The 11th IWA Leading Edge Conference on Water and Wastewater Technologies

the international water association

Conference Programme

26 - 29 MAY 2014
YAS MARINA CIRCUIT EVENTS CENTRE
YAS ISLAND, ABU DHABI
UNITED ARAB EMIRATES

www.let2014.org

Organized by:

the International water association

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Official Publication:

water21 magazine of the International Water Association

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the international water association

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CONTENTS

WELCOME FROM THE IWA PRESIDENT

The flagship IWA Leading Edge Water and Wastewater Technology (LET) conference is designed to be the place where new ideas are introduced and the opportunity is provided to interact with the "best of the best". For those who are looking to introduce new ideas and concepts, and those looking for them, this is the one conference of the year that should not be missed. Based on more than a decade of experience, I am proud to say that the LET delivers on these objectives. Consisting of invited speakers to frame the issues and topics to be discussed and a combination of platform and poster presentations from submitted abstracts, here is where one can come to present and to learn about the latest on water and wastewater technology.

In addition to the introduction of new technology, we have been increasingly focusing on the process by which it is adopted. This is the innovation process where new ideas must meet real needs and the innovator must connect what the new technology can do with what an owner needs to be done. This is a critical step as new ideas, concepts, and technologies do not truly produce benefits until they are put into practice. We continue to expand our discussions and workshops on this topic and will do so in 2014. These discussions are useful for both those who introduce the new and those who look to move it into practice.

We will also be going to a new venue and a new region in 2014. Middle East and North Africa (MENA) certainly represents a region with significant water challenges. There is often the temptation to conclude that those in this region have the resources necessary to address their problems – it is only a matter of money. While this impression leads to easy conclusions, it is inaccurate. Not all in MENA have oil and gas. I can tell you from personal experience that MENA is a diverse region, offering an interesting and varied context for our discussions of water needs and solutions. Abu Dhabi, itself, is a growing and robust metropolitan area with all of the amenities one can wish for. This is further supplemented with regional favorites, like dune busting and camel rides.

I personally am looking forward to a thought provoking, interesting, and highly useful experience at the 2014 LET.

Glen Daigger
President
International Water Association

WELCOME FROM THE CHAIRMAN OF THE PROGRAMME COMMITTEE

Water is essential for human life and society. Increasing urbanization and pressure on resources creates a pressure to continuously innovate the current urban water systems. This becomes even more evident in areas as in the Gulf area with a desert climate.

The 'IWA-Leading Edge Technologies' conference has developed in the primary global platform for in depth presentations and discussions on water technology innovations between research and development leaders in academia, industry and utilities.

On behalf of the Program Committee, I would strongly encourage you to join and actively participate in this conference. We hope to again attract many quality academic professionals and scientists from all over the world, like how the LET conferences had done in the past decade. I look forward to welcoming many of you at the LET in Abu Dhabi in May 2014. And I am confident we will have a stimulating and invigorating exchange on all many innovative ideas and solutions.

Mark van Loosdrecht
Chairman
Programme Committee
TU Delft, The Netherlands

WELCOME FROM THE CHAIRMAN OF THE ORGANIZING COMMITTEE

On behalf of the Organising Committee, I would like to invite water researchers and professionals to the IWA's Leading Edge Technology Conference 2014 (LET2014). This year's conference will be hosted by Masdar Institute of Science and Technology, a not-for-profit research-driven graduate-level university in Abu Dhabi, the capital of the UAE.

The fast growing economies in the Gulf region where water resources are extremely scarce have put water at the top of the governments' agendas, above energy itself. Securing water resources requires best practices in policy, management and technology worldwide especially in the Gulf region.

This edition of the LET will bring to the table leaders in water technologies of regional and global relevance. I am confident the numerous attractions in Abu Dhabi and the UAE will make your stay a memorable experience, both professionally and socially. Welcome to Abu Dhabi.

Jorge Rodríguez
Chairman
Organizing Committee
Masdar Institute, UAE

Leading-Edge Technology

ABOUT THE ORGANIZER

About International Water Association

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

The strength of IWA lies in the professional and geographic diversity of its membership – a global mosaic of member communities, including academic researchers and research centres, utilities, consultants, regulators, industrial water users and water equipment manufacturers. IWA members from each of the 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.

ABOUT THE INSTITUTIONAL PARTNER

About King Abdullah University of Science and Technology

King Abdullah University of Science and Technology (KAUST) is an international, graduate research university located on the shores of the Red Sea in Saudi Arabia.

KAUST is dedicated to advancing science and technology through interdisciplinary research, education, and innovation. Students, faculty, scientists, and engineers conduct fundamental and goal-oriented research to address the world's pressing scientific and technological challenges related to water, food, energy, and the environment.

In 2011, KAUST was named Lab of the Year by leading science and technology publication, R&D Magazine. In 2012, the University's Research Park was named Emerging Research and Science Park by AURP.

ABOUT THE GOLD SPONSORS

Abu Dhabi Education Council

Abu Dhabi Education Council (ADEC) was established in accordance with law No. 24 of 2005, issued by His Highness Sheikh Khalifa Bin Zayed Al-Nahyan, the UAE president, the supreme commander of the Armed Forces and the ruler of Abu Dhabi.

The Council seeks to develop education and educational institutions in the emirate of Abu Dhabi, implement innovative educational policies, plans and programs that aim to improve education, and support educational institutions and staff to achieve the objectives of national development in accordance with the highest international standards.

ADEC Vision – Education First
To be recognized as a world-class education system that supports all learners in reaching their full potential to compete in the global market.

ADEC Mission
To produce world-class learners who embody a strong sense of culture and heritage and are prepared to meet global challenges.

ADEC Values
ADEC's core values are the foundational principles for continually improving performance:

- Teamwork: Emphasize the virtues of cooperation and coordination
- Integrity: Doing the right thing no matter what the circumstances may be
- Transparency: Open, true and honest communications and actions
- Respect: Respect children, colleagues, parents and community
- Accountability: Take personal responsibility for action
- Compassion: Caring and responsibility toward others

For more information, please visit: http://www.adec.ac.ae/en/AboutADEC/Pages/default.aspx

CO-ORGANIZER & PLATINUM SPONSOR

About Masdar Institute of Science and Technology

Masdar Institute of Science and Technology is an independent, research-driven graduate-level university focused on advanced energy and sustainable technologies. Established by the Government of Abu Dhabi as an ongoing collaboration with the Massachusetts Institute of Technology (MIT) in Boston, US, Masdar Institute serves as a "knowledge-hub" for the region and works towards creating indigenous R&D capabilities, while addressing regionally-relevant issues.

Masdar Institute's mission is in keeping with the ideals of the late Sheikh Zayed bin Sultan Al Nahyan, the Founding Father of the UAE, who believed strongly in responsible conservation, sustainable development and the importance of education. Dedicated to the science and engineering of advanced alternative energy, environmental technologies and sustainability, Masdar Institute exemplifies an unparalleled commitment by the Emirate of Abu Dhabi to take a leading role in the search for viable solutions that address today's energy challenges.

With ongoing support from MIT, Masdar Institute has developed an academic and research platform that articulates its mission and vision according to critical energy and sustainability challenges. It currently offers post-graduate (M.Sc.) degrees in eight programs and an Interdisciplinary Doctoral Degree Program (PhD). With one issued patent, 21 patents pending, and 38 invention disclosures, Masdar Institute leads research in clean energy and advanced technology.

Full-time Masdar Institute faculty spend up to one year at MIT in Cambridge, Massachusetts, working with MIT faculty members on joint research projects - on topics of relevance to Abu Dhabi. Masdar Institute graduates are issued a joint certificate by both academic institutions.

Abu Dhabi Convention Bureau

Established in March 2013, Abu Dhabi Convention Bureau sits within Abu Dhabi Tourism & Culture Authority and drives and supports the development and promotion of business events throughout the emirate efficiently, effectively, and transparently, and in partnership with all its stakeholders. Its main mission is to champion the emirate as a dynamic global business events leader.

Abu Dhabi Convention Bureau can assist with any planners' needs and acts as a one-stop shop, offering free advice, help with planning, and local knowledge. Key assistance includes researching bid opportunities, assisting with a tailored bid strategy to ensure competitiveness, providing destination promotional collateral and boosting delegate numbers through the authority's international offices. The Abu Dhabi Convention Bureau team provides co-ordination with local partners, and helps arrange introductions to key Abu Dhabi stakeholders, secures support from mainline industry and tourism leaders, and assists with government liaison, researching appropriate venues, offering PR and marketing support, and providing innovative activities and pre- and post- conference ideas. Our ground breaking Advantage Abu Dhabi is aimed at catalysing and seeding innovative and viable business events aligned to the Abu Dhabi Government's 2030 Economic Vision

PROGRAMME COMMITTEE CORE GROUP MEMBERS

- **Pedro Alvarez** Rice University, USA
- **Gary Amy** KAUST, Saudi Arabia
- **Jurg Keller** University of Queensland, Australia
- **Mark van Loosdrecht** Delft University of Technology, The Netherlands
- **Bruce Rittmann** Arizona State University, USA

ORGANIZING COMMITTEE MEMBERS

- **Jorge Rodriguez** (Chair) Masdar Institute, UAE
- **Farrukh Ahmad** Masdar Institute, UAE
- **Gary Amy** KAUST, Saudi Arabia
- **Peng Wang** KAUST, Saudi Arabia
- **Hong Li** International Water Association, The Netherlands
- **Orsolya Bagdi** International Water Association, The Netherlands

OTHER PROGRAMME COMMITTEE MEMBERS

- **Mark van Loosdrecht** (Chair) Delft University of Technology, The Netherlands
- **Lars Angenent** Cornell University, USA
- **Joerg Drewes,** Technische Universität München, Germany
- **Peter Fox** Arizona State University, USA
- **David Furukawa** Murdoch University, Australia
- **Robert Maliva,** Schlumberger Water Services USA Inc., USA
- **Richard Luthy** Stanford University, USA
- **Eberhard Morgenroth** ETH/Eawag, Switzerland
- **Wolfgang Rauch** University Innsbruck, Austria
- **Jorge Rodriguez** Masdar Institute, UAE
- **Rene Rozendal** Paques bv, The Netherlands
- **Rhodes Trussell** Trussell Technologies, USA
- **Peng Wang** KAUST, Saudi Arabia

Leading-Edge Technology

CONFERENCE THEMES

THEME 1: BIOFILMS PROCESSES
Eberhard Morgenroth & Bruce Rittmann

Biofilm reactors offer many benefits over suspended-growth reactors: e.g., more compact due to higher biomass concentrations, retains slow-growing and specialized strains, and allows intimate contact with an active surface. Biofilm accumulation often results in mass-transfer limitations that can be viewed as drawbacks, but the resulting gradients also provide unique opportunities to create heterogeneous environments inside the biofilm. This session will present the latest findings for biofilm reactors used in water and wastewater treatment, with a special emphasis on how microbial interactions and heterogeneous environments inside of biofilms provide opportunities for novel biofilm reactors.

THEME 2: CATALYSIS AND NANOTECHNOLOGY-ASSISTED PROCESSES
Pedro Alvarez & Peng Wang

Through control over material size, morphology and chemical structure, nanotechnology offers novel materials that are nearly "all surface" and that can be more reactive per atom than bulk materials. Such nanomaterials can offer superior and tunable catalytic, adsorptive, optical, electrica,l and/or antimicrobial properties that enable new technology platforms for the development of next-generation water treatment systems. This session will report state-of-art developments in the field of nanotechnology-enabled and/or catalysis-assisted processes for water supply and water purification, including but not limited to: new separation or pollutant removal paradigms, multifunctional membrane processes, selective adsorption, waste stream minimization, sensor development, and advanced oxidation processes.

THEME 3: LOW-ENERGY AND RENEWABLE ENERGY-DRIVEN DESALINATION TECHNOLOGIES
Gary Amy & David Furikawa

Conventional water desalination technologies -- thermal and membrane based -- exhibit a high specific energy consumption with concomitant green house gas (GHG) emissions. This session will address technologies that overcome these deficiencies: e.g., (i) energy-optimization of conventional desalination processes, (ii) new and emerging desalination processes with lower energy requirements, (iii) integration of renewable energy (solar, wind, geothermal) into desalination processes, (iv) process hybridization for energy efficiency, and (v) operational strategies for reducing GHG emissions.

THEME 4: MANAGED AQUIFER RECHARGE
Peter Fox & Robert Maliva

Managed Aquifer Recharge is the intentional replenishment of aquifers for the purpose of subsequent recovery or for environmental benefit. This makes use of surplus water, such as recycled water, stormwater, desalinated water, by-product water from mining or energy industries, and natural surface water supplies. The water is infiltrated from the land surface or via wells for storage in aquifers for use at a later time. Various hydrogeological, geochemical, and microbiological processes in soils and aquifers change the quality of water before recovery. This session will address research and applications of Managed Aquifer Recharge systems. The emphasis will be on mechanistic insight into the sub-surface processes that improve water quality.

THEME 5: NEW DIRECTIONS AND TECHNOLOGY TRENDS IN WATER RECLAMATION AND REUSE
Joerg Drewes & Rhodes Trussell

With increasing water scarcity in many regions worldwide, water reuse is being recognized as a viable option to provide water supplies in the future for non-potable and potable uses. While water reuse initially was viewed as a wastewater disposal option, recent trends emphasize opportunities for resource recovery and energy efficiency. This session will focus on the latest development in reuse applications (in particular potable reuse) and technology advancements in water reclamation to lower carbon and energy footprints.

THEME 6: RESOURCE RECOVERY FROM THE WATER CYCLE: SHORT ROUTES TO RE-USE CHEMICALS
Largus Angenent & Rene Rozendal

Industrial, agricultural, and municipal wastewater streams in theory are abundant sources of organic compounds, metals, and nutrients. In addition, the production of potable water also generates side streams that potentially represent a valuable product (e.g., ferric sludge). The challenge is that the valuable components in the streams are typically dissolved or suspended at low concentrations in the water matrix. Therefore, these valuable components are not readily captured in an energy-efficient way. This session will focus on novel processes -- including biological and chemical conversion, precipitation, crystallization, and separation — that can enable energy-efficient resource recovery from the various water sources.

THEME 7: TOWARDS ENERGY-POSITIVE WASTEWATER TREATMENT
Jurg Keller & Jorge Rodriguez

The drive towards better energy efficiency in the water industry is clear, and some of the committed designers and operators have made their wastewater treatment plant completely energy self-sufficient. This session will focus on how this can be achieved by optimising existing processes to achieve a net energy output and by developing novel approaches that drive the energy recovery further. Energy-positive wastewater treatment must be put into context of achieving treatment performance in terms of all major effluent parameters: COD/BOD, nitrogen, phosphorus and even biological contaminants and micropollutants. This session will focus on full-scale implementation and research-stage developments that illustrate and stimulating energy-positive wastewater treatment.

THEME 8: URBAN INFRASTRUCTURE AND WATER SENSITIVE CITY
Wolfgang Rauch & Richard Luthy

Urban water systems are under increasing pressure due to climate change, population growth, and limitations on water imports. Conventional centralised water infrastructure and "business as usual" is unsuitable for the future. While conservation has helped address these needs, new technologies and approaches are needed in the future. For example, new decentralised technologies have emerged over the past two decades . How can they be mixed with existing centralised technologies? Likewise, water from unconventional sources, such as brackish water, storm water, and wastewater reuse, can augment our urban water supplies. This session will address these issues from the point of view of technologies, hybrid systems, design innovations, and scale-up.

CONFERENCE PROGRAMME

Monday, 26 May 2014

Venue: Masdar Institute of Technology, Building 1A, 3rd Floor Classrooms, Masdar City – Opposite to Presidential Flight, Abu Dhabi

11:30	Registration Opens		
13:30 - 17:30	**Workshop 1** Biofouling of membrane systems	**Workshop 2** International Trends in Sustainable Water Reuse Technologies	**Workshop 3** BlueTech Workshop: Exploring the Oil and Gas Innovation Landscape
18:00	**Welcome Reception** (Sponsored by Masdar Institute)		

WORKSHOP SESSIONS

Structure: Panel discussions in between presentations and after all the presentations

Workshop 1
Biofouling of membrane systems

Organizers:
King Abdullah University of Science and Technology (KAUST) and Delft University of Technology (TU Delft)

Objective:
Present and discuss the state of the art (research and practical experience) as well as future directions for biofouling control

20 mins	**30 Years of biofouling research** Harry Ridgway
20 mins	**Tools for biofouling research and monitoring** Hans Vrouwenvelder
20 mins	**Numerical modelling of fouling processes: The way to gain insight in control strategies** Cristian Picioreanu
20 mins	**(Bio)fouling revealed through membrane autopsies** Jean Philippe Croue
20 mins	**Global Membrains, Lessons learned from practice** Koos Baas

Workshop 2
International Trends in Sustainable Water Reuse Technologies

Organizer:
WateReuse Association

Objective:
Introduce WateReuse Association and its benefits to water professionals in the world

20 mins	**Research program of WateReuse Research Foundation and its achievements over the past two decades** Melissa Meeker
20 mins	**Latest technologies for production of high-quality recycled water for a wide variety of reuse applications** Gary Amy
20 mins	**Regulatory frameworks for water reuse and their evolution and most recent trends** James Crook
20 mins	**Soil Aquifer Treatment (SAT) Research, Results, and Implications for Groundwater Recharge with Reclaimed Water** Peter Fox
20 mins	**The results of a five-year field research that led to acceptance of use of recycled water by farmers in Monterey County, California for irrigation of raw-eaten vegetable crops** Bahman Sheikh

Workshop 3
BlueTech Workshop: Exploring the Oil and Gas Innovation Landscape

Organizer:
BlueTech Research

Objective:
To provide an overview of the innovative landscape for water technologies within the Oil and Gas sector

60 mins	**Water Innovation in Oil and Gas** A panel of expert research and technology officers will discuss their experience and current research on water and wastewater within the oil and gas sector, concluding with an interactive Q&A session. Session will include a presentation on leading research in the area from Dr. Pedro Alvarez of Rice University, and a presentation from Nidal Samad, Environmental Consultant of Saudi Aramco, who will provide an end user perspective
45 mins	**Mapping the Innovation Landscape in the Oil and Gas Sector** BlueTech Research will present the innovation landscape in the oil and gas sector for water and wastewater technologies, covering key technology trends and opportunities, and areas for investment. Attendees are encouraged to participate in the following Q&A session. Paul O'Callaghan, Founder and CEO, and Aoife Maloney, Senior Water Analyst, of BlueTech Research will present
60 mins	**BlueTech Oil and Gas Technology Showcase** Innovative water technology companies in the oil and gas sector will present on various aspects of its company, technology and value proposition, providing delegates the opportunity to judge each company based on its disruptive potential and go-to-market strategy. Presenting companies include WaterTectonics, OxyMen and ABS Materials

Leading-Edge Technology

Tuesday, 27 May 2014

Venue: Zone 1, Yas Media Centre

08:00	Registration Opens	
09:00	**Opening Address** Mark van Loosdrecht, Helmut Kroiss, Jorge Rodriguez	
09:30	**Environmental Risks to Public Health in the United Arab Emirates: A Comprehensive View** Jacqueline MacDonald Gibson, University of North Carolina, Chapel Hill, USA	
10:15 - 10:45	**Morning Tea/ Coffee**	*Venue: Zone 2, Yas Media Centre*
10:45	**Toward Water Security in the Arab and GCC Countries** Walid Abderrahman, King Fahd University of Petroleum and Minerals, Saudi Arabia	
11:30	**Application of Advanced Water Treatment Technologies for the Oil & Gas Industry** Samer Adham, ConocoPhillips, Houston, USA	
12:15	**Sanitation Service Provision Post 2015: Why Innovative Technologies are Going to Change "Business As Usual"** Doulaye Kone, Bill & Melinda Gates Foundation, USA	
13:00 - 14:00	**Lunch**	*Venue: Paddock Suite, Yas Media Centre*
14:00	**Recent Advances in Membranes and Processes for Water Purification** Tony Fane, SMTC/NTU, Singapore	
14:45	**Recovery of Chemicals from Waste and Wastewater Treatment** Mark van Loosdrecht, TU-Delft, The Netherlands	
15:30	**The Gut Microbiome: Lessons to and from our Field** Rosa Krajmalnik-Brown, Arizona State University, USA	
16:15	**Afternoon Tea/ Coffee**	*Venue: Zone 2, Yas Media Centre*
16:30 - 18:00	**Poster Session**	*Venue: Zone 2, Yas Media Centre*

Plenary Speakers

Environmental Risks to Public Health in the United Arab Emirates: A Comprehensive View

Jacqueline MacDonald Gibson
University of North Carolina, Chapel Hill, USA

Dr. Jacqueline MacDonald Gibson specializes in quantitative methods for analysing interventions to reduce environmental risks to public health, and currently an assistant professor in the Department of Environmental Sciences and Engineering at the University of North Carolina, Chapel Hill. She previously served as associate director of the Water Science and Technology Board of the U.S. National Academy of Sciences and as a senior engineer at The RAND Corp. She recently served as principal investigator for a three-year project funded by the Environment Agency-Abu Dhabi to quantify the environmental burden of disease in the United Arab Emirates (UAE) and to advise the UAE government on cost-effective interventions (resulted to a published book and 10 peer-reviewed journal articles).

Recovery of Chemicals from Waste and Wastewater Treatment

Mark van Loosdrecht
TU-Delft, The Netherlands

Mark van Loosdrecht is professor in Environmental Biotechnology at the Delft University of Technology. He studied Environmental Engineering at Wageningen University where he also obtained his PhD in 1988. His research focusses on the understanding and application of microbial ecology in engineered ecosystems with a special emphasizes on biofilm systems, nutrient removal and resource recovery. He is editor in chief of Water Research and an active IWA member. He has been elected fellow of the Royal Dutch Academy of Sciences, The Dutch Academy of Engineering and IWA. He received several awards and reco0gnition among which the Lee Kuan Yew Prize, The Simon Stevin Award and a honorary doctorate from the ETH in Zurich.

Sanitation Service Provision Post 2015: Why Innovative Technologies are Going to Change "Business As Usual"

Doulaye Kone
Bill & Melinda Gates Foundation, USA

Dr Doulaye Koné was born in Côte d'Ivoire. He holds a PhD and MAS in sanitary and environmental engineering; a certificate in environmental communication; MSc. and BSc in Physics and Chemistry. He is currently working as Senior Program Officer, on the Water, Sanitation & Hygiene Program (Global Development) at the Bill & Melinda Gates Foundation. In this capacity, his investment (grant making) portfolio focuses on innovation in science and technology to reinvent the Toilet and its associated business models for sustainable sanitation service delivery.

Plenary Speakers

Toward Water Security in the Arab and GCC Countries

Walid Abderrahman
King Fahd University of Petroleum and Minerals, Saudi Arabia

Dr. Walid Abderrahman is a Professor of Water Resources Management, King Fahd University of Petroleum and Minerals, Advisory Board for the Minister of Water and Electricity, Saudi Arabia, President of Saudi Water Association, and Senior Executive Consultant Acwa Power. He is also a Member of the Governing Board of the UNESCO-IHE Water Institute for Water Education representing the Arab Region, Governing Board Member of the UNESCO Regional Center for Water Training and Studies, Cairo, Egypt, Ex Director of the International Water Resources Association (IWRA), Member of Executive Board and Governing Board of the Arab Water Council, Member of the International Advisory Committee (IAC) of the International Network for Water, Health and Environment (INWEH), of the United Nation University (UNU), Hamilton, Canada, and Member of the Groundwater Protection Network for Arab Countries (UNESCO-IHP), Cairo, Egypt. He obtained his PhD from University of Reading, England in 1977. His major qualifications, teaching and research experiences are in water resources management especially in arid regions. Professor Abderrahman has been working as a part time consultant to several international organizations such as ESCWA/UN, UNESCO/UN, FAO/UN, UNEP/UN, World Bank/UN and Arab League. He managed more than sixty major applied research projects in water resources management, planning, development, utilization and operation in urban and rural areas in Saudi Arabia. Professor has contributed to writing 13 international books and more than 150 technical papers. He has also served as editor, technical editor and on the editorial board of five international refereed journals in water resources. Professor Abderrahman has won the prize as the Best Water Scientist in Arab Countries by the Council of Arab Ministers for Environment in 1996 in addition to five awards in recognition for his scientific achievements. He has participated in organizing and in the scientific committees of many water conferences in the Gulf and Arab Countries and worldwide.

Application of Advanced Water Treatment Technologies for the Oil & Gas Industry

Samer Adham
ConocoPhillips, Houston, USA

Dr. Samer Adham is the Manager of Water Solutions at ConocoPhillips in Houston, Texas. He is responsible for delivery of technical support, innovative solutions and analytical capability as well as advancing technology and functional development across the whole water spectrum, from sourcing and/or production to treatment to reuse and/or disposal.

Prior to the above assignment, Dr. Adham was the Managing Director of the Global Water Sustainability Centre (GWSC) in Doha, Qatar. Dr Adham was also a vice president and the manager of MWH's Applied Research Department in Pasadena, California.

Dr. Adham has more than 20 years' experience in the development of innovative solutions to the environmental challenges in the fields of water and wastewater treatment, and water reclamation. He received his Bachelor of Science in Civil Engineering and a Master of Science in Environmental Engineering from King Fahd University of Petroleum and Minerals in Saudi Arabia. He also received his Ph.D. in Environmental Engineering from the University of Illinois at Urbana-Champaign in 1993.

Recent Advances in Membranes and Processes for Water Purification

Tony Fane
SMTC/NTU, Singapore

Prof. Tony Fane is a Chemical Engineer from Imperial College, London, who has worked on membranes since 1973. His current interests are in membranes applied to environmental applications and the water cycle, with a focus on sustainability aspects of membrane technology, including desalination and reuse. He is a former Director of the UNESCO Centre for Membrane Science and Technology at the University of New South Wales and Head of Chemical Engineering at UNSW. Since 2002 he has directed membrane research in Singapore as Temasek Professor (2002-2006) at Nanyang Technological University, then since 2008 as Founding Director of the Singapore Membrane Technology Centre (SMTC) at NTU. He is now Director-Mentor at SMTC. The SMTC has a group of over 85 researchers dedicated to fundamental and applied research into membranes for the water cycle. He is on the Advisory Board of the Journal of Membrane Science (former editor from 1992 to 2005) and Editorial Board of Desalination. He is a Fellow of the Academy of Technological Science & Engineering and the Patron of the Membrane Society of Australasia.

The Gut Microbiome: Lessons to and from our Field

Rosa Krajmalnik-Brown
Arizona State University, USA

Dr. Rosa Krajmalnik-Brown is an Associate Professor at the School of Sustainable Engineering and The Built Environment and the Swette Center for Environmental Biotechnology at Arizona State University. She Joined the SSEBE faculty in 2007. She has Ph.D. in Environmental Engineering from Georgia Tech. She is an NSF career awardee. She is author of 5 patents and more than 45 peer-reviewed publications. She specializes on molecular microbial ecology for bioremediation, the use of microbial systems for bioenergy production, and the human intestinal microbial ecology and its relationship to obesity and autism.

Leading-Edge Technology

Wednesday, 28 May 2014

	Venue: Zone 1, Yas Media Centre	*Venue: Zone 3, Yas Media Centre*
	SESSION 1: BIOFILMS PROCESSES Chairs: Eberhard Morgenroth and Bruce Rittmann	**SESSION 2: LOW-ENERGY AND RENEWABLE ENERGY-DRIVEN DESALINATION TECHNOLOGIES** Chairs: Gary Amy and Stephen Gray
08:30	**Keynote (1): Advances in Biofilm Modeling** Cristian Picioreanu, Delft University of Technology (The Netherlands)	**Keynote (1): The Pursuit of PRO for Sustainable Seawater Desalination** Amy Childress, University of Southern California (USA)
09:00	**The Role Of Biofilm Thickness On Partial Nitritation/anammox Performance At Low Temperature** E. M. Gilbert, S. Agrawal, H. H. Horn, and S. Lackner (Germany)	**Microbial Desalination Cell: A Novel Technology for Simultaneous Organic Matter and Salt Removal** H. Pradhan, and M. M. Ghangrekar (India)
09:15	**Integrated Sidestream And Mainstream Biofilm-based Deammonification** P. L. Dold, R. L. Walker, W. Du, G. Burger, and C. M. Bye (Canada)	**Vacuum Membrane Distillation System Using Aspirator for Reduced Cost and Enhanced Water Recovery** H. Arafat, M. I. Hassan, and A. T. Brimmo (UAE)
09:30	Discussions	Discussions
10:00 - 10:30	**Morning Tea/ Coffee** *Venue: Zone 2, Yas Media Centre*	
10:30	**Keynote (2): Analysis of exoelectrogenic and electrotrophic biofilms in microbial electrochemical technologies** Bruce Logan, Penn State University (USA)	**Keynote (2): Recent developments in Low-Energy and Renewable Energy Driven Desalination: The Australian Experience** Stephen Gray, Victoria University, National Centre of Excellence in Desalination (Australia)
11:00	**Presence Of Biofilms On Ultrafiltration Membrane Surfaces Increases The Quality Of Permeate** N. Derlon, J. Mimoso, M. Peter-Varbanets, S. Kötzsch, and E. Morgenroth (Switzerland)	**Economic Analysis and Feasibility of Small-Scale Solar Powered RO Desalination in Arid Regions** M. A. Dawoud (UAE)
11:15	**Chemical, Microbiological, And Physical Structures Of H2-Based Biofilms** A. Ontiveros-Valencia, B-O. Kim, H-P. Zhao, Y. Tang, R. Krajmalnik-Brown, D. Friese, R. Overstreet, J. Smith, P. Evans, and B. E. Rittmann (USA)	**Integrated Thermal and Membrane-Based Renewable Energy-Driven Desalination Systems** Y-D. Kim, N. Ghaffour, K. Thu, G. L. Amy, and K. C. Ng (Saudi Arabia)
11:30	Discussions	Discussions
12:00 - 13:00	**Lunch** *Venue: Paddock Suite, Yas Media Centre*	
	SESSION 3: TOWARDS ENERGY-POSITIVE WASTEWATER TREATMENT Chairs: Jurg Keller and Jorge Rodriguez	**SESSION 4: CATALYSIS AND NANOTECHNOLOGY-ASSISTED PROCESSES** Chairs: Pedro Alvarez and Peng Wang
13:00	**Keynote (1): Anaerobic fluidized bed MBR for highly-efficient energy-neutral domestic wastewater treatment, even in temperate climates** Jaeho Bae, Inha University (Korea)	**Keynote (1): Nano-Enabled Reactive Membranes for Water Treatment Applications** Chad D. Vecitis, Harvard School of Engineering and Applied Sciences (USA)
13:30	**A Novel Anaerobic Electrochemical Membrane Bioreactor With Conductive Hollow-fiber Membranes Serving As Cathode And Membrane Filter** K. Katuri, C. M. Werner, R. J. Sandoval, W. Chen, Z. Lai, G. L. Amy, and P. E. Saikaly (Saudi Arabia)	**Bridged Polysilsesquioxane For Water Purification And Catalyst Supports** P. L. Edmiston, and S. L. Dean (USA)
13:45	**Where Did The Bubbles Go? How To Reduce The Energy Requirements For Municipal Wastewater Treatment** E. Syron, P. Vale and E. Casey (Ireland)	**A Novel Persulfae Activation Without Sulfate Radical Generation For Efficient Pollutant Degradation** T. Zhang, Y. Wang, J. Le Roux, J-P. Croué (Saudi Arabia)
14:00	Discussions	Discussions
14:30 - 15:00	**Afternoon Tea/ Coffee** *Venue: Zone 2, Yas Media Centre*	

Wednesday, 28 May 2014 (Cont'd)

	Venue: Zone 1, Yas Media Centre	Venue: Zone 3, Yas Media Centre
15:00	**Towards Energy Neutral Wastewater Treatment By Implementing Anammox In The Mainstream, A Pilot Scale Evaluation and Implementation at Dokhaven WWTP** M. Hoekstra, T. Lotti, R. Kleerebezem, C. van Erp Taalman Kip, T. L. G. Hendrickx, and M. C. M. van Loosdrecht (The Netherlands)	**Keynote (2): Hierarchical materials as a design concept for catalytic membrane reactors** Volodymyr V. Tarabara, Michigan State University (USA)
15:15	**Activity And Growth Of Suspended Anammox Sludge In Pre-treated Municipal Wastewater** M. Laureni, I. Szivák, D. Weissbrodt, E. Morgenroth, and A. Joss (Switzerland)	
15:30	**The Biodrying Concept: An Innovative Technology Creating Energy From Sewage Sludge** M-K. H. Winkler, M. H. Bennenbroek, F. H. Horstink, M. C. M van Loosdrecht, and G-J. van de Pol (The Netherlands)	**Mixed Matrix Membranes With In-situ Generated Polymeric Nanoparticles** M. S. Diallo , M. R. Kotte, and M. Cho (Korea)
15:45	**Proof Of Concept For A New Energy-positive Wastewater Treatment Scheme** E. Le Vaillant, C. Remy, M. Boulestreau, and B. Lesjean (Germany)	**Degradation Of Trichloroethanoic Acid Using Solar Photocatalysis And Titanium Dioxide And Zinc Oxide** K. Tota-Maharaj, D.E. Meeroof, and P. Paul (UK)
16:00	Discussions	Discussions
16:30	**End of Day**	

Thursday, 29 May 2014

	Venue: Zone 1, Yas Media Centre	Venue: Zone 3, Yas Media Centre
	SESSION 5: NEW DIRECTIONS AND TECHNOLOGY TRENDS IN WATER RECLAMATION AND REUSE Chairs: Jörg Drewes and Samer Adham	**SESSION 6: URBAN INFRASTRUCTURE AND WATER SENSITIVE CITY** Chairs: Wolfgang Rauch and Richard Luthy
08:30	**Keynote (1): Overcoming the Barriers to Direct Potable Water Reuse in California** David Sedlak, University of California (USA)	**Keynote (1): Re-inventing urban water infrastructure for resiliency to water shortages** Richard Luthy, Stanford University (USA)
09:00	**The Effectiveness Of Non-Membrane Multiple Barriers For CECs In Potable Reuse** J. E. Drewes, P. Roa, and K. Linder (Germany)	**Economic and Environmental Benefits in the Use of Seawater as an Alternative Water Resource for Densely Populated Coastal Cities** X. M. Liu, T. L. Ng, J. Dai, H. K. Chui, G. A. Ekama, M. van Loosdrecht, and G. H. Chen (Hong Kong, China)
09:15	**Formation And Toxicity Of Emerging Disinfection Byproducts In Reclaimed Wastewater Effluents** J. Le Roux, J-P. Croué, B. J. Mariñas, M. J. Plewa (Saudi Arabia)	**New Fibre Optic Sensors For Monitoring Deterioration And Pre-empting Failure In Wastewater Networks** P. Davis, J. Arkwright, and D. C. O. Marney (Australia)
09:30	Discussions	Discussions
10:00 - 10:30	**Morning Tea/ Coffee** *Venue: Zone 2, Yas Media Centre*	
10:30	**Keynote (2): Water Reuse and Reclamation: a contribution to energy efficiency in the water cycle** Peter Cornel, Technische Universität Darmstadt (Germany)	**Keynote(2):Stormwater Management – closing gaps by decentralised Technology, local Administration and suitable funding?** Axel Waldhoff, Hamburg Wasser (Germany)
11:00	**Alternative Energy Efficient Membrane Bioreactor (MBR) Using Reciprocating Submerged Membrane** J. Ho, S. Smith, J. Patamasank, P. Tontcheva, G. D. Kim and H. K. Roh (USA)	**Advanced Bioretention Systems Modified With Metal-organosilica Hybrid Composites For Stormwater Retrofits** H. Yang, P. L. Edmiston, and S. Spoonamore (USA)
11:15	**Integrating Microconstituent Management In Biological Treatment For Water Reuse Strategies** S. Sathyamoorthy, C. Hoar, C. A. Ramsburg, K. Chandran (USA)	**Studies On Granular Filters And Their Relationship To Geotextiles For Stormwater Pollutant Reduction** K. Tota-Maharaj, P. Paul, and D. E. Meeroof (UK)
11:30	Discussions	Discussions
12:00 - 13:00	**Lunch** *Venue: Paddock Suite, Yas Media Centre*	

IWA the international water association Leading-Edge Technology

Thursday, 29 May 2014 (Cont'd)

	Venue: Zone 1, Yas Media Centre	Venue: Zone 3, Yas Media Centre
	SESSION 7: RESOURCE RECOVERY FROM THE WATER CYCLE: SHORT ROUTES TO RE-USE CHEMICALS Chairs: Peter Cornel and Rene Rozendal	**SESSION 8: MANAGED AQUIFER RECHARGE-** Chairs: Peter Fox and Robert Maliva
13:00	**Keynote (1): Environmental Materials Research for Sludge Beneficial Uses and Resource Recovery** Kaimin Shih, University of Hong Kong (Hong Kong, China)	**Keynote (1): Managed Aquifer Recharge: State of the Art and Opportunities** Robert Maliva, Schlumberger Water Services (USA)
13:30	**Acetic acid recovery from a hybrid biological-hydrothermal treatment process of sewage sludge – a pilot plant study** J. Andrews, and D.Gapes (New Zealand)	**Application Of Horizontal Directional Drilled Wells For Fresh Water Management In Coastal Areas** D. G. Cirkel, K. G. Zuurbier, R. D. Rothuizen, K. J. Raat (The Netherlands)
13:45	**Microbial Enhanced Oil Recovery from Oily Sludge** E. M. N. Chirwa, and O. Fayemiwo (South Africa)	**Advanced Groundwater Technology Applied in MAR in the Middle East** R. Herrmann (UAE)
14:00	Discussions	Discussions
14:30 - 15:00	**Afternoon Tea/ Coffee** *Venue: Zone 2, Yas Media Centre*	
15:00	**Keynote (2): Rethinking water and waste - Crystallising the problem** Alison Lewis , University of Cape Town (South Africa)	**Keynote (2): Strategies to enhance removal efficiencies through contemporary MAR design** Jörg Drewes, Technische Universität München (Germany)
15:30	**The Value Of NOM In An Ion Exchange Saline Brine** E. Vaudevire, E. Koreman, and G. Galjaard (The Netherlands)	**Informed Design For Optimal Removal Of CECs In MAR Systems Using Parameter Based Decay Constants** M. Alidina, J. Regnery, and J. E. Drewes (Saudi Arabia)
15:45	**Electrolytic Membrane Extraction Enables Fine Chemical Production From Biorefinery Sidestreams** S. J. Andersen, T. Hennebel, S. Gildemyn, M. Coma, J. Desloover, J. Berton, J. Tsukamoto, C. Stevens, and K. Rabaey (Belgium)	**Organic Micropollutant (OMP) Elimination In Hybrid Constructed Wetland/Soil Aquifer Treatment System** A. F. Hamadeh, E. K. Tsehaye, S. K. Sharma, and G. L. Amy (Saudi Arabia)
16:00	Discussions	Discussions
16:30	**Closing Session** *Venue: Zone 1, Yas Media Centre*	
16:45	**End of Conference**	
18:00	**Closing Gala Dinner**	

SOCIAL PROGRAMMES

Welcome Reception
(Sponsored by Masdar Institute)

Date: 26 May 2014, Monday

Venue: Muti-use Hall (Sport Centre)
Masdar Institute Campus
Masdar City – Opposite to Presidential Flight
Abu Dhabi

Time: 18:00 to 20:00 hr

The welcome reception offers you vast networking opportunities to meet other attendees and speakers. Start generating stimulating and insightful dialogues among the guests before the conference commences the next day.

Closing Gala Dinner

Date: 29 May 2014, Thursday

Venue: Al Manaar Ballroom, Yas Viceroy Hotel
Ground Floor
P.O. Box 131808
Yas Island, Abu Dhabi UAE

Time: 18:30 to 22:00 hr

An architectural triumph acting as the centerpiece of Yas Island, Yas Viceroy Abu Dhabi hovers over land and water and spans the Yas Marina Circuit, the favored racetrack for Formula 1™ legends. Marvel at the incredible LED canopy that not only emits a concert of color and shade but also embraces the exhilarating Yas Marina Formula 1™ Circuit, defining the Abu Dhabi hotel as a landmark across Yas Island and one of the world's most extraordinary destinations.

IWA the international water association Leading-Edge **Technology**

11th IWA Leading Edge Conference on Water and Wastewater Technologies

PLENARY PRESENTATIONS ABSTRACTS

Environmental Risks to Public Health in the United Arab Emirates: A Comprehensive View

Jacqueline MacDonald Gibson, University of North Carolina, Chapel Hill (USA)

Since the formation of the United Arab Emirates (UAE) in 1971, environmental risks to health have shifted rapidly from infectious to noninfectious diseases, necessitating a change in environmental health management strategies. This talk will present an overview of this disease transition in the UAE along with the results of a recent project to quantify the total environmental burden of disease in the UAE. The project found that the public health risks of drinking water contamination in the UAE are low by global standards and relative to other environmental risk factors currently facing the UAE. Nonetheless, the UAE faces challenges in protecting the quality of potable water in the distribution system due to high water loss rates and frequent low-pressure events. Furthermore, high per-capita water use in the UAE--along with the high energy demands of producing freshwater via desalination--contributes to ambient air pollution, which the project found is the leading environmental contributor to premature mortality in the UAE.

Jacqueline MacDonald Gibson, University of North Carolina, Chapel Hill, USA (jackie.macdonald@unc.edu)

Toward Water Security in the Arab and GCC Countries

Walid Abderrahman, King Fahd University of Petroleum and Minerals (Saudi Arabia)

The Arab world is dominated by chronic water scarcity, coupled with increasing food and energy demands. It extends over 12 million Km^2, mostly within arid regions and inhabited by about 370 million. The water scarcity, food and energy challenges have been aggravated, by rapid growth in demands due to high population growth rates, improved standard of living, vast urbanization, industrialization, and increased irrigated agriculture. This is accompanied by climate changes, water pollution, exploitation of local aquifers, and weak management, and inefficient socio-economic and governance systems in some countries. The irrigation sector consumes about 250 billion m^3/yr or 86% of the total regional water use, and it suffers from losses of about 60-70%. The domestic sector use is about 24 billion m^3/yr, of which 10-60% are incurred losses. The food imports to the region exceed 50% of its needs. The average domestic water consumption is about 150 litres /capita/day, while, in Gulf countries, where tariff is low, the average consumption is globally the highest, as it ranges between 300 to 750 litres /capita/day. There is more dependence in the region on non-conventional resources such as desalination and wastewater reuse to augment the water supplies. Presently, the Arab countries, especially Gulf countries are producing more than 7 billion m^3/yr or more than 50% of the world desalination production, and treat about 5 billion m^3/yr or 40% of its produced wastewater (highest in developing countries), and about 40% of the effluents are reused. Since three decades, the Arab countries have been exerting increasing efforts to improve the access to safe drinking water and sanitation, as stated by the New Millennium Development Goals (MDGs). In 2013, about 82% of the local inhabitants have access to safe drinking water, and 76% have access to improved sanitation services, and more progress are required especially in low income countries. Most countries in the region have adopted different levels of integrated water management (IWRM) and governance frameworks. Hence, holistic approaches are still needed to adopt more effective IWRM schemes and advanced governance frameworks, which include effective stakeholder participation, broader public-private partnership, cost effective and more transparent decision making processes, and more integration with agricultural policies and energy production, under climate change to achieve sustainable water, food and energy security, and to protect the environment. Regional and international efforts coupled with more financial and technical resources are needed for lower income countries to help in achieving MDGs, and to reach bilateral agreements with riparian countries regarding shared rivers.

Walid Abderrahman, Resources Management, King Fahd University of Petroleum and Minerals, Saudi Arabia (Walid.a@miahona.com)

Application of Advanced Water Treatment Technologies for the Oil & Gas Industry

Samer Adham, ConocoPhillips' Water Solutions, Houston, USA

Produced Water (PW) is the highest volume liquid waste stream generated by the petroleum industry. Historically, the treatment of PW has typically been limited to free oil and suspended solids removal and subsequent discharge into water bodies or injection in disposal wells. Only a small fraction of the PW is currently being treated to an extent that allows it to be recycled and/or reused.

However, due to factors such as legislation, geological restrictions and local water scarcity, the drive for a greater fraction of the PW to be extensively treated and ultimately recycled and/or reused is increasing. This is becoming even more critical with the development of the unconventional resources worldwide that require water for efficient oil & gas production and also generate produced water to be treated. As a consequence, the petroleum industry will have to change how it has historically dealt with PW and starts managing it in a more sustainable manner.

This presentation focuses on the application of Advanced Water Treatment Technologies (AWTTs) for the treatment of PW. The specific technologies presented include membrane filtration and desalination, biological treatment in membrane-bioreactors (MBRs), thermal evaporators and oxidation processes. The presentation will also provide a brief overview of the laboratory and field testing carried out at the Global Water Sustainability Center in Doha, Qatar; where various AWTTs are being evaluated for PW treatment.

Samer Adham, ConocoPhillips' Water Solutions, Houston, USA (Samer.Adham@conocophillips.com)

Sanitation service provision post 2015: Why Innovative Technologies are Going to Change "Business As Usual"?

Doulaye Kone, Bill & Melinda Gates Foundation (USA)

The need for better sanitation in the developing world is clear. Forty percent of the world's population—2.5 billion people—practice open defecation or lack adequate sanitation facilities, and the consequences can be devastating for human health as well as the environment. Even in urban areas, where household and communal toilets are more prevalent, 2.1 billion people use toilets connected to septic tanks that are not safely emptied or use other systems that discharge raw sewage into open drains or surface waters. Poor sanitation contributes to about 700,000 child deaths from diarrhea each year. Chronic diarrhea can hinder child development by impeding the absorption of essential nutrients and reducing the effectiveness of life-saving vaccines.

To address these challenges, the Bill & Melinda Gates Foundation Water, sanitation and hygiene program took an approach to develop the next generation of innovative technologies for the 21st century sanitation industry. The portfolio of technologies range from reinvented toilets products, pit latrines emptying solutions to off-grid and financially viable resource recovery processing plants. The reinvented toilets, unlike existing ones, destroy pathogens from human waste, recover resources such as water, energy, fertilizer for reuse/recycling, support businesses opportunity for local entrepreneurs. Similarly the pit emptying technologies and waste processing plants are being designed to support affordable service delivery and profitability of local entrepreneurs.

Beside the technologies developed with support from the Gates Foundation, there is a nascent, but fast growing, sanitation industry (inventors, manufacturers, investors, services providers) that is experimenting with success, market led approaches for sanitation service delivery. These examples have inspired several other investors and governments and are beginning to lay the groundwork to support this growing industry in the very near future. The untapped opportunity is huge. For example, the market size for people without toilet is 2.5 billion and the market for pit latrines emptying is double that number.

Over the last 5 years, several business models have been tested. A closer look at those models provide strong evidence that sanitation service provision for poor communities can be structured as a utility service for the benefits of clients (families and communities), service providers and government. There is also more a growing consensus from ongoing case studies that innovative technologies that enhance service quality by destroying pathogens; are aesthetically appealing; provide security for women and girls, affordable or recover valuable resources; and have a potential to create demand. This presentation at LET 2014 focuses on leading technologies developed with support from by the Bill & Melinda Gates Foundation, and will shocase chemical engineering approaches to reinvent the toilet. The Author will also share potential business approaches and investment models that will lay the path for a new sanitation industry.

Doulaye Kone, Bill & Melinda Gates Foundation, USA (Doulaye.Kone@gatesfoundation.org)

Recent Advances in Membranes and Processes for Water Purification

Tony Fane, SMTC/NTU (Singapore)

Membrane technology continues to develop in response to increasing demands for more effective water technologies. This presentation reviews recent advances, challenges and trends. Developments in low and medium pressure membranes include high flux ceramics, low flux-low energy gravity driven systems and novel hollow fibre nanofiltration. RO desalination plant trends are to increasingly larger capacity and use of 16 inch modules. At the same time the quest continues for enhanced performance from super permeability RO using novel materials. It is likely the full potential will be limited by the challenges of engineering suitable modules and systems; strategies will be discussed. Interest in forward osmosis continues with novel membranes and module development, and the focus on applications using available draws. Efficient reversible 'engineered' draws remain elusive, but R&D is ongoing. Although Pressure Retarded Osmosis has recently lost a key proponent it continues to excite interest as a route to osmotic power recovery. Membrane Distillation provides an option when thermal energy is available at modest cost, and developments include new membrane materials and expanding applications. For wastewater processing the MD bioreactor (MDBR) provides a potential for high quality water for reuse in a single step. Other MBR developments include the anaerobic MBR and renewed interest in the Extractive MBR for difficult wastewaters. Membranes also offer water supply solutions in chronic and acute scenarios. Examples include gravity-driven UF for developing countries and 'bulk membrane' cryogel pellets incorporating Ag nanoparticles for emergency water purification. Finally, all membrane processes are prone to fouling and novel developments include 'biomimicry' to control biofouling and the use of sensors to provide early warning of imminent fouling.

A.G. (Tony) Fane, Singapore Membrane Technology Centre, NTU, Singapore (AGFane@ntu.edu.sg; A.Fane@unsw.edu.au)

Recovery of Chemicals from Waste and Wastewater Treatment

Mark van Loosdrecht, TU-Delft, The Netherlands

Wastewater treatment has traditionally been focussed on providing clean water, safe enough to be brought back in the natural ecosystem. With the ongoing increase in human population and urbanisation there is a strong need to increase reuse and recovery of materials. Recovery of water is a logical activity certainly for water scarce areas. Recovery of energy is the generally the second item. However from a global perspective recovery of materials/chemicals will in general be more efficient since the embedded energy content is often larger than the enthalpy of the chemicals/materials concerned. The presentation will give an overview of potential products that can be recovered from wastewater an discuss potential bottlenecks in developing system where resources are effectively recovered from wastewater and converted into marketable products.

Mark van Loosdrecht, TU-Delft, The Netherlands (M.C.M.vanLoosdrecht@tudelft.nl)

The Gut Microbiome: Lessons To and From our Field

Rosa Krajmalnik-Brown, Arizona State University, USA

Although energy capture has a different meaning in the human gut versus anaerobic treatment systems such as anaerobic digesters or microbial electrochemical cells (MXCs), similarities of these systems allow us to learn to and from these systems and advance multiple scientific fields with this common understanding. Hydrolysis, fermentation, the fates of hydrogen and acetate, and the resulting microbiology are the most important factors that govern human and engineered systems. Our ongoing studies look at the variance in the gut microbiome in children with autism and in patients undergoing bariatric surgeries to assess contributions of fermentation products to: human gut health, possible gut-brain interactions, and energy extraction. To better understand microbiome effects on host metabolism, we analyze the microbial community structure and measure fecal pH, total chemical oxygen demand (TCOD), soluble chemical oxygen demand (SCOD), and short-chain fatty acids (SCFAs). Key microbial interactions in the gut involve partnerships between fermenters and H_2 consumers who appear to act syntrophically to affect energy uptake by the human host. For example, Prevotella, a carbohydrate-degrading genus, is mostly depleted in children with autism and seems more abundant in post bariatric surgery than in obese and normal-weight patients. Most important for fermentation outcomes, Prevotella are usually correlated to the presence of H_2 consumers such as methanogens and sulfate-reducing bacteria. The final fate of acetate is critical to "success" or "failure" in the human gut and in engineered systems. For example, the SCOD/TCOD ratio seems to be significantly higher in fecal samples of obese patients than in patients who are normal weight or have had successful bariatric surgery. This trend supports that fermentation efficiency and acetate's fate have a significant impacts on energy extraction in humans.

Rosa Krajmalnik-Brown, Arizona State University, USA (Dr.Rosy@asu.edu)

11th IWA Leading Edge Conference on Water and Wastewater Technologies

PLATFORM PRESENTATIONS INDEX

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Platform Presentations Index

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11th IWA Leading Edge Conference on Water and Wastewater Technologies

PLATFORM PRESENTATIONS ABSTRACTS

SESSION 1: BIOFILMS PROCESSES

Keynote (1): Advances in Biofilm Modeling

Cristian Picioreanu, Delft University of Technology (The Netherlands)

This presentation will introduce concepts and particularities of biofilm modeling on membrane devices. On the whole, two- or three-dimensional fluid dynamics models in complex geometry media are coupled with solute transport supplying several nutrients needed for biofilm development. The formation of mixed-species biofilms can be described by different models including growth dependent of nutrient concentrations, as well as cells attachment and biofilm detachment function of local hydrodynamic conditions. Mineral precipitation has also been introduced in this modeling framework.

A first series of modeling examples will illustrate the negative effects of biofouling and mineral scaling in spacer-filled channels of spiral-wound membrane devices for water desalination by reverse osmosis. The 3-d numerical simulations show how biofilm accumulation strongly affects the feed channel pressure drop, flow channeling, and leads to a decline in permeation characteristics. Furthermore, accumulation of salts near the membrane (concentration polarization) and mineral precipitation is stimulated by the biofilm. Other micro-scale models can also explain experimental observations on specific particle deposition patterns, biofilm and crystal formation.

On the other hand, hollow-fiber membrane biofilm reactors (MBfR) can be used to supply the attached biomass with sparingly soluble gaseous substrates (H_2, O_2, volatile organics, etc.), leading to a number of interesting counter-diffusional biofilm applications. Models will be presented, which evaluate the effects of process parameters on denitrification in a hydrogen-based MBfR, and of competition among denitrifying, sulfate-reducing and methanogenic microorganisms. Model simulations show how spacers and operating conditions can be strategically designed to manage excessive biofilm growth and avoid fouling, while maintaining an effective nitrogen removal capacity.

Cristian Picioreanu, Department of Biotechnology, Delft University of Technology, The Netherlands (c.picioreanu@tudelft.nl)

The Role Of Biofilm Thickness On Partial Nitritation/anammox Performance At Low Temperature

E. M. Gilbert, S. Agrawal, H. H. Horn, and S. Lackner (Germany)

Different Kaldnes carrier material was used to evaluate the role of biofilm thickness in the partial nitritation/anammox (PNA) process: While K3® allows biofilm growth up to 10 mm, BiofilmChip M® limits the biofilm thickness to max. 2.1 mm. Temperature was varied between 10°C and 20°C to simulate a typical yearly temperature cycle expected in wastewater at a moderate climate. Reactor data, regularly performed activity measurements and molecular genetic community analyses clearly revealed a much more stable partial nitritation/anammox community in the thick and well protected biofilm in the MBBR with K3® carriers. Especially at temperatures below 12°C, the thinner biofilm on BiofilmChip M® could not provide sufficient anaerobic volume in the biofilm to assure effectual anammox metabolism: A permanent nitrite build up and a recessive anammox activity was observed, which was not the case in the thicker biofilm on K3® carriers.

Eva M. Gilbert, Karlsruhe Institute of Technology, Engler-Bunte-Institut, Water Chemistry and Water Technology, Germany (eva.gilbert@kit.edu)

Integrated Sidestream And Mainstream Biofilmbased Deammonification

P. L. Dold, R. L. Walker, W. Du, G. Burger, and C. M. Bye (Canada)

An energy-efficient configuration integrating biofilm-based deammonifaction in sidestream and main-stream reactors is proposed for municipal wastewater treatment. The first stage in the system is a high rate activated sludge process (SRT ~ 0.5 – 1 day) to maximize organic substrate capture for anaerobic digestion and methane generation.

Peter L. Dold, EnviroSim Associates, Ltd., Canada (dold@envirosim.com)

SESSION 1: BIOFILMS PROCESSES

Keynote (2): Analysis of exoelectrogenic and electrotrophic biofilms in microbial electrochemical technologies

Bruce Logan, Penn State University (USA)

The ability of certain microorganisms to transfer electrons outside the cell and accept electrons into the cell, has created opportunities for new methods of renewable energy generation and storage based on: microbial fuel cells (MFCs) that can be used to produce electrical power; microbial electrolysis cells (MECs), for transforming biologically generated electrical current into transportable fuels such as hydrogen and methane gases; as well as other devices that can be used to desalinate water, efficiently capture energy from salinity gradients, capture phosphorus, or fix CO_2. In this presentation I will focus on the microbiology of novel electroactive biofilms. Exoelectrogenic microorganisms produce electrical current, and community analyses has shown that the highest current densities are associated with bacteria most similar to Geobacter sulfurreducens, independent of the source of the inoculum (anaerobic digestors or natural bog sediements) or the use of a set or variable potential. However, studies of isolates obtained from these exoelectrogenic biofilms suggest that a Geobacter species with sufficiently different properties than G. sulfurreducens may predominate these systems. We have also examined electrotrophic and methanogenic communities that develop in these systems on the cathode. Community analyses of these methanogenic biofilms suggests that there may also be an archaeon that becomes predominant in biofilms when the main method of methane production is direct electron transfer from the cathode. It will be shown that the communities on these methanogenic biocathodes with direct electron transfer are quite distinct from those that develop on electrodes when hydrogen evolution is catalyzed by platinum.

Bruce Logan, Department of Civil & Environmental Engineering, and the Engineering Energy & Environmental Institute, Penn State University, USA (blogan@psu.edu)

Presence Of Biofilms On Ultrafiltration Membrane Surfaces Increases The Quality Of Permeate

N. Derlon, J. Mimoso, M. Peter-Varbanets, S. Kötzsch, and E. Morgenroth (Switzerland)

In this study we propose to evaluate how tolerating the formation of biofilm on membrane surfaces helps to increase the quality of permeate produced during gravity-driven membrane (GDM) filtration. Instead of trying to remove the biofilm, the focus in GDM filtration is to modify biofilm structure so that biofilm accumulation has only a limited influence on the quantity of produced water (i.e., the water flux). In fact, we observed that biological processes in the biofilm help to significantly improve the quality of the permeate produced (e.g., in terms of organic substrate removal, virus retention, etc). This novel concept of focusing process operation on peaceful “biofilm-membrane” coexistence is not limited to ultrafiltration based GDM filtration, but it is also relevant for other membrane systems (UF, NO, etc).

Nicolas Derlon, Eawag: Swiss Federal Institute of Aquatic Science and Technology, Switzerland (nicolas.derlon@eawag.ch)

Chemical, Microbiological, And Physical Structures Of H_2-Based Biofilms

A. Ontiveros-Valencia, B-O. Kim, H-P. Zhao, Y. Tang, R. Krajmalnik-Brown, D. Friese, R. Overstreet, J. Smith, P. Evans, and B. E. Rittmann (USA)

The membrane biofilm reactor (MBfR) delivers hydrogen gas (H_2) directly to a biofilm of bacteria that reduce oxidized contaminants (Nerenberg and Martin, 2012). We completed a pilot study using the MBfR to treat a groundwater containing multiple electron acceptors: NO_3^- at ~9 mg N/L, ClO_4^- at ~180 µg/L, O_2 at ~8 mg/L, and SO_4^{2-} at ~21 mg/L. The treatment goal for the MBfR pilot study was to achieve nearly complete removals of NO_3^- and ClO_4^-, but avoiding significant reduction of SO_4^{2-}. We tested a two-stage MBfR in which we could control the reduction of electron acceptors in each stage. The pilot results showed that the lead MBfR reduced all of the O_2 and 63-88% of the NO_3^-, depending on the loading. While ClO_4^- respiration occurred in the lead MBfR, most ClO_4^- reduction occurred at the lag MBfR, where competition from NO_3^- and O_2 respirations was minimized. The typical effluent concentration for the lag MBfR was ~6 µg/L (~98% removal). However, lowering the flow rate (and, thus, the total acceptor loading) in an attempt to attain lower effluent ClO_4^- concentrations led to SO_4^{2-} reduction in the lag MBfR, and the ClO_4^- reduction flux was inversely correlated to the SO_4^{2-}-reduction flux.

Bruce E. Rittmann, Swette Center for Environmental Biotechnology, Biodesign Institute at Arizona State University, USA (Rittmann@asu.edu)

SESSION 2: LOW-ENERGY AND RENEWABLE ENERGY-DRIVEN DESALINATION TECHNOLOGIES

Keynote (1): The Pursuit of PRO for Sustainable Seawater Desalination

Amy Childress, University of Southern California (USA)

Reverse osmosis desalination is currently the most efficient, widely adopted commercial desalination technology; however, it still requires a great deal of energy to create the high pressures necessary to overcome the osmotic pressure of saline waters. In addition to energy costs for seawater desalination, there are also environmental concerns associated with the discharge of concentrated brine through ocean outfalls. With the worldwide production of fresh drinking water from desalination plants at approximately 24.5 million m^3/d and increasing, a process that can synergistically reduce the energy demand of RO desalination systems and mitigate issues associated with discharge of RO brine to sensitive receiving environments could have wide application. In this presentation, experimental results from a reverse osmosis-pressure-retarded osmosis (RO-PRO) sytem will be presented.

The RO-PRO pilot system was designed and constructed to evaluate RO energy reduction that can be achieved using PRO. The RO-PRO experimental system is the first known system to utilize energy from a volume of water transferred from atmospheric pressure to elevated pressure across a semi-permeable membrane to pre-pressurize RO feed water. In other words, the system demonstrated that pressure could be exchanged between PRO and RO sub-systems. Additionally, the first experimental power density data for a RO-PRO system is now available. Average experimental power densities for the RO-PRO system ranged from 1.1 to 2.3 W/m^2. This is higher than previous river-to-sea PRO pilot systems (1.5 W/m^2) and closer to the goal of 5 W/m^2 that would make PRO an economically feasible technology. Furthermore, isolated PRO system testing was performed to evaluate PRO element performance with higher cross flow velocities; power densities exceeding 8 W/m^2 were achieved with a 28 g/L NaCl draw solution. From this empirical data, inferences for future system performance can be drawn that indicate future RO-PRO systems may reduce the specific energy requirements for desalination by ~1 kWh/m^3.

In considering pressure-retarded osmosis (PRO) as one component of an alternative energy portfolio that will reduce dependence on fossil fuel combustion, comparisons with leading renewable energy technologies are necessary. Estimations of land use required can be made; additional comparisons to consider for full-scale pilot RO-PRO facilities include capital costs, operating costs, and availability of the renewable energy source.

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Microbial Desalination Cell: A Novel Technology for Simultaneous Organic Matter and Salt Removal

H. Pradhan, and M. M. Ghangrekar (India)

A five-chamber microbial desalination cell (MDC) having: anode, cathode, one desalination and two concentrate chambers separated by ion exchange membranes (IEMs) was operated in batch mode for more than 60 days. The performance of the MDC was evaluated for chemical oxygen demand (COD) removal in anodic chamber and total dissolved solids (TDS) removal in desalination chamber and overall energy production. An average COD removal of 81 ± 2.1% was obtained using acetate fed synthetic wastewater as substrate in anode chamber. TDS removals of 58%, 70%, and 78% were observed with TDS of 8, 20, and 30 g/L in the middle desalination chamber. A maximum power output of 16.87 mW/m^2 was observed with 30 g/L of TDS in desalination chamber. Coulombic efficiency of 14 was observed while desalinating 30 g/L TDS in this system. The system effectively demonstrated the ability of simultaneous organic matter removal and desalination along with electricity generation.

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Vacuum Membrane Distillation System Using Aspirator for Reduced Cost and Enhanced Water Recovery

H. Arafat, M. I. Hassan, and A. T. Brimmo (UAE)

In a typical vacuum membrane distillation (VMD) processes, a vacuum pump is used to draw the water vapor out of the permeate chamber, which then passes through a condenser to condensate and recover the vapor. A liquid trap is usually used to protect the vacuum pump. In this new process, an aspirator (a simple device with no moving parts, used to generate vacuum by running water through a venture) is used to create the vacuum (based on Bernoulli’s principle) and, in the same step, condensate the vapor into the aspirator circulating liquid (water), thus eliminating the need for the vacuum pump, liquid trap, and the condenser, and ensuring full recovery of all water vapor. This new design allows cost reduction of the process and enables easier control of the vacuum level by controlling the flow rate of liquid through the aspirator.

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SESSION 2: LOW-ENERGY AND RENEWABLE ENERGY-DRIVEN DESALINATION TECHNOLOGIES

Keynote (2): Recent developments in Low-Energy and Renewable Energy Driven Desalination: The Australian Experience.

Stephen Gray, Victoria University, National Centre of Excellence in Desalination (Australia)

The National Centre of Excellence in Desalination Australia (NCEDA) instigated a research theme for low energy desalination in response to industry and community interest and the increasing use of desalination for delivery of fresh water supplies. The presentation will cover a range of low energy and renewable energy driven technologies under development within the NCEDA.

Technologies to be discussed include the use of capacitive deionisation coupled with photovoltaic cells for desalination in remote communities, cogeneration approaches for supply of fresh water from membrane distillation using waste heat from local power generators and improved multi-effect distillation that improves water yields by 30%. Each of these technologies have progressed from laboratory scale testing to small pilot plant demonstrations, providing valuable insights into practical application.

Stephen Gray, Victoria University, National Centre of Excellence in Desalination, Australia (stephen.gray@vu.edu.au)

Economic Analysis and Feasibility of Small-Scale Solar Powered RO Desalination in Arid Regions

M. A. Dawoud (UAE)

Fresh water supply in arid regions becomes an increasingly important issue. Desalination of brackish and saline groundwater could play an important role in water supply for areas that are remote from both seawater and freshwater resources. The main challenge is saving the required power to operate the desalination plants in areas where there is no power grid. Using sustainable and renewable energy source such as solar for operating a groundwater desalination system include a high recovery ratio, and high water output per unit of energy and land could be a solution. A pilot solar powered reverse osmosis (RO) has been designed, constructed and operated in Abu Dhabi in 2010 to assess the feasibility of using solar energy o desalinate the brackish and saline groundwater in remote areas. Using solar power can help to overcome a series of desalination related problems, the most significant of which are those related to energy consumption and environmental pollution caused by the use of fossil fuels.The aim of this study is to demonstrate the feasibility of using of photovoltaic solar energy for powering RO system for the desalination of brackish and saline groundwater abstracted from the shallow aquifer system located in the western region of Abu Dhabi Emirate, with salinity ranges between 5,000 to 20,000 ppm. The design capacity of the system is 5 m^3/hr with photovoltaic solar system of 45 kW hours. To minimize the cost, the system was operated during day time only to avoid using batteries for electricity storage. The produced fresh water stored in ground elevated tank to be used for 24 hrs. Also, a mathematical model was developed to calculate the required brackish groundwater and design of an RO system powered by photovoltaic energy (RO size and the number and configuration of the solar cells panels). The model was used as a tool for the design, optimization and costs.

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Integrated Thermal and Membrane-Based Renewable Energy-Driven Desalination Systems

Y-D. Kim, N. Ghaffour, K. Thu, G. L. Amy, and K. C. Ng (Saudi Arabia)

In this paper, a hybrid desalination method has been developed by our group, comprising adsorption desalination (AD) and membrane distillation (MD), simply called the AD-MD cycle, is presented. The synergetic integration of the AD and MD is demonstrated where both useful effects of the AD cycle are channelled to boost the operation of the MD process, namely (i) the cooling capacity for the condensation of water vapor that emanates from a microporous hydrophobic membranes and (ii) the low vacuum environment to maintain the high pressure and thermal gradients across the pore surfaces of membranes. The simulated results in the AD-MD cycle are presented for a range of heat source and cooling temperatures, and the range of sub-atmospheric vacuum. The suitability of the AD-MD cycle is also presented with respect to meteorological weather data of Saudi Arabia as well as the energy resource of a geothermal hard rock well. Challenges of current technologies, energy and economics aspects are also discussed in this paper.

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Platform Presentations Abstracts

SESSION 3: TOWARDS ENERGY-POSITIVE WASTEWATER TREATMENT

Keynote (1): Anaerobic fluidized bed MBR for highly-efficient energy-neutral domestic wastewater treatment, even in temperate climates

Jaeho Bae, Inha University (Korea)

For the anaerobic MBR to become an energy- and cost-effective alternative to aerobic processes for domestic wastewater treatment in temperate regions, high effluent quality is necessary. A pilot-scale staged anaerobic fluidized membrane bioreactor (SAF-MBR) has shown such promise in the treatment of primary-settled domestic wastewater over a temperature range of 8 to 30 ^{o}C and at total hydraulic retention time (HRT) of 4.6 - 6.8 h. Chemical oxygen demand (COD) and biochemical oxygen demand (BOD_5) removals averaged 90%-94% and 90%-98%, respectively, with average effluent COD never higher than 23 mg/L nor BOD_5 higher than 9 mg/L. Use of fluidized granular activated carbon (GAC) in the SAF-MBR provided energy effective membrane fouling control compared to the conventional gas sparging approach. Organism growth on GAC allowed separation of organism SRT from bulk VSS SRT, thus permitting a high treatment efficiency coupled with short HRT. The system provides exceptional trace organic removals and its GAC provides a good buffer against organic overload. Operational energy requirement for the SAF-MBR system, estimated at 0.23 kWh/m^3, could be met with the produced methane. Biosolids production averaged 0.051 g volatile suspended solids per g COD removed, significantly less than normally found with the typical aerobic system. Although the SAF-MBR has operated continuously for 525 d without chemical cleaning of membranes at a net flux of 4.1 – 7.5 L/m^2/h, further improvement of the SAF-MBR is likely through optimization of reactor design and operation. For the practical application of the SAF-MBR, further research is needed for recovery of dissolved methane, gas pre-treatment, and nutrient management.

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A Novel Anaerobic Electrochemical Membrane Bioreactor With Conductive Hollow-fiber Membranes Serving As Cathode And Membrane Filter

K. Katuri, C. M. Werner, R. J. Sandoval, W. Chen, Z. Lai, G. L. Amy, and P. E. Saikaly (Saudi Arabia)

This study successfully demonstrated the proof-of-concept for a novel anaerobic process that integrates a microbial electrolysis cell with a membrane bioreactor for treatment of a low strength organic solution with resource recovery (energy and reclaimed water). Nickel-based hollow fiber membranes served the dual purpose of cathode electrode and membrane filter. Energy was recovered in the form of biogas composed predominantly of methane that was generated via hydrogenotrophic methanogenesis. As a result, the system produced a net energy of 0.24 kWh/m^3 when operated at 0.7 V. Biofouling was reduced when the rate of hydrogen production was increased at high applied voltage (0.9 V).

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Where Did The Bubbles Go? How To Reduce The Energy Requirements For Municipal Wastewater Treatment

E. Syron, P. Vale and E. Casey (Ireland)

Bubble aeration has been the cornerstone of aerobic biological wastewater treatment for the past 100 years and while it is effective, it is also inherently inefficient with maximum oxygen transfer efficiencies of 40%. Bubbleless-aeration technology has evolved to the point where it is now ready to effectively and efficiently meet the requirements of a wastewater treatment plant. To demonstrate this, a 1000 litre OxyMem Membrane Aerated Biofilm Reactor (MABR), was installed at a full scale municipal wastewater treatment plant, downstream of the primary treatment tanks. The reactor was operated in parallel to the full scale Activated Sludge (AS) plant. After a 3 month start up, the MABR achieved COD and ammonia removal rates of greater than 75% and 80% respectively with a remarkably low aeration energy requirement. Aeration energy was estimated at 8kg O_2/kWhr for the MABR compared to 2.2kg O_2/kWhr for the fine bubble diffusers installed in the AS. This is the first time a MABR of this scale has been successfully deployed for at a wastewater treatment plant.

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SESSION 3: TOWARDS ENERGY-POSITIVE WASTEWATER TREATMENT

Towards Energy Neutral Wastewater Treatment By Implementing Anammox In The Mainstream, A Pilot Scale Evaluation and Implementation at Dokhaven WWTP

M. Hoekstra, T. Lotti, R. Kleerebezem, C. van Erp Taalman Kip, T. L. G. Hendrickx, and M. C. M. van Loosdrecht (The Netherlands)

The application autotrophic nitrogen removal at lower temperatures and lower nitrogen concentrations would allow extending anammox-related processes to municipal sewage treatment. This opens new possible scenarios in the energy balance, because less aeration will be needed to convert the nitrogen present in the waste stream and all BOD can be used to generate biogas. In this study the Anammox® process was established in a plug-flow granular pilot-scale reactor (4 m^3) continuously fed with the actual effluent of the A-stage of the WWTP of Dokhaven, Rotterdam in the Netherlands (20±15 mg BOD/L and 30±5 mg NH_4-N/L). The one-stage process with granular sludge and tilted plate settler (TPS) for sludge retention, was operated at 19±1°C. Nitrogen removal rate corresponded to an average specific N-removal rate of 13 mgN $(gVSS{\cdot}d)^{-1}$. The system was shown to efficiently retain granules enriched in anammox bacteria while suspended flocs enriched in heterotrophs and nitrifiers were washed out. Evidence for anammox growth in the system was demonstrated.

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Activity And Growth Of Suspended Anammox Sludge In Pre-treated Municipal Wastewater

M. Laureni, I. Szivák, D. Weissbrodt, E. Morgenroth, and A. Joss (Switzerland)

Anammox bacteria where shown to be able to grow in pre-treated municipal wastewater (MWW) (with the addition of NO_2^-) at 28°C and to prevail, on the long term (>120d), over potential competing biomasses (e.g. heterotrophs). The observed activities (>400 mgN L^{-1} d^{-1}) and corresponding estimated doubling times (18-25d) are relevant for application in MWW, further supporting the potential for anammox-based systems to be applied for mainline treatment. Further research will evaluate the feasibility of operating without temperature control and with partial nitritation in the first stage.

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The Biodrying Concept: An Innovative Technology Creating Energy From Sewage Sludge

M-K. H. Winkler, M. H. Bennenbroek, F. H. Horstink, M. C. M van Loosdrecht, and G-J. van de Pol (The Netherlands)

During wastewater treatment circa 40% of the biologically removed organic carbon is converted to biomass (sludge). This excess sludge is an unwanted by-product and presents rising challenges since it accounts for about half of the total cost of a wastewater treatment plant. Due to stringent EU-guidelines sludge usually cannot be applied on land and henceforth the sludge must be incinerated for which a dry solid content of 45% [w/w] or more is needed to gain energy from the combustion, which is typically not attained by sludge composting (Kudra et al. 2002). Other techniques such as thermal drying or direct combustion do not rely on microbial produced heat. Instead external energy needs to be supplied to evaporate water leading to high costs. A new technology, which is based on a similar process as composting, is the biodrying concept in which the metabolic heat is used to remove water from the waste matrix at the lowest possible residence time and minimal biodegradation hence preserving most of the gross calorific value of the waste matrix. The end product (fuel / granules) contains a high energy value and can be used as a replacement of coal and for thermal energy generation but it is not well recognized for excess sludge treatment. Bio-drying of sludge can (in contrast to landfilling) reduce fossil fuel requirements and henceforth greenhouse gas emissions if combusted to produce steam and or power henceforth positively contributing to prevent climate change (Navaee-Ardeh et al. 2010). Since the European Union targets a reduction of waste disposal by 50% by 2050, technologies realizing a reduction of waste is a hot topic (Lundin et al. 2004). The capacity of a successfully running full-scale biodrying installation is presented in this study. The plant treats excess sludge and is compared with other sludge handling processes in order to evaluate its feasibility.

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SESSION 3: TOWARDS ENERGY-POSITIVE WASTEWATER TREATMENT

Presentations Abstracts

Platform

Proof Of Concept For A New Energy-positive Wastewater Treatment Scheme

E. Le Vaillant, C. Remy, M. Boulestreau, and B. Lesjean (Germany)

For better exploitation of the high energy potential in the organic matter of raw wastewater, this study explored new treatment schemes for municipal wastewater treatment in pilot-scale with the final goal of an energy-positive process. The schemes include an advanced primary sedimentation process with coagulant and polymer dosing followed by a microsieve separation of the organic sludge. Another configuration includes a Moving Bed Biofilm Reactor (MBBR) upstream of the chemical dosing. After gravity thickening, the separated sludge fed a digester pilot plant to evaluate its biogas potential. Results showed that up to 80% of COD could be extracted from raw wastewater, yielding +60% biogas in relation to the influent wastewater volume if compared with current nitrification/denitrification activated sludge processes. Energy balances including post-treatment for nitrogen and extrapolated to full-scale conditions show that the new concepts can yield an energy-positive process with comparable effluent quality than conventional treatment schemes.

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SESSION 4: CATALYSIS AND NANOTECHNOLOGYASSISTED PROCESSES

Keynote (1): Nano-Enabled Reactive Membranes for Water Treatment Applications

Chad D. Vecitis, Harvard School of Engineering and Applied Sciences (USA)

Classically, water treatment technologies have fallen into two categories; separations where the hazardous species is separated from the water and transformations where the hazardous species is transformed into an innocuous species. Nanotechnology has enabled the development of separation-transformation hybrids. For example, reactive nanomaterials can be embedded in polymer membranes without loss of permeability or rejection performance. Here, a recently developed electrochemical carbon nanotube (CNT) filter will be discussed. Hybridization of electrochemistry and filtration yields a number of synergisms between the two normally disparate processes such as increases in electrochemical kinetics by >10-fold due to internal electrode convection and in situ reduction of foulant or poison accumulation. The electrochemical filter has been observed to be effective and efficient for drinking water (quantitative bacteria and virus removal) and wastewater (fossil fuel produced waters) treatment as well as resource recovery (mining wastewater copper), waste-to-energy (waste to hydrogen), and sequential reduction-oxidation (single-pass nitrobenzene mineralization) processes. Recent results on a conductive non-Faradaic CNT-PVDF membrane will be highlighted. The CNT-PVDF can protect against electrochemical and mechanical degradation of a Faradaic CNT electrode and can reduce organic fouling at low power via capacitive charging of the membrane surface.

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Bridged Polysilsesquioxane For Water Purification And Catalyst Supports

P. L. Edmiston, and S. L. Dean (USA)

Molecular scale self-assembly was used to create nanocomposites of bridged silsesquioxanes which are flexibly linked in a continuous network. The hydrophobic surface properties makes the material highly porous to organic solutes, but impervious to water. Absorption of organic liquids leads to instantaneous swelling and capture of up to twelve times the dry weight of the material. Methods to produce bridged polysilsesquioxane nanocomposites have been scaled and the material is commercially available as Osorb® media. The selective absorption of large amounts of organic solutes makes these materials suited for industrial water purification. Absorption is reversible allowing for multiple reuse cycles. Catalytic nano-scale metals can be synthesized within the polysilsesquioxane by utilizing the ability to swell. In situ reduction of sorbent entrained metal ion solutions was used to created segregated 2-10 nm particles of zero-valent Pd, Ru, Co, and Ni within a network of interlinked pores. Supported metal nanoparticles were explored as a water treatment system for chlorinated contaminants where the organophilic polysilsesquioxane matrix absorbs solutes and dissolved hydrogen. Hydrodechlorination reactions are accomplished inside of the nanocomposite support to yield benign products.

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A Novel Persulfae Activation Without Sulfate Radical Generation For Efficient Pollutant Degradation

T. Zhang, Y. Wang, J. Le Roux, J-P. Croué (Saudi Arabia)

A novel peroxydisulfate (PDS) activation process using CuO as a catalyst was introduced. This process is characterized by non-sulfate radical production but high efficiency in the degradation of phenol, chlorophenols and trichloroethylene. The advantage of this process lies in minimized consumption of the total oxidation capacity of PDS in presence of the ubiquitous chloride and other radical scavengers in water.

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Presentations Abstracts Platform

SESSION 4: CATALYSIS AND NANOTECHNOLOGYASSISTED PROCESSES

Keynote (2): Hierarchical materials as a design concept for catalytic membrane reactors

Volodymyr V. Tarabara, Michigan State University (USA)

Phase inversion of polymer casting mixtures filled with hierarchical functional nanostructures is proposed as a synthetic route for the design of reactive membranes. The structure and reactivity/function of such membranes can be independently controlled by regulating the relative content of components representing different levels in the nanostructure hierarchy. Gold and bimetallic nanoparticles supported on exfoliated graphite platelets and other carrier particles are used to illustrate benefits of the proposed approach. We report successful applications of these novel membranes to reductive dehalogenation and other reactions.

Volodymyr V. Tarabara, Department of Civil and Environmental Engineering, Michigan State University, USA (tarabara@egr.msu.edu)

Mixed Matrix Membranes With In-situ Generated Polymeric Nanoparticles

M. S. Diallo , M. R. Kotte, and M. Cho (Korea)

In this paper, we describe a facile and simple route to the preparation of mixed matrix polyvinylidene fluoride (PVDF) membranes with in-situ generated polyethylenimine (PEI) nanoparticles. Preliminary experiments suggest that our mixed matrix PVDF membranes with embedded PEI particles could provide new opportunities to develop a versatile platform of high performance membrane absorbers, affinity membranes and catalytic membranes for water purification.

Mamadou S. Diallo, Graduate School of Energy, Environment, Water and Sustainability (EEWS) Korea Advanced Institute of Science and Technology (KAIST), Korea (mdiallo@kaist.ac.kr)

Degradation Of Trichloroethanoic Acid Using Solar Photocatalysis And Titanium Dioxide And Zinc Oxide

K. Tota-Maharaj, D.E. Meeroof, and P. Paul (UK)

Advanced oxidation processes driven by solar energy can be an efficient method in removing organochlorine compounds from river water. The feasibility of solar photocatalytic degradation of the organochlorine compound Trichloroethanoic acid was assessed separately for two different photocatalysts (i.e. TiO2 and ZnO) in solution. This compound is commonly used as a herbicide in the Southern Caribbean islands. The prototype solar photoreactor operated and performed efficiently for the photo- degradation of Trichloroethanoic acid. The various photocatalytic disinfection methods of water treatment utilising solar energy as the primary driver of disinfection in addition to the application of the two photocatalysts increased the decomposition rates of the organochlorine compound. The results showed that for various concentrations of Trichloroethanoic acid and photocatalyst the organochlorine compound was completely photocatalytically degraded within a short period using solar radiation.

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SESSION 5: NEW DIRECTIONS AND TECHNOLOGY TRENDS IN WATER RECLAMATION AND REUSE

Keynote (1): Overcoming the Barriers to Direct Potable Water Reuse in California

David Sedlak, University of California (USA)

Population growth, competing demands on water resources and concerns about decreases in future availability of imported water are creating incentives for cities in California to develop local water sources. Among the various options, potable water reuse is particularly attractive because it is less susceptible to drought than stormwater capture, consumes less energy than seawater desalination and does not require the construction and maintenance of additional water distribution infrastructure as is the case for non-potable water reuse systems. California has a long history of soil aquifer treatment and groundwater recharge with water from advanced treatment plants (i.e., practices that are sometimes referred to as indirect potable water reuse). However, many cities in California lack access to aquifers that can receive and distribute treated water. As a result, direct potable water reuse (i.e., the recycling of wastewater without passage through an environmental buffer) is being considered as an alternative.

Prior to widespread investment in direct potable water reuse several barriers must be overcome. The technological means to treat municipal wastewater to drinking water standards are well established, but monitoring systems capable of quickly detecting and responding to failures are needed if the environmental buffer is to be eliminated. In addition, a better understanding is needed of the sources and concentrations of chemicals in recycled water that pose potential human health risks (e.g., NDMA, 1,4-dioxane) as well as compounds that compromise the aesthetic properties of drinking water (e.g., 2,4,6-trichloroanisole). From the perspective of community acceptance and societal legitimacy, sector-wide systems of independent oversight and public outreach will be critical to efforts to establish credibility of the practice and to assure the public that health protection and safety will not be compromised as utilities gain experience with this new technology. Lessons from California's analysis of direct potable water reuse will be important to efforts to expand potable water reuse worldwide.

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The Effectiveness Of Non-Membrane Multiple Barriers For CECs In Potable Reuse

J. E. Drewes, P. Roa, and K. Linder (Germany)

Contemporary potable reuse schemes favour membrane-based treatment process trains, which are particular difficult to implement for inland communities. This study investigated the effectiveness of a combination of natural treatment processes (modified managed aquifer recharge, MAR), advanced oxidation processes (UV/H_2O_2) and activated carbon filtration to remove a wide range of chemicals of emerging concern. The main objective of this study was to fully utilize the synergies of these different processes with the goal to minimize energy and chemical input while maintaining effective removal of a wide range of trace organic chemicals. The study was conducted using controlled laboratory-scale experiments to optimize the performance of MAR and the advanced oxidation process. Findings were subsequently validated at a full-scale potable reuse scheme employing MAR, AOP and activated carbon filtration.

Jörg E. Drewes, Urban Water Systems Engineering, Technische Universität München, Germany (jdrewes@tum.de)

Formation And Toxicity Of Emerging Disinfection Byproducts In Reclaimed Wastewater Effluents

J. Le Roux, J-P. Croué, B. J. Mariñas, M. J. Plewa (Saudi Arabia)

The aim of this study was to investigate the formation mechanisms and toxicity of emerging nitrogenous DBPs (e.g., haloacetamides) during disinfection of wastewater effluents. Cytotoxicity and genotoxicity of wastewater effluents were compared before and after monochloramine disinfection. The conditions of formation of target DBPs (haloacetamides) were studied. We also focused on the identification of unknown nitrogenous, brominated and iodinated DBPs using analytical tools such as GC-MS-MS and GC-ICP-MS.

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SESSION 5: NEW DIRECTIONS AND TECHNOLOGY TRENDS IN WATER RECLAMATION AND REUSE

Keynote (2): Water Reuse and Reclamation: a contribution to energy efficiency in the water cycle

Peter Cornel, Technische Universität Darmstadt (Germany)

Water and energy are two of the most important resources of the 21st century. Water is required to supply energy and, at the same time, energy is required to supply water. In urban water management, the key factor is warm water heating. Depending on the quality of the raw water, the provision of drinking water requires the application of different process technologies; and the more complex the methods, the higher the energy demand. As in metropolitan areas, in particular, water consumption exceeds local availability, water pipelines are necessary with respective energy demand. The reuse of water can contribute significantly to conserve water and energy resources. Usually, the water to be reclaimed is supplied locally, making long-distance transport dispensable. By adjusting the process technology to the intended function (Fit for Purpose), it is possible to minimize the energy demand as well. Water use implies the input of energy (heat, chemically bound energy in form of organic matter) as well as nutrients (nitrogen, phosphorus, etc.). In the context of implementing water reuse technologies, they can also be reclaimed.

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Alternative Energy Efficient Membrane Bioreactor (MBR) Using Reciprocating Submerged Membrane

J. Ho, S. Smith, J. Patamasank, P. Tontcheva, G. D. Kim and H. K. Roh (USA)

An innovative MBR system, called reciprocation MBR (rMBR) prevents membrane fouling without the use of air scouring blowers. The mechanism featured is a mechanical reciprocating membrane frame that uses inertia as an advantage to prevent fouling. Direct reciprocation of the fiber is also beneficial for the constant removal of solids built up on the membrane surface. The rMBR pilot consumes less energy than coarse air scouring used in conventional MBR systems. Specific energy consumption for the membrane reciprocation was 0.08 kWh/m³ permeate produced at 20 LMH flux which is more than 50% less than conventional air scouring system (0.2 to 0.3 kWh/m³).

Jaeho Ho, Doosan Hydro Technology, USA (jho@doosanhydro.com)

Integrating Microconstituent Management In Biological Treatment For Water Reuse Strategies

S. Sathyamoorthy, C. Hoar, C. A. Ramsburg, K. Chandran (USA)

Managing the discharge of microconstituents (MCs) is an important element in water reuse applications. The high energy costs associated with tertiary treatment processes bring into question the sustainability of widespread water reuse. Here we report finding related to the biodegradation of MCs during wastewater treatment with an emphasis on the role of nitrification and nitrifying organisms. Our research results indicate that ammonia oxidizing bacteria are primarily responsible for MC biodegradation during nitrification. Importantly, however our result suggest that generalizations based on MC class or function are recommended when making process design decisions targeting MC management. We are currently using molecular biotechnology tools to assess the 'active' microbial fraction responsible for MC biodegradation and assimilation.

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SESSION 6: URBAN INFRASTRUCTURE AND WATER SENSITIVE CITY

Keynote (1): Re-inventing urban water infrastructure for resiliency to water shortages through stormwater capture and recharge

Richard G. Luthy, Stanford University (USA)

Many cities in the west and southwest regions of the United States face increasing water scarcity and a mounting water crisis arising from droughts, population growth, ecosystem demands and deteriorating infrastructure. These challenges can be addressed in part through centralized and decentralized stormwater systems for capture, treatment and aquifer recharge. This requires technical appraisals on the number, scale and operation of such systems, as well a recognition of the social and institutional changes necessary for better regional approaches for stormwater use.

This presentation will discuss the situation for coastal cities in California with respect to current practices and future approaches to urban stormwater capture, treatment and use. While in theory there exists a significant potential to augment urban water supplies, practical implementation is difficult to achieve in Mediterranean climates where the rainfall occurs in only a few major storm events during part of the year. In Southern California the potential exists to almost triple the amount of stormwater infiltrated within the urbanized regions of the Los Angeles and San Gabriel River watersheds. How this might be achieved for Los Angeles, and other coastal cities, raises questions about the number, size and location of capture basins, treatment technologies to prevent groundwater contamination, and public acceptance for land use and zoning. Experiences from the Chino Basin, Los Angeles Basin, and Sonoma County illustrate some of the possibilities and challenges associated with augmenting urban potable water supplies with stormwater.

Richard G. Luthy, Department of Civil and Environmental Engineering, Stanford University, USA (luthy@stanford.edu)

Economic and Environmental Benefits in the Use of Seawater as an Alternative Water Resource for Densely Populated Coastal Cities

X. M. Liu, T. L. Ng, J. Dai, H. K. Chui, G. A. Ekama, M. van Loosdrecht, and G. H. Chen (Hong Kong, China)

This study aims at evaluating the economic benefits and energy consumption of the newly developed seawater-based water supply and wastewater treatment systems as compared with the conventional processes for a densely populated city. Six scenarios were developed with unit processes including freshwater treatment plant, seawater supply system, wastewater reuse, water distribution network, sewerage, traditional biological sewage treatment and the SANI process. The results indicated that the use of seawater for toilet flushing and the SANI process is an economic and energy efficient alternative, especially in water scarce situation. Compared with conventional activated sludge treatment process, SANI process saves 35% energy and 40% construction cost.

Guang-Hao Chen, Department of Civil and Environmental Engineering, The Hong Kong University of Science and Technology, Hong Kong, China (cegchen@ust.hk)

New Fibre Optic Sensors For Monitoring Deterioration And Pre-empting Failure In Wastewater Networks

P. Davis, J. Arkwright, and D. C. O. Marney (Australia)

Sewer corrosion problems are widespread within the global water sector. In Australia, abnormally fast asset depreciation and mitigation of corrosion problems costs the water industry hundreds of millions of dollars a year. Problem solutions have been hindered by a lack of technologies for cost-effective monitoring and early detection of deterioration in wastewater networks. This paper describes the development and trialling of new Fibre Optic (FO) sensors for distributed monitoring of internal environments within wastewater networks. The FO sensor developed relies on detecting changes in the wavelength of light propagating along the length of an optical fibre as a result of exposure to potentially corrosive environments within gravity sewer pipelines. The paper describes how chemically-reactive polymers have been used to provide an actuating mechanism that perturbs the FO sensor at in response to changes in pH, humidity and temperature within the gas phase of gravity sewer pipelines. Results from proof of concept experimental trials are presented.

Paul Davis, CSIRO Urban Water Systems Engineering, Australia (Paul.Davis@csiro.au)

SESSION 6: URBAN INFRASTRUCTURE AND WATER SENSITIVE CITY

Keynote (2): Stormwater Management – closing gaps by decentralised Technology, local Administration and suitable funding?

Axel Waldhoff, Hamburg Wasser (Germany)

The City of Hamburg is facing, as any other growing metropolis, the challenges of increasing surface sealing (by redensification and new site development) and changing precipitation pattern as a consequence of climate change. Both aspects lead to more (surface) stormwater runoff in the city which has to be managed in quality and quantity. Furthermore legal and quality demands concerning stormwater management (SWM) and flood control have risen in the last decades while stagnant water consumption leads to decreasing financial resources of water and drainage companies. Is there any Solution for cities like Hamburg facing these exogenous variables in drainage planning?

The project RISA** – Rain InfraStructure Adaption – aims at developing adequate responses concerning SWM in order to avoid flooding of streets and properties as well as further water pollution from (combined) sewer overflow and street run-off on the administrational and technical level in combination with a distinct modification of the charging system. The main project objectives are to maintain the common drainage comfort and to guarantee and improve water protection and inland flood protection.

On the technical level the project focuses on the identification and development of technical tools (e.g. GIS-based maps for flood risk analysis or infiltration and space capacity analysis for the implementation of decentralised storm water management measures) and design requirements e.g. to determine the necessity of storm water treatment.

On a more administrational level, the project seeks to integrate water management measures into urban and regional planning and to adapt the institutional setting correspondingly. Furthermore, the necessity of joint municipal tasks concerning stormwater management is realised by RISA which incorporates multidisciplinarity of different domains (e.g. spatial planners, traffic planners, urban drainage and water body planners, civil engineers). The project seeks to create the appropriate conditions enabling the implementation of a forward-looking and sustainable stormwater management in Hamburg. The holistic communication concept of RISA ensures the information and education of all relevant stakeholders (citizens, municipal and political administration, operating companies for drainage system and water body, consultant and engineering companies, universities,…).

The results of the project will support the development of a so called “structural plan storm water”, which provides the basis for political decision-making by the Senate of Hamburg. In doing so, a guidance document for administrations, experts and property owners for the implementation of consequent SWM should be given. Hence, the project RISA contributes to the climate protection concept and the climate change adaptation strategy of the Senate of Hamburg.
Within the keynote speak a critical overview about the main topics under discussion and development as well as the lessons learned so far concerning urban infrastructure and water sensitive city will be given.

***RISA was funded by the State Ministry of Urban Development and Environment of Hamburg (Behörde für Stadtentwicklung und Umwelt) in co-operation with HAMBURG WASSER, the municipal Water Supply and Wastewater Disposal Company of Hamburg in September 2009. Project work completes in 2014 via starting implementing work.*

Axel Waldhoff, Hamburg Wasser, Germany (axel.waldhoff@hamburgwasser.de)

Advanced Bioretention Systems Modified With Metal-organosilica Hybrid Composites For Stormwater Retrofits

H. Yang, P. L. Edmiston, and S. Spoonamore (USA)

Innovative bioretention fill media were developed to enhance remediation of runoff pollutants using unique engineered metal-silica (Osorb®) composites as an amendment in bioretention systems. Osorb is classified as a swellable organically modified silica forming fine-grained, glass-like powder. The material physically absorbs a wide variety of organic pollutants from water. A field-scale Osorb-enhanced bioretention system was constructed in spring 2012 at an urban brownfield site in Ohio, USA and evaluated the effectiveness of the Osorb amendments under extreme urban runoff conditions. Influent and effluent of the Osorb-enhanced bioretention system from various runoff events were monitored during a 1.5-yr study. The installed Osorb-enhanced bioretention system in our study were highly effective in removing nutrients (41~99%) and herbicides (77~ 99%), and heavy metals (99%) under high levels of pollution loading, demonstrating that the Osorb-enhanced bioretention system has the potential for being an effective best management practice for extreme urban runoff conditions.

Hanbae Yang, ABSMaterials, Inc., USA (h.yang@absmaterials.com)

SESSION 6: URBAN INFRASTRUCTURE AND WATER SENSITIVE CITY

Studies On Granular Filters And Their Relationship To Geotextiles For Stormwater Pollutant Reduction

K. Tota-Maharaj, P. Paul, and D. E. Meeroof (UK)

Geotextiles can serve as cost effective stormwater filtration devices within the urban water environment. This project assessed the applications of three experimental granular filters as a sustainable urban drainage system (SuDS) for the decomposition of organic pollutant load present in the stormwater. The three filters were packed with alternating layers of filter media consisting of gravel, pea gravel, sand and either a single, double or no layer of geotextile membrane. The hydraulic loading capacity for the three filters matched that commonly used with conventional sand filters systems. Water quality parameters were quantified by measuring suspended solids, chemical oxygen demand, dissolved oxygen, pH, Nitrate-Nitrogen, and Phosphate concentrations. It was found that Filter No.3 (upper and lower geotextile membrane) had a significant statistical difference from Filter No.2 (single geotextile membrane).

Parneet Paul, Water Sustainability Research Centre and Department of Civil Engineering, School of Engineering and Design, Brunel University London, UK (parneet.paul@brunel.ac.uk)

SESSION 7: RESOURCE RECOVERY FROM THE WATER CYCLE: SHORT ROUTES TO RE-USE CHEMICALS

Keynote (1): Environmental Materials Research for Sludge Beneficial Uses and Resource Recovery

Kaimin Shih, University of Hong Kong (Hong Kong, China)

Large quantities of sewage (municipal wastewater) sludge are being produced in urban environment and their treatments have become a strong attention and challenge. Comparing to the conventional way of landfilling the sewage sludge, more sustainable strategies aiming at recovering valuable materials and/or converting the sludge into a renewable resource are urgently needed. Major recoverable materials in sewage sludge may include nutrients (mainly nitrogen and phosphorus), organic and inorganic fractions. At this moment, the sludge beneficial uses and recovery approaches are mainly land application, phosphorus extraction, anaerobic digestion, incineration, wet air oxidation, pyrolysis, gasification, supercritical water oxidation, construction material fabrication and heavy metal extraction. This talk provides a short review to report the advantages and shortcomings of these sludge management approaches, and also introduced examples to demonstrate the assist environmental materials research in the development of beneficial use and resource recovery strategies.

Kaimin Shih, Department of Civil Engineering, The University of Hong Kong, Hong Kong (kshih@hku.hk)

Acetic acid recovery from a hybrid biologicalhydrothermal treatment process of sewage sludge – a pilot plant study

J. Andrews, and D. Gapes (New Zealand)

A two-stage process consisting of anaerobic fermentation followed by sub-critical wet oxidation was used to generate acetic acid from sewage sludge at pilot scale. Organic acids were produced over 4-6 days in the 2000L fermentation reactor which also achieved 30-50% solids reduction. Using a 200L wet oxidation reactor operating in continuous and batch mode, the second stage achieved greater than 90% organic solids destruction. Acetic acid produced in this stage was recalcitrant to further degradation and was retained in solution. This acid has the potential to be used to offset ethanol requirements in the biological nutrient removal (BNR) plant.

John Andrews, Sustainable Design, Scion, New Zealand (john.andrews@scionresearch.com)

Microbial Enhanced Oil Recovery from Oily Sludge

E. M. N. Chirwa, and O. Fayemiwo (South Africa)

A silica/oil mixture was used to simulate a stable emulsion of oily waste sludge. The activity of biosurfactant producing bacteria in demulsifying the prepared emulsion was investigated as a possible alternative (cheaper) process for oil recovery from sludge. The activity of a commercial surfactant [sodium dodecyl sulphate (SDS)] was used as a baseline for the study. Although oily separation was slower using biosurfactant producing culture, better quality oil was recovered from the biosurfactant/sludge mixture. The slower reaction rate in the biological system was attributed to the low biosurfactant concentrations in the mixed cultures with most of the space of the biosurfactant medium taken up by water and cells. However, the quality of the recovered oil from the biological system had better quality than the oil recovered from SDS dosed emulsion due to biological degradation organic aromatic impurities by the microbial community.

Evans M. N. Chirwa, Water Utilisation Division, Department Of Chemical Engineering, University of Pretoria, South Africa (Evans.Chirwa@up.ac.za)

SESSION 7: RESOURCE RECOVERY FROM THE WATER CYCLE: SHORT ROUTES TO RE-USE CHEMICALS

Keynote (2): Rethinking Water and Waste: The State of the Art of Eutectic Freeze Crystallization

Alison Lewis , University of Cape Town (South Africa)

Eutectic Freeze Crystallization (EFC) is a novel technology for the “deconstruction” of highly saline solutions into pure water and pure, crystallized solutes. The water is recovered as ice, and the solutes as individually crystallized phases. From a thermodynamic point of view, EFC is a highly energy efficient process. This paper discusses the state of the art of the technology with respect to a number of different aspects: (1) the fact that this technology has the potential to catalyse a shift in thinking around wastewater treatment. The reason for this is that it is not just a “treatment” process, but is also a “resource recovery” process; (2) the ability of EFC to recover multiple products from multicomponent wastes through a process of sequential EFC; (3) challenges and developments in crystallizer design (suspension vs layer crystallizers, designs to prevent solid body rotation, designs to prevent or reduce ice scaling) as well as the challenges in scale up of EFC crystallizers to industrial scale operation (4) challenges in scale-up of the process as a whole, including the process synthesis, integration and optimisation of various unit operations and lastly (5) the development of a sound scientific understanding of the Eutectic Freeze Crystallization process itself.

Alison E. Lewis, Crystallization and Precipitation Research Unit, Chemical Engineering Department, University of Cape Town, South Africa (Alison.Lewis@uct.ac.za)

The Value Of NOM In An Ion Exchange Saline Brine

E. Vaudevire, E. Koreman, and G. Galjaard (The Netherlands)

At PWN, water supply North Holland, a full scale ion exchange treatment designed for direct NOM and nitrate removal from surface water is currently under construction. The regeneration of the ion exchange resin of the new treatment will lead to the production of 10m^3/h of saline brine. Over 3 years extensive pilot investigations focused on NaCl recovery and zero liquid discharge, using biological denitrification, followed by nanofiltration and evaporation, resulted in 98% volume reduction and 50 to 60% NaCl reuse. However, energy requirement (around 9Kwh/m^3 brine) and high capital costs of the treatment were not financially competitive with sea discharge. To keep the treatment financially viable, further resources had to be explored. Humic substances extraction from the brine and sale would represent a substantial source of revenue as these constitute a valuable by product for agriculture, animal food and human health. Simple modification of the NF into diafiltration process allowed increased NaCl recovery of 70% and the desalination of the humic substance.

Elisabeth Vaudevire, PWN Technologies, The Netherlands (evaudevire@pwntechnologies.nl)

Electrolytic Membrane Extraction Enables Fine Chemical Production From Biorefinery Sidestreams

S. J. Andersen, T. Hennebel, S. Gildemyn, M. Coma, J. Desloover, J. Berton, J. Tsukamoto, C. Stevens, and K. Rabaey (Belgium)

Short chain carboxylates such as acetate are easily produced through mixed culture fermentation, though challenging to extract and purify. Here we present a two-step processing pipeline for recovering and upgrading short chain carboxylates to volatile esters: (i) Membrane Electrolysis, the electrolytic extraction of ionic fermentation products across an anion exchange membrane into a clean acid concentrate, and (ii) Biphasic Esterification, the acid concentrate and an added alcohol interfaces with a water-excluding solvent layer to generate volatile esters. From a real biorefinery fermentation broth at 5 g.L-1, acetate was extracted at 379 g.m-2.d-1 to achieve a clean concentrate at 14 g.L-1 acetic acid. In a biphasic esterification reactor, 58 ± 3% of this concentrate was converted to ethyl acetate by the addition of excess ethanol and heating to 70°C. This approach enables direct production of fine chemicals following undefined mixed culture fermentation.

Stephen J. Andersen, Laboratory of Microbial Ecology and Technology (LabMET), Ghent University, Belgium (stephen.andersen@ugent.be)

SESSION 8: MANAGED AQUIFER RECHARGE

Keynote (1): Managed Aquifer Recharge: State of the Art and Opportunities

Robert G. Maliva, Schlumberger Water Services (USA)

Managed aquifer recharge (MAR) is defined as the intentional banking and treatment of waters in aquifers. The implementation of MAR is accelerating because MAR technologies are often less expensive than conventional water storage and treatment options and often are more environmentally friendly in terms of lesser impacts on surface environments and carbon footprints. MAR is thus a leading-edge technology whose implementation can be improved through the application of leading-edge aquifer characterization and modelling technologies. The performance of MAR systems is highly dependent upon local hydrogeology, which controls the movement and mixing of stored water, and fluid-rock interactions, which can impact recharged water quality. The leading-edge technologies associated with MAR thus involve methods to better characterize utilized aquifers and simulate the flow, mixing, and reaction of recharged water. Borehole and surface geophysical technologies and geostatistical and stochastic modelling methods, in particular, offer opportunities for improved aquifer characterization and modelling. The objective is to develop more accurate groundwater models that can be used as site screening tools to identify locations and aquifers that have the greatest potential for successful implementation of MAR and to evaluate various design and operational options to find optimal local solutions. Targeted employment of technology offers the opportunity to improve the implementation of MAR and thus obtain greater water resources management and societal benefits.

Robert G. Maliva, Schlumberger Water Services, USA (rmaliva@slb.com)

Application Of Horizontal Directional Drilled Wells For Fresh Water Management In Coastal Areas

D. G. Cirkel, K. G. Zuurbier, R. D. Rothuizen, K. J. Raat (The Netherlands)

Horizontal wells can be used to efficiently abstract and infiltrate water from thin aquifers, to abstract water of constant quality and to cut down on the numbers of wells. Recent R&D in the Netherlands has greatly improved the applicability of horizontal directional drilled wells (HDDW), by improving techniques to remove drilling fluids and to create functional gravel packs. Techniques were tested in the lab and field, resulting in the successful construction of a pilot scale HDDW. HDDWs can greatly improve the applicability of aquifer storage and recovery (ASR). The use of parallel, superimposed HDDWs is proposed to combine shallow ASR with deep interception of underlying saltwater. This ‘Freshmaker’ was successfully installed in a coastal aquifer and is currently running, aiming to store and recover 4,200 m^3 of freshwater. Results indicate that the feasibility perspectives of ASR in coastal aquifers worldwide requires revision thanks to developments in hydrologic engineering.

Koen G. Zuurbier, KWR Watercycle Research Institute, The Netherlands (Koen.Zuurbier@kwrwater.nl)

Advanced Groundwater Technology Applied in MAR in the Middle East

R. Herrmann (UAE)

Many parts of the world experience seasonal or long-term imbalances of water supply and demand. Groundwater reserves are often fully exploited in many countries, especially in the Middle East. There are concerns with pollution, salt intrusion and evaporation, if the water does not actually infiltrate into the ground then it will not reach the aquifers to replenish the capacities there.

To help manage and sustain dependable groundwater supplies, advanced subsurface technologies applied in the oil & gas industry are being adapted for the water industry and have been successfully applied there for years. Geophysical logging and modeling technology applied for over 30 years in the oil and gas industry have been deployed in groundwater characterization and modeling and used in water resource studies. The insight in such advanced technologies and integrated aquifer characterization workflows for hydrogeological assessment will add a new perspective in how to value the input data to build the groundwater model, the calibration of the simulation results and subsequently future supply and demand predictions.

The Middle East has long dealt with challenges imposed by climate, but now is facing increased rates of water consumption to meet the needs of a burgeoning population and economy. Excess production from desalination plants or treated wastewater can be stored for future demand and certain shallow aquifers in the area may be well suited for this purpose. In arid climates, managed aquifer recharge in natural aquifers provides a favorable alternative to storage in surface reservoirs, lakes or tanks. Examples of successful MAR projects in the Middle East will be discussed.

Rolf Herrmann, Schlumberger Water Services, Abu Dhabi, UAE (rherrmann@slb.com)

SESSION 8: MANAGED AQUIFER RECHARGE

Keynote (2): Strategies to enhance removal efficiencies through contemporary MAR design

Jörg Drewes, Technische Universität München (Germany)

There is increasing interest worldwide to utilize unconventional water resources to augment drinking water supplies. Given the presence of microbial and chemical contaminants in reclaimed water and impaired surface water, efficient and reliable treatment processes are needed to assure a product water quality that is protective of public health. Natural treatment processes, such as managed aquifer recharge (MAR), combine the benefits of efficient treatment for these contaminants with a low carbon footprint and a residual free operation. The drawbacks of MAR are the rather large physical footprint and a lack of detailed process understanding that can guide design and operation of these facilities. This paper reviews the role of hydrological and geobiochemical conditions using modified MAR design approaches to enhance attenuation of pathogens and chemicals of emerging concern. This study builds upon results from controlled laboratory-scale studies as well as monitoring campaigns at full-scale MAR facilities in different locations.

Jörg Drewes, Technische Universität München, Germany (jdrewes@tum.de)

Informed Design For Optimal Removal Of CECs In MAR Systems Using Parameter Based Decay Constants

M. Alidina, J. Regnery, and J. E. Drewes (Saudi Arabia)

Optimizing managed aquifer recharge (MAR) systems for removal of chemicals of emerging concern (CEC) requires an understanding of the various processes affecting attenuation. With practical application in mind, optimization entails designs which reduce the required retention time and minimize the footprint of such schemes. The effect of three parameters deemed important to CEC attenuation: primary substrate, temperature and redox state, on kinetics of removal were investigated using laboratory soil columns equipped with intermediate sampling ports. Analysis of samples collected at varying retention times, and at different parameter conditions allowed the derivation of parameter-specific decay constants for each of the CECs. Decay constants obtained were noted to be chemical dependent. A decision making tool combines these decay constants to obtain an overall decay constant for each CEC. These composite decay constants provide the basis for predicting minimal retention times required for selected CECs to achieve desired removal, informing design considerations for optimized MAR schemes.

Mazahirali Alidina, Water Desalination and Reuse Center, King Abdullah University of Science and Technology, Saudi Arabia (mazahirali.alidina@kaust.edu.sa)

Organic Micropollutant (OMP) Elimination In Hybrid Constructed Wetland/Soil Aquifer Treatment System

A. F. Hamadeh, E. K. Tsehaye, S. K. Sharma, and G. L. Amy (Saudi Arabia)

Constructed wetlands (CW) and soil aquifer treatment (SAT) represent two natural wastewater treatment systems (NWTS). However, each of these processes alone has some limitations removal of different contaminants. The use of CW as pre-treatment for SAT can create a synergistic dual barrier for different chemical and microbial contaminants and enhance treated water quality. The combination of these NWTS (CW and SAT) could be an attractive, efficient and cost-effective technology for water reclamation and reuse. Laboratory-scale simulations of SAT, CW and a CW-SAT hybrid system were conducted at two different hydraulic loading rates (HLRs) for SAT and CWs using secondary effluent as feed water. The focus was on the performance of these processes in removal of a selected group of 13 organic micropollutants (OMPs). High removals (> 90 %) were achieved by SAT for 9 of 13 OMPs. Through CW, 3 OMPs showed high removals (>90%). However, a group of 3 OMPs were difficult to remove by either SAT or CW. The (CW-SAT) hybrid system showed a better removal for the 3 refractory OMPs than either SAT or CW alone. Moreover, the hybrid system enhanced removals to more than 90% for all other compounds except for 2. It was also found that a 50% reduction of the HLR of the hybrid system (both SAT and CW) could eliminate all the selected OMPs to the detection limit except for 3 refractory compounds.

Gary L. Amy, Water Desalination and Reuse Center, King Abdullah University of Science and Technology, Saudi Arabia (gary.amy@kaust.edu.sa)

Leading-Edge Technology

11th IWA Leading Edge Conference on Water and Wastewater Technologies

POSTER PRESENTATIONS LISTING

Note: All posters' abstracts are available on the conference USB

THEME 1: BIOFILMS PROCESSES

101	**UV Photolysis For Relieving Inhibition Of Pyridine And Quinoline To Biofilms** Y. Zhang, L. Chang, Y. Tang, Q. Bai, N. Yan, B. E. Rittmann (China)
102	**Autotrophic Denitrification Granular Sludge Of The SANI Process Mitigates N_2O Emission Significantly** W. Yang, H. Lu, Q. Hu, Z. Ding, T. Hao, G.-H. Chen (China)
103	**Mineral Fouling Of Anaerobic Biofilms Under Saline, Sulphate-reducing Conditions** A. M. Wan, B. Mansoor, F. Ahmad (UAE)
104	**Effect Of The Operating Conditions On Nitrogen Removal Performance Of Membrane-aerated Biofilms** D. Yuan, X. Guo, J. Liu (China)
105	**NOB Activity Suppression In The Anammox Based Process ELAN® Applied To The Water Line Of A WWTP** A. Val del Río, N. Morales, J. R. Vázquez-Padín, R. Fernández-González, J. L. Campos, A. Mosquera-Corral, R. Méndez (Spain)
106	**Effect Of Salt On Granulation, Nutrient Removal And Microbial Community Dynamics In Aerobic Granular Sludge** Z. Wang, S. Bagchi, M. C. M. van Loosdrecht, P. E. Saikaly (Saudi Arabia)
107	**Novel Strategy To Mitigate Nitrous Oxide Emissions From Biological Denitrification Biofilm Processes** A. Eldyasti, G. Nakhla, J. Zhu (Canada)
108	**Deammonification Process Combined With UASB Reactor For Treatment Of Mainstream Wastewater** A. Malovanyy, E. Plaza, M. Rajkowski, J. Trela (Sweden)
109	**Moving Bed Biofilm Reactor For Selenium Reduction In Mine And FGD Effluents** C. Dale, M. Ekenberg, F.Wessman, M. Sjölin (Sweden)
110	**Nitrite Inhibition And Potential As Electron Acceptor For DPAO In IFAS Systems** P. Jabari , G. Munz, J. A. Oleszkiewicz (Canada)
111	**A Pilot Scale Study On Performance Of PVA Gel Beads Based MBBR For Domestic Sewage Treatment** N. K. Singh, J. Singh, V. Rose, A. A. Kazmi (India)
112	**Designed Biofilm Reactors: A Way To Remove Recalcitrant Organic Micro-pollutants From Wastewater?** M. Escolà Casas, K. Bester (Denmark)
113	**Nitritation And Denitritation Of Anaerobic Digestion Effluent At Low Temperatures** M. Kinyua, S. Ergas, J. Bartacek (USA)

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Poster Presentations Listing

THEME 2: CATALYSIS AND NANOTECHNOLOGY-ASSISTED PROCESSES

201	**Fe_3O_4 @ MnO_2 magnetic nanoplates research on its adsorption capacity for arsenite removal** Z. W. Zhao, T. Y. Sun, J. Liu, W. X. Shi (China)
202	**Adsorption Removal Of BTEX During Produced Water Treatment Using Multiwalled Carbon Nanotubes** Q. Zaib, O. D. Aina, F. Ahmad (UAE)
203	**MWNTs-TiO_2 Water Permeable Membrane Adsorbs And Photo-catalyzes Organic Micropollutants In Water** Q. Zaib, B. Mansoor, F. Ahmad (UAE)
204	**QDs Double Side Titanium Dioxide Nanorod Array Applied To Photoelectrochemical Hydrogen Production** L. C. Kao, Y. H. Liou (Taiwan)
205	**Nano-TiO_2 Photocatalytic Mechanism Of Model Virus--f2 Bacteriophage** Q. Wang, X. Zheng, J. Wang, R. Cheng (China)
206	**Evaluation Of Nanoparticles Separation Effect Of UF Membrane** M. Luo, X. Zheng, M. Shang, R. Cheng (China)
207	**Formation Of AOBr And Disinfection By-products From Oxidation Of NOM With Sulfate Radical** Y. R. Wang, T. Zhang, J. Le Roux, J.P. Croué (Saudi Arabia)
208	**Effects of the Solvent Ratio on Membrane Fouling of the Carbon Nanotube Blended Membranes** E. Celik, Ö. Çakmakcı, İ. İşgüder, N. Ö. Yiğit, M. Kitis, İ. Koyuncu, H. Choi (Turkey)
209	**Visible-light Photocatalytic Degradation Of Paracetamol Using Ordered Mesoporous Cu-TiO_2 Spheres** C-J. Lin, Y-H. Liou, C. L. Chen, C-L. Dong (Taiwan)
210	**Photocatalytic Properties Of TiO_2 Supported On Diatomaceous Earth** B. Hamdi, T. Belkacem, R. Calvet, S. Chernai (Algeria)
211	**Biogenic Metal Oxide Nanoparticles In Advanced Water Treatment - Influence Of Organic Matter** K. Furgal, K. Bester, R. L. Meyer (Denmark)

Note: All posters' abstracts are available on the conference USB

THEME 3: LOW-ENERGY AND RENEWABLE ENERGY-DRIVEN DESALINATION TECHNOLOGIES

301	**Seawater Desalination Concentrate Management In Florida** E. Kasirga, D. Moore, L. Tilahun (USA)
302	**Removal Of Hardness Ions By Capacitive Deionization Using Sugarcane Bagasse Derived Ordered Mesoporous Carbon Electrodes** Y-C. Tsai, R. Doong (Taiwan)
303	**Experimental Evaluation Of A Prototype For Solar Desalination Based On Vacuum Multi-effect Membrane Distillation** G. Zaragoza, A. Ruiz-Aguirre (Spain)
304	**The Viability Of Solar/ Wind Power And Energy Storage To Operate RO Plant In Massawa, Eritrea.** C. Dansoh (UK)
305	**Saline Conditions Stimulate Microbial Electroactivity In Microbial Desalination Cells** Z. Borjas, A Larrosa-Guerrero, J. M. Ortiz, A. Esteve-Nuñez (Spain)
306	**Microbial Desalination Cell For Simultaneous Brackish Water Desalination And Waste Water Treatment** J. M. Ortiz, A. Larrosa-Guerrero, Z. Borjas, E. Maneiro Franco, F. Rogalla, A. Esteve-Nuñez (Spain)
307	**Developing Tools For Biodesalination Using Cyanobacteria** E. Karunakaran, M. Templeton, J. Amezaga, C. A. Biggs, T. Bond, C. Gandy, A. Honsbein, L. Lawtonx, M. Madsen, K. Minasxx, A. Amtmann
308	**Comparative Performance Evaluation Of Membranes For Energy Efficient Desalination** A. Hauser, S. Pattanayak (Singapore)
309	**Prediction Of TMP Rises Due To Adhesion Of Substances On RO Membranes In The Early Phase Of Fouling** M. Sumikura, K. Kageyama, S. Yoshikawa (Japan)
310	**Membrane surface modification via iCVD for improved membrane distillation performance** A. Servi, F. Guo, A. Liu, G. Rutledge, K. K. Gleason (USA)
311	**Membrane Distillation For High Salinity Feed Desalination** J. Swaminathan, D. M. Warsinger, J. H. Lienhard (USA)
312	**Energy efficiency and GOR analysis of Direct Contact Membrane Distillation Using Thermal Rejected Brine** A. Kayvani Fard, Y. Manawi (Qatar)
313	**An Investigation into the Potential of Industrial Low Grade Heat in Membrane Distillation (MD) For Freshwater Production** Y. Manawi, A. Kayvani Fard (Qatar)
314	**Realistic Power and Desalted Water Production Costs in Qatar and GCC** M. A. Darwish, H. K. Abdulrahim, A. S. Hassan (Qatar)
315	**Microbial Electrodeionization Cell Stack for Sustainable Desalination, Wastewater Treatment and Energy Recovery** N. Shehab, B. E. Logan, G. Amy, P. E. Saikaly (Saudi Arabia)

THEME 4: MANAGED AQUIFER RECHARGE

401	**Drainage And Imbibition Invasion Patterns For Two Phase Flow In Porous Media: Heterogeneity Effects** H. Nadeem, S. Chevalier, M. Sassi (UAE)
402	**Effectivity Online Turbiditimeter On Drinking Water Quality Of Damghan Distribution Network** E. Shahmansoorian, M. Hosseini, M. A. Gharehkhani (Iran)
403	**The Study Of Garmsar Water Treatment Plant Saving Lagons Efficiency (2009-2011)** E. Shahmansorian, M. Ghanadi (Iran)
404	**Identification Of The Optimum Conditions To Remove Emerging Pollutants In MAR Systems** E. Vilanova, M. Miret, M. Hernandez Garcia, C. Sprenger, N. Hartog, , S. Hannappel, G. Grützmacher (Spain)
405	**Groundwater Cycled For Clay Aquifer** S. Musa, N. A. Zakaria, T. L. Lau (Malaysia)
406	**Managed Aquifer Recharge With Reclaimed Water --Optimization Of Pre-treatment Via Ozonation** U. Miehe, M. Stapf, P. Roche, G. Gruetzmacher (Germany)
407	**Storm Water Management And Aquifer Recharge In Southeastern Nigeria** E. I. Okpoko (Nigeria)
408	**Artificial Replenishment Of The Deep Aquifers** A. D. Hurynovich, V. I. Ramanouski, E. Sycheva, A. Yakubov (Belarus)
409	**Strategic Water Reserve Using Aquifer Recharge With Desalinated Water In Abu Dhabi Emirate** M. A. Dawoud (UAE)

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THEME 5: NEW DIRECTIONS AND TECHNOLOGY TRENDS IN WATER RECLAMATION AND REUSE

501	**Getting Net Environmental Sustainability By Resources Gain From Wastewater: What Do We Really Know?** X. Wang, J. Liu (China)
502	**Sulfate Reduction In Membrane Concentrate Significantly Increases Mine Water Recovery Rate** K. Banerjee, C. D. Blumenschein, C. Howell, H. Buisson (USA)
503	**Saline Water Intrusion In Sewage Pipes Shifts Post-treatment THM Speciation To Brominated Compounds** O. D. Aina, J. Adeoye, F. Ahmad (UAE)
504	**Pathogen Detection And Microbial Community In Treated WW For Reuse Applications Using Molecular Tool** R. Kumaraswamy, Y. M. Amha, J. Rodríguez, F. Ahmad (UAE)
505	**Bromate And Brominated Compound Formation During Chlorination Process In Presence Of Metal Oxides** C. Liu, U. von Gunten, J-P. Croué (Saudi Arabia)
506	**Biological Removal Of Sulfamethoxazole By Sulfate-reducing Bacteria Activated Sludge In SANI Process** Q. Gao, L. Qiu, Q. Li, H. Lu, G-H. Chen (China)
507	**Wastewater Reclamation Using Ultrafiltration And Reverse Osmosis For Potable Water Reuse** M. F. Hamoda, N. F. Attia, I. A. Al-Ghusain (Kuwait)
508	**Effect Of Toxic Compounds On Aerobic Granular Sludge Degrading Municipal Wastewater** S. G. Santiago-Cruz, I. Moreno-Andrade (Mexico)
509	**Does Access To Improved Sources Of Drinking Water Result In Less Diarrhea In A Village?** D. B. Oerther, L. Voth-Gaeddert, A. Schriner (USA)
510	**Phototrophic Bacteria For Complete Nutrient Recovery From Domestic Wastewater** T. Hülsen, D. J. Batstone, J. Keller (Australia)
511	**Composite Adsorbent Prepared from Diatomite /Charcoal and Its Application to Removal of Dye From Aqueous Solution** S. Chernai, N. Khelifa, B. Hamdi (Algeria)
512	**Pharmaceuticals Removal From MWTP Effluent Concentrates With Photo-Fenton Using Iron Complexes** S. Miralles-Cuevas, I. Oller, J. A. Sánchez Pérez, S. Malato (Spain)
513	**Removal Of E. Coli, F. Solani And Clostridium Sp From Contaminated Water Using Solar Membrane Distillation** A. Ruiz-Aguirre, M.I. Polo-López, P. Fernández-Ibáñez, G. Zaragoza (Spain)

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Poster Presentations Listing

THEME 5: NEW DIRECTIONS AND TECHNOLOGY TRENDS IN WATER RECLAMATION AND REUSE

514	**Solar Water Disinfection Using A 20-litre Water Dispenser Container (WDC)** M. Castro-Alférez, M.B. Keogh, M. I. Polo-López, I. Fernández-Calderero, K. G. McGuigan, P. Fernández-Ibañez (Spain)
515	**Detection And Removal Of Pathogenic Norovirus In Wastewater And Water Treatment Facilities** K. Fitzhenry, M. Barrett, E. Clifford, V. O'Flaherty, W. Dore, M. Cormican (Ireland)
516	**Selection of Microalgae Harvesting Strategies: Bottleneck in Microalgae Wastewater Treatment Technologies** Z. Arbib, I. de Godos, E. Lara, F. Rogalla (Spain)
517	**"BactoSense", A New And Easy-to-use Instrument For Continuous Assessment Of Microbiological Quality of Drinking Water** S. Kuenzi, F. Merenda, F. Bosshard, S. Marclay, Y. Chevallier, T. Egli, P. Ryser (Switzerland)

THEME 6: RESOURCE RECOVERY FROM THE WATER CYCLE: SHORT ROUTES TO RE-USE CHEMICALS

601	**Fate and Behaviour of Natural Organic Matter (NOM) on Reverse Osmosis Filtration and its Reuse** R. Saravanane, S. Virappan (India)
602	**Material Recovery At 4 Sites Using Novel Engineered Systems And Nano-glass Adsorptives** S. Spoonamore, H. Yang, P. Edmiston, P. Ortiz (USA)
603	**Phosphorus Recovery From Anaerobic Digested Sludge As Struvite** S. Ohchi, Y. Nakata, T. Matsushita, T. Nakamura (Japan)
604	**Use Of Sewage Sludge Derived Compost For External Road Landscaping In The Arid Emirate Of Abu Dhabi** J. R. Bastidas-Oyanedel, F. Ayllon, J. E. Schmidt (UAE)
605	**Treatment Of Scrubber Wastewater By Four-stage Electrochemical System** C. G. Park, E. Y. Jo, J. D. Cha (Korea)
606	**Conversion Of Organic-waste Derived Volatile Fatty Acids Into Biodiesel Through Enhanced Microbial Lipid Production – A novel Platform Technology** S. Vajpeyi, K. Chandran (USA)

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THEME 7: TOWARDS ENERGY-POSITIVE WASTEWATER TREATMENT

701	**A Novel Hybrid Anaerobic Membrane Bioreactor For Sewage Treatment** D. W. Gao, Q. Hu, C. Yao, H. Liang (China)
702	**Performance Of Low Cost Scalable Air-cathode Microbial Fuel Cell Made From Ceramic Cylinder** A. N. Ghadge, M. M. Ghangrekar (India)
703	**Enhanced Nutrients And Micro-pollutants Removal By Vegetation In FBR System For Wastewater Treatment** F-Y. Sun, J-J. Yuan, W-Y. Dong, X-L. Yan, Y-R. Gu (China)
704	**Comparison of Soluble Microbial Products (SMPs) from an Upflow Anaerobic Sludge Blanket (UASB) and a Submerged Anaerobic Membrane Bioreactor (SAMBR)** C. Kunacheva, D. C. Stuckey (Singapore)
705	**Nitrous Oxide Emissions from Wastewater Treatment Processes - Tracking Mechanisms with High Temporal Resolution** K. Koch, C. Leix, M. Weißbach, C. Haisch, J. E. Drewes (Germany)
706	**Recovery Of Anaerobic Digestion Processes From Toxic Shock Using Activated Carbon Addition** Y. Xiao, C. De Araujo, C. C. Sze, D. C. Stuckey (Singapore)
707	**Biotoxicity Sensor For Anaerobic Digestion Based On Resazurin Reduction** J. L. Chen, R. Ortiz, T. W. J. Steele, D. C. Stuckey (Singapore)
708	**Effect of Iron Oxide Nanoparticle Size on the Performance of Polyamide Membrane** A. S. AL-Hobaib, Kh. M. AL-Sheetan, L. El Mir (Saudi Arabia)
709	**Combination Of Ion Exchange And Deammonification Processes As An Innovative Way Of Nitrogen Removal** A. Malovanyy, E. Plaza , J. Trela, M. Malovanyy (Sweden)
710	**Effect Of Salinity On The Characteristics Of Soluble Microbial Products (SMP) And Membrane Fouling** L. Chen, H. C. Tan, D. C. Stuckey (Singapore)
711	**Effect Of Metal Deficiency During Shock Loading In A Submerged Anaerobic Membrane Bioreactor** B. Ketheesan, P. M. Thanh, D. C. Stuckey (Singapore)
712	**Exploration Of A Completely New Enhanced Biological Phosphate Removal (EBPR) For Warm Climate** H. G. Wang, D. Wu, G. Ekama, M. van Loosdrecht, H. K. Chui, G-H. Chen (Hong Kong, China)
713	**MBR Effluent Polishing Using Membrane Photobioreactor: Coupled Cultivation And Microalgae Harvesting** M.R. Bilad, L. Marbelia, I. Passaris, V. Discart, H. Arafat, I. F. J. Vankelecom (UAE)

THEME 7: TOWARDS ENERGY-POSITIVE WASTEWATER TREATMENT

714	**A Hybrid Vertical Anaerobic Biofilm (HyVAB®) Process Toward Zero Energy Use In Wastewater Treatment** G. Xin, J. Siljudalen, T. O. Leiknes (Norway)
715	**Role Of Membrane Porosity In Magnetically Induced Membrane Vibration System For Membrane Bioreactor** M.R. Bilad, L. Marbelia, H. Arafat, I. F. J. Vankelecom (UAE)
716	**Long Term Demonstration Of A Bioelectrochemically-assisted Wetland For Urban Wastewater Treatment** A. Esteve-Nuñez, A. Berna, A. Reija, C. Aragon, A. Aguirre, A. Lopez, T. Baccheti, R. Esteve, R. Bouza, B. Barroeta, J. R. Pidre,, J. Fernández-Ontivero, J. J. Salas (Spain)
717	**Optimization Of Photofermentative Hydrogen Production Using Mixtures Of Volatile Fatty Acids** G. Buitrón, R. Cardeña, G. Moreno (Mexico)
718	**Assessment Of A Wastewater-based Microalgae Cultivation System For Methane Production** G. Cea Barcia, G. Buitrón (Mexico)
719	**Carbon Management During Wastewater Treatment To Improve Energy Self-sufficiency** T. Rauch-Williams, R. Reardon, N. G. Love, L. Raskin, A. Dapcic, S. Hough (USA)
720	**Effect Of Doping Elements On The Performance Of Polyamide Membrane Reached By ZnO Nanoparicles For Ground Water Purification** A. S. AL-Hobaib, L. El Mir (Saudi Arabia)
721	**Potential Energetic Of Algal Biomass Fed With Municipal Wastewater** M. J. Feria, E. Lara, F. Rogalla (Spain)
722	**Effect of Solids Retention Time on the Use of Anaerobically Digested Swine Waste as a Substrate for Denitrification** M. Kinyua, J. Cunningham, S. Ergas (USA)
723	**Performance Of Pilot-Scale Microbial Fuel Cells Treating Wastewater And Bioenergy Production** K. Tota-Maharaj, P. Paul, D. E. Meeroof (UK)

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THEME 8: URBAN INFRASTRUCTURE AND WATER SENSITIVE CITY

801	**Occurrence Of Cryptosporidium And Giardia In Reclaimed Wastewater Used For Irrigation Of Public Parks In Dubai, United Arab Emirates** M. A. Khan, H. S. S. Alkitbi, A. A. A. Aljanahi, R. Dghaim (UAE)
802	**Halophyte Farming Using Seawater In Water-stressed Coastal Communities** J. T. Adeoye, Q. Ning, A. M. Wan, F. Ahmad (UAE)
803	**New Method Of Disinfecting Water Wells** V. I. Ramanouski, A. D. Hurynovich (Belarus)
804	**Which Has Greater Liquidity: Money, Education, Or Drinking Water?** D. B. Oerther, A. Schriner (USA)
805	**Probabilistic-based Optimization Methods To Design Water Distribution Network For Fire Protection** B-S. Jung, Y. Filion (UAE)

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