The 16th IWA Leading Edge Conference on Water and Wastewater Technologies

the international water association

Water Technology Innovations for Emerging Challenges

Conference Programme

10-14 JUNE, 2019
EDINBURGH, UK
www.iwa-let.org

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BLACK & VEATCH Building a world of difference.

Black & Veatch consult, deliver and manage critical human infrastructure in water, energy and telecoms. What sets Black & Veatch apart is the ability to support every point in the lifecycle of our clients' assets – from early involvement in projects and programmes; to design, build and asset management. For Black & Veatch, our clients' reputation is as important to us as our own. This means we are committed to delivering the best outcome for our clients' customers. We have worked with all of the UK's water companies, as well as government and industrial clients in the UK, and around the world. Safe sites; carbon reduction and environmental awareness; and community involvement are central to the way we carry out projects.
Black & Veatch's professionals are forward thinking. So finding the answers to clients' needs always starts with a conversation about the outcome their customers want. By understanding our clients business and being a trusted partner, Black & Veatch can challenge the norm by bringing innovation to the agenda.
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Kemira is a global chemicals company serving customers in water intensive industries. We provide expertise, application know-how and chemicals that improve our customers' product quality, process and resource efficiency. Our focus is on pulp & paper, oil & gas and water treatment. Kemira shares are listed in the Nasdaq Helsinki Ltd. Kemira is the only manufacturer to offer a full product portfolio of coagulants, polyacrylamide polymers, process chemicals, and other water treatment chemicals, enhanced by smart digital technologies. Kemira supports its customers through deep R&D and application know-how, a secure supply network, and a complete technology portfolio for safe, efficient, and sustainable chemical water treatment.
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Contents

Welcome to Edinburgh

& the IWA Leading Edge Conference on Water and Wastewater Technologies 2019

Invitation from the IWA President

Diane D'Arras
President, International Water Association

As president of the International Water Association and as a passionate water professional, I am delighted to welcome you to the 16th IWA Leading Edge Conference on Water and Wastewater Technologies (LET) in Edinburgh, United Kingdom from 10th to 14th of June, 2019.
Fast growing cities, with rapidly expanding populations and industrial bases, are challenging the traditional model of large-scale centralised technology and infrastructure solutions. The world faces a situation in which over 80% of wastewater is discharged untreated into nature. The increased presence of chemical micro-pollutants, including pharmaceuticals, pathogenic microorganisms and antibiotic resistant bacteria, threatens the quality of water around the globe and leads towards a significant opportunity for building a circular, green economy.
Being the window to the world for water sector technology, the LET gathers international experts on water technology innovations for the water sector. The Leading Edge Conference series on Water and Wastewater Technologies have built a world-class reputation as the forum for leading researchers to share and debate.
The key to the success of the LET conferences, and their strong reputation, is the excellent scientific programme that has a perfect blend of academic research and implementation of novel technologies.
The IWA, and the Leading Edge Conference on Water and Wastewater Technologies, are ready to provide a platform where technological innovations and ideas for a sustainable, water-wise future can flourish. We come together in Edinburgh to reimagine the future of water. I hope you will enjoy and benefit from an inspiring programme and a memorable conference.

Invitation from the Chairs of the Programme Committee

Jonathan Clement
Nanostone Water Inc
(The Netherlands)

Mark van Loosdrecht
TU Delft
(The Netherlands)

In its 16th year, the LET has grown into a high-class forum of significant importance in the technical water and wastewater sector world. Here, we will present and discuss the most significant global technology developments in water.
New critical water technology developments are emerging continuously and we all know about the importance to keep in exchange on latest research, to keep the momentum vibrant. Bringing innovations, novel technology developments, and leading edge applications from across the industry is key to this conference. The LET Programme Committee focuses on the issues which are of highest concern globally and regionally. The conference embraces these concerns with the careful development of each session to create cohesive and interesting discussions on innovative and sustainable technology approaches and guarantee the participation of the most impactful water technology leaders of the industry.
This 2019 edition gives you the platform to share and debate with leading researchers pioneering science, technological innovation and top practices that will provide solutions the emerging water challenges the world is facing.
The success of this conference depends on your participation and active contribution. As Chairs of the 16th Leading Edge Conference on Water and Wastewater Treatment (LET) Programme Committee, we are most happy to welcome you, dear participant, to the 16th LET conference in Edinburgh.

Invitation from the Chair of the Organising Committee

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

As Chair of the local organiser committee is my pleasure to welcome you to the 16th IWA Leading Edge Conference on Water and Wastewater Technologies that is taking place in the beautiful city of Edinburgh, in Scotland in the United Kingdom.
The UK water industry market is one of opportunities. There are many issues that need to be addressed, such as: ageing infrastructure; compliance with ever stringent regulation; fast growth of urban centres and the need to develop sustainable solutions for rural communities; energy and carbon prices; reduction of quality of water sources; variable weather patterns leading to severe draughts and floods; the need to engage with local communities and governments promoting circular economy; etc. are forcing water professionals to think creatively and move innovation to full-scale implementation at an unprecedented rate.
Cranfield University, the lead LET2019 organiser, has partnered with two key water utilities in the UK. Scottish Water is the publicly owned utility providing water and wastewater services to 2.5 million households and 156,000 businesses and Thames Water, the UK's largest water and wastewater services provider.
Edinburgh is one of Europe's most beautiful cities, surrounded by rocky hills overlooking the sea, renowned for its heritage, culture and festivals. With walking distance you can visit and explore World Heritage Sites, as well as all the area's museums and galleries. On behalf of the local organising committee it is a pleasure to welcome you in Edinburgh.

Programme and Organising Committee

Programme Committee Core Group

Bruce Rittmann	Arizona State University (United States)
Mark van Loosdrecht (Chair)	Delft University of Technology (The Netherlands)
Jonathan Clement (Chair)	Nanostone Water Inc. (The Netherlands)
Jurg Keller	The University of Queensland (Australia)
Pedro Alvarez	Rice University (United States)

Programme Committee Members

Ahmed Al Amoudi	Desalination Technology Research Institute (DTRI) of SWCC (Saudi Arabia)
Ana Soares (Chair)	Cranfield University (United Kingdom)
Bill Barber	Cambi (United States)
Despo Fatta-Kassinos	University of Cyprus (Cyprus)
Domenico Santoro	Trojan Technologies (Canada)
Elise Cartmell	Scottish Water (United Kingdom)
Francesco Fatone	Università Politecnica delle Marche (Italy)
Jonathan Clement	Nanostone Water Inc. (The Netherlands)
Jorg Drewes	Technical University of Munich (Germany)
Jurg Keller	The University of Queensland (Australia)
Mari Winkler	University of Washington (United States)
Nikolay Voutchkov	Water Globe Consultants (United States)
Pedro Alvarez	Rice University (United States)
Shane A. Snyder	Nanyang Technological University (NTU) (Singapore)
Stewart Sutherland	Scottish Water (United Kingdom)
Thomas Ternes	Federal Institute of Hydrology (BfG),Koblenz (Germany)

Organising Committee Members

Ana Soares (Chair)	Cranfield University (United Kingdom)
Eva Estevan	International Water Association (The Netherlands)
Eve Germain-Cripps	Thames Water (United Kingdom)
Fernanda Wolter	International Water Association (The Netherlands)
Lorraine Bruce	Scottish Water (United Kingdom)
Paul Jeffrey	Cranfield University (United Kingdom)
Simon Parsons	Scottish Water (United Kingdom)
Tania Rice	Cranfield University (United Kingdom)

Organisers

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, with the framework of the total water cycle.

Cranfield University, and more specifically the Cranfield Water Sciences Institute (CWSI) is recognised internationally for its research, education, training and consultancy. Cranfield offers leading expertise water and sanitation, water policy and governance, modelling, water and wastewater technology and risk management for the water sector. Most of our research is applied and industry focussed, helping to solve real problems for a diverse range of companies, government agencies and NGOs, both in the UK and overseas. Our research, consultancy and training activities are underpinned by world class facilities, including a pilot-plant hall at the University's own wastewater treatment works, state-of-the-art soil and water laboratories with extensive advanced analytical services, a grey water treatment pilot area, a managed borehole drilling site and soil and irrigation testing facilities.

Scottish Water is the publicly-owned utility providing water and waste water services to 2.5 million households and 156,000 businesses. It manages a vast network of reservoirs and water sources, water treatment works, waste water treatment works and more than 60,000 miles of underground pipes across the country.
During the current investment period (2015-2021) £3.5 billion will be invested in maintenance and improvements to drinking water, protecting the environment and supporting the Scottish economy. Scottish Water International also continues to develop transformation opportunities abroad using existing Scottish Water skills and expertise including ongoing work in Europe, Australasia and Qatar and most recently a third assignment in Canada.

Thames Water is the UK's largest water and wastewater services provider. The company supplies almost one third of the 9 billion litres of water used by people and businesses in the UK each and every day, while removing and treating over four billion litres of sewage for 15 million customers. Employing around 5,000 people, its service area stretches from the eastern fringes of Gloucestershire and Wiltshire in the west, through London and the Thames Valley, to the western edges of Essex and Kent in the east.

IWA Leading Edge Technology
the international water association

Practical Information

REGISTRATION DESK

The registration desk will be open from:
Monday 10.06 – 08:30 until 17:30
Tuesday 11.06 – 08:15 until 18:15
Wednesday 12.06 – 08:15 until 18:15
Thursday 13.06 – 08:15 until 16:00

DIGITAL ONLINE PRE-PRINT PROCEEDINGS:

Do you want to read all the details of the content being presented during the conference? Visit the Digital Proceedings: https://iwa-let.org/proceedings/

IWA MOBILE APP – IWA-CONNECT

Want to stay in touch with the IWA network after the event? Connect to the global platform for water professionals. Access experts from across sectors and disciplines; Learn and share world-class best practices and find career development opportunities.
www.iwa-connect.org

Become an agent of change!

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.

Come meet us at the IWA stand and discover a world of opportunities.

Special 20% discount on IWA membership available until 1 July 2019 with the code: IWA20LET.

Also, delegates of LET can get a 25% discount on IWAPublishing books or ebooks with the code IWAPLET19 until the end of June.

iwa-connect.org

SOCIAL MEDIA

Planning to use social media while at the conference?

Join the conversation:

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

WiFi Password:

Network: delegate
Password: haymarket

Points of interest

1 **Edinburgh International Convention Center**
Conference Venue
The Exchange, 150 Morrison St, Edinburgh EH3 8EE, United Kingdom

2 **The Hub**
Welcome Reception Venue
348-350 Castlehill, Edinburgh EH1 2NE

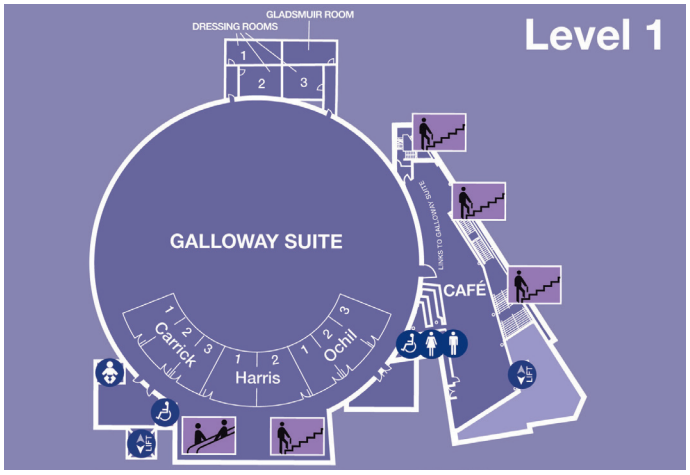
3 **National Museum of Scotland**
Gala Dinner Venue
Chambers Street, Edinburgh, EH1 1JF

LET2019 Conference Programme

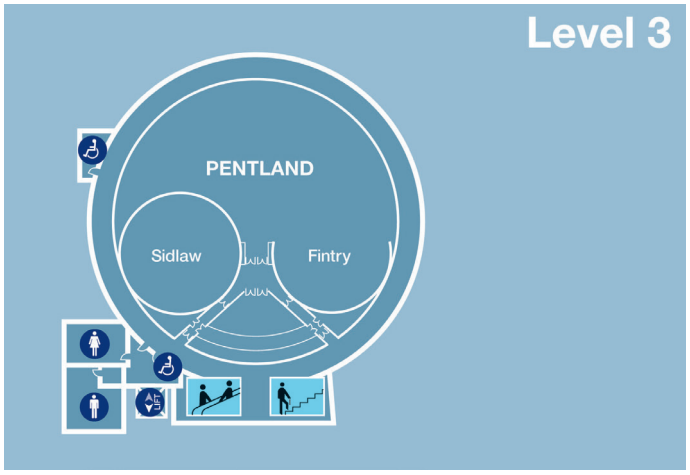
Monday, 10 June 2019
Workshops Programme

8:30	**Registration opens**		
9:30 - 13:00	**Workshop 1:** Frontiers in Engineering Biology: New Paradigms for the Water Industry	**Workshop 2:** Microplastics – Concern of Water Sector?	**Workshop 3:** Digital Water: Enabling, Empowering and Accelerating the Digital Water Revolution through Information Exchange
	Room: Carrick Suite	**Room:** Harris Suite	**Room:** Ochil Suite
13:00 - 14:00	**Lunch Break (Strathblane Hall)**		
14:00 - 15:30	**Workshop 4:** Recent Developments in Implementing Granular Sludge Technology	**Workshop 5:** Dissolved Organic Carbon in Drinking Water – a Complex Mix of Challenges	**Workshop 6:** Bringing Leading Edge Technology to Market – the Long and Difficult Path
	Room: Carrick Suite	**Room:** Harris Suite	**Room:** Ochil Suite
19:00	**Welcome Reception** (The Hub - 348-350 Castlehill, Edinburgh EH1 2NE)		

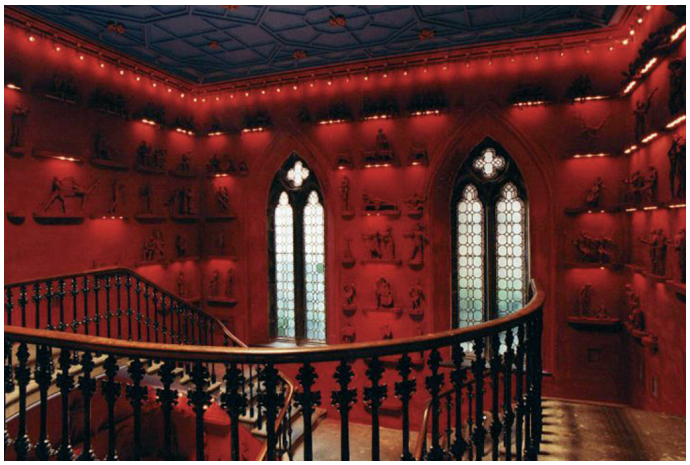
EICC LEVEL 1 – Workshops Rooms



EICC LEVEL 3 – Plenary and Technical Sessions



Welcome reception (The Hub, Edinburgh)



Workshops details:

Workshop 1:	Frontiers in Engineering Biology: New Paradigms for the Water Industry
Organiser:	**Tom Curtis (Newcastle University, United Kingdom) and William Sloan (Glasgow University, United Kingdom)**
Room:	**Carrick Suite**
Objective:	To take the participants on the steps from the genome to individual cells (using genomics and simple metabolic models), from cells to small communities (using individual based models) and from small communities to entire systems (using statistical emulators and computational fluid dynamics). The stumbling blocks will be identified and "work arounds" proposed.
Expected outputs:	A knowledge and understanding of the strategy and associated tools for systematic scale up from the level of the cell to an entire system.
9:30-9:50	**The conceptual frame work for multiscale modelling of biological water treatment systems** Tom Curtis
9:50-10:10	**Developing Component Process Based Models** Bill Sloan Why technical innovation is slow and expensive and the framework for taking genome level knowledge to scale can deliver solutions 100 times more quickly than at present. **Cell to Community** • Individual based models with real chemistry and mechanics running on high performance computers can model up to 108 bacteria Valentina Goulancea, Denis Taniguchi, Bowe Li **Community to System** • Using statistical emulators to scale up individual based models. Ben Allen • Using intelligent robotic platforms to scale up to deliver systems scale models Lucile Chatelard
11.00-11.20	**Coffee Break**
11.20-12.10	**Community to Technology** • Connecting biological to Multiphysics representation of the technology using computational fluid dynamics in Openfoam Andrew Coughtrie • Rapid prototyping using model outputs Stephanie Connelly • Validation a different scales Russ Davenport and Mat Brown
12:10	**Next steps and challenges** • Genome to metabolism • Mechanics • Your Challenge (Facilitated discussion)
13:00	**Close**

Workshop 2:	Microplastics – concern of water sector?
Organiser:	**Riku Vahala (Aalto University, Finland) and Julia Talvitie (Marine Research Center, Finnish Environment Institute, Finland)**
Room:	**Harris Suite**
Objective:	To provide an overview of the current knowledge on microplastics in water sector and identify the main knowledge gaps.
Expected outputs:	The workshop will bring together utilities, scientists and other water professionals to share the current knowledge, to discuss about the best practices and to identify main knowledge gaps in the role of water sector on microplastic pollution.
9:30-9:50	**Introduction and welcome**
10:00-11.00	**The role of microplastics in different waters** • The fate of microplastics in wastewater treatment plants • Wastewater-derived microplastics as carriers of pathogens and micropollutants • Microplastics in natural and storm waters • Microplastics in drinking and bottled water
11.00-11.20	**Coffee break**
11.20-11.50	**Round tables** The tables are given questions related to the workshop's topics. Experts from the field are supporting the discussions. Preliminary questions for round tables: 1. Do we have enough knowledge on MPs in water sector? 2. How should we communicate environmental and health risks to water users? 3. What information we still need & how the information would reach people working in a water sector? 4. What is the quality of the current data?
12:10	
11.50-12.00	**Table conclusions**
12.00-12.30	**Panel discussion**
12.30- 13.00	**Concluding remarks**

Workshop 3:	Digital Water: Enabling, Empowering and Accelerating the Digital Water Revolution through information exchange
Organiser:	**Pablo Ledezma (The University of Queensland, Australia) and Jürg Keller (The University of Queensland, Australia)**
Room:	**Ochil Suite**
Objective:	To have in-depth discussions about the role of Digital Water and its deployment across the Water Sector.
Expected outputs:	This workshop is for all professionals who want to gain a deeper understanding of and/or wish to lead the **#DigitalWaterRevolution**. Through interaction with experienced **#WaterLeaders** in the form of panel and group discussions, professionals will expand their understanding of the **#DigitalWaterRevolution**, obtain practical knowledge about numerous case-studies and participate in general discussions, with the aim to develop an IWA-wide initiative.
9:30-9:35	**Introduction: background, motivation and objectives**
9:35-9:45	**Introducing Case-Study panellists**
9:45-11:00	**Case Studies on Water Digitalisation x4 (10 min each) + Questions to panel** (Panelists: Xylem, Scottish Water, Suez and Northumbrian Water)
11:00-11:20	**Coffee break**
11:20-11:25	**Open discussion: what are the opportunities, barriers and needs to move the Water Sector into the Digital era?**
11:25-11:30	**World Café introduction**
11.30-11:40	**World Café round 1**
11:40-11:50	**World Café round 2**
11:50-12: 00	**World Café round 3**
12:00-12:45	**In-depth general discussion:** 1. Reports from Wold Café tables (2min each) 2. How can we enable environments, innovative approaches, and information exchange to meet the predicted billion-dollar boom for the Water sector? 3. Targeted actions: how can the IWA enable, empower and accelerate the Digital Water Revolution?
12:55-13:00	**Conclusions and closing**

Workshop 4:	Recent Developments in Implementing Granular Sludge Technology
Organiser:	**Edward van Dijk (RHDHV, The Netherlands), Mario Pronk (RHDHV and TUDelft, The Netherlands), Ana Soares (Cranfield University, United Kingdom) and Scottish Water (United Kingdom)**
Room:	**Carrick Suite**
Objective:	Aerobic granular sludge provides advantages over conventional activated sludge in terms of increased biomass density, reduced energy requirement, reduced surface requirements for treatment and clarification. The objective is to provide an overview of the recent developments in implementing granular sludge technology.
Expected outputs:	Learn from the experiences from current AGS plants, gain insight about design considerations, and find out about where and where not to implement AGS technology.
14:00-14.10	**Introduction** Mario Pronk/Edward van Dijk/Ana Soares
14:10-14:40	**Nereda application operational windows** Andreas Giessen (Royal HaskoningDHV)
14:40-15:05	**How can biofilm technology help us to improve wastewater treatment?** Jeremy Biddle (Bluewater Bio)
15:05-15:30	**Lessons learned of a full-scale granular sludge process in a continuous flow activated sludge BNR WWTP** Pascal Harper (AECOM)
15:30-15:50	**Coffee break**
15:50-16:25	**Reasoning and decision making; what are the decisive factors for using AGS?** Rachel Fox and Gordon Reid (Scottish Water)
16:25-17:00	**Which methods are suited to separate a granular sludge fraction from a flocculent sludge fraction?** Viktor Haaksman (TU Delft)
17:00-17:30	**Plenary discussion and closure.** Mark van Loosdrecht (TU Delft)

Workshop 5:	Dissolved Organic Carbon in Drinking Water – a Complex Mix of Challenges
Organiser:	**Chris Rocky (SWW, United Kingdom) and Graeme Moore (Scottish Water, United Kingdom)**
Room:	**Harris Suite**
Objective:	Effectively managing dissolved organic carbon (DOC) in the water cycle is of key importance to many water utilities around the world. This workshop will focus discussions on the nature of DOC in source water, its impact on drinking water quality and how quantity and character can be assessed and managed from catchment to consumer.
Expected outputs:	The diverse nature of DOC impacts treatment, disinfection and distribution of drinking water; it effects the efficiency and sustainability of processes as well as the aesthetic, chemical and microbiological quality of tap water supplies provided to consumers. Changes in both the quantity and character of DOC are noted globally due to the impacts of climate change and the search for new fresh water sources including the re-use wastewater. This workshop will share current knowledge and promote discussion on current and future challenges.
14:00-14:20	**DOC in drinking water - why it is important , a utilities perspective.** Chris Rockey (South West Water and the DOC2C's research project)
14:20-14.50	**Panel Session 1 The impact of DOC - treatment and distribution** Christine Murray (Scottish Water)
14.50-15:30	**Panel Session 2 Characterisation of dissolved organic carbon: what should we be measuring?** Peter Jarvis (Cranfield University)
15:30 – 15:50	**Coffee break**
15:50-16:30	**Panel Session 3 Treatment technologies for the optimum removal of DOC from Surface Water** Liesbeth Verdickt (DeWatergroep)

Workshop 6:	Bringing Leading Edge Technology to Market – the Long and Difficult Path
Organiser:	**Jonathan Clement (Nanostone, The Netherlands) and Paul O'Calaghan (BlueTech Research, United Kingdom)**
Room:	**Ochil Suite**
Objective:	The emergence of new water technologies is dramatically slow compared to other industries. There are numerous barriers to break through before a technology is adopted and accepted by utilities. On can visualize a pyramid where at the bottom there are numerous ideas, and these most often can develop and studied at the university level. In the middle are the technology companies which must work out the engineering details to make the technology functional and acceptable. Finally, at the top are the adopters which must be convinced of the merits and proven performance of the technology and have a need. The pathway to the top is long and most technologies never make it to adoption. The success rate in the water sector to move to profitably is typically > 12 years. This workshop will involve discussions across the three important sectors; academic, technology providers, and adopters, with the goal of finding ways of bringing valuable technology faster to market.
14:00-14:05	Opening Jonathan Clement – the nature of the problem
14:05-14:10	Paul O'Callaghan – the objectives of the workshop
14:10-14:30	**University Perspective 4 panelists moderator Paul O'Callaghan** Mark van Loosdrecht - TU Delft (The Netherlands) Shane Snyder - Nanyang Technological University (NTU) (Singapore) Jorg Drewes - Technical University of Munich (Germany) Bruce Rittmann - Arizona State University (United States)
14:30-14:50	**University Discussion with audience**
14:50-15:10	**Technology companies moderator Paul O'Callaghan** Randy Cable – IXOM Imran Jafferey – Nanostone Michael Flynn - Nasa TBD
15:10-15:30	**Technology company discussion with audience**
15:30-15:50	**Coffee break**
15:50-16:10	**Utility and End User Perspective Moderator Jonathan Clement** Steve Capewell – Water corp Simon Parsons – Scottish Water Uwe Solfrank - Holinger Jeff Yarne – Yarne Consulting
16:10-16:30	**Utility discussion with whole audience**
16:30 – 17:30	**Summary discussion significant take away points** Paul O'Callaghan. Whole group

Tuesday, 11 June 2019
Plenary Sessions

8:15 - 9:00

Registration opens

9:00 - 9:30

ROOM: PENTLAND AUDITORIUM (LEVEL 3)

Welcome addresses
Kala Vairavamoorthy (Chief Executive IWA)
Ana Soares (Cranfield University)
Douglas Millican (Chief Executive Scottish Water)
Andy Dunn (Chief Executive Thames Water)

9:30 - 10:15

Entrepreneurial Adventures in Water: Lessons Learned and Future Outlook
Eric Hoek
Water Planet, United States

Dr. Eric Hoek has over 20 years of experience in water treatment research, education, philanthropic, consulting and entrepreneurial activities.
Dr. Hoek has been an engineering professor since 2002 with 140+ peer-reviewed scientific publications and 70+ patents filed globally. Dr. Hoek has also co-founded numerous successful water technology businesses including NanoH2O, Water Planet, PolyCera Membranes, IntelliFlux Controls and MembranePRO Services. Dr. Hoek is co-Editor-in-Chief of the John Wiley & Sons Encyclopedia of Membrane Science and the Editor-in-Chief of the npj Clean Water – a Nature publishing group online, open access scientific journal.
Dr. Hoek has a Ph.D. in Engineering from Yale University and completed UCLA's Anderson School of Management, Executive MBA Program.

ABSTRACT: In this talk, I will present a historical overview of my many and varied entrepreneurial ventures starting with my first lemonade stand. Then, I will relate a few more recent experiences using Water Planet and NanoH2O as case studies to help understand why some water technology startups succeed and others fail. I will go on to talk about what unique characteristics define entrepreneurs and startup companies, as well as the myriad challenges a startup must overcome to grow into a mature business or risk perishing in the "valley of death." Next, I will talk about what investors look for in technology startups and their processes for making investment decisions. Last, I will summarize various lessons learned and discuss the future outlook based on my new work with the next generation of water technology entrepreneurs.

10:15 - 10:45

Coffee Break (Cromdale Hall-Exhibition)

10:45 - 11:45

Digital Water: The journey for the water sector
How will digital technologies transform our relationship with water – not just the water and wastewater utility sector but how all stakeholders connect to and manage water?
Following the launch of the first in a series of whitepapers from the IWA Digital Water Programme - Digital Water: Industry leaders chart the transformation journey – the plenary panel will be an opportunity to explore how digitalisation is transforming the water sector including the value drivers, enablers and the challenges the sector faces.

11:45 - 12:00

Ministerial address
Roseanna Cunningham (Scottish Government Cabinet Secretary for Environment, Climate Change and Land Reform)

12:00 - 12:45

How Do We Make A New Paradigm For Water Reality?
Maxine Mayhew
Executive Director, Group Capability & Water, Costain Group P, United Kingdom

Dr Maxine Mayhew is the Water Sector Director for Costain, the technology based engineering solutions provider where she is responsible for the P&L delivery and continued development of the ambitious Water Services Business. Previously she was Group Commercial Director at Northumbrian Water Limited where she was responsible for supply chain and marketing functions as well as leading the sourcing, negotiation and delivery of high value commercial contracts. Maxine completed a PhD in 1998 and has held a variety of roles in the water Industry. During recent years Maxine has focussed on commercial leadership and strategy development and implementation and she has held Director roles which have covered all aspects of the industry from operations and engineering, through to support services including health, safety, risk, security, procurement and marketing. She is also an independent member of the Cranfield University Council and a member of the Anaerobic Digestion and Biogas Association Board.

(continued on next page)

ABSTRACT: Ensuring an affordable sustainable water supply along with protecting and enhancing the environment have never been more important for the UK water industry. This need is against a backdrop of growing population, climate change and aging infrastructure.
Water was at the heart of the first industrial revolution when the use of water and steam to mechanise production transformed working practices in the 1800s. And now the fourth industrial revolution is accelerating with developments in areas such as artificial intelligence already well advanced. The opportunities this fourth revolution creates need to be at the heart of the water industry. But how do we harness this digital landscape in an industry that has an abundance of existing aging assets and a need to deliver improvement in performance, efficiency and innovation alongside decreasing bills for customers.
The application of asset optimisation to truly drive more for less is not new, yet it is still not universally adopted nor has the overlay of data analytics to create intelligent networks and systems been fully exploited. Buzz words like digital twin and systems thinking are becoming normal parlance in the sector. However, for these concepts to be suitably disruptive clarity about what they are in each scenario and how to successfully deploy for sustainable solutions needs to be defined and developed. Using experience from other industry sectors and collaboration in its broadest sense we are starting to drive a different set of approaches. So how do we now make a new paradigm reality for water in a timeframe that matches the scale of the challenges?

12:45 - 13:45 Lunch Break (Cromdale Hall-Exhibition - Level -2)

13:45 - 14:30

Micropollutants – Challenges and Current Experiences in Switzerland

Uwe Sollfrank
Holinger AG, Switzerland

Dr. Uwe Sollfrank is president of the HOLINGER Group, a Swiss based engineering company specialized in water and environment. He joined HOLINGER in 1992 and worked in the beginning of his career for more than 20 years as a project manager and process engineer for environmental projects in several countries around the world.
He holds a PhD in natural sciences of the Swiss Federal Institute of Technology Zurich, Switzerland and a master in environmental engineering of the Technical University of Berlin, Germany as well as a postgraduate in environmental engineering and water pollution control of the Swiss Federal Institute of Technology in Zurich.
Dr. Sollfrank started his scientific career as a research assistant at the Institute for Water, Soil and Air Hygiene (WaBoLu) of the German Federal Health Office in Berlin. After his move to Switzerland he was working as an Assistant Professor in process engineering in water pollution control at the Swiss Federal Institute of Technology Zurich before joining the technology development competence centre of Sandoz Technology Switzerland where he was responsible for environmental engineering projects worldwide as well as technology planning and transfer and economical and ecological project approvals. He is responsible for the subsidiaries of the HOLINGER group and a Member of the Board of Directors of the environmental analysis company Envilab in Zofingen. Since 2010 he is as well executive director of HOLINGER Ingenieure, Germany and HOLINGER International Consultants, Switzerland. Furthermore Dr. Uwe Sollfrank is Member of the Board of Directors of the United Association of Swiss Engineers and Consultants (USIC) and the Swiss Water Association (VSA).

ABSTRACT: Based on a national survey of micropollutants as well as reported declines in fish health and trout catch in Swiss streams and rivers, it became evident that residues of organic substances – like detergents, pesticides and pharmaceuticals - in our waterbodies can cause negative effects on water organisms, fish reproduction and our drinking water resources. After a broad dialogue with all stakeholders and the acceptance by a great majority of the eligible voters, the Swiss government extended the environmental law to reduce the pollution of micro-contaminants from wastewater. The changes in legislation has come into force by January 1st, 2016 and demands mainly from the owners of larger wastewater treatment plants and plants discharging to receiving water bodies used for drinking water supplies to upgrade their plants with an additional step to remove micropollutants by more than 80%. The national program is limited from 2016 until 2040. The overall investment is estimated to 1.2 billion CHF and will be financed up to 75% by a specifically launched fund. About 100 of our more than 700 plants in Switzerland, treating more than 50% of all our wastewater, will have an additional step to remove micropollutants in near future.
Currently in Switzerland 9 full scale plants are in operation – 5 steps with activated carbon treatment and 4 with ozonation followed by sand filtration, 3 are under construction and 19 are in the design phase. A majority of the newly built plants will use different process technologies or will even combine ozone and activated carbon. For the evaluation of process suitability, a standard procedure is used in Switzerland to characterize wastewater and to identify effects of ozonation or ozonation by-products. The performance of selected plants as well as pilot tests with combined systems under typical municipal wastewater conditions will be presented. Bioactive granular activated carbon filters combined with ozonation are shown to be an interesting alternative, cost effective and flexible in operation even if advanced treatment is required.

14:30 - 15:15

Arsenic Technology Research: Crossing Borders and Disciplines

Doris van Halem
TU Delft, The Netherlands

Doris van Halem is associate professor in the field of drinking water treatment, with a specific focus on groundwater contaminants, including arsenic and fluoride. Her research has a global orientation with an emphasis on filtration systems for low resource environments. The past years she has been leading PhD/ Postdoc research projects in Bangladesh, India, Nicaragua as well as the Netherlands, supported by NWO-WOTRO (SAR/DELTAP), NUFFIC, NWO-TTW (FixAs) and Delft Global.
Doris graduated from Delft University of Technology in Civil Engineering and Geosciences with a cum laude MSc degree (2007).In 2011 she completed her PhD research (with honours) on subsurface iron and arsenic removal for drinking water supply in Bangladesh under the guidance of prof. J.C. van Dijk (TU Delft) and prof. dr. G.L. Amy (Unesco-IHE).

ABSTRACT: The role of water engineers in arsenic contaminated regions is shifting, demanding for a new generation of adaptive drinking water technologies. Technologies that benefit from current (digital) innovations but connect to the end-user's context and resources.
Although arsenic has been on the global radar for decades now, still new contaminations of drinking water sources are detected every year. Implementation of mitigation strategies remains a challenging task for many water companies and governments, particularly in regions relying on decentralized groundwater sources. The scattered nature of contaminated wells, as well as the diverse water matrices in which this anion is found, adds to the complexity of applying engineered solutions. In this plenary presentation the role of arsenic removal technology research will be discussed from an interdisciplinary and cross-border perspective, with an emphasis on end-user inclusion. With results from ongoing research in Bangladesh and India Dr. van Halem will illustrate that mobile crowd participation, through smart phones, is a powerful tool for modern water engineers. Particularly when this digital form of end-user participation is combined with empowerment of end-users through do-it-yourself practices. DIY construction of arsenic filters is done with clever (open-source) plastic reuse machines and locally available resources, such as waste plastic and bamboo. Filter design and manufacturing is achieved by involving local craftsmen, universities, small entrepreneurs and women's groups. This end-user inclusive approach assumes that grass roots initiatives, where enthusiasm and commitment of individuals is key, can grow into a larger movement, resulting in future blueprints for mitigation strategies.
This means that as a water engineer your role changes. The boundary conditions under which technical solutions have to sustain are more complex, as well as the modes of monitoring safe operation. As a consequence, a new generation of technologies is required, a generation of innovations where the end-user's context is taken into account early in the development.

15:15 - 15:45

Coffee Break (Cromdale Hall-Exhibition - Level -2)

15:45 - 16:25

Environmental Biotechnology: Opening the Black Box of the Slime Layers

Mark van Loosdrecht
TU Delft, The Netherlands

Mark van Loosdrecht is Professor in Environmental Biotechnology at Delft University of Technology, The Netherlands. He graduated from and did his PhD research at Wageningen University. His PhD topic was a combination of microbiology and colloid chemistry. He was appointed at Delft in 1988 and became Full Professor in 1998. His research is characterized by the combination of scientific understanding of complex systems and development of new processes. Dr. van Loosdrecht's scientific interests are mainly related to biofilm processes, nutrient conversion processes and the role of storage polymers in microbial ecology. In particular, he is interested in new processes related to wastewater treatment and resource recovery. His research has resulted in several processes currently applied on full scale such as the Sharon process, Anammox process and Nereda process.
He was awarded the Spinoza Award, Simon Stevin Award and a knighthood in the order of the Dutch Lion. He is the co-winner of the 2018 Stockholm Water Prize. He has published over 600 scientific papers, has 20 patents and has supervised over 50 PhD students.

ABSTRACT: Bacteria in most natural and engineered systems tend to immobilize themselves as biofilms. Biofilm studies are too often monodisciplinary in nature (either engineering or microbiology oriented). Many of the factors that govern biofilm processes can be derived from engineering principles, yet microbial knowledge is needed to understand the true mechanisms behind biofilm processes. Examples are the principle that bacteria only make biofilms if they cannot grow as planktonic cells or as a flocculent community; driven by mass transfer resistance. Formation of dense biofilms (and therefore also granular biomass) is related to biomass potential growth rate. The successful principle on which also the Nereda technology is based. The next stage in biofilm research is the formation and complexity of the extracellular matrix. For long time a kind of dark matter of microbiology. Better understanding of this dark matter will enable production of high performance resources from waste organic carbon.

Environmental Biotechnology: Biofilms on Active Substrata

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.
Dr. Rittmann was awarded the first Clarke Prize for Outstanding Achievements in Water Science and Technology from the NWRI, the Walter Huber Research Prize and the Simon Freese Award from ASCE, the G.M. Fair Award from AAEES, and the Perry L. McCarty/AEESP Founders Award. He is the co-winner of the 2018 Stockholm Water Prize. Dr. Rittmann has published over 700 journal articles, books, and book chapters, and he has 16 patents. With Dr. Perry McCarty, Dr. Rittmann co-authored the textbook Environmental Biotechnology: Principles and Applications (McGraw-Hill Book Co.).

ABSTRACT: The capabilities of biofilm processes can be enhanced when they are grown on active substrata. In this case, an active substratum provides the microorganisms' essential electron donor or electron acceptor. The prime example of providing an electron donor is the Hydrogen-based Membrane Biofilm Reactor (MBfR), in which H2 gas is delivered to a biofilm by its diffusion through the wall of a non-porous gas-transfer membrane. The MBfR makes it possible to supply microorganisms with a low-solubility electron donor so that the biofilm can reduce one or several of a wide range of oxidized contaminants: e.g., nitrate, perchlorate, selenate, chromate, and uranyl. The donor supply is on-demand and 100% efficient. The best example of providing an electron acceptor is the anode of a microbial electrochemical cell. Anode-respiring bacteria (ARB) oxidize organic electron donors (i.e., BOD) and use the anode as their terminal electron acceptor for energy generation. The respired electrons move through a circuit to the cathode, where they can create value by generating electrical power, H2 gas, hydrogen peroxide, or organic chemicals. Thus, the microbial electrochemical cells provide two benefits: removing BOD and investing the electrons in valuable outputs.

16:25 - 17:00

Lydia Whyatt
Resonance Asset Management Limited, United Kingdom

Lydia is MD at Resonance Asset Management in charge of water Investments and is managing $320m fund focussed on industrial water infrastructure finance, which she developed and raised.
Lydia has over 13 years' experience investing in water technology, infrastructure and service businesses and has over 18 years investment experience in PE/VC and infrastructure.
Prior to joining Resonance, Lydia was a Managing Director of the Environment Group at Fourwinds Capital Management and was responsible for managing Aqua Resources Fund, where she was on the board of Waterleau Group, a leading wastewater treatment business, and Monsal, the UK's leading AD business, which was acquired by GE. She was also part of Kennet Venture Partners, and a management consultant with McKinsey in London.
Lydia has a Finance degree from London School of Economics and a postgraduate degree in Physics from Moscow State University.

ABSTRACT: The commercialisation of water technology is not an easy feat, and is not for fainthearted investors. Sales cycles are long, and appetite for risk taking by clients (utilities in particular) is practically non-existent. During my almost 20-year experience in the sector, I have seen a lot of companies that did not succeed in bridging this "Death Valley" of commercialisation as their investors lost patience and gave up.
There are a number of ways to overcome this problem. Most of these, however, involve significant capital injection to prove the technology as well as to market it. If this capital comes in the form of equity, the entrepreneurs face significant dilution, to the point of losing control over the company they have created. I have developed a different approach to the problem, and with my partners raised a fund that helps technology companies reduce the amount of equity capital they need to raise, while eliminating the need for their clients to take the technology risk. I hope to be able to share our approach in my presentation.
In brief, our fund invests capital into a water treatment plant that uses the new technological approach the company is trying to market, assuming the client is willing to commit to a fixed long-term contract to use this plant if it works. The clients do not pay anything upfront, and only pay if the plant is delivering to specifications agreed in advance. In a time when so much new water technology has come of age, we are excited to be able to pioneer this financing approach.
We see a lot of opportunities in using brine concentration, biological treatment, more efficient aeration technologies, disinfection, and general digitisation of plant operations that bring significant benefits in efficiency and quality of water treatment.

17:00 - 18:00

Panel Discussion

How to integrate generational experience with millennial communication technology within the workforce?

Panelists: Randy Cable (IXOM), Roderick Abinet (Kemira), Steve Dawson (Xylem), Simon Parsons (Scottish Water), Jonathan Clement (Nanostone)

Wednesday, 12 June 2019
Technical Sessions

8:15 - 9:00	**Registration opens***	**Registration opens***
	DRINKING WATER TRACK Room: Sidlaw Auditorium (Level 3)	**WASTEWATER TRACK** Room: Fintry Auditorium (Level 3)
	SESSION 1: RECENT DEVELOPMENTS TO IMPROVE DESALINATION **Co-Chairs:** Nikolay Voutchkov, Ahmad Al Amoudi	**SESSION 2: EMERGING CONTAMINANTS: MICROPLASTICS, PHARMACEUTICALS AND PERSONAL CARE PRODUCTS (PPCP) AND ANTIBIOTIC RESISTANCE** **Co-Chairs:** Pablo Campo Moreno, Thomas Ternes
9:00 - 9:30	**Keynote (1)** **Pre-treatment alternatives for large scale seawater desalination: the Perth Experience** Steve Capewell, Water Corporation (Australia)	**Keynote (1)** **Urban wastewater treatment plants as hot spots for release of antibiotic resistances to the aquatic environment** Thomas Berendonk, TU-Dresden (Germany)
9:30 - 9:45	**Assessment Of A Desalination Pilot Plant Reliability Against Extreme Seawater Quality Events By Means Of Threshold Tests** Olga Ferrer Mallén, ACCIONA Agua S.A.U. (Spain)	**Antibiotic Resistance Dissemination In Municipal Reclaimed Water Distribution Systems By Culture And Metagenomic** Ishi Keenum, Virginia Tech (United States)
9:45 - 10:00	**Chemical Handling Free Inline Coagulation To Control UF Fouling** Loreen Villacorte, Grundfos Holding A/S (Denmark)	**PS-oxidation-assisted Membrane Distillation Process For Emerging Micropollutant Degradation And Membrane Fouling Control** Faisal Hai, University of Wollongong (Australia)
10:00 - 10:30	**Discussions**	
10:30 - 11:00	**Coffee Break (Cromdale Hall-Exhibition - Level -2)**	
11:00 - 11:30	**Keynote (2)** **Theoretical Assessments Of Leading-edge Technologies For Low-energy Seawater Reverse Osmosis Process** Kiho Park, Korea University (Korea)	**Keynote (2)** **Fate and removal of emerging contaminants and plastic in wastewater** Adriano Joss, EAWAG (Switzerland)
11:30 - 11:45	**A Techno-economic Evaluation Of Incorporating Energy Recovery Devices Within Continuous-batch Reverse Osmosis Processes** Mícheál Cairns, Dublin City University (Ireland)	**Removal Of Organic Micropollutants From Wastewater Treatment Plant Effluents Using The Nyex™ Process** Lucile Francois, Arvia Technology (United Kingdom)
11:45 - 12:00	**Towards The World's Largest Microbial Desalination Cell For Simultaneous Wastewater Treatment And Water Desalination** Patricia Zamora, FCC Aqualia (Spain)	**A Novel Advanced Bio-oxidation System For The Treatment Of Urban Wastewater And Emerging Pollutants** Fernando Martinez, Rey Juan Carlos University (Spain)
12:00 - 12:30	**Discussions**	
12:30 - 12:45	**Poster Pitch Session 1**	**Poster Pitch Session 2**
12:30 - 12:35	**Spatially Isolating Salt Crystallisation For Continuous Solar Steam Generation And Salt Harvesting** Xiwang Zhang, Monash University (Australia)	**Effect Of Ozone/Biologically-Active Carbon Filtration On Microbial Community Structure And Antibiotic Resistance Genes** Matthew Blair, Virginia Tech (United States)
12:35 - 12:40	**REvivED Water: Efficient And Low Energy Electrodialysis System For Brackish Water Desalination, Case Study** Abdulsalam Alhadidi, Fujifilm Manufacturing Europe B.V. (The Nehterlands)	**Validation Of A Protocol For The Analysis Of Microplastics In Sludge** Pablo Briones, Cranfield University (United Kingdom)
12:40 - 12:45	**High Recovery Desalination System Based On Brine Treatment By Previous Softening And Membrane Distillation Process** Olga Ferrer Mallén, ACCIONA Agua S.A.U. (Spain)	**Inactivation Of Antibiotic Resistant Bacteria And Genes By Conventional And Advanced Disinfection Methods** Kuichang Zuo, Rice University (United States)

* Join the Water Test Network and Hydro Nation Water Innovation Service at a FREE breakfast event to find out how your business could benefit from their transnational network of test facilities and 100% funded support packages to accelerate new innovations. The event takes place on 12 June from 8.00 at EICC, Edinburgh. Spaces are limited, so book your place NOW:http://www.nweurope.eu/projects/project-search/water-test-network/events/let2019/. More information at: watertestnetwork@scottishwater.co.uk

12:45 - 14:00	Lunch Break (Cromdale Hall-Exhibition - Level -2)	
	SESSION 3: MICRO-CONTAMINANT CONTROL IN DRINKING WATER **Co-Chairs:** Shane Snyder, Jorg Drewes	**SESSION 4: ENERGY EFFICIENCY AND RESOURCE RECOVERY IN WASTEWATER TREATMENT** **Co-Chairs:** Ana Soares, Francesco Fatone
14:00 - 14:30	**Keynote (1)** **UV based advanced oxidation for emerging organic contaminants removal** Jiangjong Hu, National University of Singapore (Singapore)	**Keynote (1)** **Energy or resources from wastewater: using LCA to make sustainable choices** Enna Klaversma, Waternet (The Netherlands)
14:30 - 14:45	**Algae-Related Micro-Contaminants: Multi-Barrier Oxidation Technology Solutions For An Emerging Threat** Beatrice Martin, Xylem Water Solutions UK Ltd (United Kingdom)	**Is There A Water - Chemistry Nexus?** Korneel Rabaey, Ghent University (Belgium)
14:45 - 15:00	**Monitoring The Breakthrough Of PFAS In Packed Bed Adsorption Columns By EEM-fluorescence Monitoring The Breakthrough Of PFAS In Packed Bed Adsorption Columns By EEM-fluorescence** Paolo Roccaro, Università degli Studi di Catania (Italy)	**Technoeconomic Analysis For Energy Efficiency And Resource Recovery Adoption -- Case Studies** Leon Downing, Black & Veatch (United States)
15:00 - 15:30	Discussions	
15:30 - 16:00	Coffee Break (Cromdale Hall-Exhibition - Level -2)	
16:00 - 16:30	**Keynote (2)** **Next generation Biofiltration Systems for Trace Organic Chemical and Pathogen Removal** Jorg Drewes, TU Munich (Germany)	**Keynote (2)** **Water and the Exploration of Space** Michael Flynn , Water recycling technology development at NASA (United States)
16:30 - 16:45	**How Will Switching From Aerobic MBRs To Anaerobic MBRs Impact Disinfection By Product Formation?** Bruce Jefferson, Cranfield University (United Kingdom)	**Disruptive Water Reuse Scheme Based On Direct Ultrafiltration (DUF) Of Municipal Wastewater** Hugues Humbert, Veolia Technical & Performance Department (France)
16:45 - 17:00	**Transforming Drinking Water Treatment - MBBR For Taste And Odour Compound Removal** Jurg Keller, The University of Queensland (Australia)	**Effect Of The Fe Dosing Increase On The Sludge Composition In A WWTP Using The CPR Strategy** Thomas Prot, Wetsus/TU Delft (The Netherlands)
17:00 - 17:30	Discussions	
17:30 - 17:45	Poster Pitch Session 3	Poster Pitch Session 4
17:30 - 17:35	**Transformation Of Methamphetamine And Analogues To (Halo)nitromethane Carcinogens By Water Treatment With Ozone/Chlorine** Daniel McCurry, University of Southern California (United States)	**Multivariate Analysis For Behavioural System Analysis In The SCENA Process** Evina Katsou, Brunel University London (United Kingdom)
17:35 - 17:40	**PFAS And PFOS: A New Challenge For The Australian Water Industry** Steve Capewell, Water Corporation (Australia)	**NPHarvest -- A New Energy Efficient Nitrogen Recovery Technology** Juho Kaljunen, Aalto University (Finland)
17:40 - 17:45	**Full Scale Implementation Of New Zirconium Coagulant In Water Treatment** Tor Hakonsen, NTNU / Norconsult (Norway)	**Production Of Bacterial Lipids From Hydrocarbon-based Wastewaters In Sequencing Batch Airlift Reactors (SBAR)** Ana Marques Silva, University of Minho (Portugal)

Thursday, 13 June 2019
Technical Sessions

8:15 - 9:00	**Registration opens**	**Registration opens**
	DRINKING WATER TRACK Room: Sidlaw Auditorium (Level 3)	**WASTEWATER TRACK** Room: Fintry Auditorium (Level 3)
	SESSION 5: NOVEL DISINFECTION TECHNOLOGIES **Co-Chairs:** Bruce Rittmann, Domenico Santoro	**SESSION 6: EMERGING TECHNOLOGIES FOR NUTRIENT REMOVAL** **Co-Chairs:** Jurg Keller, Mari Winkler
9:00 - 9:30	**Keynote (1)** **Towards Risk Based Optimal Design Of Chemical Disinfection Systems** Charles N. Haas, Drexel University (United States)	**Keynote (1)** **Purple Phototrophic Bacteria for Nutrient Recovery** Tim Hülsen, The University of Queensland (Australia)
9:30 - 9:45	**Improving Disinfection Using Molecular-based Microbiological Analyses** Claire Thom, Scottish Water/University of Glasgow (United Kingdom)	**Sulphur-Enabled Electrochemical Nitrogen Recovery From Anaerobically Treated Wastewater** William Tarpeh, Stanford University (United States)
9:45 - 10:00	**Evaluation Of Enhanced UV Disinfection For Planned Indirect Potable Reuse Schemes - Laying The Path To A Regulatory Fram** Ian Mayor-Smith, University of Brighton (United Kingdom)	**Pilot Up-scaling, Decentralisation And Automation Of A Microbial Electrochemical System For Nutrient Recovery From Urine** Pablo Ledezma, The University of Queensland (Australia)
10:00 - 10:30	**Discussions**	
10:30 - 11:00	**Coffee Break (Cromdale Hall - Exhibition - Level -2)**	
11:00 - 11:30	**Keynote (2)** **State Of The Art Of The Production Of Harmful Disinfection By-Products In The Netherlands** Joop Kruithof, Wetsus European Centre of Excellence for Sustainable Water Technology (The Netherlands)	**Keynote (2)** **What's In Your Sludge? Hunting For Baby Granules In Full-Scale Activated Sludge Treatment Plants** Stephany Wei, University of Washington (United States)
11:30 - 11:45	**A Novel Method Using Natural Occurring Viruses For Log Removal Determination In Full Scale Ceramic Microfiltration** Bram Martijn, PWN Technologies (The Netherlands)	**Design And Start-Up Of The Full-Scale MABR Demonstration At The Ejby MøLle WRRF** Nerea Uri Carreño, VCS Denmark (Denmark)
11:45 - 12:00	**Understanding UV Disinfection Under Dynamic Conditions For Energy Optimization Using CFD And Plant-Wide Models** Domenico Santoro, Trojan Technologies (Canada)	**New Directions In Process Modelling -- Catching Up With Industry** Imre Takacs, Dynamita (France)
12:00 - 12:30	**Discussions**	
12:30 - 12:45	**Poster Pitch Session 5**	**Poster Pitch Session 6**
12:30 - 12:35	**The Role Of Microbubbles In Water Treatment: Next Generation Oxidation** Alexander John, Cranfield University (United Kingdom)	**Achieving Stable Mainstream Nitrite Shunt: NOB Adaptation Solved** Zhiyao Wang, The University of Queensland (Australia)
12:35 - 12:40	**Novel Electrochemical Drinking Water Treatment Process For Small And Remote Community Applications** Sean McBeath, Imperial College London (United Kingdom)	**New Generation Of MBBR For Biological Treatment Of Carbon, Nitrogen And Phosphorus** Hugues Humbert, Veolia Technical & Performance Department (France)
12:40 - 12:45	**Validation Of A UV Light Emitting Diodes (LEDs) Reactor For Low-energy Disinfection Of Municipal Drinking Water** Olivier Autin, Typhon Treatment Systems (United Kingdom)	**Full-Scale Demonstration Of Aerobic Granular Sludge In A Conventional Continuous Flow Activated Sludge BNR Plant** Beverley Stinson, AECOM (United States)
12:45 - 14:00	**Lunch Break (Cromdale Hall-Exhibition - Level -2)**	
	SESSION 7: ADVANCED MEMBRANE APPLICATIONS IN DRINKING WATER **Co-Chairs:** Jonathan Clement, Stewart Sutherland	**SESSION 8: SLUDGE MANAGEMENT - INCLUDING RESOURCE RECOVERY** **Co-Chairs:** Bill Barber, Elise Cartmell
14:00 - 14:30	**Keynote (1)** **Recent Developments in the Membrane Filtration Market** Graeme Pearce, Membrane Consultancy Associates (MCA) (United Kingdom)	**Keynote (1)** **Occurence and Reduction of Emerging Contaminants in Sludge** Dilek Sanin, Middle East Technical University (Turkey)

14:30 - 14:45	**Novel Drinking Water Treatment Solution Using Low Pressure NF On Colored Surface Waters** Philippe Sauvignet, Veolia (France)	**Mainstream Deammonification Achieved By Redirecting THP-AD Stream** Zhiyao Wang, The University of Queensland (Australia)
14:45 - 15:00	**HAOPs - A Novel Anti-fouling Material For Membranes Treating Surface Water To Drinking Water Quality.** Eilen Vik, Aquateam COWI (Norway)	**Achieving Energy Self-sufficiency And Reducing GHG Emissions By Optimizing Sludge Treatment In Lingen, Germany.** Ulrich Knörle, Eliquo Stulz (Germany)
15:00 - 15:30	Discussions	
15:30 - 16:00	Coffee Break (Cromdale Hall-Exhibition - Level -2)	
16:00 - 16:30	**Keynote (2)** **Past, Present and Future of Ceramic Membranes** Gilbert Galjaard, Nanostone (The Netherlands)	**Keynote (2)** **Improved Treatment Processes Support the Role of Biosolids in Sustainable Agriculture** Bill Toffey, BlueTech Research (United States)
16:30 - 16:45	**Hybrid catalytic ozonation with ceramic membrane filtration process for synergistic degradation and mineralization of organic micropollutants** Teik-Thye (T.T.) Lim, Nanyang Technological University (Singapore)	**PReconstructing Velocity Profile To Predict The Formation Of Sheared And Unsheared Regions: Impact On Anaerobic Digesters** Flora Markis, Hunter H2O Holdings Pty Ltd (Australia)
16:45 - 17:00	**Evaluation Of TiO_2-GO Modified Ceramic Membranes For Water Treatment** Chen Li, Tsinghua University (China)	**The Effect Of Geometrical And Operational Parameters On Maceration Of Faecal Sludge** Kristin Ravndal, Cranfield University (United Kingdom)
17:00 - 17:30	Discussions	
17:30 - 17:45	Poster Pitch Session 7	Poster Pitch Session 8
17:30 - 17:35	**Membranes In UK Potable Water Treatment: The Past, The Present And The Future** Tony Koodie, Black & Veatch (United Kingdom)	**Moving Towards Maximum Biosolids Reduction: Achieving Ultra-dewatering Of Sludge** Marlene Choo-Kun, Suez (France)
17:35 - 17:40	**Dissolved Methane Removal And Recovery From Groundwater Using Vacuum And Sweep Gas In Hollow Fibre Membrane Contactors** Abel Heinsbroek, Vitens NV (The Netherlands)	**Application Of Hydrothermal Carwwwwwbonization For A Sustainable Valorization Of Sewage Sludge** Gemma Mannarino, Università di Firenze (Italy)
17:40 - 17:45		**Sludge Management Improvements Through The Implementation Of Real-time Analytics And Electronic Anti-Fouling Treatment** Payam Malek, Environmental Treatment Concepts Ltd (United Kingdom)
17:45 - 18:00	Closing Ceremony (Fintry Auditorium - Level 3)	
19:00	Gala Dinner (National Museum of Scotland; Chambers Street, Edinburgh)	

Friday, 14 June 2019 (09:00 - 12:30)
Technical Visits

Glencorse Water Treatment Works
Edinburgh, Scotland

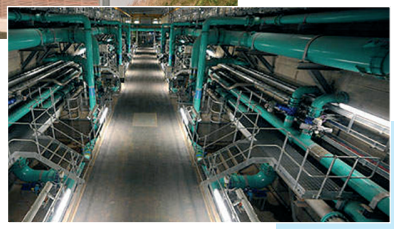
The Glencorse Water Treatment Works nestles in the valley just below the beautiful Pentland Hills Regional Park, to the south of Scotland's Capital City, Edinburgh. In order to blend into the landscape the structures and buildings are fully or partially buried and covered with grass roofs. The grass roofs are the largest in Scotland and harvest rain water to provide habitats for wildlife, plants and insects. The works is one of Scottish Water's largest water treatment facilities and provides potable water to around half a million people across the capital city and parts of Midlothian. The plant is designed to provide up to 175 million litres of potable water a day.

The Glencorse WTW project was required to replace Edinburgh's two main water treatment works at Fairmilehead and Alnwickhill. These two works were originally built in the Victorian era and had served the city of Edinburgh for more than a century, but by the turn of the 21st Century, they were in need of replacement to ensure potable water standards could be maintained well into the future as Edinburgh continues to grow and expand.

Black & Veatch (B&V) was engaged as a design and build contractor for the Glencorse project. The construction works were successfully completed in March 2012 It was one of Scottish Water's largest construction projects, with an investment of £130m ($205m).
The WTW comprises four main structures:
- The intake building, which blends raw water from reservoirs 30km away and generates power for the plant,
- The water treatment building for the CoCo DAFF process,
- The Chlorine contact-tank for final disinfection,
- and a large clear water storage tank capable of holding 90 million litres.

The treatment process consists of a pioneering CoCo DAFF process. The counter-current dissolved air flotation and filtration (CoCo-DAFF) process is a compact water treatment process designed to remove coagulated particulate material from the source water. This process differs from tradition flotation and filtration processes DAF cell sits directly above the filter.

Drinking water visit:
Delegates collected from Edinburgh – EICC – 9:20
Arrive at Site and H&S briefing: 10:00 to 10:30
Project Background & Construction 10:30 to 11:00
Tour of Site 11:00 to 12:00
Bus back to Edinburgh 12:15



Seafield Wastewater Treatment Plant
Edinburgh, Scotland

Seafield WWTP is the largest in Scotland and serves nearly 1 million people, having celebrated its 40th anniversary in 2018. Since 2011 Scottish Water and Veolia have invested £34 million into Seafield, installing new equipment to improve odour as well as a thermal hydrolysis plant which treats and pasteurises the raw sewage, generating biogas energy which provides 85% of Seafield's electricity. The sewage is then turned into sludge cake and sold to farmers as organic fertiliser. This process makes it one of the greenest waste water treatment plants in the UK. The plant is capable of producing up to 2300 kilowatts of sustainable electricity.

Wastewater visit:
Delegates collected from Edinburgh – EICC – 9:20
Arrive at Site and H&S briefing: 10:00 to 10:15
Project / Background 10:15 to 10:45
Short Break/Change into PPE: 10:45 to 11:00
Tour of Site: 11:00 to 12:00
Bus back to Edinburgh: 12:15

IWA World Water Congress & Exhibition 2020

the international water association

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DANVA
The Danish Water and Wastewater Association

IWA DENMARK
the international water association

SESSION 1: Recent developments to improve desalination

PRESENTATIONS

IS01 Pre-treatment Alternatives For Large Scale Seawater Desalination: the Perth Experience
Capewell, Steve

In an effort to combat the effects of climate change and a reduction in runoff into surface storages, the Water Corporation commissioned two large scale seawater desalination plants in 2006 and then again in 2012 to secure drinking water supplies for the city of Perth in Western Australia.

Whilst the two plants utilise reverse osmosis technology to achieve desalination, they have very different pre-treatment designs primarily as a result of differing seawater intake qualities and coastal conditions.

The first plant employs conventional coagulation and multimedia pressure filtration, and the second (larger) plant utilises (chemical-free) ultrafiltration. This presentation will compare the operational performance of the two different pre-treatment processes and share experiences with maintenance regimes, fouling and downstream high pressure membrane performance. The discussion will also provide some insights from the Perth experience into factors which should be considered by utilities when selecting a pre-treatment design for any new large scale seawater desalination facilities.

Steve Capewell, Australia

OP01 Assessment Of A Desalination Pilot Plant Reliability Against Extreme Seawater Quality Events By Means Of Threshold Tests
Sanromà, Clara; Bayona, Carlos; Ferrer Mallén, Olga; Malfeito, Jorge

A pilot plant consisting in dissolved air flotation, disk filters, ultrafiltration and reverse osmosis to desalinate seawater was designed, constructed, operated and optimized. It mimicked a full scale plant and treated the same influent water. Influent seawater composition fluctuated during the 1-year evaluation period, which enabled testing the treatment scheme performance under different conditions. Moreover, turbidity and algae threshold tests were conducted, pushing the technology to its limits and characterizing its hydraulic and quality performance.

Optimal operational conditions, associated chemical consumption and water yield were defined per unitary process. Moreover, treated effluent quality of each unit was determined, demonstrating that the final permeate fulfilled the quality requirements during the whole operational period in a reliable way. Membrane autopsies and cleaning studies provided more insights to further optimize the full-scale operation. Threshold tests conducted demonstrated that the units presented a stable operation, proving the system capacity to deal with extreme episodes.

Olga Ferrer Mallén, ACCIONA Agua S.A.U., Spain

OP02 Chemical Handling Free Inline Coagulation To Control UF Fouling
Villacorte, L.O.; Gissel, R.E.

Onsite production of inorganic coagulant using electrocoagulation (EC) offers a greener alternative to conventional chemical coagulation (CC) typically used to improve RO feedwater quality and hydraulic performance of pretreatment processes in RO desalination plants. We developed an EC system using innovative design and smart controls to reduce maintenance and energy consumption without adding complexity to the operation. We have demonstrated its application for inline coagulation in UF under challenging algal bloom conditions. Test results showed significant improvement in hydraulic performance with EC, which was comparable with chemical coagulation performance. However, there are more proven and potential advantages of EC over CC which includes no handling/storage of active/unstable chemicals, wider spectrum of contaminants can be targeted, lower chemical consumption and lower waste sludge volume.

Loreen Villacorte, Grundfos Holding A/S, Denmark

IS02 Theoretical Assessments Of Leading-edge Technologies For Low-energy Seawater Reverse Osmosis Process
Park, Kiho; Kim, Jungbin; Hong, Seungkwan; Yang, Dae Ryook

To fundamentally reduce specific energy consumption apart from improving mechanical efficiency, we calculate theoretical minimum energy and maximum available margin of the seawater reverse osmosis (SWRO) process. Based on the calculation, we present three strategies to improve the energy efficiency of SWRO: minimizing irreversible work of high-pressure pump, decreasing osmotic pressure of feed, and recovering osmotic energy from concentrate. The suggested strategies are not just technically described but also critically evaluated in reducing the energy consumption of SWRO. Since this research includes both practical and theoretical perspective in energy saving in SWRO, it would provide clear ideas to lower SEC of current and future SWRO desalination plants.

Kiho Park, Korea University, South Korea

OP03 A Techno-economic Evaluation Of Incorporating Energy Recovery Devices Within Continuous-batch Reverse Osmosis Processes
Cairns, Mícheál

Global water scarcity has resulted in the need for alternative water sources, independent of potable supplies, to meet the ever-growing demands of industrial partners. Water reuse and recycle options help to close the loop on water engineering processes, in turn mitigating freshwater extraction. Closed loop water circulation and zero liquid discharge are often the aims in industrial processing, however, still today, these aims are not being realised and wastewaters are generated, leading to environmental discharge and increased economic cost. The main objective of this research is to design and manufacture a pilot scale reverse osmosis (RO) test rig that will contribute a detailed evaluation study between closed loop water recuperation and its respective energy requirements for industrial saline wastewaters. Other project objectives include the optimisation of RO processing control strategies and the trailing/testing of a novel high-pressure pump (HPP)/energy recovery device (ERD) with respect to a regular commercial HPP/ERD system benchmark.

Mícheál Cairns, Dublin City University, Ireland

OP04 Towards The World's Largest Microbial Desalination Cell For Simultaneous Wastewater Treatment And Water Desalination
Zamora, Patricia; Rodenas, Pau; Ortiz, Juan M.; Arévalo, Juan; Monsalvo, Víctor; Rogalla, Frank; Esteve-Núñez, Abraham

Microbial Desalination Cell (MDC) has emerged as an energy-efficient alternative for simultaneous wastewater treatment, saline water desalination and energy production. A pre-pilot MDC of 600 cm2 electrode area was tested using real industrial wastewater (brewery) and NaCl as saline stream. A current density up to 3-6 Am-2 was obtained, desalination rates up to 2.7 L m-2h-1 and salt removal above 95%. Our next step is to run an MDC stack comprising 12 single cells able to treat up to 75 Ld-1 of saline water and 180 Ld-1 of wastewater. This pathway ends up with the construction of the world's largest demonstrator of the innovative MDC technology in three sites: Spain, Tunisia and Chile. Three pilot plants of 150 Ld-1 will be constructed and operated under real environments in desalination plants.

Patricia Zamora, FCC Aqualia, Spain

POSTER PITCHES

P101 Spatially Isolating Salt Crystallisation For Continuous Solar Steam Generation And Salt Harvesting
Xia, Yun; Zhang, Xiwang

As a low-cost green technology, solar-driven steam generation using nanostructured photothermal materials has been drawing increasing attention in various potential applications, e.g. seawater desalination, zero-liquid-discharge of industrial wastewater. However, the accumulation and crystallisation of salts on the surface of photothermal materials during the steam generation impair the light absorption, which consequently leads to a gradual decline in water evaporation rate. In this study, this challenge is overcome by a novel design via employing controlled water distribution, edge-preferential crystallisation and gravity-assisted salt harvesting. In this design, the crystallisation sites of salts are spatially isolated from the active surface for water evaporation, achieving continuous steam generation and salt harvesting for over 600 h without any stop. The study provides new insights into the design of solar-driven steam generation devices and advances their applications in sustainable seawater desalination and wastewater management.

Xiwang Zhang, Monash University, Australia

P102 REvivED Water: Efficient And Low Energy Electrodialysis System For Brackish Water Desalination, Case Study
Alhadidi, Abdulsalam; Martini, F.; Rapp, H.J.; Gutierrez, L.

Over the world, it is confirmed that the balance between the availability of water and the demand is reaching a critical level. In some developing countries, people are suffering from all kind of diseases in relation to the availability of clean drinking water and sanitation systems. In 2015, the access to clean water and safe sanitation systems was set as one of the 17 global sustainable development goals (SDGs). In many cases, the available water is contaminated with microorganisms, organic matters and/or high concentrations of dissolved ions. Therefore, clean water should go through many treatment steps to remove all the suspensions. In order to lower the concentration of the dissolved ions, a desalination step has to be introduced in the treatment process. The state of the art technology in the desalination field is reverse osmosis (RO). RO has some drawbacks such as the need for continuous supervision, vulnerability to fouling, sensitivity to chlorine, use of different chemicals and high energy consumption. REvivED water aims to introduce a new desalination system for brackish water desalination based on an innovative concept of capacitive electrodialysis (CED). The new concept has the advantages of lower energy consumption, low maintenance and independence from any kind of infrastructure which is ideal for remote areas.

Abdulsalam Alhadidi, Fujifilm Manufacturing Europe B.V., The Netherlands

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P103 High Recovery Desalination System Based On Brine Treatment By Previous Softening And Membrane Distillation Process
Bayona, Carlos; Carvalho, Joana; Llopart, Nil; Repollès, Carme; Nelemans, Bart; Ferrer Mallén, Olga; Malfeito, Jorge

Membrane distillation (MD) can play an important role in the increment of the net water yield of reverse osmosis (RO) desalination plants. When treating brines, scaling is a main concern since salts solubilities are often overcoming their saturation limit.

As part of the LIFE-Dreamer project, the proposed brine treatment process consists on two alternative softening methods prior to MD treatment; a first system based on alkaline precipitation of the divalent salts followed by a ceramic ultrafiltration (UF) and another one based on high divalent ions rejection Nanofiltration (NF) membranes. This work will focus on the performance of the former one (NF) coupled with MD to treat RO bines and thus, increase the system recovery.

Brine softening by NF showed a divalent ion rejection over the 85% for calcium, the 90 % of magnesium and a complete removal of sulfates. Magnesium and calcium-rich streams originated in both systems may be used for remineralization, resulting in a highly sustainable treatment process.
MD process results show a conductivity removal of 99.8% (±0.1%) at the whole range of inlet brine conductivities tested, enabling the production of high quality permeate and increasing the overall desalination system recovery. Temperature makes distillate flow increase but also cross velocity plays a key role on distillate production.

Olga Ferrer Mallén, ACCIONA Agua S.A.U., Spain

SESSION 2: Emerging Contaminants: Microplastics, Pharmaceuticals and Personal Care Products (PPCP) and Antibiotic Resistance

PRESENTATIONS

IS03 Urban Wastewater Treatment Plants As Hot Spots For Release Of Antibiotic Resistances To The Aquatic Environment
Berendonk, Thomas

There is increasing public concern regarding the fate of antibiotic resistance genes (ARGs) and antibiotic resistant bacteria (ARB) during wastewater treatment, their persistence during the treatment process and potential impacts on the receiving water bodies and in the context of wastewater reuse. To illustrate the international context of antimicrobial resistance in the aquatic environment, I will present results of studies that determine the abundance ARGs and an integrase-coding gene in several wastewater treatment plants (WWTP) from several different European countries as well as an investigation focusing on sewage from airplanes. In order to assess the impact on the receiving water bodies and agricultural soil, results on gene abundances in the latter two compartments will also be presented. The results depend on several complementary approaches: metagenomics, genomics, quantitative PCR and cultivation. Generally, the studies show that antibiotic resistance genes vary among different European nations and that a considerable diversity of ARGs are released into the environment via the water cycle.

Thomas Berendonk, TU Dresden, Germany

OP05 Antibiotic Resistance Dissemination In Municipal Reclaimed Water Distribution Systems By Culture And Metagenomic

Keenum, Ishi; Majeed, Haniyyah; Peraud, Jayme; Calarco, Jeanette; Bott, Charles; Xia, Kang; Garner, Emily; Harwood, Valerie; Pruden, Amy

Wastewater reuse for potable and nonpotable uses is becoming a necessity due to water scarcity in many parts of the world. While a substantial knowledge base has been built with respect to identifying processes that effectively remove chemical contaminants of emerging concern (CECs), less is known about which barriers are most effective against propagating the spread of antibiotic resistance. One challenge to making this assessment is the need for consensus on standard approaches for monitoring "antibiotic resistance" in environmental samples. Here we compare the use of direct culturing of antibiotic-resistant pathogens (ARPs) of concern relative to various metrics for analysing antibiotic resistance genes (ARGs) identified via shotgun metagenomic sequencing. ARPs were readily detected through various stages of treatment at two water reclamation facilities, one producing water for non-potable reuse and the other for indirect potable reuse. Bioinformatic tools will be applied to compare ARP occurrence with metagenomic-based characterization.

Ishi Keenum, Virginia Tech, United States

OP06 PS-oxidation-assisted Membrane Distillation Process For Emerging Micropollutant Degradation And Membrane Fouling Control

Hai, Faisal; Asif, Muhammad; Price, William

In this study, a combined persulfate oxidation (PS) - membrane distillation (MD) process was developed for effective removal of 12 micropollutants from secondary treated effluent. The integrated PS-MD system achieved an overall removal of above 99% for all micropollutants. Importantly, PS (1 mM) dosing resulted in micropollutant degradation that ranged between 25-100%. Along with micropollutants, PS degraded other effluent organic matters (up to 70%) present in the secondary treated effluent, which reduced their accumulation in the MD feed. This improved the hydraulic performance of the integrated PS-MD system by minimizing the membrane fouling. This is the first study that shows the performance of persulfate oxidation process in a continuous system for micropollutant removal and membrane fouling control.

Faisal Hai, University of Wollongong, Australia

IS04 Fate And Removal Of Emerging Contaminants And Plastic In Wastewater Treatment

Joss, Adriano

The focus of this contribution is on microplastics (MP) since the fate of emerging organic contaminants is discussed by Uwe Sollfrank in this conference or was presented in previous LETs.
In this presentation, MP are referred to as plastic fragments <5mm, and nanoplastics (NP) cover the size range between 1 to 100 nm. Primary plastics are intentionally produced (e.g. tooth paste ingredients) and secondary MP refer to fragments generated from larger plastic items.
The quantitative assessment of MP in environmental matrices is still cumbersome and mostly based on particle counting (microscope) after sample preparation for reducing non-plastic fractions. Published values, thus, span over orders of magnitudes due to analytical uncertainties.
Microplastics are efficiently removed by state-of-the-art wastewater treatment plants (WWTP) and accumulated in the sewage sludge. Comparing MP concentrations in the influents and in the effluents of WWTPs revealed high correlations between the removal of MP and the removal of suspended solids, suggesting an efficient attachment of MP to biosolids. Although the nanoplastic fraction is analytically largely inaccessible due to current analytical limitations, experiments conducted with inorganic nanoparticles confirmed a rapid attachment to the sludge. Therefore, a comparable fate is expected for NP, as the behaviour of nano sized particles is dominated by diffusion whereas density or surface properties don't play a relevant role in wastewater. Thus, in WWTPs fate of nano- and microplastics can be quantitatively inferred from solids removal, a core competence of WWTPs: 85% to 99% removal is achieved by state-of-the-art WWTPs, 99% to 99.9% if a sand or membrane filtration is installed. In case of agricultural sludge use the influent MP load is directly conveyed to the soils.
MP discharged to surface waters via WWTP effluents are generally of minor importance compared to other inputs of MP like road runoff that largely bypass WWTPs. Given the persistence of plastics in the environment, this anthropogenic material ought to be defined as a persistent organic pollutant (POP). Strategies for MP reduction need to focus on source control and on MP pathways outside WWTPs (e.g. waste management). Measures should also include macroplastics since the formation of secondary MPs is quantitatively relevant.

Adriano Joss, EAWAG, Switzerland

OP07 Removal Of Organic Micropollutants From Wastewater Treatment Plant Effluents Using The Nyex™ Process
Sellers, Nicole; Francois, Lucile

Cost effective removal of organic micropollutants has proven to be one of the most significant challenges facing the water industry and industrial manufacturing. This paper presents a different approach to removal and destruction of these micropollutants using a continuous process of adsorption coupled with simultaneous electrochemical regeneration. Initial trials using two separate wastewater treatment plant effluents have shown it can achieve high removal rates of a range of organic micropollutants (typically >95%).

Lucile Francois, Arvia Technology, United Kingdom

OP08 A Novel Advanced Bio-oxidation System For The Treatment Of Urban Wastewater And Emerging Pollutants

Molina, Raúl; Cruz del Alamo, Ana; Pariente, Maria Isabel; Martínez, Fernando

An advanced bio-oxidation system based on immobilization of Trametes versicolor in a Rotating Biological Contactor reactor is proposed and evaluated for the treatment of urban wastewater and removal of pharmaceutical compounds. The system overcomes all the problems usually associated to the water treatment technologies based on white rot fungi that makes difficult the scaling up of the process and its implementation in full-scale wastewater treatment plants: sterile conditions, addition of supplementary biodegradable nutrients for an optimal C/N ratio, experiences on batch or semi-continuous rectors with high HRT and periodically refreshment of active fungal biomass. The proposed ABOP-RBC system working with 1-day of HRT under non-sterile conditions and without addition of supplementary biodegradable substrates nor programmed refreshment of the fungal biomass is a sound alternative for biological urban wastewater treatment with pharmaceutical removal.

Fernando Martinez, Rey Juan Carlos University, Spain

POSTER PITCHES

P231 Effect Of Ozone/Biologically-Active Carbon Filtration On Microbial Community Structure And Antibiotic Resistance Genes
Blair, Matthew; Pruden, Amy; Bott, Charles

The purpose of this research is to proactively address concerns about the potential for antibiotic resistance to propagate during wastewater and subsequent reuse treatments. Ozone/biologically-active carbon (BAC)-based water reuse is gaining popularity as an alternative to membranes and for producing a water chemistry that is more compatible for aquifer recharge. However, especially given the fundamentally biological BAC process, there is need to evaluate the fate of antibiotic resistance genes (ARGs) through a typical ozone/BAC treatment train. Here we profile ARGs via shot-gun metagenomic sequencing and quantitative polymerase chain reaction and the microbial community using 16S rRNA gene amplicon sequencing. The overall approach can help elucidate which advanced water treatment processes are the most effective barriers against antibiotic resistance and can help inform improved operation and performance towards addressing ARGs as key contaminants of emerging concern.

Matthew Blair, Virginia Tech, United States

P226 Validation Of A Protocol For The Analysis Of Microplastics In Sludge
Campo, Pablo; Holmes, Anita; Coulon, Frederic; Briones, Pablo

The focus of this study was to identify and validate a methodology to quantify microplastics (MPs) in sludge. The selected methodology applied techniques such as freeze-drying and sieving to remove water, and Fenton digestion to remove the organic matter. The methodology was validated with sludge samples spiked with low density polyethylene particles. The extraction efficiency for particles below 0.5 mm was 97 ± 1% while for particles between 0.5 and 0.15 mm the efficiency was 80 ± 8%. Weight recovery efficiency for the spiked MPs exceeded 100% with an error up to ± 33% due to organic matter remaining on the MPs. Real sewage sludge samples collected from Cranfield wastewater treatment plant had an average of 5.58 ± 2.51 * 10^3 MP kg-1 (dry weight). Of the detected MPs, 83% were low density polyethylene, with polyester and polyethylene terephthalate fibres also identified.

Pablo Briones, Cranfield University, United Kingdom

P230 Inactivation Of Antibiotic Resistant Bacteria And Genes By Conventional And Advanced Disinfection Methods.

Patel, Manisha; Jia, Wenlin; Yu, Pingfeng; Alvarez, Pedtro; Li, Qilin; Zuo, Kuichang
This research investigates the impact of chlorination, ultraviolet-C (UVC) irradiation, and titanium dioxide photocatalysis (UVA/TiO2) on the destruction of the multi-drug resistant New Delhi metallo-beta-lactamase (blaNDM-1) gene and the inactivation of carrying the gene. The blaNDM-1 E. coli was obtained by transferring plasmids carrying the blaNDM-1 gene to the control strain, E. coli K12, and experiments were performed with both the blaNDM-1 E. coliand the untreated E. coli K12. Our results show that the blaNDM-1 E. coliwas significantly more resistant to all three disinfection methods especially TiO2 photocatalysis, compared to the non-resistant E. coli K12. ARG results showed a lower overall microbial inactivation than ARB results. ARG demonstrating higher resistance implies a need to better understand the proliferation of resistant extracellular genes and how to properly control them in wastewater treatment plants.

Kuichang Zuo, Rice University, United States

SESSION 3: Micro-contaminant Control in Drinking Water

PRESENTATIONS

IS05 Innovative UV Process For Micropollutant Removal And Microorganism Inactivation
Hu, Jiangyong

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

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

Jiangyong Hu, National University of Singapore, Singapore

OP09 Algae-Related Micro-Contaminants: Multi-Barrier Oxidation Technology Solutions For An Emerging Threat

Green, Steve; Scheideler, Jens; Zhang, Yaning; Martin, Beatrice

Harmful Algal Blooms (HABs) pose a significant challenge for surface water treatment plants that rely on conventional treatment schemes without the utilization of oxidative treatment technologies. Compounds like Geosmin, 2-Methylisoborneol or toxins such as Microcystin can pass conventional treatment steps and cause consumer complaints or even "Do not drink" advisories. Advanced Oxidation Processes (AOPs) and ozonation are well known as a robust barrier against these pollutants, however they are also associated with significant investments and operational costs. This paper will demonstrate the synergistic effect of multi-barrier AOPs and oxidation followed by biologic active filtration resulting in significantly lower capital and operational expenditures while achieving highest removal rates of 90-99%. Studies from Singapore, Korea and the United States were used for this paper providing real world data and full scale examples.

Beatrice Martin, Xylem, Inc., United Kingdom

OP10 Monitoring The Breakthrough Of PFAS In Packed Bed Adsorption Columns By EEM-fluorescence
Roccaro, Paolo; Sgroi, Massimiliano; Anumol, Tarun; Gagliano, Erica; Vagliasindi, Federico G. A.; Snyder, Shane A.

This study investigated, using rapid small-scale column testing, the effect of natural organic matter (NOM) on the breakthrough of three different perfluoroalkyl substances (PFAS), namely perfluorooctanoic acid (PFOA), perfluorodecanoic acid (PFDA) and perfluorooctane sulfonate (PFOS), during granular activated carbon (GAC) filtration. Experiments were accomplished using three different water qualities, including surface water and synthetic water (riverine NOM dissolved in deionized water). Adsorption of NOM in GAC filters was evaluated by dissolved organic carbon (DOC) concentration measurements, UV absorbance and fluorescence spectroscopy. The fastest NOM breakthrough was observed during synthetic water filtration. Although differences between the rates of carbon fouling were observed during filtration of different water qualities, adsorption of PFAS compounds showed very similar breakthrough curves and it seemed to be independent of water quality.

Paolo Roccaro, Università degli Studi di Catania, Italy

IS06 Next Generation Biofiltration Systems For Trace Organic Chemical And Pathogen Removal
Drewes, Jorg

Managed aquifer recharge (MAR) systems such as soil-aquifer treatment, riverbank filtration or artificial groundwater recharge take advantage of natural attenuation processes for chemical and microbial contaminants without any residual generation and chemical addition, while damping varying feed water concentrations and in many cases resulting in dilution by other water sources. The interplay of different removal mechanisms (such as biotransformation, filtration, adsorption and ion exchange) in porous media treatment systems provides effective removal of many trace organic chemicals (TOrCs) and offers efficient inactivation of pathogens, especially viruses or protozoa. Previous studies demonstrated that carbon-limited and oxic conditions are favorable for enhanced trace organic chemical transformation in porous media processes such as MAR or above-ground biofiltration. To take advantage of these favorable conditions, sequential MAR technology (SMART) combining two infiltration steps with an intermediate aeration was developed and validated at pilot- and full-scale recharge sites in the USA and Germany for the production of drinking water from surface waters impaired by wastewater effluents. Conventional MAR systems commonly employ open recharge basins to facilitate infiltration of water through the vadose zone, which requires large physical areas and suitable subsurface conditions. In addition, the subsurface commonly exhibits an inherent hydrogeological variability due to site-specific heterogeneity. In order to establish a sequence of controlled redox conditions during subsequent travel through the saturated zone, well-controlled flow conditions are required. To address these issues a novel design concept was employed building upon previous research. This novel SMARTplus concept is utilizing high-rate infiltration trench technology followed by a biofiltration system with plug-flow conditions characterized by highly controlled redox zonation and an in-situ introduction of electron acceptors as well as online monitoring and control systems. The SMARTplus concept is designed to be hydraulically decoupled from the native groundwater and can be deployed independent of local hydrogeological conditions with a significantly reduced physical footprint.

Jorg Drewes, Technical University of Munich, Germany

OP11 How Will Switching From Aerobic MBRs To Anaerobic MBRs Impact Disinfection By Product Formation?
Jefferson, Bruce; Sfynia, Chrissa; Goslan, Emma; Jarvis, Peter; Navalon, Sergio

The aspiration to maximise recovery from wastewater has led to the development of resource factory flowsheets many of which utilise anaerobic rather than aerobic biological processes at their heart. This has the potential to alter the make-up of the residual organics and hence alter the disinfection by products that will form. Accordingly, it is important to understand if use of anaerobic systems poses additional risk on the reuse water generated, especially when thinking about the increase in direct potable reuse applications. The work responded to this by operating an aerobic and an anaerobic MBR in parallel treating municipal wastewater. The produced water was disinfected by either chlorination or chloramination in the presence / absence of bromine/ammonia to simulate the range of potential situations. The overall picture is that a switch to an anaerobic MBR from an aerobic MBR will decrease THMs, maintain HAAs and increase emerging DBP formation potentials. However, when converted to a hazard index this simplified to understanding the differences in brominated HAAs.

Bruce Jefferson, Cranfield University, United Kingdom

OP12 Transforming Drinking Water Treatment - MBBR For Taste And Odour Compound Removal
Doederer, Katrin; Gale, Deb; Keller, Jurg

Biodegradation is an effective method for the removal of taste and odour (T&O) compounds from drinking water sources. In this study, the applicability of a moving-bed biofilm reactor (MBBR) as biological treatment step for the control of MIB and geosmin was studied at pilot-scale. The application of MBBR merges wastewater technology within drinking water treatment for T&O removal for the first time. After a 3.5 month acclimation period both T&O compounds could be reliably removed >80%. Biodegradation was found to be the dominating removal mechanism with air stripping contributing up to 25%. The biodegradation of MIB and geosmin followed pseudo-first-order kinetics.

Jurg Keller, The University of Queensland, Australia

POSTER PITCHES

P321 Transformation Of Methamphetamine And Analogues To (Halo)nitromethane Carcinogens By Water Treatment With Ozone/Chlorine
Shi, Jiaming (Lily); McCurry, Daniel

The occurrence of illicit drugs in wastewater effluents is well-documented, and some are known to persist to some degree in the environment. However, less is known about their fate in drinking water treatment and wastewater reuse operations. Most drugs would be expected to be rejected well by reverse-osmosis during traditional full advanced treatment of wastewater, but interest is rapidly developing in alternative reuse treatment trains, such as ozone/biological activated carbon (BAC) due to lower energy consumption than reverse-osmosis. We confirmed efficient (50-80%) transformation of stimulant drugs in the N-methylamine class (e.g., methamphetamine, ephedrine) to nitromethane by ozone under laboratory conditions, and subsequent quantitative transformation of this nitromethane to halonitromethanes disinfection byproducts (e.g., chloropicrin) during chlorination. We investigated the mechanism of this transformation to understand the relationship between chemical structure and nitromethane yield.

Daniel McCurry, University of Southern California, United States

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P318 PFAS And PFOS: A New Challenge For The Australian Water Industry
Capewell, Steve; Capewell, Steve

Per- and polyfluoroalkyl substances (PFAS) are a manufactured group of compounds that do not occur naturally in the environment. These compounds have the potential for bioaccumulation and biomagnification in natural systems and some have been found to be toxic in animal studies (Dept. Health, 2018). There is evidence that exposure to PFAS can lead to adverse human health effects (Sharma et al., 2016). The Australian National Environmental Management Plan (NEMP) and recently-released Australian Drinking Water Guidelines (ADWG) factsheet respectively outline ecological and drinking water guideline levels for three PFAS compounds (PFOS, PFOA and PFHxS). In Western Australia, there have been a number of detections of PFAS found during site investigations run by the Department of Defence (DoD) and the Department of Fire and Emergency Services (DFES), which have attracted media interest and community concern. This paper outlines the Water Corporation's approach to implementing the NEMP, and outlines the challenges and limitations understood to date, all of which are relevant for water utilities across Australia.

Steve Capewell, Water Corporation, Australia

P327 Full Scale Implementation Of New Zirconium Coagulant In Water Treatment
Hakonsen, Tor; Hakonsen, Tor; Christensen, Ekaterina

A new coagulant based on zirconium as the active ingredient has been implemented on several water treatment plants in Norway. Scientific studies imply this coagulant as more powerful than aluminium for removal of natural organic matter.

The coagulant is used in conjunction with chitosan-based coagulants which are gaining popularity in Norway due to its reduced sludge production and renewable nature.

This paper summarizes the practical experiences and results achieved from full scale operation as well as scientific results from virus removal testing with the new coagulant. A brief discussion on the benefits and draw backs from its use compared to traditional coagulants is provided.

Tor Hakonsen, NTNU / Norconsult, Norway

SESSION 4: Energy efficiency and Resource Recovery in Wastewater Treatment

PRESENTATIONS

IS07 Energy Or Resources From Wastewater: Using LCA To Make Sustainable Choices
Klaversma, Enna

Life Cycle Assessment (LCA) is a technique to measure the environmental impact associated with the entire life cycle of a product or process. In the Netherlands, the public water authorities used the technique to compare the environmental benefits of different resources that can be recovered from wastewater. An outcome was among others that bioplastic production has a higher benefit than biogas (energy) production. However, since bioplastic production is in an early stage of development, a lot of assumptions had to be made, which gave the LCA outcome a high uncertainty margin. Another conclusion from the LCA was that struvite recovery at a wastewater treatment plant (WWTP) is more sustainable than phosphorus recovery from fly ash after sludge incineration. This can be explained by the fact that struvite also contains nitrogen and magnesium, both have a theoretical value as fertilizer and are included as a positive contribution in the LCA. One can discuss whether this assumption is correct, because fertilizer manufacturers use struvite mainly for the phosphorus content.
Both outcomes show that LCA is a tool that can be used to compare the environmental impact of different wastewater innovations, that otherwise would not be comparable except for their costs. The most important disadvantage of LCA is that the outcome is strongly dependent of the used assumptions. Besides that, LCA is mainly suitable for comparing global environmental impacts like climate change. For local impacts, like surface water pollution, the technique often does not give correct results.
Despite the described shortcomings, it is recommended to use LCA for environmental comparisons. However one should be aware that the tool cannot be used solely to make policy decisions.

Enna Klaversma, Waternet & Energy and Resources Factory (EFGF), The Netherlands

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OP13 Is There A Water – Chemistry Nexus?
Rabaey, Korneel; De Meester, Steven; Sedlak, David L.; Pikaar, Ilje

Considerable attention has been given recently to the so-called water – energy nexus as well as the related concept of the food – energy – water nexus. These relationships are now well recognized. In contrast, the relationship between chemical use and water treatment (i.e., the water – chemistry nexus) has not received much scrutiny. To demonstrate the possible importance of these relationships, we have conducted a screening analysis of six chemicals (i.e., chlorine, sodium hydroxide, hydrogen peroxide, ferric chloride, aluminium sulfate and ozone). On the basis of their estimated use in water treatment, we estimate an energy consumption of approximately 85.5 TWh per annum and water consumption over 15 BN m3 per annum. In terms of energy consumption, this value (i.e., 69 TWh per annum) is on the same order of magnitude as annual energy consumption for the US water sector. Considering the unintended consequences of chemical use in the water sector (e.g., enhanced corrosion, formation of toxic byproducts) as well as the global trend of increased chemical use for treatment of source waters of diminished quality), we conclude that the water – chemistry nexus should be considered when developing and selecting among water treatment options.

Korneel Rabaey, Ghent University, Belgium

OP14 Technoeconomic Analysis For Energy Efficiency And Resource Recovery Adoption – Case Studies
Downing, Leon; Downing, Leon; Koodie, Tony

Application of leading edge technologies often needs to be driven by a technoeconomic life cycle assessment (LCA) that not only includes the current economic environment, but also accounts for long term variability in operating costs drivers. This presentation will provide case studies related to resource recovery technologies, and how uncertainty analysis is utilized to determine the long-term viability of resource recovery from both a technical and economic viewpoint.

Leon Downing, Black & Veatch, United States

IS08 Water And The Exploration Of Space
Flynn, Michael

Water is critical to the exploration of space. It provides a roadmap to direct the search for life in our Universe and is an important metabolic requirement to support human exploration. The search for life in the Universe has become the search for water because it is the single ubiquitous requirement for all known life. Water also accounts for 85% of the metabolic mass required to keep an astronaut alive in space. Since the cost of space flight is defined by launch costs and launch costs are determined by mass on the launch pad water is a key factor determining the cost of space exploration. This talk will discuss the importance of water to the search for life in our universe and will describe water recycling technologies currently in use on the International Space Station. It will also cover advanced research into the next generation water recycling systems and technology transfer activities relevant to terrestrial distributed water recycling applications.

Michael Flynn, NASA Ames Research Center, United States

OP15 Disruptive Water Reuse Scheme Based On Direct Ultrafiltration (DUF) Of Municipal Wastewater
Humbert, Hugues; Saudrais, Isabelle; Daines, Catherines; Boisquillon, Frédéric; Faujour, Hervé; Poussade, Yvan

A new scheme for centralized or decentralized applications able to treat raw municipal wastewaters directly with membranes without a biological treatment step was investigated at pilot scale. Main expected benefits are (i) significant footprint reduction (ii) lower sludge production and iii) easier start-up and operation with less odor nuisances than conventional schemes including biology processes. Pilot trials were conducted under continuous operation using real sewage wastewaters. Capacities of the DUF and RO pilot units are 100-300L/h. High and stable fluxes were achieved on DUF and RO units. In the conditions of our trials it was possible to maintain 40LMH@20°C at a constant TMP of 1bar on the DUF unit for several weeks of filtration. RO pilot unit was operated with a constant flux of 12LMH@20°C at 70% conversion rate by keeping feed and differential pressures stable over the period. RO permeate quality was as good as traditional reuse schemes based on secondary and advanced tertiary treatment. Removal rates of most of the parameters especially COD, TSS, TN and TP exceeds 97%.

Hugues Humbert, Veolia, France

OP16 Effect Of The Fe Dosing Increase On The Sludge Composition In A WWTP Using The CPR Strategy
Prot, Thomas; Wijdeveld, Wokke; Korving, Leon; Witkamp, Geert-Jan; Van Loosdrecht, Mark

In the CPR WWTP of Nieuwveer (The Netherlands), the quantity of Fe dosed has been doubled and the consequences on the sludge line have been studied. The main focus of this study is the evolution of the vivianite (Fe(II)3(PO4)2*8H2O) content in the sludge. An increase of its content would mean that more P are available to be recovered as vivianite by magnetic separation. Moreover, the formation of vivianite in sludge is a complicated process and the study of its supersaturation at different places of the WWTP aimed to understand it better. The S cycle was also studied considering the competition between FeS compounds and vivianite formation.

Thomas Prot, Wetsus/TU Delft, The Netherlands

POSTER PITCHES

P439 Multivariate Analysis For Behavioural System Analysis In The SCENA Process
Vasilaki, Vasileia; Conca, Vincenzo; Frison, Nicola; Fatone, Francesco; Katsou, Evina

Integration of new technological solutions in wastewater treatment plants (WWTPs) requires identification of trade-offs between direct and indirect GHG emissions to ensure that they will not adversely impact on the overall carbon footprint. Multivariate statistical techniques (clustering, changepoint detection) are applied to the online data collected from long-term energy consumption and nitrous oxide (N_2O) monitoring campaigns in a sidestream full-scale short-cut nitritation/denitritation sequence batch reactor (SBR). The variables monitored online were extracted (i.e. mean, variance, autocorrelation) together with features characterising the batch (i.e. batch and phase duration). The aim is to i) link the environmental performance of the system (dissolved N_2O and energy consumption) with operational conditions, ii) identify disturbances in the operation of the process and their effect on energy consumption and N_2O and iii) visualize the range of the operating parameters that optimize the environmental performance of the system.

Evina Katsou, Brunel University London, United Kingdom

P408 NPHarvest -- A New Energy Efficient Nitrogen Recovery Technology
Kaljunen, Juho; Mikola, Anna; Sah, Rajeev; Pradhan, Surendra; Vahala, Riku; Aurola, Anne-Mari

NPHarvest process is built to recover nitrogen and phosphorus from liquid waste streams. While phosphorus recovery is a combination of familiar technology with a twist of new idea for product quality, the innovative tech is nitrogen recovery using gas permeable hydrophobic membranes. Current commercially available membrane contactors are not designed for liquids containing suspended solids. A new design for membrane reactor was built and tested to harvest nitrogen from waste liquids with higher solids content. It is beneficial because it is not economically viable to pre-treat the liquid waste streams with rich nitrogen content up to the degree required by current commercial membrane contactors.

Juho Kaljunen, Aalto University (Finland)

P419 Production Of Bacterial Lipids From Hydrocarbon-based Wastewaters In Sequencing Batch Airlift Reactors (SBAR)
Marques Silva, Ana; Fernandes, Margarida; Fiume, Francesca; Castro, Ana Rita; Pereira, Alcina

Produced water (PW) and spent oil-based wastewaters (SOW) are some of the largest oily wastewaters produced. Due to the high toxicity of hydrocarbons, these oily wastewaters need to be treated before discharge. In this work, production of bacterial lipids from SOW and PW is demonstrated in two SBAR inoculated with Rhodococcus opacus B4 and Alcanivorax borkumensis SK2, respectively. Different process conditions (carbon/nitrogen ratio and feast stage times) were tested in order to maximize neutral lipids production and hydrocarbons biodegradation. Storage lipids compounds produced by R. opacus B4 were associated with nitrogen-scarcity conditions (high Chemical Oxygen Demand (COD)/nitrogen (N) ratio) while for A. borkumensis SK2 it was growth-related (low COD/N ratio). The observed differences highlight the need for different operational strategies to optimize production of bacterial lipids from the two different oily wastewaters under study.

Ana Marques Silva, University of Minho, Portugal

SESSION 5: Novel Disinfection Technologies

PRESENTATIONS

IS09 Towards Risk Based Optimal Design Of Chemical Disinfection Systems
Haas, Charles

Chemical disinfection of waters is one of the most complex unit processes in that the design and operations need to balance conflicting goals of adequate pathogen reduction, low capital and energy costs, and low production of potentially harmful disinfection byproducts (DBP's). Classically, designers have based their decisions on choosing disinfectants that perform adequately with respect to both pathogen reduction and DBP formation, and then allowing sufficient flexibility in operations to vary chemical doses to meet both pathogen and DBP targets.

Developments in risk assessment, including quantitative microbial risk assessment (QMRA), disinfection kinetic modeling, computational fluid dynamics (CFD) of processes, and approximation by metamodels, now allow us to see a framework whereby the optimal probabilistic design of chemical disinfection systems to satisfy multiple objectives can be performed. While we understand where we need to go, some of the inputs needed remain incomplete.

Charles Haas, Drexel University, United States

OP17 Improving Disinfection Using Molecular-based Microbiological Analyses
Thom, Claire; Smith, Cindy; Weir, Paul; Moore, Graeme

Demonstrating the safety of drinking water supplies is of paramount importance to utilities, yet culture-based methodologies are relied upon, yet these are laborious, yield false positives and provide no result for significant non-culturable microorganisms. Two case studies from a UK water utility are presented here, employing molecular-based techniques to assess disinfection. In the first, a flow cytometric methodology is applied. Results indicate high variability in disinfection processes- 0.1-3 log intact cells mL-1 removed. Removal was influenced by seasonal changes, primary treatment and chlorine contact time. The second case study outlines initial development of a qPCR methodology to target coliforms via the lacZ gene. Testing a range of lacZ primer sets in-silico showed wide range of target coverage (0-89%), although a potential new primer set has been identified. Phylogeny of lacZ demonstrates that Coliforms are a problematic target for molecular assays.

Claire Thom, Scottish Water/University of Glasgow, United Kingdom

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OP18 Evaluation Of Enhanced UV Disinfection For Planned Indirect Potable Reuse Schemes - Laying The Path To A Regulatory Fram
Bell, Katherine; Mayor-Smith, Ian

Population increases, dependency on high-water-demand agriculture both coupled with urbanisation are affecting land use changes that exacerbate water supply challenges. Sea level rise and increasing intensity and variability of local climate patterns are predicted to alter hydrologic and ecosystem dynamics and composition (Bates et al., 2008). The resultant economic impacts due to such events are demonstrated by the 2003 EU drought which was estimated to result in loss of more than EUR 8.7 billion, mainly in Mediterranean countries, France and the UK (EC, 2007). With climate change, the frequency and intensity of droughts and their environmental and economic damages have drastically increased over the past thirty years; and the droughts of the summer of 2017 further illustrate the dimensions of economic losses - the Italian farming sector alone predicts losses of EUR 2 billion (BBC, 2018). This trend is expected to continue with water scarcity no longer confined to a few corners of Europe, but already a concern across the continent with significant environmental and economic consequences.

Ian Mayor-Smith, Brown and Caldwell, United Kingdom

IS10 State Of The Art Of The Production Of Harmful Disinfection By-Products In The Netherlands
Kruithof, Joop

Since the beginning of the last century, chlorine has been used for the disinfection of drinking water. Originally, people were very reluctant against the use of chlorine, “a poisonous chemical”, but soon drinking water chlorination was generally accepted without any attention for potential harmful aspects. In 1973 this situation changed completely when Rook showed the production of trihalomethanes (THM’s), suspect carcinogens for humans. Originally maintenance of chlorination was pursued, restricting the formation of disinfection by-products (DBP’s) by optimizing the chlorine use and the removal of the produced DBP’s by granular activated carbon (GAC) filtration. Much attention has also been paid to the removal of DBP-precursors. Worldwide standards have been set for chlorination by-products. To satisfy these standards, measures have been taken to restrict the use of chlorine.

Joop Kruithof, Wetsus European Centre of Excellence for Sustainable Water Technology, The Netherlands

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OP19 A Novel Method Using Natural Occurring Viruses For Log Removal Determination In Full Scale Ceramic Microfiltration
Martijn, Bram

PWN Water Supply Company North-Holland in The Netherlands produces drinking water using eutrophic surface water from the IJssel Lake. To protect public health, a multi barrier approach for the treatment strategy is applied, especially for micropollutants and disinfection. The strict THM regulation in The Netherlands (25ug/L) limited the application of chlorination for disinfection in the drinking water production and distribution; none of the water treatment plants is using chlorination for disinfection. Disinfection relies now on treatment technologies such as membranes and UV in engineered systems and artificial ground water replenishing and slow sand filtration in more biological / natural systems. The level of disinfection and the contribution of the multi barriers is evaluated in a regulatory mandatory risk assessment.

Bram Martijn, PWN Technologies, The Netherlands

OP20 Understanding UV Disinfection Under Dynamic Conditions For Energy Optimization Using CFD And Plant-Wide Models

Santoro, Domenico; Crapulli, Ferdinando; Boiocchi, Riccardo; Raspa, Giuseppe

Ultraviolet disinfection is a key process for controlling pathogen spread in the environment and water-related diseases. In order to optimize the operation of ultraviolet processes in wastewater treatment plants, the variability of the influent quality – i.e. typically the secondary effluent from an activated sludge process – must be taken into account. More specifically, the diurnal profiles of variables such as plant flowrate, water transmittance and influent microbial concentration could profoundly affect disinfection performance. Therefore, optimal energy management of ultraviolet disinfection technologies requires an advanced understanding of influent water quality variability especially when especially when advanced microbial quality standards must be met, such as in the case of wastewater reuse. While considerable efforts have been made towards the understanding of UV technologies under highly controlled conditions (i.e., validation using surrogates), the same cannot be said for the case of naturally occurring variability occurring in real wastewater treatment plants. In this paper, a modeling study has been carried out to achieve the following goals:

- Extending plant-wide process simulation models to UV disinfection by developing a statistical model able to predict the diurnal trends of key variables affecting dose control in a UV technology such as water transmittance (at 254 nm) and influent microbial concentration;
- Incorporating a CFD-based UV reactor model into into a plant-wide wastewater process simulation model (BSM2) in order to predict UV disinfection performance under dynamic conditions
- Optimizing UV disinfection performance under various operating scenarios to develop advanced control strategies for energy optimization;

The modeling study was carried out using the IWA Benchmark Simulation Model n.2, which was extended to UV disinfection using copula (for influent water quality) and CFD-based (for UV reactor performance) sub-models.

Domenico Santoro, Trojan Technologies, Canada

POSTER PITCHES

P503 The Role Of Microbubbles In Water Treatment: Next Generation Oxidation

John, Alexander; Jarvis, Peter; Carra, Irene; Brookes, Adam; Jefferson, Bruce

A common method for the removal of humic acid from water is oxidation. In this work, humic acid and pesticides was ozonated using microbubbles (<100Ã‚Âµm diameter) and coarse bubbles (~2-6mm diameter). The experimental results show that microbubble ozonation was 1.0-1.2 times more effective than porous diffusion in total removal of UV-254, treated humic acid at a 1.8-2.8 times faster rate and removed a higher percentage of dissolved organic carbon than equivalent ozone gas flow rates with porous diffusion.

Alexander John, Cranfield University, United Kingdom

P504 Novel Electrochemical Drinking Water Treatment Process For Small And Remote Community Applications

McBeath, Sean; Hajimalayeri, Adel; Mohseni, Madjid; Wilkinson, David; Graham, Nigel

This research investigates two novel processes for the management of groundwater contaminants, manganese and iron, via two methods: (i) electrocoagulation and an oxidative media filter for the physical removal of Mn and Fe, and (ii) the electrosynthesis of powerful oxidants, ferrate and permanganate, in-situ, using the ambient dissolved Mn and Fe. Both technologies have yielded promising results, whereby Mn was significantly removed using EC and ferrates were successfully produced by electro-oxidation. These technologies may have a potentially powerful impact for small and remote community applications, as they eliminate the chemical supply chain required for conventional coagulation and oxidation processes.

Sean McBeath, Imperial College London, United Kingdom

P506 Validation Of A UV Light Emitting Diodes (LEDs) Reactor For Low-energy Disinfection Of Municipal Drinking Water

Autin, Olivier; Renton, Alister; Simpson, Matthew; McNulty, Peter

In this study, we present the results of a full-scale validation testing of Typhon Treatment Systems' BIO-310 UV-C LEDs disinfection unit conducted in July 2018 in the United Kingdom. The reactor has been validated as a 2 to 4-log Cryptosporidium and Giardia barrier and can treat up to 250 m^3/h (6 MLD) of water for UVTs in the range 90 to 98%. The validation followed the Ultraviolet Disinfection Guidance Manual (UVDGM) adapted according to the draft "Innovative Approaches for Validation of Ultraviolet Disinfection Reactors for Drinking Water Systems" guidelines from the US-EPA using MS2 as challenge microorganism.
This work represents what is believed to be the first validation of a UV-LED reactor for municipal drinking water disinfection purposes using the combined variable approach.

Olivier Autin, Typhon Treatment Systems, United Kingdom

SESSION 6: Emerging Technologies for Nutrient Removal

PRESENTATIONS

IS11 Purple Phototrophic Bacteria For Nutrient Recovery
Huelsen, Tim

Anoxygenic purple phototrophic bacteria (PPB) are an emerging biological mediator for resource recovery from various wastewaters, particularly agri-industrial streams. PPB are preeminent photoheterotrophs and can be applied for primary treatment. Under anaerobic, irradiated conditions, PPB simultaneously remove organics, nitrogen and phosphorous. At the same time, PPB biomass with a consistent crude protein content (>60%), at biomass yields close to unity, can be generated. Bulk substitution of fishmeal with PPB biomass has been successfully tested, which potentially adds value to the biomass. However, there are currently no full-scale installations. The vast majority of work has been done in controlled laboratory environments with artificial light supply and axenic cultures. While this extended the potential applications and has led to a crucial knowledge base, the technology is still in its infancy. To advance PPB based resource recovery, systems have to move outdoors to cost effectively generate biomass and treat wastewater. As experienced with other photosynthetic organisms (e.g. microalgae), upscaling and outdoor operation adds several hurdles that affect the overall feasibility. These include environmental (sun, temperature), biological (selection and predation) as well as economic factors (harvesting and capital costs). Some of these aspects can be addressed by applying PPB biofilm growth systems.

Tim Huelsen, The University of Queensland, Australia

OP21 Sulphur-Enabled Electrochemical Nitrogen Recovery From Anaerobically Treated Wastewater
Tarpeh, William; Shao, Xiaohan

Nitrogen as ammonium and sulphur as sulphide are pollutants in anaerobically treated secondary effluent. By employing two electrochemical processes, we recover both contaminants as ammonium sulphate, a common fertilizer. Sulphide is electrochemically oxidized to sulphuric acid, which is used to trap ammonium during electrochemical ammonia stripping. In addition to producing a valuable fertilizer, these approaches can help achieve secondary effluents with anaerobic treatment trains, reduce oxidant demand, and facilitate reuse of treated wastewater effluent.

William Tarpeh, Stanford University, United States

OP22 Pilot Up-scaling, Decentralisation And Automation Of A Microbial Electrochemical System For Nutrient Recovery From Urine
Ledezma, Pablo; Monetti, Juliette

Since March 2018, a decentralised pilot-sized bio-electroconcentration (BEC) system has been operating in a fully-autonomous manner to recover nutrients from source-separated urine in a purposely-built toilet block in Brisbane, Australia. This talk will present the optimisation strategies and IoT-enabled operational controls that have allowed for the successful up-scaling and automated operation of the pilot, as well as the data demonstrating that the electrochemical and nutrient-recovery rates of the pilot match previously-demonstrated laboratory performances, a world-first for any up-scaled microbial electrochemical technology (MET) to date.

Pablo Ledezma, The University of Queensland, Australia

IS12 What's In Your Sludge? Hunting For Baby Granules In Full-Scale Activated Sludge Treatment Plants
Wei, Stephany; Stensel, David; Nguyen Quoc, Bao; Lee, Po-Heng (Henry); Winkler, Mari

Mixed liquor samples collected from 12 different continuous-flow activated sludge systems (CFAS) contained 0.7 - 80% granules (% weight of TSS retained on 212-µm sieve). These so-called baby granules are small (mostly <400 - 600 µm in diameter) and displayed smooth morphology and dense core. The baby granules resulted in lower SVI30/SVI5 and had higher abundance of PAO and GAO than the flocs. Analysis of the plant operational data indicated that higher %granules were related to anaerobic staging and more soluble BOD fraction. This work is the first to show that granules are indeed present in CFAS facilities and to observe types of system and factors that encourage granular growth. Methods to assess granular presence in CFAS were shown. Granule growth at existing CFAS facilities can be utilized as seed source to speed up startup of AGS SBR systems. This work provides understanding in the factors contributing to the presence of granules in activated sludge plants, which can lead to expansion of granular sludge applications in existing infrastructure.

Stephany Wei, University of Washington, United States

OP23 Design And Start-Up Of The Full-Scale MABR Demonstration At The Ejby MøLle WRRF
Uri Carreño, Nerea; Uri Carreño, Nerea; Nielsen, Per; Constantine, Tim; Sandino, Julian

MABR technology has great potential to allow facilities achieve more intensified and energy efficient biological nutrient removal. Despite the many efforts at laboratory and pilot-scale, this technology has yet to prove its many benefits at full-scale. VCS Denmark, with the help of Jacobs, has developed a demonstration program to test MABR technology in one of its facilities: Ejby Mølle WRRF. Four cassettes in total, two from each of the main two vendors in the market, were installed and commissioned in the summer 2018. This paper will discuss considerations for the design, installation and start-up of one of the first full-scale MABR installations.

Nerea Uri Carreño, VCS Denmark, Denmark

OP24 New Directions In Process Modelling – Catching Up With Industry
Takacs, Imre; Hauduc, Helene; Wadhawan, Tanush; Varga, Erika; Menniti, Adrienne; Schauer, Peter; Al-Omari, Ahmed; Barnard, James; Jimenez, Jose; Johnson, Bruce; Bott, Charles; Wett, Bernhard

"Wastewater treatment" is changing into "water resources recovery" with an impressive speed while maintaining the original role of producing clean water for reuse or release into the environment. Traditional process models do not describe many of the new innovations as the focus not long time ago was still efficient carbon, nitrogen and phosphorus removal without a lot of consideration for recovery or energy efficiency. This paper investigates new developments in process models that are occurring or should be occurring to describe new and existing processes accurately. On the process side new carbon (energy) capture mechanisms, biological and chemical phosphorus removal improvements and the impact of neglecting sulfur components are described. On the technology side modelling is moving from describing activated sludge and digestion separately or in whole-plant models to include newer processes such as granular aerobic sludge, MABRs (specialized biofilm processes), as well as side stream treatment, thermal hydrolysis and high rate and co-digestion.

Imre Takacs, Dynamita, France

POSTER PITCHES

P611 Achieving Stable Mainstream Nitrite Shunt: NOB Adaptation Solved
Duan, Haoran; Ye, Liu; Lu, Xuanyu; Yuan, Zhiguo; Wang, Zhiyao

Stable suppression of nitrite oxidising bacteria (NOB) is one of the major barriers for achieving stable mainstream nitrite shunt or partial nitritation/anammox (PN/A). It is increasingly experienced that NOB could develop resistance to suppressions over an extended time, leading to failure of nitrite shunt or PN/A. This study reports and demonstrates the first effective strategy to overcome NOB adaptation through alternating sludge treatment with free nitrous acid (FNA) and free ammonia (FA). During over 600 days reactor operation, NOB adaptation to both FNA and FA was observed but the adaptation was successfully addressed by deploying the alternate treatment strategy. Microbial community analysis showed Nitrospira and Nitrobacter, the key NOB populations in the reactor, have the ability to adapt to FNA and FA, respectively, but do not adapt to the alternation. Stable nitrite shunt with nitrite accumulation ratio over 95% and excellent nitrogen removal was maintained for the last 8 months with only one alternation applied. By using onsite-produced nitrite and ammonium, the proposed strategy is feasible and sustainable. This study brings the mainstream nitrite shunt and PN/A one step closer to wide applications.

Zhiyao Wang, University of Queensland, Australia

P628 New Generation Of MBBR For Biological Treatment Of Carbon, Nitrogen And Phosphorus
Humbert, Hugues; Lemaire, Romain; Germain, Tristan; Scherpereel, Guillaume; Bigot, Bruno

The development of a new biofilm process was investigated for two different objectives of treatment: biological removal of carbon and phosphorus only (CP) and biological removal of carbon, nitrogen and phosphorus (CNP). The process is based on the Moving Bed Biofilm Reactor (MBBR) technology operated in a Sequencing Batch Reactor (SBR) mode and can be referred to as a biofilm SBR. It can be implemented either in a 1-stage or 2-stage configuration. Lab and pilot trials have demonstrated that efficient biological P-removal with a MBBR is feasible. For CP applications, treatment performances of the 1-stage configuration are meeting the set targets in a highly compact process. For CNP applications, both nitrification and denitrification were obtained rapidly in the 1-stage configuration while maintaining targeted C and P performances. In some specific conditions, improvement of denitrification was required and was possible with the addition of a post-anoxic period. The 2-stage configuration is expected to improve both compactness and performances. The 2-stage trials are on-going with promising preliminary results.

Hugues Humbert, Veolia, France

P624 Full-Scale Demonstration Of Aerobic Granular Sludge In A Conventional Continuous Flow Activated Sludge BNR Plant
Stinson, Beverley; Stinson, Beverley; Galvagno, Giampiero; Sears, Keith

Formation of granular sludge was examined in a novel configuration of a full scale continuous flow activated sludge wastewater treatment plant at temperatures between 15°C and 25°C for over 1 year (began in January 2018 and is ongoing). The Westbank process was the baseline configuration but minor modificatoiuns were made to enhance granule formation retention. There are many intensification benefits of aerobic granular sludge including, increased capacity through increased MLSS and SRT, coupled with energy reduction and resource recovery. However, the commercially available technologies and full scale experience is limited to up-flow sequential batch reactors which account for only a small % of the plants globally and an even smaller % of the global wastewater flow. Most large facilities operate in conventional continuous flow activated sludge mode and generally find it costly and challenging from an operational perspective to convert the shallower side water depth reactors to a deep SBR system. Under this full-scale demonstration, AECOM, in partnership with the City of Penticton British Columbia, demonstrated a full scale granular sludge process in a continuous flow activated sludge BNR WWTP. This paper will share the details on the various process flow configurations tested, successes and failures, lessons learned and future work. Aerobic granulation was demonstrated feasible under continuous flow providing adequate treatment effluent TP < 0.3 mg/l and TN< 6 mg/l.

Beverley Stinson, AECOM, United States

SESSION 7: Advanced Membrane Applications in Drinking Water

PRESENTATIONS

IS13 Recent Developments in the Membrane Filtration Market
Pearce, Graeme

The membrane filtration market is reaching maturity after 20 years of strong sustained growth. Arguably the market has now reached the stage of early maturity, but commercial products still face quality/performance issues in the field. This paper poses four key topical questions about the market, and seeks to shed light on what we can expect in the future:
- How suitable are membranes for the water treatment duties that they are being used for?
- Is there a replacement market yet for membrane filtration?
- What impact is being made by new entrants?
- Whatever happened to China's membrane aspirations?

UF/MF has been readily accepted for industrial water and wastewater reuse. However, drinking water, the original driver, has had issues with integrity, which has created an interest in ceramics. Meanwhile, desalination pre-treatment has suffered from downstream RO biofouling.

Users and engineers have foreseen UF/MF mimicking the commoditization RO. However, suppliers have cited the importance of optimizing system design based on fundamental differences in product properties dependent on materials and format. Accordingly, different approaches have developed towards the 'open platform' with potential interchangeability either at the module or rack level. The market is current dominated by 4-5 major players with a similar number of significant others. The track record of new entrants shows that these companies struggle to gain traction, unless acquired by a major player, in which case their fortunes can be transformed.

Finally, the paper considers the China market. Initially, foreign suppliers dominated, followed by a period of investment by foreign companies in Chinese players. Subsequently, very few Chinese companies have made an impact outside China with one or two notable exceptions. However, Chinese investors are now turning the tables and acquiring foreign membrane companies. In the meantime, the explosion of the domestic MBR market has made Chinese suppliers the World's largest players.

Graeme Pearce , Membrane Consultancy Associates (MCA), United Kingdom

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OP25 Novel Drinking Water Treatment Solution Using Low Pressure NF On Colored Surface Waters
Sauvignet, Philippe; Gaid, Abdelkader; Goirand, Justine; Held, Henrik

The aim of this study was to verify the viability and the efficiency of a novel treatment process using low pressure NF on colored surface water. This process is particularly targeting Nordic surface waters. These waters are generally soft and are characterized by high NOM (Natural Organic Matter) content. The aim of the process is mainly to remove color. This paper presents the material and method used to demonstrate the viability of the novel treatment solution for drinking water production.

Philippe Sauvignet, Veolia, France

OP26 HAOPs - A Novel Anti-fouling Material For Membranes Treating Surface Water To Drinking Water Quality.
Vik, E.A.; Manamperuma, L. D.

Fouling of low-pressure membranes treating natural surface waters can be substantially mitigated by pre-depositing a thin layer of micron-size adsorbent Heated Aluminium Oxide Particles (HAOPs) on a microsize membrane. HAOPs had, in laboratory scale and University projects proven to be a novel, efficient antifouling material for membranes. A North American/Norwegian joint R&D initiative was in 2014 made to qualify the technology. Two prototypes were developed for drinking water and wastewater treatment and is being studied in the US and one prototype to treat typical surface water containing high content of humic substances or natural organic matter (NOM) was developed in Norway. The work presented in this abstract is based on results from the Norwegian prototype. This paper present state-of the art (SOA) of the existing plant, experiences from membrane filtration plants treating NOM containing surface water and the promising results obtained with the new technology tested from Sept-Dec 2018.

Eilen Vik, Aquateam COWI, Norway

IS14 Past, Present And Future Of Ceramic Membranes
Galjaard, Gilbert

This presentation will discuss ceramic membranes for the drinking water industry in general. Starting with a definition and some history to create a background. Followed by the advantages, disadvantages compared to polymeric membranes and recent developments that combined has led to a noticeable increase in applications since 2014. Recent adjustments in membranes and technology has led to overall lower costs or made it possible to integrate treatment steps. A good example of new technology was the Ceramac design of PWNT for Metawater membranes leading to quite a jump in total installed capacity. Or the relatively new segmented ultrafiltration monolith of Nanostone Water suitable to retrofit existing polymeric plants, leading to a rapid implementation on sites were polymeric membranes failed. Especially the combination of ozone on the surface of the ceramic membrane has potential to combine treatment steps while preventing flux decline by membrane fouling. Also a recent new approach by utilities looking more to life cycle costs in stead of capital costs has been of major importance for the increase in applications. What the future will bring is always difficult to asses. Still a lot can be done by looking differently to ceramic membranes then just an absolute barrier for suspended matter. These membranes are in example the ideal contactors for ozone leading to lower ozone dosages and contact time then standard ozone contactors. Surface charge effects are unexplored and can besides sometimes unpleasant surprises also bring new oppertunnities like the removal of Bromate. Pre-treatment applications for seawater desalination will definitly increase the coming years. While polymeric membranes will continue to dominate the drinking water sector a further positive shift in the market share of ceramic membranes can be expected. This since utilities worldwide will rely more and more on difficult to treat sources with challenges ceramic membranes will be able to address.

Gilbert Galjaard, Nanostone, The Netherlands

OP27 Hybrid Catalytic Ozonation With Ceramic Membrane Filtration Process For Synergistic Degradation And Mineralization Of Or
Lim, Teik-Thye (T.T.); Lim, Teik-Thye (T.T.); Lee, Wen Jie

This study investigated catalytic degradation of three micropollutants, i.e., bisphenol A (BPA), benzotriazole (BTZ) and clofibric acid (CA), by a hybrid catalytic ozonation-ceramic membrane filtration system. In this system, catalytic ceramic membrane (CCM) was fabricated through isotropic impregnation of nanosized metal oxides such as CeO2 and MnO2 which decorated the inner pore walls of the alumina membrane. They can catalytically decompose O3 to producing various reactive oxygen species including hydroxyl radical. The performance of CCMs was evaluated using a custom-made catalytic membrane reactor which was operated for dead-end filtration of the feed water containing the micropollutants and pre-ozonated water. Results indicated that CeO2-loaded CCM exhibited excellent mineralization ability of micropollutants and better stability with lower metal leaching. A membrane contact (hydraulic retention) time of 13.7 s was able to achieve 38±5% TOC removal of the micropollutants over 1 h of operation.

Teik-Thye (T.T.) Lim, Nanyang Technological University, Singapore

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OP28 Evaluation Of TiO2-GO Modified Ceramic Membranes For Water Treatment
Li, Chen; Sun, Wenjun

In this study, modified ceramic membranes functionalized with TiO_2-GO via vacuum method were prepared and the effects of modification on microstructure, surface chemistry, retention property and fouling mechanism of ceramic membranes were systematically investigated. The characterization of modified membrane and nanocomposites demonstrated the successful synthesis of TiO_2-GO nanocomposites and extremely higher hydrophilicity and negative charge of modified membrane surface. Higher removal of humic acid (HA), tannic acid (TA), ions and pharmaceuticals and better HAA FPs control were observed for TiO_2-GO modified ceramic membrane than those for the pristine ceramic membrane while maintaining a relatively high permeate flux. TiO_2-GO modified ceramic membrane also exhibited a lower fouling and irreversible fouling ratio after both HA and TA fouling for an hour, suggesting improved antifouling property. Modified Hermia's model fit accurately to the experimental data obtained from long-term TA and HA fouling protocols for both pristine and modified ceramic membrane. TA fouling mechanism transformed from standard blocking to intermediate blocking for TiO_2-GO modified membrane, indicating the dramatic decrease in membrane pore size after modification. Gel layer formation model fit well for modified ceramic membrane during HA filtration, which explained the decrease in selected pharmaceuticals retention by HA fouled-membranes while pore blocking governed the HA fouling for the pristine membrane causing an increase in pharmaceutical retention by HA fouled membranes. TiO_2-GO modified membrane had a strong effect against bacterial adhesion, but only exhibited a minor inhibition of biofouling after 24 h protocol in cross-flow filtration.

Chen Li, Tsinghua University, China

POSTER PITCHES

P703 Membranes In UK Potable Water Treatment: The Past, The Present And The Future
Koodie, Tony; Ostrowski, James; Elphinston, Andrew; Veerapaneni, Vasu

The pursuit of developing new membrane materials to enhance performance and cost effectiveness has provided much competition between suppliers as they seek to gain market share for potable water applications. Membrane filtration technology has historically been dominated by polymeric membranes although in recent years advances in ceramic membranes have meant that they are now well positioned to challenge this dominance. Presently there is much optimism that graphene can make a step change to revolutionise water filtration. The aim of this paper will be to highlight the adoption and application of membrane technology in the UK for potable water treatment. A comparison of technical and performance data for membrane options will be provided to aid plant selection.

Tony Koodie, Black & Veatch, United Kingdom

P702 Dissolved Methane Removal And Recovery From Groundwater Using Vacuum And Sweep Gas In Hollow Fibre Membrane Contactors
Heinsbroek, Abel; Sjoerdsma, Peter

Anaerobic groundwater can contain a high amount of dissolved methane gas that must be removed to prevent biofouling issues in the treatment plant and distribution network. As an alternative for intensive air stripping, Hollow Fibre Membrane Contactors can be used in combination with vacuum and sweep gas as a highly effective method to not only remove the dissolved methane gas, but to allow for recovery of the methane gas as well. The recovered methane gas can then be used for energy production. This paper presents the modelling, design and operation of a two-stage membrane contactor system, with the first stage used for bulk methane recovery at usable concentrations for energy production, and the second stage for polishing and conditioning. A demonstration-scale pilot plant was connected to the permeate of a Reverse Osmosis plant treating anaerobic, methane rich groundwater. The pilot plant was used to test and demonstrate the technology at scale and to validate the simulation model.

Abel Heinsbroek, Vitens NV, TheNetherlands

SESSION 8: Sludge Management - including resource recovery

PRESENTATIONS

IS15 Occurence and Reduction of Emerging Contaminants in Sludge
Sanin, Dilek

Emerging contaminants consist of a wide range of anthropogenic as well as natural substances which include pharmaceuticals, personal care products, steroid hormones, industrial chemicals, pesticides and many other emerging compounds. Since their concentrations vary from a few ng/L to several µg/L, they may also be called as micropollutants. There has been a growing awareness and concern about these chemicals for the last few decades since many of these are known to have toxic, carcinogenic or endocrine disrupting properties.

Limited removal of most of these compounds during wastewater treatment processes, cause them enter the water resources and move up the food chain. The hydrophobic nature of many of these compounds promote their accumulation in organic phases including sludge during wastewater treatment plants. This creates extra concern due to the beneficial use of sewage sludge in soil in many countries around the World. The chemically complex nature of many micropollutants make them hard to degrade during conventional wastewater and sludge treatment systems. Besides, the presence of wide variety of chemicals indicate that one single treatment type (aerobic or anaerobic) may not be enough to effectively remove them from wastewater and sludge.

The way wastewater treatment plants and sludge treatment units operated act as an important determinant on the final concentration of these chemicals. This talk will highlight the occurrence of emerging contaminants in wastewater and sludge and the governing factors to reduce them from wastewater effluents and from sludge.

Dilek Sanin, Middle East Technical University, Turkey

OP29 A Novel Method of Achieving Mainstream Deammonification
Wang, Zhiyao; Zheng, Min; Hu, Shihu; De Clippeleir, Haydee; Al-Omari, Ahmed; Yuan, Zhiguo

Mainstream deammonification is gaining escalating attention, driven by the on-going paradigm shift in wastewater treatment plant from energy-consumer to energy-generator. However, suppressing nitrite-oxidizing-bacteria while retaining ammonium-oxidizing bacteria, the key to mainstream deammonification, remains an unsolved challenge despite a decade of efforts. Here, we proposed a novel method of achieving stable NOB suppression in mainstream. In a 2 L membrane reactor fed with real domestic wastewater, nitrite accumulation ratio was stably maintained above 90% for more than 6 months and is still continuing. NOB are undetectable either by activity test or amplicon sequencing while ammonium oxidation rate is still within normal range, 0.20 kg N/(m3 · d). The proposed technology provides a brand-new insight into solving the biggest challenge of mainstream deammonification.

Zhiyao Wang, The University of Queensland, Australia

OP30 Achieving Energy Self-sufficiency And Reducing GHG Emissions By Optimizing Sludge Treatment In Lingen, Germany.
Cadavid, Gloria; Knörle, Ulrich; Dittmann, Maria

The goal of the project was to convert the wastewater treatment plant of the city of Lingen (Ems), Germany not only to an energy autonomous wastewater treatment plan (i.e. to a so-called “Zero-Energy Wastewater Treatment Plant), but to a wastewater treatment plant with an energy surplus (i.e. to a so-called “Plus-Energy Wastewater Treatment Plant”). Measures to increase biogas production during sludge digestion and to optimize the energy recovery from biogas were implemented. The sludge digestion process was upgraded with mechanical primary sludge thickening, thermal sludge disintegration (LysoTherm®), phosphate precipitation and recovery from digested sludge (EloPhos®) and vacuum degassing (EloVac®), a centrifuge for the dewatering of digested sludge and new CHPs with higher electrical efficiency. In 2018 at the project’s conclusion, the electrical power self-supply increased from 61% to 83% and total carbon footprint of the sludge treatment was reduced by a total of 400 tons/year, or by 17% prior to the implementation. This paper discusses the implications for becoming a ‘Plus-Energy Waste Water Treatment Plant’ over the six-years of the project.

Ulrich Knoerle, Eliquo Water Group, Germany

S16 Improved Treatment Processes Support The Role Of Biosolids In Sustainable Agriculture
Toffey, Bill

Biosolids produced by municipal treatment works is a source of nutrients and organic matter welcomed by farmers world-wide as a supplement or replacement to chemical fertilizers. The capability of biosolids to meet farmers' crop yield targets, at a low or no cost to farmers, has been repeatedly shown and is fundamental to land application having a central position among options for biosolids managers, even in face of occasional public scrutiny and regulatory change. An array of sustainability evaluation tools, such as calculation of carbon footprint and life cycle assessment, have reaffirmed the reasonableness of this central position, as have many scientific investigations showing low health and environmental risks of exposure to microbes and micropollutants in biosolids. No less important for sustainability, conventional technology for producing, transporting and using biosolids in agricultural settings is well established, dependable and cost-effective, which allows land application to "hold its owns" as a practicable option for plant owners. Sustainability is further supported by the amplified concern among scientists of a looming global "environmental breakdown," as biosolids use offers a credible response. It is a source of recycled phosphorus and nitrogen for animal feed and energy crop production, and it supplies organic matter for repairing degraded soils and sequestering carbon. Further, new technologies are producing improved quality biosolids for land application. Several examples include fine screening, advanced digestion (notably thermal hydrolysis and multiple stage digestion), phosphorus extraction, high-performance dewatering, belt dryers, and enclosed composting systems. These technologies achieve the balanced nutrient content, low odor and handleability desired by biosolids users

Bill Toffey, BlueTech Research, United States

OP31 Reconstructing Velocity Profile To Predict The Formation Of Sheared And Unsheared Regions: Impact On Anaerobic Digesters
Markis, Flora; Baudez, Jean Christophe; Eshtiaghi, Nicky

Design and optimization of unit processes of the waste water treatment process, most notably anaerobic digesters are an essential requirement of sludge management and needs accurate prediction of sludge rheology. However, the rheology of sludge has been studied extensively with studies focusing on the flow behaviour of activated sludge, digested sludge and more recently primary sludge in both the liquid regime and solid regime. In the liquid regime sludge is always defined as a non-Newtonian, shear thinning material exhibiting a yield stress. In the solid regime, the shear and loss moduli are studied with sewage sludge exhibiting viscoelasticity. As such, there is little information on the physical aging, shear rejuvenation and shear banding of sludge and its impact on the anaerobic digestion process.

In this paper, rotation velocity profiles are reconstructed for a primary – secondary sludge mixture and digested sludge as well as mixtures of these sludges to attempt to show and explain how the physical aging, shear rejuvenation and shear banding impacts anaerobic digesters.

The rotation velocity profile shows that primary – secondary – digested sludge mixtures undergo physical aging and shear rejuvenation such that shear banding is detected. This is a clear indication of the heterogeneity within the anaerobic digesters and may lead to the existence of sheared and un-sheared regions which may ultimately lead to digester failure.

Flora Markis, Hunter H2O Holdings Pty Ltd, Australia

OP32 The Effect Of Geometrical And Operational Parameters On Maceration Of Faecal Sludge
Ravndal, Kristin; Commenges, Aude; Collins, Matt; Kolios, Athanasios; Parker, Alison; Williams, Leon; Tyrrel, Sean; McAdam, Ewan

In onsite sanitation systems sludge with a high solids content accumulates over time, and the systems require desludging regularly. As an alternative to pumps, screw conveyance can be used for desludging. In this work, maceration has been investigated as a pretreatment to improve the consistency of the sludge for screw conveyance. In addition maceration can cut up coarse particles to prevent blockages of the screw. We found that with the right geometry, maceration can be operated rotational speeds down towards 600 rpm, hence lowering the energy need of the system.

Kristin Ravndal, Cranfield University, United Kingdom

POSTER PITCHES

P807 Moving Towards Maximum Biosolids Reduction: Achieving Ultra-dewatering Of Sludge
Choo-Kun, Marlene; Fournot McGill, Alexandra; Camacho, Patricia; Poignant, Alain; Bourdais, Jean-Louis; chevrel, Marc

Suez has been developing for three years the technology Dehydris Ultra™ performing ultra-dewatering for both municipal and industrial sludge. This process couples a thermal conditioning process in order to achieve the hydrothermal carbonization thermo-chemical reaction (Danso-Boateng, 2015) with a final dewatering step using a piston press. Thanks to this innovative coupling of technologies applied to dewatered sludge, the final dryness of the cake achieved is as high as 65%-70% Dry Matter (DM). In addition, this process increases the Lower Heating Value (LHV) of the sludge cake by 20% relative to its Volatile Solids content. Combining very high sludge cake dryness and increase in calorific value enables to reach a final product with the same LHV as municipal waste of OECD countries, opening the possibility to co-incineration, biomass heater or high agronomic value class A biosolids. Furthermore, depending on the final dewatering technology chosen, a wide range of 40-70% DM is achievable in order to propose flexibility to the WWTP operations. Besides, from conventional dewatered sludge of 20-25% DM to ultra-dewatered sludge, 70% biosolids production reduction is achieved. Eventually, coupling ultra-dewatering with digestion enables to increase the overall biogas production of up to 32% or if needed to cover the thermal energy needs of the overall process in order to have an thermally energy self-sufficient ultra-dewatering process.

Marlene Choo-Kun, Suez, France

P805 Application Of Hydrothermal Carbonization For A Sustainable Valorization Of Sewage Sludge
Mannarino, Gemma; Mannarino, Gemma; Puccini, Monica; Vitolo, Sandra; Gori, Riccardo; Aiello, Massimo; Salimbeni, Andrea; Caffaz, Simone

Hydrothermal carbonization (HTC) is a relatively innovative alternative for sewage sludge management. Since sludge treatment is becoming a real emergency in Tuscany (Italy), the Tuscany water utilities have promoted the joint action SLUDGE4.0 with the aim to integrate HTC and wastewater treatment plants (WWTPs). The purpose of this work has been to focus on the integration of HTC technology and San Colombano WWTP (Florence, Italy). The liquid fraction (process water) obtained as a by-product during HTC was characterized, in order to define a useful recovery for it inside WWTP, in line with circular economy. For this purpose, the model of San Colombano WWTP was developed and then it was integrated with HTC process, considering the process water as a new input in the anaerobic digestion (AD) to enhance the biogas production.

Gemma Mannarino, Università di Firenze, Italy

P803 Sludge Management Improvements Through The Implementation Of Real-time Analytics And Electronic Anti-Fouling Treatment
Malek, Payam; Downes, Graham; Buchanan, Annelle; Steele, Chris

Mineral fouling is a major issue for many water and wastewater processes. Conventional methods of fouling/scaling treatment are based on mechanical and/or chemical cleaning procedures, both of which are un-sustainable, expensive and require regular shutdowns. Alternatively, there are advanced methods that offer more cost effective and environmentally friendly solutions. The electronic anti fouling (EAF) technique, ParaDox by Environmental Treatment Concepts, is a non-intrusive treatment based on inducing modulating frequencies of ultrasonic harmonics in liquid streams to minimise mineral fouling or scaling build-up (e.g. struvite, calcite, etc.). Effective mineral fouling reduction could lead to large operational savings (case studies show savings up to 40%). EAF, when combined with near real-time analytics, a service offered by Black & Veatch, allows quantitative benefits of EAF to be measured and further process optimisation to be realised. This system optimisation approach enables clients to make holistic improvements to operational and wider asset management needs.

Payam Malek, Environmental Treatment Concepts Ltd, United Kingdom

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Session 1: Recent Developments to Improve Desalination

P101	**Spatially Isolating Salt Crystallisation For Continuous Solar Steam Generation And Salt Harvesting** Xia, Yun; Zhang, Xiwang (Australia)
P102	**REvivED Water: Efficient And Low Energy Electrodialysis System For Brackish Water Desalination, Case Study** Alhadidi, Abdulsalam; Martini, F.; Rapp, H.J.; Gutierrez, L. (Netherlands)
P103	**High Recovery Desalination System Based On Brine Treatment By Previous Softening And Membrane Distillation Process** Bayona, Carlos; Carvalho, Joana; Llopart, Nil; Repollès, Carme; Nelemans, Bart; Ferrer Mallén, Olga; Malfeito, Jorge (Spain)
P104	**Volume Reduction Of RO Concentrate From Coal Chemical Industry (CCI) By Forward Osmosis (FO)** Wang, Xiuheng; Lu, Jiandong (China)
P105	**A Custom Workforce: Novel Use Of The Gradostat For The Adaptation Of Microbes For Microbial Electrochemical Devices** Wardman, Colin; Rodenas Motos, Pau; Esteve-Núñez, Abraham; Ortiz, Juan M. (Spain)
P106	**Origami System For Efficient Solar Driven Desalination In Emergency Water Supply** Xu, Ying; Wang, Wei; Ma, Jiaxiang; Liu, Dongqing; Xu, Hongbo; Cui, Fuyi (China)
P107	**Boron Selective Removal By Novel Ion Exchange Column With Partial Resin Transfer Before Regeneration** Kim, Yu Chang; Kim, Yu Chang; Lee, Sungyun (Korea Republic of)
P108	**Enabling Novel Electrothermal Membrane Distillation Using HBN Coated Metal Mesh For Desalination Of Hypersaline Water** Zuo, Kuichang; Wang, Weipeng; Elimelech, Menachem; Ajayan, Pulickel; Lou, Jun; Li, Qilin (United States)

Session 2: Emerging Contaminants: Microplastics, Pharmaceuticals and Personal Care Products (PPCP) and Antibiotic Resistance

P201	**Exploring The Potential For Regeneration Of Micropollutants From Loaded Activated Biochar** Oesterle, Pierre; Lindberg, Richard; Jansson, Stina (Sweden)
P202	**Magnetic Rod-Like Mn-Fe Oxycarbide Catalyzed Peroxymonosulfate For Efficient Oxidation Of Butyl Paraben** Jia-Cheng, Yang; Ming-Lai, Fu (China)
P203	**Tetracycline Degradation And Toxicity Assessment During MPUV/PMS Process** Ao, Xiu-wei; Sun, Wen-jun (China)
P204	**Occurrence Of Micro Pollutants In Raw Water And Drinking Water In Lake Constance** Petri, Michael ; Jiang, Jia-Qian (United Kingdom)
P205	**Enhanced Photocatalytic Ibuprofen Removal By Magnetically Recyclable High O-species G C3N4/TiO2 Heterojunction** Kumar, Ashutosh; Lo, Irene M. C.; Wu, Baile (Hong Kong China)
P206	**Electrochemical Removal Of Emerging Contaminants From Effluent** Ferreira, Ana Rita; Guedes, Paula; Mateus, Eduardo; Ribeiro, Alexandra; Couto, Nazaré (Portugal)
P207	**Emerging Contaminants In Soil Irrigated With Effluent: Electrokinetic process As A Remediation Strategy** Ferreira, Ana Rita; Guedes, Paula; Mateus, Eduardo; Ribeiro, Alexandra; Couto, Nazaré (Portugal)
P208	**Microplastics In Urban Stormwaters -- Designing A Method To Evaluate The Microplastic Concentrations In Stormwater Run-o** Talvitie, Julia; Talvitie, Julia (Finland)
P209	**FIBERCLEAN: Monitoring And Minimisation Of Microplastics In The Lifecycle Of Textile Products And Wastewater Treatment** Sánchez Ramirez, Javier ; Sánchez Ramírez, Javier Eduardo (Spain)
P210	**Simultaneous Removal Of Diclofenac And Phosphorus Using A Novel Polypyrrole-modified Red Mud Adsorbent** Li, Xin; Ji, Min; Zhao, Yingxin (China)
P211	**An Investigation Of Extraction And Leaching Of Plastic Additives** Tseng, Linda; Bonte, Jeremy; Levy, Jake; Chistolini, Matthew; Tiroumalechetty, Araven (United States)
P212	**The Role Of Naturally Occurring Nano-phases In The Transport And Fate Of Genetic Debris** Chowdhury, Nadratun; Wiesner, Mark (United States)
P213	**Investigations On Degradation Of Venlafaxine Using UV/H_2O_2: Connecting Laboratory And Pilot Scale** Hollman, Jordan; Dominic, John; Achari, Gopal; Tay, Joo-Hwa (Canada)

POSTER PRESENTATIONS

P214	**Highly Recyclable Au@graphitic Carbon Nitride Nanocomposites For The Enhanced Catalytic Reduction Of Nitroarenes** Nguyen, Thanh Binh; Doong, Ruey-An (Chinese Taipei)
P215	**Benefits Of Advanced Activated Sludge Technologies For Handling Emerging Micropollutants At Low Temperature** Kruglova, Antonina; Mikola, Anna; Vahala, Riku (Finland)
P216	**The Role Of Microplastics In Transfer Of Wastewater Bacteria To The Aquatic Environment** Kruglova, Antonina; Talvitie, Julia; Gonzales-Martinez, Alejandro; Mikola, Anna; Vahala, Riku (Finland)
P217	**Ozone Dosage For The Removal Of Pharmaceuticals In Secondary Effluent From A Wastewater Treatment Plant Of Korea** KIM, ILHO; LEE, Jaiyeop; TANAKA, HIROAKI (Korea Republic of)
P218	**Effect Of Rainfall Events On Variation, Partition, And Fate Of Tetracycline Antibiotics In A Rural Watershed** Dong, Jianwei; Yan, Hanlu; Chen, Qiuwen (China)
P219	**Effect Of Multiple Selective Pressures On Bacterial Community In Drinking Water Treatment Process** Bai, Xiaohui; Ma, Xiaolin; Liu, Kunming; Miao, Xiaocao (China)
P220	**Development Of An Efficient And Sustainable Methodology For EMerging POllutants REmoval In WWTPs (EMPORE)** García, Héctor; Martínez, Miguel; González, Raquel; Bernal-Romero, Maria Ángeles; Santos, Jose Maria; Martínez, Francisco; Oyonarte, Silvia; Bosch, Francisco; Andreu, Javier; Company, Miguel; Prats, Daniel (Spain)
P221	**Micropollutant Removal -- Full-Scale Reality For The Largest Sewage Treatment Plant In Switzerland** Dinkloh, Ludwig; Dinkloh, Ludwig; Puehmeier, Tim; Ried, Achim; Stapel, Harald (Germany)
P222	**Saccharin Degradation By Means Of Titanate Nanotubes Covered Onto Activated Carbon** Davididou, Konstantina; Liu, Wen; Borthwick, Alistair; Chatzisymeon, Efthalia (United Kingdom)
P223	**Presence, Removal And Ecological Risk Assessment Of Antibiotics In A Wastewater Treatment Plant With Extended Aeration** Martínez-Alcalá, Isabel; Lahora, Agustin (Spain)
P224	**Heterogeneous Catalyst Of Peroxymonosulfate For Degradation Of Diclofenac** Fu, Kun; Wu, Minhui; Deng, Huiping (China)
P225	**Microplastics' Temporal And Spatial Dynamics Of An Urban River Network Area In Wuxi, China** Qian, Xin; Fan, Yifan (China)
P226	**Validation Of A Protocol For The Analysis Of Microplastics In Sludge** Campo, Pablo; Holmes, Anita; Coulon, Frederic; Briones, Pablo (United Kingdom)
P227	**An Evaluation Of Toxicity Removal From Pharmaceutical Wastewater With Membrane Bioreactor And Nano-filtration Technology** Miguez, Diana; Msamala, Jeffrey; Garcia, Hector; Hooijmans, Tineke; Brdjanovic, Damir (Netherlands)
P228	**Occurrence Of Pharmaceuticals In Urban Wastewater Treatment Plants From Different Geographic Regions -- A Review** Samaniego, Marvin; Vasquez, Magdaleno Jr.; Saroj, Devendra (United Kingdom)
P229	**Removal Of Fluoxetine And Metoprolol From Wastewater Using Attached Growth Aerobic Bioreactor With Immersed Membrane** Ramirez Vargas, Luis; Mijaylova Nacheva, Petia (Mexico)
P230	**Inactivation Of Antibiotic Resistant Bacteria And Genes By Conventional And Advanced Disinfection Methods.** Patel, Manisha; Jia, Wenlin; Yu, Pingfeng; Alvarez, Pedtro; Li, Qilin; Zuo, Kuichang (United States)
P231	**Effect Of Ozone/Biologically-Active Carbon Filtration On Microbial Community Structure And Antibiotic Resistance Genes** Blair, Matthew; Pruden, Amy; Bott, Charles (United States)
P232	**Removal Behaviour Of Tetracycline From Aqueous Solution By MPAC-H<startsub>2<endsub>O<startsub>2<endsub> System** Zhou, Jiahui; Guo, Haijuan; Ma, Fang (China)
P233	**Continuous Hospital Wastewaters Treatment By Trametes Versicolor : Comparison Between Operational Strategies** Blánquez, Paqui; Torán, Maria Josefina; Mir-Tutusaus, Josep Anton; Sarrà, Montserrat; Villagrasa, Marta; Rodriguez-Mozaz, Sara; Caminal, Glòria (Spain)
P234	**Occurrence Of Microplastics In Water ... Size Does Matter!** Olabode, Lola; Olabode, Lola; Radke, Christine (United States)
P235	**Critical Evaluation And Assessment Of Health And Environmental Risks From Antibiotic Resistance In Reuse And Wastewater** Olabode, Lola; Olabode, Lola; McGregor, Stefani (United States)

P236	**Integrating Management Of Emerging Contaminants In Biological Treatment When Developing A Broad Reuse Portfolio** Sathyamoorthy, Sandeep; Hoar, Catherine; Ramsburg, Charles Andrew; Chandran, Kartik (United States)
P237	**Monitoring Emerging Contaminants In Wastewater Treatments By Fluorescence EEM** Roccaro, Paolo; Sgroi, Massimiliano; Anumol, Tarun; Vagliasindi, Federico G. A.; Korshin, Gregory V.; Snyder, Shane A. (Italy)

Session 3: Micro-contaminant Control in Drinking Water

P302	**Biodegradation Of Non-sterodial Anti-inflammatory Drugs By *Pseudoxanthomonas* Sp. DIN-3 Isolated From BAC Process** Lu, Zedong; Sun, Wenjun (China)
P303	**Biological Enhancement By Phosphate Addition For Organic Matter Removal In MBR System** Zhang, Yongji; Zhou, Lingling; Wang, Yuan (China)
P304	**Real-time And Selective Detection Of Nitrates In Water Using Graphene-based Field-effect Transistor Sensors** Chen, Xiaoyan; Pu, Haihui; Fu, Zipeng; Sui, Xiaoyu; Chang, Jingbo; Chen, Junhong; Mao, Shun (China)
P305	**Nitrogen-doped Nanocarbons For Metal-free Catalytic Oxidation: Integrated Experimental And Theoretical Investigations** Li, Huarui; Tian, Jiayu; Cui, Fuyi; Duan, Xiaoguang; Wang, Shaobin (China)
P306	**Kinetics Of Lipid Regulator Degradation By Solar/chlorine: Mechanism And Affecting Factors** Fang, Jingyun; Kong, Xiujuan; Wang, Liping; Wu, Zihao (China)
P307	**Zero Valent Iron Catalytic Fenton Oxidation In The Treatment Of Micro Pollutant -- Evidence Of Synergetic Effect** Goswami, Anuradha; Jiang, Jia-Qian (United Kingdom)
P308	**Ultratrace Antibiotic Sensing In Running Water Using Aptamer/Graphene-based Field-effect Transistors** Chen, Xiaoyan; Chen, Xiaoyan; Mao, Shun (China)
P309	**Enhanced Photochemical Oxidation Of PPCPs Using A Combination Of Solar Irradiation And Free Available Chlorine** Cheng, Shuangshuang; Zhang, Xinran; Yang, Xin (China)
P310	**Influences Of Dissolved Organic Matter Composition On Microbial Community Composition In Drinking Water Supply System** Chen, Jiping (China)
P311	**Effect Of Biological Activated Carbon Filter Depth And Backwashing Process On Transformation Of Biofilm Community** Qi, Wanqi; Li, Weiying (China)
P312	**Adsorption Of Phosphate And Heavy Metals Onto Micro-sized Ferric Hydroxide In Fluidized Bed Reactors** Hilbrandt, Inga; Ruhl, Aki Sebastian; Jekel, Martin (Germany)
P313	**Ciprofloxacin Removal Catalysed By Conductive Carbon Materials** Pereira, Luciana; Antunes, Ana Catarina; Cavaleiro, Ana Júlia; Silva, Ana Rita; Soares, Salomé; Pereira, Manuel Fernando; Alves, Maria Madalena (Portugal)
P314	**Kinetic Of Haloacetamides Stability In Drinking Water** Ding, Shunke; Chu, Wenhai (China)
P315	**Mechanistic Identification Of Key Photocatalytic Property(ies) Governing PPCPs Removal** Khan, Musharib; Fung, Christopher S. L.; Kumar, Ashutosh; He, Juhua; Lo, Irene M. C.; Wu, Baile (China)
P316	**Chemical Regeneration Of Activated Carbon Exhausted By Problematic Micro-pollutants In Water Treatment** Larasati, Amanda; Graham, Nigel J. D.; Fowler, Geoff (United Kingdom)
P317	**LED Based TiO2 Photocatalytic Degradation Of Sulfolane** Dharwadkar, Sripriya; Yu, Linlong; Achari, Gopal (Canada)
P318	**PFAS And PFOS: A New Challenge For The Australian Water Industry** Capewell, Steve; Capewell, Steve (Australia)
P319	**Chlorate Occurrence And Operational Implications In Drinking Water.** Briones, Pablo; Goslan, Emma (United Kingdom)
P320	**Recovery Of Giardia Spp. Cysts And Cryptosporidium Spp. Oocysts By Calcium Carbonate Flocculation** Freitas, Bárbara; Fava, Natália; Terin, Ulisses; Medeiros, Raphael; Andreoli, Fernando; Sabogal-Paz, Lyda Patricia (Brazil)

POSTER PRESENTATIONS

P321	**Transformation Of Methamphetamine And Analogues To (Halo)nitromethane Carcinogens By Water Treatment With Ozone/Chlorine** Shi, Jiaming (Lily); McCurry, Daniel (United States)
P322	**A Potential Approach For The OH Radicals Scavenging Factor In The UV Advanced Oxidation Process Using FEEM/PARAFAC** HWANG, TAE-MUN; Nam, Sook-Hyun; Koo, Jae-Wuk; Kim, Eun-Jun (Korea Republic of)
P323	**Biological Triple Bed Filters For Achieving The New Arsenic Target Of <1 µG/L** van Halem, Doris; van Halem, Doris; de Ridder, David (Netherlands)
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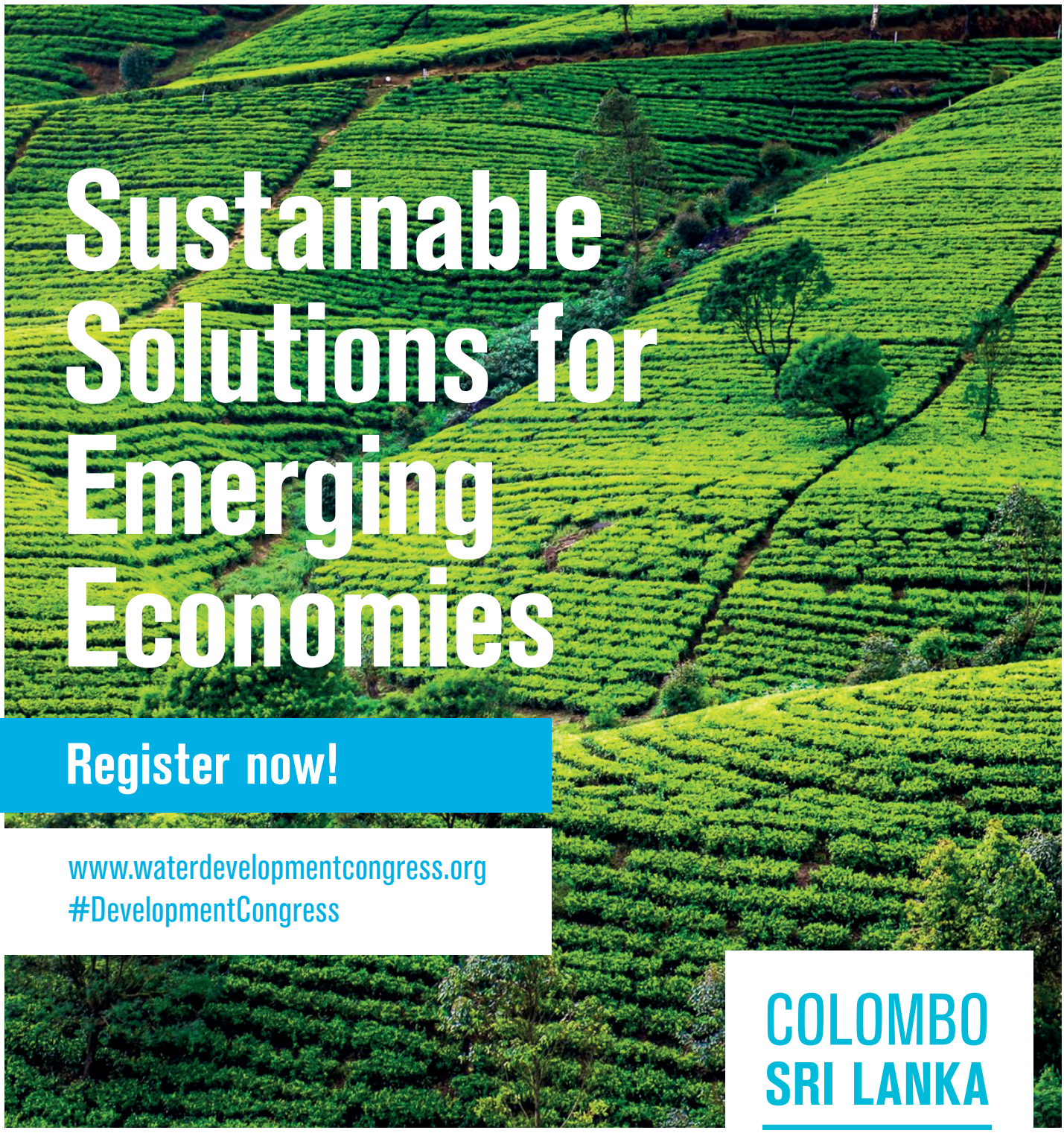

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SRI LANKA

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Organised by

IWA the international water association

Co-organised by

Sri Lankan Government

National Water Supply & Drainage Board