes **Hannah Ray,** *Southern Nevada Water Authority (United States)*	Treatment train technology for emerging contaminants in water systems and corresponding microbial ecology **Shaily Mahendra,** *University of California, Los Angeles (United States)*
17:00 - 17:30	**Discussions**	
	Poster Pitch Session 3	**Poster Pitch Session 4**
17:30 - 17:35	SWIFT's successful operation of an ozone-biofiltration potable reuse scheme **Tyler Nading,** *Jacobs and* **Germano Salazar-Benites,** *HRSD (United States)*	Mechanistic elucidation and technology advancement toward the complete destruction of per- and polyfluoroalkyl substance **Jinyong Liu,** *University of California, Riverside (United States)*
17:35 - 17:40	Explaining new treatment trains. Why building trust in new treatment systems is critical for public acceptance **Mark Millan,** *Data Instincts (United States)*	Inductively regenerable magnetic activated carbon for removal and degradation of organic micropollutants from wastewater **Caleb Inskeep,** *University of Stuttgart (Germany)*
17:40 - 17:45	Enhancing 1,4-dioxane removal through co-metabolic biofiltration in advanced water treatment systems for potable reuse **Hannah Stohr,** *Hampton Roads Sanitation District (United Kingdom)*	Degradation of oseltamivir (tamiflu) in uv photolysis and UV|H_2O_2 reactions: performance, kinetics, and mechanism **Kyung-Duk,** *Seoul National University ((Republic of Korea)*

Thursday 31 March

LET 2022 | Morning | Technical Sessions

	Room: Cascade 1	Room: Cascade 3
	DRINKING WATER TRACK / SESSION 5 **ADAPTING WATER SUPPLY SYSTEMS FOR CLIMATE RESILIENCE** Co-chairs: **Pete Vale, Jeff Yarne**	**WASTEWATER TRACK / SESSION 6** **WASTEWATER BASED EPIDEMIOLOGY** Co-chairs: **Daniel Gerrity, Joan Rose**
9:00 - 9:30	**Keynote (1)** Technology adaptation for resilient and sustainable water **Shane Snyder,** *Nanyang Technological University (United States)*	**Keynote (1)** SARS-CoV-2 wastewater surveillance enables apportionment of infection burden and guided public health response(s) **Francis Hassard,** *Cranfield University (United Kingdom)*
9:30 - 9:45	Decentralised drinking water production from rain water — a case study on household level **Evelyn de Meyer,** *De Watergroep (Belgium)*	Outbreak detection through sewer network monitoring in wastewater based epidemiology **Laura Haak,** *University of Nevada, Reno (United States)*
9:45 - 10:00	Innovative One Water solutions for a sustainable water supply **Alex Waite,** *City of Santa Monica (United States)*	Long-term surveillance of wastewater SARS-CoV-2 in Los Angeles county **Phillip Wang,** *University of Southern California (United States)*
10:00 - 10:30	**Discussions**	
10:30 - 11:00	**Coffee Break** *(Nugget 2 Ballroom)*	
11:00 - 11:30	**Keynote (2)** Is your infrastructure ready for climate? A recent example, the NY REDI program **Jennifer Olivo,** *Ramboll (United States)*	**Keynote (2)** COVIDPoops19 analysis: equity and lessons learned **Colleen Naughton,** *University of California Merced (United States)*
11:30 - 11:45	Hybrid feed-forward and feed-back algorithm for automated control of coagulation in drinking water **Arthur Fayolas,** *Suez (France)*	Clinical testing underestimates COVID-19 incidence and variant prevalence: insights from WBE in Southern Nevada **Daniel Gerrity,** *Southern Nevada Water Authority (United States)*
11:45 - 12:00	WaterArchitect — an efficient modelling tool towards a more optimal decentralized water management **Louise Vanysacker,** *De Watergroep (Belgium)*	Monitoring the temporal dynamics of SARS-CoV-2 VOC B.1.1.7 in Germany with genome sequencing **Laura Orschler,** *Technical University of Darmstadt (Germany)*
12:00 - 12:30	**Discussions**	
	Poster Pitch Session 5	**Poster Pitch Session 6**
12:30 - 12:35	Climate resilience water supply systems in the coastal areas of Bangladesh **Toriqul Islam,** *NGO Forum for Public Health (Bangladesh)*	Estimating relative abundance of SARS-CoV-2 variants through wastewater surveillance using digital PCR assays targeting **Alexandria Boehm,** *Stanford University (United States)*
12:35 - 12:40		Bacterial pathogens and antimicrobial resistance genes identified via wastewater-based epidemiology in Harare, Zimbabwe **Nicolette Zhou,** *University of Washington (United States)*
12:45 - 14:00	**Lunch** *(Nugget 2 Ballroom)*	

Thursday 31 March

LET 2022 | Afternoon | Technical Sessions

	Room: Cascade 1	Room: Cascade 3
	DRINKING WATER TRACK / SESSION 7 **SUSTAINABLE DESALINATION** Co-chairs: **Jonathan Clement, Nikolay Voutchkov**	**WASTEWATER TRACK / SESSION 8** **TREATMENT OF COMPLEX AND HIGH STRENGTH WASTEWATER** Co-chairs: **Ana Soares, Marc Deshusses**
14:00 - 14:30	**Keynote (1)** Addressing complex seawater pre-treatment with ceramic membrane filtration **Jonathan Pressdee,** *Nanostone (United States)*	**Keynote (1)** AnMBR for global sanitation: The NEWgenerator™ for off-grid wastewater treatment in India and South Africa **Daniel H. Yeh,** *University of South Florida (United States)*
14:30 - 14:45	Optimization of UVC-LED pre-treatment embedded in spiral-wound elements for biofouling control in membrane desalination **Philipp Sperle,** *Technical University of Munich (Germany)*	Cost savings through nitritation of high strength ammonia sidestream liquors with novel biocatalysts **Felipe Munoz,** *Microvi Biotech Inc. (United States)*
14:45 - 15:00	Nanowood materials for sustainable desalination and resource recovery **Zhiyong Ren,** *Princeton University (United States)*	Design, performance and cost of faecal sludge and septage treatment plants in Odisha State, India **Prasanta Kumar,** *Odisha Water Supply and Sewerage Board (India)*
15:00 - 15:30	**Discussions**	
15:30 - 16:00	**Coffee Break** *(Nugget 2 Ballroom)*	
16:00 - 16:30	**Keynote (2)** Recovery of valuable minerals from desalination brines **Nikolay Voutchkov,** *Water Globe Consultants (United States)*	**Keynote (2)** Design of a small-footprint wastewater treatment and energy recovery process for biorefineries **Yalin Li,** *University of Illinois at Urbana-Champaign (United States)*
16:30 - 16:45	Ultra high-pressure reverse osmosis membranes for the lowest cost and energy approach to achieve minimum liquid discharge **Jishan Wu,** *UCLA (United States)*	Extreme sulfide concentrations in a sulfate reducing bioreactor select for sulfide tolerant sulfate reducing bacteria **Korneel Rabaey,** *Ghent University (Belgium)*
16:45 - 17:00	Implementation of circular economy and energy efficiency in seawater desalination by integrating brine treatment technoly **Rodoula Ktori,** *TU Delft (The Netherlands)*	Biodegradation of insensitive munition explosive formulations: IMX-101 and IMX-104 using aerobic granular sludge **Nathaniel Stein,** *University of Utah (United States)*
17:00 - 17:30	**Discussions**	
	Poster Pitch Session 7	**Poster Pitch Session 8**
17:30 - 17:35		Filtering the unfilterable: the application of graphene oxide coating technology in the toughest of applications **Tom Williams,** *Enebio (United Kingdom)*
17:35 - 17:40		Causes of souring during food waste and fats|oils|grease anaerobic co-digestion with municipal sludge **Michelle Young,** *Arizona State University (United States)*
17:40 - 17:45		Causes of souring during food waste and fats|oils|grease anaerobic co-digestion with municipal sludge **Michelle Young,** *Arizona State University (United States)*
17:45 - 18:00	**Closing Ceremony** *(Cascade 3)*	
19:00	**Gala Dinner** *(Nugget 1 Ballroom) (Sponsored by Ramboll)*	

Friday 1 April

LET 2022 | Technical Tours

TECHNICAL TOUR OF TRUCKEE MEADOWS WATER AUTHORITY'S WATER SUPPLY SYSTEM – FROM LAKE TAHOE TO CHALK BLUFF WATER TREATMENT PLANT

Starting at crystal-clear Lake Tahoe and the headwaters of the Truckee River, the "Tahoe to the Tap" tour will take participants on a trip that outlines the challenges and opportunities of operating in one of America's most scenic watersheds. From Tahoe's outlet we will travel downstream and stop at Donner Lake to discuss innovations in river operation and storage; then we will move on to the century-old Verdi Hydroelectric Plant where we'll break for lunch in a parklike setting on the bank of the Truckee River. Next, participants will tour the award-winning Chalk Bluff Water Treatment plant where we will discuss how our region's increasingly collaborative and comprehensive approach to water-resource management not only responds to the challenges of growth and climate change, but actively works to mitigate them.

09:00	Travel to Lake Tahoe
10:00	Tahoe Headwater Presentation
10:30	Travel to Donner Lake
11:00	Reservoir Management Presentation
11:30	Travel to the Verdi Hydroelectric Plant
12:00	Lunch and Hydroelectric Presentation
12:45	Travel to the Chalk Bluff Treatment Plant
13:00	Tour of Drinking Water Treatment Plant
13:45	Travel back to the Hotel

TECHNICAL TOUR OF TRUCKEE MEADOWS WATER RECLAMATION FACILITY

The Truckee Meadows Water Reclamation Facility (TMWRF) treats approximately 120,000 m^3/day wastewater servicing the cities of Reno, Sparks, and portions of Washoe County, Nevada, USA. TMWRF is a tertiary treatment plant that employs enhanced biological phosphorus removal through an anaerobic/oxic activated sludge configuration, tertiary nitrification through trickling filters, and denitrification through fluidized bed reactors. The treatment train includes polishing treatment of dual medial filters and sodium hypochlorite disinfection. In order to discharge into the Truckee River, TMWRF produces an effluent with incredibly low nutrient concentrations with total nitrogen averaging less than 2 mg/L and a TDS concentration less than 500 mg/L. Solids handling includes an acid/gas digestion process with centrifuge dewatering and a digester biogas conditioning treatment train that feeds a 1 MW cogeneration engine. Currently, a pilot scale aerobic granular sludge process is being operated for research of future treatment options for the facility.

The delegates on this tour will be able to visit the facility with the plant staff and management over a "brown bag" lunch and discussion after touring the facility.

09:00	Travel to Treatment Plant
11:30	Tour Wrap up and Lunch
12:20	Travel back to the Hotel

BOOK YOUR TOUR!

Please visit the Technical Tour desk to secure your spot if you haven't already done so online.

Price: $ 20

Photo courtesy of Reno Tourism Department

Presentations

LET 2022 | Abstracts

Session 1. Emerging technologies for digital water

PURE WATER SAN DIEGO'S IMPLEMENTATION OF A DIGITAL TWIN TO IMPROVE SYSTEM UNDERSTANDING AND SUPPORT COMMISSIONING

The City of San Diego's new 34 mgd advanced water treatment plant, the Pure Water Facility (PWF), is currently in construction and will be a large scale indirect potable reuse system. The project includes several complex components that were initially identified as system risks. A digital twin was used during the design phase that accurately represents system hydraulics and controls in order to: * Understand how flows will be managed through the PWF to achieve a consistent flow to reverse osmosis. * Develop an equalization strategy at the Water Reclamation Plant that provides consistent flow to the PWF and manages existing non-potable demands. * Reduce overall system risk by making informed decisions on future system operation. * Support start-up and commissioning of over one billion dollars of infrastructure. The application of digital twins provides meaningful value for complex systems. This presentation will highlight how the digital twin brought value to the Pure Water project.

Tyler Nading, *United States (tyler.nading@jacobs.com)*

DEVELOPMENT OF AN INTELLIGENT SYSTEM AT SEWERSHED SCALE WITH BIG DATA MANAGEMENT AND ARTIFICIAL INTELLIGENCE APPLICATION

Aging infrastructure, increasing frequency and intensity of extreme events due to climate change, and increasing population demand have induced various stresses on wastewater and stormwater infrastructure. This has led to frequent cases of Combined and Sanitary Sewer Overflows (CSOs and SSOs), among other issues. This has exacerbated the impact of sewershed on the society and environment. With the advent of efficient sensory technologies, higher computational capabilities of processors and development of advanced mathematical modeling techniques, it has become possible to create intelligent versions of sewersheds in the US. This study will propose a framework to enable implementation of Intelligent Sewersheds for water utilities in the US. The study is based on improving current understanding of system, data, model, decision and service centric aspects to enable a smarter approach to sewershed management.

Kenneth Thompson, *United States (ken.thompson1@jacobs.com)*
Dadiala, Rhea; Vishwakarma, Anmol; Sinha, Sunil; Dermody, Chris

A DIVE INTO MACHINE LEARNING IN THE WATER INDUSTRY

The water industry is beginning to recognize and apply machine learning (ML) as a tool to optimize system operations in a way that was not possible even a few years ago. This is primarily due to advances in online instrumentation, data management and loud computing. Accordingly, five applications of ML in the water industry will be presented to illustrate the power of these tools: influent flow prediction, sewer pipe deterioration, RO membrane optimization, sensor data cleaning, and predicting dewaterability. Additionally, each of these ML models provided operational staff with additional insight into their operations that could not be generated through other means (i.e., mechanistic models) as easily or as quickly.

Derya Dursun, *United States (ddursun@hazenandsawyer.com)*
Bilyk, Katya; Dunn-Reier, Malia; Blate, Micah; Roostaei, Javad

FINDINGS FROM NATIONAL SCIENCE FOUNDATION ENGINEERING RESEARCH CENTER PLANNING GRANT FOR DEVELOPMENT OF SMART ONE WATER

Collaborative planning efforts for a proposed Smart One Water Cyber-Physical-Social infrastructure

NSF-ERC have identified opportunities to transform the way people interact with smart water services, and to advance national-scale cyberinfrastructure for adaptive and intelligent management of engineered and natural water systems driven by societal needs for resilience, sustainability, and social justice. Adequate and clean water is necessary for human health and well-being, as well as for supporting ecosystems and the prosperity of water dependent economic sectors (e.g., agriculture, energy generation). As emphasized by the U.S. National Academy of Engineering, access to clean water is one of the 14 Grand Challenges facing engineers in the 21st Century.

Water supplies in the U.S. and around the world are facing new threats, and advanced technologies can help to manage and mitigate these threats. However, there is no national program that integrates the management of natural water systems along with built and socio-economic systems. This paper describes a major national initiative to converge disciplines around the challenges in water systems.

Sunil Sinha, *United States (ssinha@vt.edu)*
Dzombak, David; Gardoni, Paolo; Babbar-Sebens, Meghna

THIRD PARTY VALIDATION OF ARTIFICIAL INTELLIGENCE FOR WATER REUSE

Data-driven, efficient operation is needed to save cost and energy in the water industry, especially in the rapidly expanding reuse sector. A partnership between Yokogawa Electric Corporation and Carollo Engineers—with independent evaluation through the National Water Research Institute and extensive support from utility partners—has been conducting desktop simulations of artificial intelligence (AI) solutions for the Las Virgenes — Triunfo Joint Powers Authority for two years in both activated sludge and subsequent advanced treatment for reuse. Now, this interdisciplinary team is implementing a cloud-based, semi-autonomous, human-machine interface to implement AI solutions at full-scale in real-time. Demonstrated efficiency gains, operator experience, and lessons learned will be presented.

Elise Moore and **Eva Steinle-Darling,** *United States (emoore@carollo.com) (esd@carollo.com)*
Thompson, Kyle; Salveson, Andrew; Matsui, Yasuhiro; Kawata, Mika; Hardy, Kevin; Johnson, Darrell; Branch, Amos; Assouline, Jason

Session 2. Emerging technologies the enable high effluent quality and resource recovery

STATE OF THE ART OF GRANULAR SLUDGE TECHNOLOGY

This talk highlights the integration of the AGS technology in existing wastewater infrastructure. We reported for the first time that granules are commonly present at full-scale continuous flow systems with low SVI, and granule growth may be associated with operational factors favoring PAO/GAO growth. AGS consists of variable granule sizes and this talk will show that granule sizes strongly impact nitrification, nitrogen removal as well as N_2O production rates at different operational DO. Moreover, a proof-of-concept for phosphorus recovery from aquaculture waste was tested by utilizing the high thickening properties of AGS. We also demonstrated two full-scale applications of a novel biocarrier technology for intensifying a continuous flow plant using kenafs as carrier material to facilitate biofilm attachment. Furthermore, the talk will highlight the intensification of nitrogen removal from urine and real wastewater with hydrogel immobilized mixed communities of AOB/anammox and pure culture of comammox.

Mari Winkler, *United States (mwinkler@uw.edu)*

APPLICATION OF PARTIAL NITRIFICATION, DENITRIFICATION-ANAEROBIC AMMONIA OXIDATION FOR NITROGEN REMOVAL AT WRRFS

In this work, we demonstrate that mainstream deammonification can be achieved using partial nitrification, denitrification, and anaerobic ammonia oxidation. Effective nitrogen removal was achieved in three configurations i) step feed mainstream biological nutrient removal (BNR), ii) tertiary biofiltration downstream of mainstream BNR activated sludge and, iii) tertiary moving bed bioreactors downstream of mainstream BNR activated sludge. Supplemental carbon savings ranging from 30 to 50% were observed while also achieving total nitrogen concentrations less than 3 mg/L.

Wendell Khunjar, *United States (wkhunjar@hazenandsawyer.com)*
Sun, Yewei; Pace, Greg; Young, Anthony; McGrath, Michael; Ali, Mujahid; Chitrakar, Sajana; Marcos, Remon; Wang, Jiefu; Wang, Zhiwu; De Los Reyes, Francis; Azziz, Tarek

A NOVEL PHOTO-BIOREFINERY CONCEPT BASED ON PURPLE PHOTOTROPHIC BACTERIA FOR MIXED URBAN BIO-WASTE TREATMENT

Effective resource recovery remains as one of the biggest challenges to be addressed nowadays in wastewater management systems. Conventional wastewater treatment concepts still suffer from high energy demand whilst dissipating valuable components to be potentially recovered to produce bio-based products and materials. The rationale of DEEP PURPLE rely on a disruptive and low-cost urban bio-waste streams treatment based on the concept of purple phototrophic bacteria (PPB) photo-biorefinery. The largest photo-bioreactor built so far is located at the wastewater treatment plant Estiviel (Toledo, Spain), and has shown promising results treating domestic wastewater: nitrogen and phosphorus removal (up to 60%), and COD and TSS removal close to 90% in a single-step process, thereby avoiding the dissipation of both carbon and nutrients. Next steps involve: (i) the scale-up of the process to demonstrative plant (TRL 7) and (ii) the demonstration of the feasibility of the simultaneous treatment of domestic wastewater with another organic feedstock, i.e., the liquid stream resulting from the thermal hydrolysis of the organic fraction of municipal solid waste (OFMSW).

Patricia Zamora, *Spain (patricia.zamora@fcc.es)*
Marin, Eugenio; Díaz-Allegue, Luis; Martínez, Fernando; Melero, Juan Antonio; Puyol, Daniel; Rogalla, Frank; Victor, Monsalvo

STATE OF THE ART RESOURCE RECOVERY

For the last decades we have been developing a wide range of technologies to move “wastewater treatment” facilities to the “new” resource recovery and water recycling centres. We have been very prolific and found ways to recover/ produce a very wide range of products and commodities from wastewater including water, cellulose, hydrogen, ammonium sulphate, struvite fatty acids, bioplastics, biopolymers, calcium phosphate, protein, etc. the list is incredibly extensive! The level of development around resource recovery is equally varied with most at low technology readiness level (TRL) but a few are reaching demonstration scale. Nevertheless, implementation at full scale is still extremely limited and in need of a great boost. A key barrier for rapid uptake is to accurately quantify benefits in a holistic approach, to release investment or government support. The next generation of technologies will be hugely influenced by the need to reduce carbon emissions combined with compliance with rigorous regulations whilst adapting to local needs.

Ana Soares, *United Kingdom (a.soares@cranfield.ac.uk)*

USING A NOVEL ANAEROBIC TECHNOLOGY TO TREAT HYDROTHERMAL LIQUEFACTION AQUEOUS BY-PRODUCT

Hydrothermal liquefaction has the potential to improve resource recovery at WRRFs but the production of toxic aqueous by-product (HTL-AB) is hampering implementation. Here we have evaluated the use of a novel Recirculating Anaerobic Dynamic Membrane Bioreactor (RAnDMBR) to treat HTL-AB. The RAnDMBR could easily be operated under stable conditions, being able to remove 70% of the COD and a big part of the soluble compounds present in HTL-AB.

Xavier Fonoll Almansa, *United States (xavier.fonoll-almansa@glwater.org)*
Schmidt, Andy; Busch, Andrea; ; Thorson, Michael; Norton, John

INCORPORATING ANAMMOX INTO SND AND EBPR PROCESS FOR EFFICIENT NUTRIENT REMOVAL OF LOW-STRENGTH MUNICIPAL WASTEWATER

An anaerobic-anoxic (with micro-aeration and carriers)-anoxic-oxic operation process was designed and operated in a full-scale wastewater treatment plant in China. Efficient biological nitrogen and phosphorus removal were achieved in the bioreactor. The nitrogen and phosphorus concentrations along the process showed that multiple bioreactions, such as enhanced biological phosphorus removal, simultaneous nitrification and denitrification, anammox, and denitrifying phosphorus removal happened in the bioreactor, especially in the anoxic zone with micro-aeration and suspended carriers. Specific anammox activity was observed on the carriers in the anoxic with micro-aeration and calculated as 116 mg/L-d at 30 â"f. This work demonstrates the feasibility of incorporating anammox into SND and EBPR process for low-strength municipal wastewater treatment. This process improved nutrient removal efficiency and at the same time was easy to retrofit and maintain.

Helen Littleton, *United States (helen@lxenvironmental.com)*
He, Beiping; Qian, Liang; Daigger, Glen; Loosdrecht, Mark; Wells, George; Wang, Kaijun

Poster Pitches

MAINSTREAM ANAEROBIC TECHNOLOGIES FOR CARBON REDIRECTION AND NITROGEN REMOVAL FROM WASTEWATER

Wastewater treatment in the United States demands intense aeration, generating massive quantities of biological sludge that requires post-digestion, temporary storage, and transportation for reuse or disposal. With rising costs associated with agricultural application and landfilling sludge, water resource recovery facilities should be pursuing a shift from aerobic to anaerobic technologies to slash their sludge production. A pilot-scale anaerobic baffled reactor (ABR) at the Colorado School of Mines has continuously treated raw domestic wastewater from a student apartment complex since 2015. The ABR has demonstrated robust treatment, achieving and nearing secondary treatment standards in the US for TSS and BOD, respectively, despite seasonal temperature fluctuations and changes in wastewater composition due to a variable student resident population. By redirecting organic carbon to biogas, the ABR offers a potentially energy-positive treatment train. The ABR effluent contains 50 - 60 mg NH_3-N/L, on average. Partial-nitritation anammox, a novel biological deammonification process, was successfully applied to convert up to 90% of ammonia to nitrogen gas in a sequencing batch moving bed biofilm reactor. Minimal nitrate accumulation was observed.

Carolyn Coffey, *United States (ccoffey@mines.edu)*

MAINSTREAM ANAMMOX IN ACTION! IMPLEMENTATION OF FULL-SCALE PARTIAL DENITRIFICATION-ANAMMOX (PdNA)

Partial denitrification/anammox (PdNA) has proven to be a reliable and robust process that realizes the benefits of mainstream anammox without the need to sustain nitrite oxidizing bacteria (NOB) out-selection. Pilot-scale research has shown that PdNA is simple to control with both glycerol and methanol. Once established, anammox bacteria are easily retained and outcompete heterotrophs for nitrite. Startup of PdNA processes on plastic biofilm carriers and silica sand can be accomplished in 2-3 months in mainstream conditions without anammox biomass inoculation. The most crucial aspect of successful PdNA once anammox is established is careful control of the influent ammonia/NOx (AvN) ratio via upstream aeration control. Success at pilot scale has led to full-scale implementation of PdNA in deep-bed filters where the benefits of chemical, energy, and capacity savings have been realized. Full-scale demonstration testing for full-scale IFAS PdNA is in construction, and full-scale design of IFAS and MBBR PdNA processes are underway.

Stephanie Klaus, *United States (sklaus@hrsd.com)*
Bachmann, Megan; Fofana Rahil; Parsons Mike; De Clippeleir, Haydee; Bott, Charles

INTENSIVE MICROALGAL CULTIVATION FOR PHOSPHORUS AND NITROGEN REMOVAL FROM WASTEWATERS

Mixed community microalgal wastewater treatment technologies may recover wastewater nutrients and achieve effluent nutrient concentrations below the current limit of technology while producing biomass for biofuels and bioproducts. Greater understanding of the microbial communities and treatment processes is required to optimize system design and control to realize financially and environmentally sustainable commercialized technologies. Specifically, algal treatment technologies need to achieve high areal productivities, favorable biomass composition, and target effluent nutrient concentrations. As of Fall 2020, a 0.15 MGD CLEARAS EcoRecover microalgal treatment system has been integrated into the wastewater treatment train for phosphorus and nitrogen recovery, at Roberts, Wisconsin, to address their pending 0.04 mg L-1 total phosphorus effluent permit. Long-term characterization through continuous performance monitoring is ongoing and will be supplemented with three seasonal, month-long intensive sampling periods to study day-to-day and diel variations.

Hannah Molitor, *United States (hmolitor@illinois.edu)*
Kim, Ga-Yeong; Avila, Nickolas; Guest, Jeremy

Session 3. Potable Water Reuse and Alternative Treatment Technologies

STRATEGIES FOR COST-EFFECTIVE POTABLE REUSE PROJECT IMPLEMENTATION

Potable reuse is becoming an attractive option in building drought resiliency and achieving long-term water sustainability. The water industry has shown excellent progress in developing advanced water treatment (AWT) technology. However, assessment of intangible community benefits, and balancing safety, reliability, and cost-effectiveness of the project are critical elements for successful project implementation. Case studies from California, Nevada, Virginia, and the Caribbean involving membrane-based and carbon-based advanced water treatment solutions will be presented. Strategies and success factors developed from various case studies and to be discussed in the presentation include development and optimization of advanced water treatment (AWT) technologies for potable reuse, assessment of intangible community benefits, and balancing safety, reliability, and cost-effectiveness during potable water reuse project implementation. Additionally, the elements of potable reuse from a water operator's perspective will be highlighted. Potable water reuse is the highest and best use of highly treated municipal wastewater effluent. Protecting public health is the foremost goal of a potable reuse project. Within the context of public health protection, pathogen control is most important because of the potential acute risks from infections, followed by drinking water contaminants and the contaminants of emerging concern (CECs). Successfully implemented potable water reuse projects have shown that membrane or reverse osmosis (RO) based AWT train and Ozone/BAF or carbon-based AWT train are suitable candidates. The selection of AWT train will be based on project location (i.e., coastal vs inland), which has the highest impact on the project lifecycle cost. This presentation will provide an opportunity for the stakeholders to learn about the performance, and track record of non-RO or carbon-based advanced treatment in achieving cost-effective potable reuse. Real-world examples involving cooperative and collaborative partnerships between water users, water purveyors, regulators, academia, design professionals, and other stakeholders will be presented. Implementation strategies developed from other case studies including one of the first surface water augmentation projects in California, one of the largest carbon-based groundwater recharge programs, and the first groundwater recharge project in the Caribbean region will be presented.

Vijay Sundaram, *United States (vijay.sundaram@aecom.com)*

DIGGING DEEPER: UNCOVERING THE MAKEUP OF PATHOGEN REMOVAL MECHANISMS IN MEMBRANE BIOREACTORS

This study distinguishes between participating virus removal mechanisms in membrane bioreactors including adsorption to sludge and membrane plus biofilm removal utilizing male specific and somatic coliphages as surrogate microorganisms for human enteric viruses. It was shown that overtime, coliphage adsorption seemingly plateaus after several of hours while biofilm contribution can vary, possibly due to environmental factors. These data will also be compared to an existing pathogen removal data set from a year-long survey of a full-scale Kubota MBR to verify the impact of the contributing mechanisms to actual virus removal upon scale up.

Larry Morris, *United States (larry.morris@kubota.com)*
Branch, Amos; Fontaine, Nicola; Terao, Yasushi

REVERSE OSMOSIS WITH FLOW REVERSAL (FR-RO) TO MINIMISE CONCENTRATE DISCHARGE IN DRINKING WATER TREATMENT

The main drawback of the application of reverse osmosis in drinking water treatment is the large concentrate waste stream. This is in particular not desirable at times of great drought when groundwater resources are becoming more under pressure. The aim of this research was to find the highest possible recovery and maximum switching time at a stable operation of an FR-RO pilot installation. A stable operation without any additional dosing of acid was found at a recovery of 93%. Based on the results of the pilot investigation it can be concluded that FR-RO reduces the concentrate waste stream from 1 million m^3/year to 0.3 million m^3/year. The results of the pilot plant investigation and the assessment showed that the application of FR-RO can make a contribution to the MLD approach and the Vitens mission of "Every drop of water sustainable".

Nico Wolthek, *The Netherlands (nico.wolthek@vitens.nl)*

FREE TWO BIRDS WITH ONE KEY: COUPLING BIOLOGICAL IRON AND NITRATE REMOVAL IN ANOXIC GROUNDWATER FILTERS

Aeration and rapid sand filtration (RSF) is the most common groundwater treatment for water production. Although generally effective, stricter guidelines for dinking water drive the need for better removal of Fe_2^+, as breakthrough of Fe_3^+ flocs accelerate clogging and may cause brown water at the end-of-pipe. Additionally, nitrate levels are rising in groundwaters around the world, making complete N removal of interest to protect public health. To this end, we propose a new treatment scheme using nitrate-dependent iron-oxidizing (NDFO) bacteria. A pilot-scale RSF was continuously fed with nitrate-rich anaerobic groundwater. The rapidly formed biofilm fully removed nitrate, and the simultaneous iron oxidation did not result in iron-flocs. Interestingly, the iron-to-nitrate removal ratio was three times higher than observed in physiological studies. Likely, iron adsorption on the continuously-produced biological iron-oxides further increases removal. Ultimately, this study represents the first pilot-scale proof-of-principle for efficient NDFO-driven drinking water production at realistic temperatures.

Francesc Corbera Rubio, *The Netherlands (f.corberarubio@tudelft.nl)*
Bruins, Jantinus; Dost, Simon; van Loosdrecht, Mark; Laureni, Michele; van Halem, Doris

COMPARISON OF OXIDANTS USED IN ADVANCED OXIDATION PROCESSES WITH NON-TARGET ANALYSIS AND BIOASSAYS

Ultraviolet advanced oxidation process (UV-AOP) is utilized in potable reuse facilities as the final polishing treatment to destroy organic compounds. Hydrogen peroxide (H_2O_2), free chlorine (HOCl), and monochloramine (NH_2Cl) are three commonly used or studied UV-AOP oxidants. In this study, the destruction of organic compounds was evaluated with suspect and non-target screening and the potential of the finished water to cause oxidative stress (ARE- Nrf2) after UV-AOP with three supplemental oxidants (H_2O_2, HOCl and NH_2Cl). Based on overall destruction of organic compounds, a reduced number of new byproducts, and a lack of oxidative stress induction, H_2O_2 is the most suitable oxidant tested here for potable reuse facilities.

Mingrui Song, *United States (song.mingrui@nevada.unr.edu)*

PILOT TESTING FOR VALIDATION OF LOG REMOVAL CREDIT FOR REVERSE OSMOSIS AND NANOFILTRATION MEMBRANES

Reverse osmosis (RO) and nanofiltration (NF) are widely applied and trusted membrane treatment technologies for water and wastewater treatment due to their ability to effectively remove dissolved compounds, bacteria, and viruses. As potable water reuse expands in application, RO and NF are effective processes to achieve the safe, potable water. However, RO is given a log removal value (LRV) credit of 0.5—2 if any at all, even though research has proven RO to achieve LRVs of up to 4 for viruses. Therefore, this project tested different molecular markers such as a viral surrogate, a fluorescent dye, and native wastewater compounds to demonstrate the LRVs that RO and NF can achieve to help close the LRV discrepancy gap. Even in the presence of oxidation, RO and NF demonstrated MS2 LRVs

of 5—7.8. Sulfate and uranine were determined to be the most effective molecular markers with sulfate being the most practical as it is a native wastewater compound.

Hannah Ray, *United States (hannah.ray@lvvwd.com)*
Dickenson, Eric; Riley, Stephanie; Bellona, Christopher; Seacord, Tom; Assouline, Jason

Poster Pitches

SWIFT'S SUCCESSFUL OPERATION OF AN OZONE-BIOFILTRATION POTABLE REUSE SCHEME

HRSD has been active in the potable reuse community and SWIFT is a marquee example of an operational potable reuse facility that does not use membrane treatment. The SWIFT Research Center uses an innovated and sustainable treatment process featuring ozone, biofiltration, and granular activated carbon adsorption. This presentation will summarize the operational performance and convey the challenges in operating the 1 MGD SWIFT Research Center over the past three years. The primary objectives are to: * Provide operational results for key parameters, including TOC removal and fate of many trace organics, including bromate, NDMA, 1,4-Dioxane, and PFAS. * Review the challenging obstacles that HRSD has overcome during operation of the Research Center. The SWIFT Research Center provides an opportunity for the potable reuse community to better understand the operation and implementation of alternative treatment technologies.

Tyler Nading and **Germano Salazar-Benites,** *United States (tyler.nading@jacobs.com)* and *(GSalazar@hrsd.com)*

EXPLAINING NEW TREATMENT TRAINS. WHY BUILDING TRUST IN NEW TREATMENT SYSTEMS IS CRITICAL FOR PUBLIC ACCEPTANCE

For more than twenty years Mark Millan, principal of Data Instincts (DI), a public outreach consultancy specializing in recycled water and potable reuse projects, has been deeply involved in these key communications issues. In addition to his extensive public awareness research, he's put into practice for his clients many proven methods and tactics for helping the public to understand complex treatment trains, how these processes are verified as safe, and how they benefit communities toward expanding water supply reliability for the future. Bringing the knowledge gained from a variety of research to practical application in the field has been significant in advancing our understanding of what outreach tools may work best in a specific community.

In 2014, Mark Millan formed a team of experts and were awarded the opportunity to conduct a study for WateReuse Research Foundation called, "Model Communication Plans for Increasing Awareness and Fostering Acceptance of Potable Reuse" (WRRF-13-02). Their approach was a methodical process that embraced previous theoretical research, and augmented with an extensive sequence of in-depth interviews, focus groups, and public opinion surveys.

In addition, the findings from their information-gathering activities were used to develop a communications plan and outreach tools for use in communities considering potable reuse projects. The results were further distilled into a guidance document entitled, One Glass at a Time, Helping People Understand Potable Reuse. A Flexible Communication Plan for use by Public Information Professionals (2015). This was derived from a larger study, Model Communication Plans for Increasing Awareness and Fostering Acceptance of Potable Reuse (WRF 13-02). Alexandria, VA: WateReuse Research Foundation, published in 2015.

Mark's team has explored effective terminology and language, infographics, animations, videos, and learning centers and demonstration sites that range from visual to actual equipment, as well as the taste sampling of purified recycled water itself.

Mark Millan, *United States (millan@datainstincts.com)*

ENHANCING 1,4-DIOXANE REMOVAL THROUGH CO-METABOLIC BIOFILTRATION IN ADVANCED WATER TREATMENT SYSTEMS FOR POTABLE REUSE

1,4-Dioxane has become a concerning contaminant for potable reuse operations. Considered a probable human carcinogen by the USPEA, 1,4-dioxane is likely to be regulated with the promulgation of a maximum contaminant limit. There is need for cost effective treatment technologies to remove 1,4-dioxane in both water reuse and drinking water applications. 1,4-Dioxane has been shown to biologically degrade in the presence of chemical cometabolites (Cordone et al., 2016; Lippincott, 2015). In a multiyear pilot study, propane and tetrahydrofuran, respectively, were tested as cometabolites for 1,4-dioxane removal in biologically active filtration (BAF). Both cometabolites showed substantial removal of 1,4-dioxane in BAF. The enzymes hypothesized for the initiation of 1,4-dioxane degradation were detected in the BAFs. Discussion is also included for the addition of a cometabolite to a full-scale potable reuse facility.

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Vaidya, Ramola; Salazar-Benites, Germano; Nading, Tyler; Pruden, Amy; Bott, Charles; Wilson, Chris

Session 4. Emerging Contaminants: Microplastics, Pharmaceuticals and Personal Care Product (PPCP) and Antibiotic Resistance

DEVELOPING A HOLISTIC APPROACH TO MONITOR ARG AND ARB IN THE EFFLUENT OF AN ULTRAFILTRATION MEMBRANE

Wastewater treatment plants are hotspots for antibiotic resistance -bacteria (ARB) and -genes (ARG). Therefore, various advanced treatment stages are being investigated for their ARB/ARG removal efficiency. However, most of these investigations are based on qPCR analysis of a few specific ARB/ARGs, which is not ideal for holistic evaluation of the advanced treatment stages. Therefore, in this study, we used a targeted metagenomic approach, which targets 815 ARGs, to investigate the removal efficiency of a pilot plant consisting of powdered activated carbon and ultrafiltration membrane. Also, we combined it together with regrowth experiments to assess the removal efficiency of the ultrafiltration membrane for ARBs. This study revealed that Ultrafiltration membrane could reduce at least 3-4 Log 10 gene copies per litre, but there is still a wide range of resistance genes, especially in the low concentration range. Moreover, ultrafiltration membrane effluent still consists of the microbiome, which can regrow under milieu conditions in the presence of antibiotics.

Shelesh Agrawal, *Germany (s.agrawal@iwar.tu-darmstadt.de)*
Orschler, Laura; Lackner, Susanne

REMOVAL OF A C16-ALKYL QUATERNARY AMMONIUM COMPOUND VIA MICROBIAL PEROXIDE PRODUCTION CELL AND UV-LIGHT

Quaternary ammonium compounds (QACs) are widely used as surfactants and disinfectants for human/animal healthcare, agriculture, and industry. Although QACs are aerobically biodegradable, the positive central nitrogen of QACs acting as antibiotics led to selection pressure on the microbial community. Therefore, selected microbial communities capable of degrading QACs generally have built the resistance to overcome the stresses. In order to mitigate the threat caused by antibiotic resistant bacteria, any technique for wastewater treatment capable of removing the QACs, but not leading to selection pressure will be highly desirable. H_2O_2 as a reactive chemical has been widely used for oxidization treatment. In this study, Microbial Peroxide Production Cell (MPPC) treated with QACs as contaminants led to a promising outcome—QACs decomposition within 3 hrs. No significant shift of microbial communities in the anode chamber were identified, indicating no selection pressure occurred. A MPPC could be a practical approach for QAC removal.

YenJung Sean Lai, *United States (ylai30@asu.edu)*
Young, Michelle; Meinel, Megan; Torres, Cesar; Rittmann, Bruce

EFFECTS OF NON-ANTIBIOTIC AND ANTIBIOTIC CO-EXPOSURE ON THE DEVELOPMENT OF ANTIBIOTIC RESISTANCE IN E. COLI POPULATIONS

We investigated the development of antibiotic resistance in E. coli populations exposed to antibiotics and non-antibiotic micropollutants, which could be co-occurring in many environments during water and biosolids reuse applications. We demonstrated synergistic effects of the pesticide and antibiotic co-exposure on stimulating the emergence of antibiotic resistance in the tested E. coli populations, whereas pharmaceuticals did not show such synergistic effects. We further examined the evolutionary trajectories of the co-exposed E. coli populations in terms of resistance phenotype, genetic mutations, and growth fitness and compared them to the populations exposed to the antibiotic only. Distinct genetic mutations conferring the much stronger phenotypic resistance were identified and validated. The growth fitness of the evolved resistant mutants was also examined to predict their abilities to survive and thrive in changing environments.

Yujie Men, *United States (ymen@engr.ucr.edu)*
Xing, Yue; Kang, Xiaoxi; Zheng, Chujing

SUPERCRITICAL WATER OXIDATION FOR ON-SITE BIOSOLIDS AND EMERGING CONTAMINANTS ELIMINATION

Supercritical Water Oxidation (SCWO) is a transformative treatment that utilizes the unique properties of water above its critical point (374 °C and 218 atm). At these conditions, in the presence of oxygen, all organic molecules are rapidly oxidized to inorganic species. Emerging contaminants are effectively treated. For example, SCWO breaks the carbon-fluorine bonds within PFAS molecules resulting in full mineralization of organofluorine to inorganic fluoride. We have investigated SCWO at different scales, using a continuous pilot that can handle 1 ton of waste per day for treatability studies (e.g., for biosolids, landfill leachate, PFAS, etc.) as well as a bench-scale SCWO apparatus for kinetic studies. Systems are being commercialized through a spinoff company (374Water). In this presentation, the state of the art of SCWO, possibilities and limits will be presented and discussed.

Marc Deshusses, *United States (marc.deshusses@duke.edu)*

OPTIMIZATION OF PILOT-SCALE MEMBRANE PROCESSES HYBRIDIZED WITH INLINE DOSED POWDERED ACTIVATED CARBON OR PRE-OZONATION

Membrane ultrafiltration (UF) combined with inline dosing of powdered activated carbon (PAC) or pre-ozonation (O3) represents a promising hybrid membrane process (HMP) for the production of microbially and chemically safe reclaimed water. When employing these HMPs it is crucial to optimize the operational stability while simultaneous maintaining their removal efficiencies. In our studies we examined inline dosing of PAC or pre-O3 with or without the addition of polyaluminium chloride (PACl) coagulant prior to UF. Results obtained were compared with UF treatment with continuous coagulation only as a reference. Precoating the UF with PACl combined with continuous inline dosing of PAC or pre-O3 exhibited efficient abatement of trace organic chemicals (TOrCs) and antimicrobial resistance (AMR) along with optimized membrane fouling mitigation. In contrast, when simultaneous and continuous dosing of PAC and PACl was applied, detrimental effects of the coagulation on TOrC adsorption by PAC were observed.

Christoph Schwaller, *Germany (c.schwaller@tum.de)*
Drewes, Jörg

TREATMENT TRAIN TECHNOLOGY FOR EMERGING CONTAMINANTS IN WATER SYSTEMS AND CORRESPONDING MICROBIAL ECOLOGY

Treatment train technologies provide many alternatives and advantages for the remediation of sites with complex emerging contaminants in water system. In this study, bench-scale microcosms, prepared with groundwater collected from a contaminated military site with different levels of 1,4-dioxane and chlorinated solvents, were initially exposed to tungstated zirconia (WOx/ZrO_2) and hydrogen peroxide (H_2O_2) for 24 hours, followed by a 17 weeks incubation period to allow for biodegradation. Natural biodegradation of contaminants was inhibited by the chlorinated compounds, which were lowered by chemical oxidation, and 1,4-dioxane removal was only observed under bioaugmentation with the 1,4-dioxane-metabolizing bacteria Pseudonocardia dioxanivorans CB1190. Illumina Miseq sequencing of the 16S rRNA gene and machine learning algorithms suggested the presence of taxa sharing similar ecological niches or commensalism/synergism interactions, and r predicted that the microbial communities had been stable after 15 weeks. These findings will serve as a foundation and baseline for future water bioremediation.

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Miao, Yu; Johnson, Nicholas; Heck, Kimberly; David; Gedalanga; Adamson, Phillip; Newell, Charles; Wong, Michael

Poster Pitches

MECHANISTIC ELUCIDATION AND TECHNOLOGY ADVANCEMENT TOWARD THE COMPLETE DESTRUCTION OF PER- AND POLYFLUOROALKYL SUBSTANCE

We have systematically investigated the structure-reactivity relationships for a series of PFAS structures. Legacy structures include perfluorocarboxylates and sulfonates (PFCAs and PFSAs) and fluorotelomer carboxylates and sulfonates (FTCAs and FTSAs). The emerging structures include perfluoroether carboxylates (PFECAs), hydro-perfluorocarboxylates (H-PFCAs), and chloro-perfluorocarboxylates (Cl-PFCAs). Using kinetic measurements, product analyses, and theoretical calculations, we have identified major degradation pathways and elucidated novel reaction mechanisms. The deep understanding enabled our development of effective and efficient technology for rapid and complete defluorination (i.e., cleaving C-F bonds into F- ions) of most PFAS. To date, we have achieved this goal using practical approaches, including advanced reduction using hydrated electrons from UV-sulfite and advanced oxidation using hydroxyl radicals.

Jinyong Liu, *United States (jinyongl@ucr.edu)*
Bentel, Michael; Liu, Zekun; Gao, Jinyu

INDUCTIVELY REGENERABLE MAGNETIC ACTIVATED CARBON FOR REMOVAL AND DEGRADATION OF ORGANIC MICROPOLLUTANTS FROM WASTEWATER

This work introduces a new sustainable source of powdered activated carbon that could not only be used to adsorb organic micropollutants from wastewater effluents, but also to desorb and degrade the pollutants through inductive heating and simultaneously regenerate the carbon to enable its reuse in numerous cycles. For this purpose, commercial powder activated carbons (lignite- and coconut-based) were seeded with magnetite (Fe_3O_4) which facilitates easy magnetic separation of the carbon and simultaneously acts as a source of iron for the inductive heating of the magnetic carbon. The adsorption characteristics of this novel magnetic activated carbon (MAC) were compared against the unaltered activated carbon. The MAC showed promising results with little to no deviations in adsorption capacity, much better solid-liquid separation and ability to be regenerated inductively and reused over several cycles. This makes the proposed material superior to the existing commercial activated carbons due to the ability to regenerate and reuse the MAC, as well as the possibility for its magnetic harvesting which obviates the need to invest in large flocculation / sedimentation tanks.

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Drenkova- Tuhtan, Asya; Meyer, Carsten; Ballweg, Thomas; Mandel, Karl

DEGRADATION OF OSELTAMIVIR (TAMIFLU) IN UV PHOTOLYSIS AND UV|H_2O_2 REACTIONS: PERFORMANCE, KINETICS, AND MECHANISM

Oseltamivir (OST) is widely used as an antiviral drug and its contamination in the aquatic environment has been a concern because of the flu pandemic. In this study, the degradation mechanisms of OST were investigated through UV photolysis and UV/H_2O_2 reactions. The effects of pH, temperature, humic acid, H_2O_2 concentration, and inorganic anions such as Cl^-, HCO_3^-, and NO_3^- ions were examined with respect to the degradation kinetics. The degradation kinetics of each reaction followed the pseudo-first order. The UV/H_2O_2 reaction showed a higher removal than UV photolysis because of the effective generation of OH radical. The contribution of the OH radical under different pH conditions was determined using nitrobenzene as a radical scavenger. The OH radical contributed 88% at pH 6.5, showing the highest contribution than pH 3.5 (79%) and pH 9.5 (84%). 64% of total organic carbon in OST was mineralized after 12 h in UV/H_2O_2 reaction. 10 transformation byproducts (TPs) were identified using ultra-performance liquid chromatography-quadrupole-time of flight: six (m/z = 277, 327, 329, 347, 361, and 377) from UV/H_2O_2, two (m/z = 226 and 244) from UV photolysis, and two (m/z = 261.1 and 331.2) from both reactions. Based on the identified TPs, the potential degradation pathways of OST during UV photolysis and UV/H_2O_2 reactions were proposed.

Kyung-Duk, *Seoul National University ((Republic of Korea)*
Sohn, Erica Jungmin

Session 5. Adapting Water Supply Systems for Climate Resilience

TECHNOLOGY ADAPTATION FOR RESILIENT AND SUSTAINABLE WATER

Technological developments in the water domain are rapidly being discovered and deployed by academic, private, and government institutions. However, often times the most modern and efficient water technologies take a very long time to become widely employed by the water industry. Often, water providers are nervous to have the first full-scale application of a novel technology and/or the best available technology might appear to be more expensive or complex to utilize. This session will discuss case studies of challenges and successes along with a path forward for more rapid adaptation.

Shane Snyder, *Singapore (ssnyder@ntu.edu.sg)*

DECENTRALISED DRINKING WATER PRODUCTION FROM RAIN WATER — A CASE STUDY ON HOUSEHOLD LEVEL

In Flanders, more than 40 000 households are not yet connected to the centralised drinking water network. In many cases these households use an alternative water source for their water demand, such as ground water. However, with the climatological changes and corresponding larger periods of drought, these kind of alternative water sources are no longer sufficient. Therefore, it is important to take a look at decentralised (drinking) water production to guarantee a robust, economic and ecological water supply. In this case study rainwater was harvested, stored and treated for drinking water purposes. Three different technologies were tested to gain knowledge on water efficiency, self-reliance and produced water quality. In addition, more insights were gathered on legal compliance challenges.

Evelyn de Meyer, *Belgium (evelyn.de.meyer@dewatergroep.be)*
Ottoy, Pauline; Vanysacker, Louise

INNOVATIVE ONE WATER SOLUTIONS FOR A SUSTAINABLE WATER SUPPLY

This paper describes how the City of Santa Monica leveraged several alternative water supplies and state-of-the-art technology to deliver a one water solution for a sustainable and drought resilient water supply. The Sustainable Water Supply Program will meet over 90% of the City's water needs through local supplies and reduce the City's reliance on imported water supplies. The one water solution includes implementing the State of California's first stormwater project for groundwater augmentation via direct injection, one of the first membrane bioreactors to receive log removal credits for potable reuse, restoring an extremely impaired groundwater supply with advanced oxidation technology, and concentrate recovery at the City's brackish desalter. The $200+ million program is being delivered through a combination of alternative (e.g., Progressive Design-Build and Design-Build-Operate) and traditional delivery methods over a 3 year period that will also setup the City for future direct potable reuse in the near future.

Alex Waite, *United States (alex.waite@santamonica.gov)*
Wang, Sunny; Aguillon, Chris

IS YOUR INFRASTRUCTURE READY FOR CLIMATE? A RECENT EXAMPLE, THE NY REDI PROGRAM

In 2017 and 2019, major flooding affected the Lake Ontario and St. Lawrence River system in New York State. These flooding events, each of which reached levels of a 1% chance occurrence, caused extensive damage to shoreline systems, critical infrastructure, homes, and loss of businesses.

In response to the extended pattern of flooding along the shores of Lake Ontario and St. Lawrence River and underlying economic challenges, the Resiliency and Economic Development Initiative (REDI) was created to address the immediate and long-term resiliency of critical infrastructure and economic development needs of these areas. The REDI aimed to develop a new vision for rebuilding the Lake Ontario and St. Lawrence River shoreline, including protecting public facilities as well as enhancing natural features and processes.

Jennifer Olivo, *United States (jennifer.olivo@ramboll.com)*

HYBRID FEED-FORWARD AND FEED-BACK ALGORITHM FOR AUTOMATED CONTROL OF COAGULATION IN DRINKING WATER

In the aim of optimizing the doses of coagulant and powdered activated carbon for drinking water production, an innovative tool was implemented on a full-scale drinking water treatment plant. The innovation lies in the combination of two approaches: a predictive model and a feedback control loop which both communicate in the same algorithm. Thanks to the predictive model, the system can ensure the automatic treatment of turbidity and organic matter from a French river increasingly subjected to strong quality variations. In steady state, the feedback loop optimizes more closely the dosage. It takes about two times the retention time of the clarifier to reach the targeted settled UV with an error less than 0.05 m^{-1} and an initial offset of 0.3 m^{-1}. The system strengthens the plant resilience to climate change while optimizing costs (23% coagulant savings).

Arthur Fayolas, *France (arthur.fayolas@suez.com)*
Caudron, Christophe; Steinmann, Delphine; Baudin, Isabelle; Brehant, Anne; Cambrai, Samuel

WATERARCHITECT — AN EFFICIENT MODELLING TOOL TOWARDS A MORE OPTIMAL DECENTRALIZED WATER MANAGEMENT

In order to provide sustainable water reuse solutions on household and district level, simulations including different water management strategies are required. The use of rain water for drinking water purposes, the reuse of grey water for toilet flushing and irrigation or the implementation of water saving toilets, WaterArchitect can simulate all possible scenarios. Ultimately this efficient modelling platform gives the economic and ecological impact of the various possibilities, resulting in a more robust and substantiated decision-making for project developers and drinking water companies. Since WaterArchitect can indicate both the bottlenecks and the positive outcomes from each strategy it is able to strengthen water reuse adaptation.

Louise Vanysacker, *Belgium (louise.vanysacker@dewatergroep.be)*
De Meyer, Evelyn, Vanloo, Maarten; Schiettecatte, Wim

Poster Pitches

CLIMATE RESILIENCE WATER SUPPLY SYSTEMS IN THE COASTAL AREAS OF BANGLADESH

Bangladesh has been considered as the most vulnerable country in the world in terms of climate change impact. The coastal zone, where the land and sea met, situated in the southern part of Bangladesh is the most exposed areas of the country with hazards of cyclone, storm surge, salinity intrusion etc. A resilient water supply system using the appropriate technology like Pond Sand Filter (PSF) with involving community could be a sustainable approach to mitigate climate change and its impact as well as address the water scarcity in the coastal areas.

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Islam Sarker, Muhammad Shaiful

Session 6. Wastewater Based Epidemiology

SARS-COV-2 WASTEWATER SURVEILLANCE ENABLES APPORTIONMENT OF INFECTION BURDEN AND GUIDED PUBLIC HEALTH RESPONSE(S)

COVID-19 guidance based on SARS-CoV-2 wastewater surveillance was undertaken (01.03.2020 until 01.08.2021). Large buildings: prisons, schools, halls of residence, university buildings & residential houses were sampled daily. Downstream / within-sewer alongside interstage wastewater treatment works sites assessed to understand transport, fate and removal of SARS through different treatment processes prior to & including environmental discharge. Quantification of SARS-CoV-2 was undertaken & benchmarked against viral indicators (Φ6, crAssphage & Pepper mild mottle virus (PMMV)). Whole genome sequencing used to identify lineage defining mutations for Variants of Concern (VoC). Enrichment for >200 respiratory pathogens gave a snapshot of pathogen loading for vulnerable communities for the first time during the pandemic. Clear links between local infection dynamics & treatment works data w as found. SARS-COV-2 faecal shedding rates estimated in adults and children across sampled population. Outbreaks were tracked and public health interventions guided in vulnerable communities (prisons & schools) for the first time alongside university populations.

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Folkes, Miles; Jeffrey, Paul; Castro Gutierrez, Victor

OUTBREAK DETECTION THROUGH SEWER NETWORK MONITORING IN WASTEWATER BASED EPIDEMIOLOGY

Wastewater based epidemiology is a powerful tool identifying disease spread. However, this approach is often not applied at a granular level that permits detection of local trends. This study examines the spatial patterns of SARS-CoV-2 in sewage across neighborhood-scale sewershed catchments. Sampling was conducted across the Reno-Sparks metropolitan area from November to mid-December of 2020. This research utilized local spatial autocorrelation to identify the evolution of statistically significant neighborhood hot spot clusters. This was useful in identifying catchments that were identified to lead waves of infection, with adjacent neighborhoods observed to lag with increasing viral RNA concentrations over subsequent dates. The correlations between the sub-catchments over the sampling period was also characterized using principal component analysis.

Laura Haak, *United States (lhaak@nevada.unr.edu)*
Blaga, Delic; Li, Lin; Guarin, Tatiana; Mazurowski, Lauren; Dastjerdi, Niloufar; Pagilla, Krishna

LONG-TERM SURVEILLANCE OF WASTEWATER SARS-COV-2 IN LOS ANGELES COUNT

Here we report our wastewater-based epidemiology (WBE) surveillance results of Los Angeles County, CA. We collected weekly samples of 24-hour composite influent from five wastewater treatment plants for 44 weeks. Wastewater SARS-CoV-2 levels were quantified using RT-qPCR targeting the CDC recommended nucleocapsid genes N1 and N2. Pearson correlation analysis of wastewater SARS-CoV-2 levels for Los Angeles County with clinical data showed strong correlations of r= 0.94 for N1 and N2. Further, wastewater SARS-CoV-2 levels from daily samples, over the course of a week, led clinical testing data by 5 days. Monte Carlo simulations, using our measured wastewater SARS-CoV-2 dataset, estimated the total number of infected individuals during the duration of this study reached 3.42 million people, exceeding the cumulative clinical case count by almost 2 million people. Lastly, SARS-CoV-2 variant analysis of select composite influent samples showed evolving variant composition over the course of this study.

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COVIDPOOPS19 ANALYSIS: EQUITY AND LESSONS LEARNED

Wastewater Based Epidemiology (WBE) has expanded rapidly with the COVID-19 pandemic. The COVIDPoops19 dashboard and Twitter account have been instrumental in tracking COVID-19 WBE efforts and facilitating global coordination. The dashboard launched in September 2020 had 19 dashboards, 71 universities, and 24 countries monitoring wastewater for SARS-CoV-2. In February 2020, almost two years into the pandemic, there are over 119 dashboards, 276 universities, and 3,300 sites. Nevertheless, there are global disparities in access to COVID-19 WBE since only 35% of countries and 15% of sites are in Low and Middle Income Countries. Though a lot of data has been released and there are global and regional data centers and bases, there are challenges in releasing and standardizing the data. In this keynote, we will discuss an analysis of global WBE, equity, and lessons learned for the current pandemic and beyond.

Colleen Naughton, *United States (cnaughton2@ucmerced.edu)*

CLINICAL TESTING UNDERESTIMATES COVID-19 INCIDENCE AND VARIANT PREVALENCE: INSIGHTS FROM WBE IN SOUTHERN NEVADA

The onset of the COVID-19 pandemic initiated strong research collaborations aimed at filling critical knowledge gaps related to SARS-CoV-2. One such effort led by academic and industry researchers, the water/wastewater sector, and public health partners focused on wastewater-based epidemiology (WBE), which now provides near-real-time information on COVID-19 incidence in many communities throughout the world. In Southern Nevada, trends in clinical infections generally correlated with SARS-CoV-2 wastewater concentrations for most of the pandemic. However, the data started to deviate in the spring/summer of 2021, indicating that clinical testing was underestimating COVID-19 incidence. In fact, WBE suggests that 55% of Southern Nevada has been infected by SARS- CoV-2 at some point during the pandemic (as of August 2021), which is 4.2-fold greater than the 13% confirmed through clinical testing. Corresponding amplicon-based sequencing determined that variants of concern (VOCs) contributed to infection surges in the winter of 2020 (Alpha and Epsilon) and the summer of 2021 (Delta), with WBE sometimes providing VOC confirmation prior to clinical testing.

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Oh, Edwin; Papp, Katerina; Tillett, Richard

MONITORING THE TEMPORAL DYNAMICS OF SARS-COV-2 VOC B.1.1.7 IN GERMANY WITH GENOME SEQUENCING

SARS-CoV-2 wastewater surveillance can help identify early trends and the spread of SARS-CoV-2 variants within a city. This study monitored the concentration of SARS-CoV-2 RNA in the influent of the two wastewater treatment plants of a city in Southern Germany, with a specific focus on the SARS-CoV-2 variant B.1.1.7 which has been spreading rapidly since the beginning of 2021 in Germany. The RT-qPCR analysis revealed a dramatic decrease in the percentage of B.1.1.7 variant, i.e., >95% of total SARS-CoV-2 concentration in April 2021, to below the detection limit by the mid of June 2021 in wastewater samples. And genome sequencing analysis of the wastewater samples revealed that B.1.1.7 is being replaced with emerging B.1.617.2 variant, which corresponds to clinical data reported approximately two weeks after the B.1.617.2 variant was detected in wastewater samples.

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Agrawal, Shelesh; Lackner, Susanne

Poster Pitches

ESTIMATING RELATIVE ABUNDANCE OF SARS-COV-2 VARIANTS THROUGH WASTEWATER SURVEILLANCE USING DIGITAL PCR ASSAYS TARGETING

Monitoring for SARS-CoV-2 variants of concern (VOCs) is critical for public health management of COVID-19. We developed targeted digital RT-PCR mutation assays to monitor for presence and abundance of select mutations present in Alpha, Beta, Gamma, Delta, Mu and Lambda variants in wastewater settled solids, applied these to July 2020-August 2021 samples from two large metropolitan sewersheds, and compared results to estimates of variant abundance from publicly available case isolate sequencing in the state. Wastewater measurements were highly associated with case estimates. Given that it can take weeks to obtain sequence information from clinical samples, and just hours to get results from wastewater, monitoring wastewater for variant circulation can provide an early indication of changes in SARS-CoV-2 variant circulation in the contributing population.

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Hughes, Bridgette; Wolfe, Marlene; White, Bradley; Wigginton, Krista; Duong, Dorothea

BACTERIAL PATHOGENS AND ANTIMICROBIAL RESISTANCE GENES IDENTIFIED VIA WASTEWATER-BASED EPIDEMIOLOGY IN HARARE, ZIMBABWE

Environmental surveillance of wastewater can be a key tool to understand the prevalence of bacterial pathogens and antimicrobial resistance genes within a population. Wastewater samples were collected from high and low income suburbs in Harare, Zimbabwe and their metagenomes sequenced. The most abundant genera detected were Staphylococcus, Pseudomonas, Aeromonas, and Arcobacter. Additionally, 82 pathogenic species (classified according to the Microbial Rosetta Stone Database) were detected across the samples with key pathogens including Staphylococcus aureus, Salmonella enterica, Escherichia coli, Clostridium botulinum, Pseudomonas aeruginosa, Vibrio cholerae, Campylobacter jejuni, Mycobacterium leprae, and Mycobacterium tuberculosis. Antibiotic resistance genes and proteins were identified via the Comprehensive Antibiotic Resistance Database including tetA, C, E, and R, multiple quinolone resistance proteins, and CfxA, MOX, TEM, OXA, and GES beta-lactamases amongst others.

Nicolette Zhou, *United States (nicolette.zhou@gmail.com)*
Ruhanya, Vurayai; Chipo Berejena; Nyandoro, George; Chibukira, Paradzai; Mukaratirwa, Arnold; Muserere, Simon; Masunda, Kudzai; Ong, Angelo; Meschke, John Scott

Session 7. Sustainable Desalination

ADDRESSING COMPLEX SEAWATER PRE-TREATMENT WITH CERAMIC MEMBRANE FILTRATION

With climate change and human activities impacting our oceans, in many parts of the world treating seawater for desalination has become increasingly problematic and unsustainable with conventional pre-treatment technologies. The increased severity, duration and frequency of algal blooms in particular presents significant challenges maintaining water production ahead of RO. Ceramic membrane filtration presents an opportunity to address these particular water quality challenges given the unique structure of the membrane structure, filtration surface and robustness of the materials of construction. To demonstrate this effectiveness Nanostone has deployed two pilot facilities to treat some of the most challenging source water in Singapore and Oman. The results of the

pilot testing programs have shown great promise with stable performance and the ability to manage through algal events. This presentation will illustrate the results obtained to date and the next steps with the program.

Jonathan Pressdee, *United States (jonathan.pressdee@nanostone.com)*

OPTIMIZATION OF UVC-LED PRE-TREATMENT EMBEDDED IN SPIRAL-WOUND ELEMENTS FOR BIOFOULING CONTROL IN MEMBRANE DESALINATION

As there is a great need for biocide-free biofouling control strategies for high-pressure membrane systems, in our studies we investigated the potential of integrating feed stream UVC disinfection using UVC-LEDs in spiral-wound membrane applications to mitigate biofouling in reverse osmosis (RO) systems. Accelerated lab-scale biofouling experiments were performed using membrane fouling simulators. The effects of UV irradiation were compared to a reference line without UV treatment. Findings suggest that UV pre-treatment delays the formation of biofouling significantly and results in a more permeable biofilm, at the same feed channel pressure drop, than the reference line. Associated with the observed change in permeability, the UV treated biofilm also exhibited changes especially in its ATP levels and microbial composition. Further, this study focuses on optimizing the UVC-treatment for the most efficient fluence, pulsed UV irradiation, and if the effects are still measurable after cleaning in place.

Philipp Sperle, *Germany (philipp.sperle@tum.de)*
Wurzbacher, Christian; Drewes, Jörg

NANOWOOD MATERIALS FOR SUSTAINABLE DESALINATION AND RESOURCE RECOVERY

Water desalination and resource recovery are integral parts of the new circular economy, but current processes use non-sustainable materials such as polymers and metals for separation and purification. Nanowood materials recently emerged as renewable and potentially carbon-negative alternatives that carry desired structures, durability, and functions for water resource recovery and waste treatment. This presentation discusses recent development of nanowood materials and applications in the water and energy, such as engineered trees for continuous desalination driven by solar or sensible heat, water and mineral recovery from hypersaline waters by wood evaporators, and renewable energy production and wastewater treatment using wood-based functional electrodes in microbial electrochemical systems.

Zhiyong Ren, *United States (zjren@princeton.edu)*
Chen, XI; Zheng, Sunxiang

RECOVERY OF VALUABLE MINERALS FROM DESALINATION BRINES

Brine from desalination plants contains valuable minerals such as potassium, magnesium and calcium salts, and ocean brine mining has the potential to surpass terrestrial mining as a source of rare-earth metals such as lithium, strontium, cesium, rubidium and barium. In the past, the main challenges for extraction of minerals from brine have been the high cost and energy for mineral concentration and selective separation. With the advancement of brine concentration membranes and technologies over the last 5 years, now the desalination industry is entering a new era where production or valuable minerals and metals from brine is becoming more competitive than terrestrial mining. This presentation discusses the latest trends and processes for extraction of ocean minerals and rare metals from brine generated by desalination plants. This work features full-scale brine mining project under development and implementation by the Saline Water Conversion Corporation of Saudi Arabia in the city of Jubail.

Nikolay Voutchkov, *United States (nvoutchkov@water-g.com)*

ULTRA HIGH-PRESSURE REVERSE OSMOSIS MEMBRANES FOR THE LOWEST COST AND ENERGY APPROACH TO ACHIEVE MINIMUM LIQUID DISCHARGE

The combination of population growth, increasing industrialization, climate change-driven water scarcity and sustainability imperatives is driving RO system designs towards minimal and zero liquid discharge (M/ZLD). Herein, we define MLD as a brine concentration process following a primary RO stage, and ZLD as a brine crystallization process following a primary RO stage and a brine concentration stage. The state-of-the-art technologies for both brine concentration and crystallization are costly, energy-intense thermally-driven processes. Replacing energy-intensive thermal MLD with an ultra-high pressure (up to 200 bar) reverse osmosis (UHPRO) process has the potential to dramatically reduce the energy and cost of achieving MLD. However, the primary challenge of increasing RO membrane operating pressure to 200 bar is physical compaction of the RO membrane leading to catastrophic loss of productivity of spiral wound RO modules and (2) slow salt diffusion in viscous brines leading to massive osmotic pressure losses. The feasibility of using UHPRO to achieve M/ZLD is investigated in this study.

Jishan Wu, *United States (wujishan123@g.ucla.edu)*

IMPLEMENTATION OF CIRCULAR ECONOMY AND ENERGY EFFICIENCY IN SEAWATER DESALINATION BY INTEGRATING BRINE TREATMENT TECHNOL

Seawater desalination is an alternative source of drinking/industrial water as to freshwater. However, its high energy consumption and high volume of brine discharge increase the concerns about the environmental impacts of the process. Integrating desalination with brine treatment could help in reducing the concerns of environmental impact by recovering water, salts, and heat energy. The work presented here assesses the effectiveness of the integration using different technologies in a process train that aims to recover water and multiple high-quality salt products with the minimum energy requirements. The investigated technologies include Nanofiltration, Multi-effect distillation, Thermal crystallizer, Multiple Feed-Plug Flow Reactor, Eutectic freeze crystallization, and Electrodialysis with Bipolar membranes. A process model for the integration of these technologies is developed to provide insights into their energy requirements. The integration of desalination and brine treatment technologies reduces the energy requirements of the technologies, minimizes the environmental impact of the system, and it makes the system more economically feasible.

Rodoula Ktori, *The Netherlands (r.ktori@tudelft.nl)*
Krishnan, Adithya; Rodriguez-Pascual, Marcus; van Loosdrecht, Mark; Xevgenos, Dimitris

Session 8. Treatment of Complex and High Strength Wastewater

ANMBR FOR GLOBAL SANITATION: THE NEWgenerator™ FOR OFF-GRID WASTEWATER TREATMENT IN INDIA AND SOUTH AFRICA

Billions of people worldwide suffer from poor sanitation due to lack of wastewater infrastructure. Due to high CAPEX and OPEX, the conventional approach of centralized wastewater treatment plants served by an extensive sewer system is not an option for many communities. Accordingly, a new classification of modular and pre-fabricated non-sewered sanitation systems have been proposed as a micro-infrastructure alternative. Developed at the University of South Florida, the NEWgenerator is a solar-powered, modular, wastewater treatment and recycling system capable of operating completely off-grid from energy, water and sewer. The core technology within the NEWgenerator is the anaerobic membrane bioreactor, capable of handling a wide range of wastewater strengths, intermittent flows, and prolonged shutdowns. This presentation will follow the two-decade journey of the NEWgenerator from concept to commercialization, including field trials in India (Kerala) and South Africa (KwaZulu-Natal), and receiving the 2020 USPTO Patents for Humanity Award.

Daniel H. Yeh, *United States (dhyeh@usf.edu)*

COST SAVINGS THROUGH NITRITATION OF HIGH STRENGTH AMMONIA SIDESTREAM LIQUORS WITH NOVEL BIOCATALYSTS

Razavi, Ameen; Nair, Ajay; Dorri, Ali; Shirazi, Fatemeh

High-strength ammonia removal from digestor filtrate water was achieved using the biological MNE process. The MNE technology removed 99% of the ammonia loading in a bench-scale continuous reactor and more than 95% of the ammonia load was converted to nitrite at a 15-hour residence time in a 567 L continuous pilot reactor at Oro Loma Sanitary District in California. The MNE technology was not inhibited by nitrite concentrations exceeding 400 mg-N/L and achieved concentrations below 1 mg-N/L of ammonia in continuous operation. Following the pilot study, the MNE technology was then implemented at full scale through repurposing an existing 340 m^3 basin and has consistently achieved ammonia removal of the design-load of 158 kg/day at very low biocatalyst packing density. The process does not require operator intervention or complex control systems to maintain performance.

Felipe Munoz, *United States (fmunoz@microvi.com)*

DESIGN, PERFORMANCE AND COST OF FAECAL SLUDGE AND SEPTAGE TREATMENT PLANTS IN ODISHA STATE, INDIA

The present work demonstrates the performance of a full-scale operational faecal sludge and septage treatment plant (FSTP) with 75 m^3 per day capacity established in Bhubaneswar, the capital city of Odisha State in India, operating since October 2018. During the operation span from January 2019 to February 2020, the average COD and TSS removal rates were 99.49% and 98.32% respectively. The effluent BOD, COD and TSS meets the Indian Standards for safe discharge and reuse. The design of the FSTP is innovative and unique in the country and has been scaled up in all the 114 towns of Odisha. Presently, 57 plants are operational and remaining are slated for commissioning by the end of year 2021. The treatment process is cost effective, non-mechanised, nature based and gravity flow system. An empirical relation between the construction cost and capacity of the FSTP in the range of 10 to 75 m^3 per day was derived: FSTP construction cost (million US$) = 0.216 X^0.227 where,

X is FSTP capacity (m^3 per day). The raw septage and faecal sludge characteristics indicates medium strength sludge and of low biodegradability owing to long residence in septic tanks. FSTP performance indicates that the design adopted is efficient and can be replicated and scaled up.

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Yadav, Asheesh

DESIGN OF A SMALL-FOOTPRINT WASTEWATER TREATMENT AND ENERGY RECOVERY PROCESS FOR BIOREFINERIES

Characterized by elevated concentration of organics and nutrients, complex and high-strength wastewaters necessitate the development of high-rate, robust treatment technologies while possessing significant potentials for the generation of valuable products. In this study, we incorporated experimental characterization data of wastewater generated from bioethanol production into the design of a high-rate anaerobic treatment system, which included emerging energy recovery technologies such as internal circulation reactor and anaerobic membrane bioreactor. We further incorporated the process into biorefinery design and compared the cost and environmental impacts of the new process against an existing design. The new design was able to decrease capital cost and electricity usage of wastewater treatment by 56% [50-61% for 5th/95th percentiles] and 85% [85-86%], respectively, contributing to reductions of $0.11 [0.10-0.13] (from 2.18 to 2.08) gal-1 in minimum selling price and 0.15 [0.14-0.17] (from 0.22 to 0.08) CO2eq•gal-1 in global warming potential of the generated ethanol.

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Kontos, George; Avila, Nick; Parkinson, Thomas; Cabrera, Daniela; Viswanathan, Mothi; Singh, Vijay; Labatut, Rodrigo; Guest, Jeremy

EXTREME SULFIDE CONCENTRATIONS IN A SULFATE REDUCING BIOREACTOR SELECT FOR SULFIDE TOLERANT SULFATE REDUCING BACTERIA

Sulfate reducing bioreactors are employed to reduce sulfate to sulfides in metallurgical wastewaters, which contain up to 15 g L-1 sulfate. To avoid inhibition by H_2S, sulfides are usually stripped, precipitated or diluted. These strategies have several drawbacks such as suboptimal sulfate reduction, clogging and additional energy costs. Here, two hydrogenotrophic expanded bed bioreactors were used to treat metallurgical wastewater without additional removal of sulfides. By operating at pH 8 ± 0.15 H_2S toxicity was minimized, resulting in record high dissolved sulfide concentrations of 2.1 ± 0.2 g L-1 and peaks up to 2.3 g L-1. By increasing the ingoing sulfate concentration and maintaining high sulfide concentrations, sulfate reducers such as Desulfovibrio and Desulfomicrobium were promoted while fermenters and methanogens were suppressed.

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Ostermeyer, Pieter; Van Landuyt, Josefien; Bonin, Luiza; Folens, Karel; Williamson, Adam; Hennebel, Tom

BIODEGRADATION OF INSENSITIVE MUNITION EXPLOSIVE FORMULATIONS: IMX-101 AND IMX-104 USING AEROBIC GRANULAR SLUDGE

The United States Department of Defence (USDoD) has recently approved the use of insensitive munition explosive (IMX) formulations: IMX-101 and IMX-104 as replacements for legacy or traditional explosives in artillery and mortar cartridge production. Consisting primarily of hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX), 2,4-dinitroanisole (DNAN), 1-nitroguanidine (NQ), and 3-nitro-1,2,4-triazol-5-one (NTO), IMX-101 and IMX-104 explosive formulation constituents will inevitably enter into the environment as their use becomes widespread. However, very few studies have investigated the biodegradation of IMX-101 and IMX-104 constituents in mixture and even fewer studies have explored engineered bioreactors for the remediation of source waters containing these energetic compounds. In this study, the biodegradation of IMX-101 and IMX-104 formulation constituents was investigated in a lab-scale batch bioreactor seeded with mature aerobic granular sludge (AGS) biomass. The AGS biomass effectively and consistently removed both DNAN and NTO, where the average removal efficiency for both compounds was 99.7 ± 0.69% and 97.6 ± 6.99%, respectively. RDX and NQ were removed to a lesser extent with average removal efficiencies of 39.2 ± 18.8% and 3.44 ± 3.83% being recorded throughout reactor operation, respectively. Batch biodegradation assays revealed that reductive biotransformation for each of the respective energetic compounds could occur under bulk aerobic conditions due to the redox gradient present in the structure of mature aerobic granules. Batch tests demonstrated that increasing the amount of organic carbon in solution subsequently increased the biodegradation rates for each respective energetic compound. Biodegradation rates for DNAN, NTO, and NQ were found to be fastest when organic carbon was in abundance under anaerobic conditions. RDX biodegradation rates were fastest under bulk aerobic conditions when organic carbon was supplied in excess. Preliminary results from this study demonstrate that mature AGS biomass can degrade IMX-101 and IMX-104 explosive formulation constituents in mixture from contaminated source water.

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Goel, Ramesh

Poster Pitches

FILTERING THE UNFILTERABLE: THE APPLICATION OF GRAPHENE OXIDE COATING TECHNOLOGY IN THE TOUGHEST OF APPLICATIONS

By 2025, it is estimated that 2/3 of the world's population will face water shortages. Furthermore, between 2030 and 2050 it is calculated that 250,000 deaths per year will be directly linked to climate change, therefore it is critical promising technologies are exploited to limit environmental damage (Parncutt 2019, Masson-Delmotte 2021). Per site, industrial laundries dispose of tens of thousands of cubic meters of aqueous effluent per year, as the wastewater is notoriously difficult to recycle. Through detailed laboratory studies we have developed a graphene oxide containing formulation that we can apply directly to commercially available ceramic membranes. We have demonstrated through industrial validation using real laundry wastewater that we are able to increase the permeance of commercial membranes by up to 2.5x, with a significant reduction in fouling. This equates to a reduction to incoming mains water by 22,000 m^3/year and a site-wide saving of 1.8m kWh/year for boiler gas, translating to offsetting 350 tons CO_2e/year and futureproofing the site from water shortage through the creation of a pseudo-self-sustaining process.

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DEMYSTIFYING SIDESTREAM DEAMMONIFICATION APPLICATION PRACTICES

Sidestream nitrogen treatment based on deammonification using annamox bacteria is increasingly being applied for efficient nitrogen removal to augment mainstream nitrogen removal processes. However, there are many facility-specific drivers for considering these processes as well as differences in sidestream characteristics and treatment goals that affect implementation and operational efficiency. This paper focuses on four sidestream processes in use today, and discusses technology drivers; process efficiency and operational goals; ancillary support facilities; and lessons learned to help inform best practices in application.

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CAUSES OF SOURING DURING FOOD WASTE AND FATS|OILS|GREASE ANAEROBIC CO-DIGESTION WITH MUNICIPAL SLUDGE

Many municipalities are pursuing anaerobic co-digestion of food waste (FW) and fats/oils/grease (FOG) at municipal water reclamation facilities, but co-digestion operations can be risky due to rapid fermentation of FW/FOG to volatile fatty acids (VFAs), causing pH depression and microbial inhibition. This phenomenon is called souring. As part of a co-digestion feasibility study, we operated 1.5-L sequencing batch anaerobic digesters for up to 11 months. This allowed us to systematically explore co-digestion of thickened sludge with FW/FOG at different volumetric feeding ratios to enhance our knowledge of safe and risky operational practices. One upset scenario was ramping up loading rates too quickly, which led to an immediate accumulation of VFAs and consequent depletion of bicarbonate alkalinity in the system, causing the reactors' pH to decrease to inhibitory levels. Other reactors soured after several months of operations; while the full set of causes of the upsets are still being investigated, depletion of bicarbonate alkalinity preceded souring by 10+ days, making bicarbonate alkalinity an indicator of potential digester upset.

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Rittmann, Bruce

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