



Leading-Edge  
Technology

Programme Book

# 9th IWA Leading-Edge Conference on Water and Wastewater Technologies

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LEADING-EDGE

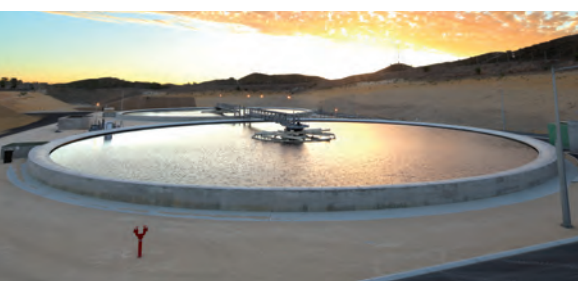


3-7 June 2012

Brisbane Convention and Exhibition  
Centre (BCEC)

South Bank, Brisbane, Australia

[www.let2012.org](http://www.let2012.org)





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## Invitation from the Chairman of the program committee

Worldwide, water is still a hot topic in the media. Either there is too much water or not enough as in many parts of the world. In the aftermath of some of the worst natural disasters the security of water supplies and wastewater services has been a challenging aspect.

In all these situations we largely rely on technologies to help overcome these challenges. The 'Leading Edge Technologies' in these cases not only include the latest and most innovative approaches, but also the truly resilient and sustainable solutions that can be easily identified in difficult situations.

On behalf of the Program Committee, I would invite you to participate in this conference. We have developed a program full of innovative and sustainable technology approaches, novel contributions and opportunities to network with Global leaders.

I look forward to welcoming many of you at the LET in June 2012. I am confident we will have a stimulating and invigorating exchange in the beautiful sub-tropical city of Brisbane, Australia.



**Jurg Keller**  
*Chair, Program Committee*

## Invitation from the IWA President

The 2012 edition of the highly successful Leading Edge Conference on Water and Wastewater Treatment Technologies (LET) moves to Australia, a continent which in many ways is a living laboratory for many of the challenges facing the water profession around the globe.

The past decade has brought drought, which further led to the application of new water supply technologies including rainwater capture, reuse (industrial, non-potable municipal, and indirect potable municipal), and desalination. These technologies have been further integrated into Cities of the Future integrated urban water and resource management approaches. Following on from this, severe flooding was experienced, leading to the application of new and emerging disaster recovery technologies. Resource abstraction is a mainstay of the Australian economy, and water supply is a key to maintain this economic driver. These, and other topics, form the basis for a rich and enlightening program that will benefit all those involved in advancing the water and wastewater treatment field.

Having been a participant in each of the previous LET conferences, I know firsthand how the information provided at these conferences can be used to advance the careers of those who attend and the interests of the institutions and companies they represent. Thus, I sincerely urge you to come "down under" and attend this one.



**Glen Daigger**  
*IWA President*

## Invitation from the chair of the organising committee

On behalf of the organising committee, I would like to invite water professionals from around the world to attend IWA's Leading Edge Technology Conference 2012.

Over the past decade Queensland and Brisbane in particular, has faced significant challenges, including a prolonged drought followed by devastating floods. In part, management of these events has depended on the effective use of leading-edge technologies, including nano and micro-filtration, desalination, indirect potable recycling of water, advanced effluent and stormwater treatment, the creation of water sensitive urban designs and other innovations. Brisbane-based technology developers and innovators are at the forefront of their fields.

With a year-round warm and sunny climate, Brisbane is a dynamic, sophisticated and cosmopolitan city with a relaxed, friendly alfresco lifestyle. We hope that you will join us for the conference and extend your visit to enjoy all that Queensland has to offer including our iconic world heritage listed natural attractions.



**Andrew Speers**  
*Chair, Organising Committee*

## About IWA

The International Water Association is a global reference point for water professionals, spanning the continuum between research and practice and covering all facets of the water cycle. Through its network of members and experts in research, practice, regulation, industry, consulting and manufacturing, IWA is in a better position than any other organisation to help water professionals create innovative, pragmatic and sustainable solutions to challenging global needs.

## About AWA

AWA is Australia's leading membership association for water professionals and organisations. Independent and not for profit AWA plays an important role in supporting the Australian water sector in the delivery of effective and sustainable water management practices. AWA works with water professionals to provide professional development and networking opportunities to help continuously advance skills and expertise within the sector.

## Organising Committee

**Chair:** Andrew Speers, *Australian Water Association*

Sandra Hall	<i>The University of Queensland</i>
Jurg Keller	<i>The University of Queensland</i>
Grant Leslie	<i>Water Services Association of Australia</i>
Richard Stuetz	<i>The University of NSW</i>

## Programme Committee

**Chair:** Jurg Keller, *The University of Queensland, Australia*

Pedro Alvarez	<i>Rice University, USA</i>
Kartik Chandran	<i>Columbia University, USA</i>
Zaid Chowdhury	<i>Malcolm Pirnie, USA</i>
Jonathan Clement	<i>PWN, The Netherlands</i>
Peter Cornel	<i>Technische Universitat Darmstadt, Germany</i>
Philippe Gislette	<i>Suez Environment, France</i>
Mark van Loosdrecht	<i>TU Delft and KWR Watercycle Research Institute, The Netherlands</i>
Nancy Love	<i>University of Michigan, USA</i>
Bram Martijn	<i>PWN, The Netherlands</i>
Takao Murakami	<i>Japan Sewage Works Agency, Japan</i>
Aik Num Puah	<i>PUB, Singapore</i>
Lutgarde Raskin	<i>University of Michigan, USA</i>
Bruce Rittmann	<i>Arizona State University, USA</i>
Rob Skinner	<i>Monash University, Australia</i>
Shane Snyder	<i>University of Arizona, USA</i>
Zhiguo Yuan	<i>The University of Queensland, Australia</i>





## Sponsors

### Dinner Sponsor

### AURECON

#### INNOVATIVE THINKING FOR INTEGRATED MULTIDISCIPLINARY WATER PROJECTS

Aurecon provides engineering, management and specialist technical services for government and private sector clients globally. The group, with an office network extending across 23 countries, has been involved in projects in more than 70 countries across Africa, Asia Pacific and the Middle East and employs around 7,000 people across 11 industry groups.

Our extensive programme, project management and delivery capabilities provide our clients with certainty of programme and project outcomes and are focused on achieving our client's objectives whether they are business, planning, transactional, delivery or operationally orientated. Aurecon has global experience and industry leading expertise in a wide range of procurement and commercial management methodologies. These can provide our clients with contemporary advice on broad transactional issues, traditional procurement strategies, supply chain management, Engineering, Procurement, Construction Management (EPCM) and Public Private Partnerships (PPP).

Our expert team strives to combine innovative thinking with constructive project delivery models to deliver cost-effective solutions to clients. We offer interactive and responsive solutions to the changing requirements of the water industry.

#### Specific Water Capabilities

Our team of leading water specialists understands that water poses a vital challenge in coming decades. Business and government worldwide are searching for sustainable solutions to manage this vital resource.

We work with clients across every facet of the water cycle to design and deliver the most cost-effective and sustainable infrastructure solutions, ranging from network modeling and sewer tunneling to treatment plant design and total operations management.

Our team offers world-class technical skills as well as significant expertise in the legal, environmental, planning and community consultation issues around water projects.



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#### Our areas of expertise include:

##### Water and Wastewater Treatment

Domestic and industrial water and wastewater, distribution, tunnels, pipelines, treatment, desalination, reuse, odour management and control.

##### Dams and Water Resources

Bulk supply and irrigation headworks, dams, weirs, storages, surface water and groundwater resource planning.

##### Waterways and Bulk Stormwater

Urban drainage systems, river and creek networks, hydrologic analysis, flood management, habitats.

##### Water Sciences

River health, water quality and environmental flows, catchment management, salinity, fluvial geomorphology, environmental management, audits and impact assessments.

##### Water Planning and Management

Strategic planning and policy advice on all aspects of integrated water management to federal, state and local governments. Site supervision, commissioning, construction services and management.

##### Sustainability and Climate Change

Marine, coastal, estuarine environments, impact assessment, climate change, sediment and erosion control.

#### Please contact your local Aurecon water expert to find out more:

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Silver Sponsor

## PENTAIR

### Innovators in membrane technology

Pentair delivers proven solutions to the global water challenge, building upon its solid foundation in membrane technology. Pentair X-Flow develops and supplies membrane technology globally to municipal and industrial markets. The product portfolio contains numerous standard membranes and systems for filtration and purification processes. Throughout Asia Pacific, Pentair X-Flow acts as membrane technology and systems provider to end users, construction and engineering companies for small to mega-scale projects. In recent years, X-Flow has been selected as the preferred supplier of UF membrane technology for a number of innovative projects covering potable water treatment, wastewater reuse and seawater pre-treatment.

### Entering new markets

Two recent X-Flow innovations – tight UF membranes (HF) for silica removal and Anaerobic MBR (AnMBR) for industrial waste water treatment both offer significant operational, water quality and economic benefits in process water and wastewater reuse application.

### New Technology for the Management of Silica in Power Plants;

Even low levels of silica in boiler feed water can concentrate and deposit as glassy and hard scales on turbine blades resulting in expensive maintenance, and upon failure, replacement of turbine blades. Conventional technology can effectively reduce particulate and reactive silica however the removal of colloidal silica remains problematic: the application of RO, whilst effective, can suffer from severe membrane fouling.

*Innovation; HF 60 Silica Capillary Membrane;* With the development of the HF membrane, X-Flow is the first to successfully introduce a tight UF membrane with the robustness required for long lasting performance under demanding conditions. In a single process step, HF membranes are capable of removing 99.8% of colloidal silica and meeting low levels required for high pressure boilers, increasing efficiency significantly reducing plant shutdowns. The robustness of the HF membrane module allows installation upstream of the reverse osmosis system or downstream of ion exchange systems. The HF membrane is back-washable, has high chemical resistance and requires minimal pre-treatment.

HF is the first in a new line of tight ultrafiltration membranes to be commercialised. A new, ultra tight UF membrane and application expertise, is currently being developed for DOC removal in potable water and industrial wastewater applications.

### New Technology for the Management of High Strength Organic Wastewater;

Anaerobic treatment is an established and effective technology for the treatment of high strength liquid organic waste – a key benefit of the process is the production of biogas and the opportunity to utilise this to produce energy. Appropriate pre-and post-treatment is however critical and expensive.

For over 20 years, X-Flow UF technology has been employed in aerobic MBR applications to remove biological suspended solids and produce unmatched effluent quality. While the aerobic MBR style UF filtration has been applied in hundreds of applications worldwide, the application of UF in anaerobic MBR is more complex and adoption has been limited.

*Innovation; AnMBR Anaerobic Membrane Bio-Reactor;* In close cooperation with Veolia Biothane, X-Flow has applied its expertise in UF to develop an “anaerobic bio-reactor-membrane’ process which combines several units of a conventional process train including pre-treatment (i.e DAF), anaerobic treatment and solids removal. Treated water quality is very often enabling elimination of post-treatment polishing.

Several existing full scale AnMBR systems are in operation. Applied to various high strength COD wastewaters, the anaerobic and membrane separation process typically achieves 98 to 99.5 % COD removal – applied in dairy wastewater treatment, COD and solids are reduced from 60,000 to less than 200 ppm and turbidity < 0.1 NTU. This performance is substantially higher than ‘classical’ anaerobic treatment where 80 - 85 % removal of COD is achieved.

Similar to X-Flow’s Aerobic MBR filtration concept, the AnMBR process applies membranes in a side-stream configuration –the process therefore consists of a discrete bioreactor and a skid mounted pressurised UF system. The external skid mounted and modular design allows ease of expansion and great operational flexibility including ability to isolate units for cleaning and the elimination of gas scouring making the system safer, simpler and more reliable.

## Workshops

### Anaerobic Treatment of Low-Strength Wastewaters

Sunday 3rd June 2012 1pm

Moderators: Adam Smith, Damien Batstone, Lutgarde Raskin

A growing interest in sustainability within water management is driving efforts to reevaluate low-strength wastewater treatment practices. Anaerobic biological processes are likely to be strongly considered over aerobic treatment in the future as a means of reducing energy demands and environmental impacts. This workshop aims to share the benefits and potential of anaerobic treatment of low-strength wastewater with utility managers, consultants, regulators, and researchers, while considering constraints related to technology implementation. A diverse group of experts with broad, international experience with anaerobic treatment of low-strength wastewater will discuss their views and respond to questions of workshop moderators and participants.

### Direct Potable Reuse: Why Not?

Sunday 3rd June 2012 1pm

Moderators: Jonathan Clement and Ian Law

The indirect reuse of wastewater has become commonplace throughout the world especially on arid and densely populated regions. Despite the ability of recently advanced technology to purify severely impaired water sources to well beyond drinking water standards, the direct reuse of wastewater on a global scale is extremely rare. As easy to treat waters decrease and water scarcity increases the necessity of direct potable reuse becomes more evident. Yet there are many institutional aspects opposing this need. The workshop will bring together a diverse panel of experts to have a serious debate and discussion about direct potable reuse.

**Setting the Stage** . . . . .Jonathan Clement  
**A history of reuse and regulation** . . . . .James Crook  
**What treatment can and cannot do.** . . . . .Shane Snyder  
**A position against direct potable reuse** . . . . .Don Bursill  
**A position for direct potable reuse**  
**Roundtable discussion and concluding remarks**

## LET 2012 Program Summary

### Sunday 3rd June 2012

12:00	Registration Opens – Boulevard Level	
13:00	<b>Workshop</b> <b>Anaerobic Treatment Of Low-Strength Wastewaters</b> <b>Moderators:</b> Adam Smith, Damien Batstone, Lutgarde Raskin	<b>Workshop</b> <b>Direct Potable Reuse: Why Not?</b> <b>Moderators:</b> Jonathan Clement and Ian Law
18:00	Welcome Reception – Skyroom	

### Monday 4th June 2012

8:00	Registration
09:00-09:30	<b>Opening Session</b> Welcome from IWA Welcome from Organising Committee
09:30	<b>Enabling The Uptake And Diffusion Of New Technology. The Political, Institutional And Social Contexts For Change</b> Rebekah Brown, Monash University, Australia
10:15-10:45	Coffee
10:45	<b>Micropollutants And Transformation Products: What's New And What's Not</b> Shane Snyder, University of Arizona, USA
11:30	<b>Flow Cytometry In Microbiological Drinking Water Analysis – New Technology For An Old Problem</b> Thomas Egli, EAWAG, Switzerland
12:15	<b>A Systems Approach For Mine Site Water Management And Its Analogy With Urban Water Management</b> Chris Moran, The University of Queensland, Australia
13:00-14:00	Lunch
14:00	<b>Disaster Management And Technologies</b> Tatsuo Omura, Tohoku University, Japan
14:45	<b>Resilient Technologies And The 2011 Flood In Brisbane/South East Queensland</b> Paul Belz, Queensland Urban Utilities, Australia
15:30	<b>How To Create Successful Technology Solutions That Address All Sustainability Criteria – The New Zealand Journey</b> Jim Bradley, MWH New Zealand Ltd, New Zealand
16:15-17:45	<b>Poster Session – Boulevard Auditorium Foyer</b>
19:00	<b>Conference Dinner – Boulevard Room</b>

## Tuesday 5th June 2012

	Room 1	Room 2
08:30 - 10:00	<b>Innovative Water Technologies In Resource Industries</b> Moderators: Zaid Chowdhury and Jurg Keller	<b>Integrated And New Technologies For Cities Of The Future</b> Moderators: Rob Skinner, Lut Raskin, Nancy Love and Owen Phillis
08:30	<b>Beneficial Use Of Produced Water From Coalbed Methane – Water Quality And Treatment Aspects</b> Jorg Drewes, Colorado School of Mines, USA	<b>Reinventing America's Urban Water Infrastructure – Tailored Water For Distributed Non-Potable And Potable Reuse</b> Kara Nelson, UC Berkeley, USA
09:00	<b>Innovations In Produced Water Treatment – Case Studies</b> M. van Winden, K.P. Molloy and C.H. Nolen, Australia	<b>Intelligent Efficient Water Networks</b> A. Chapman, P. Guttman and J. Westcott, Australia
09:15	<b>An Innovative Process For Sulfate Treatment Of Membrane Concentrate From Mining Operations</b> K. Banerjee, C.D. Blumenschein, H. Buisson and R. Zick, USA	<b>The Future Is Now: First Application Of Integrated Dry And Wet Weather Water Reclamation Technology In An Indirect Potable Reuse Scheme</b> J. Sandino, R. Boe, D. McKnight and B. Cole, USA
09:30	Discussion	Discussion
10:00 - 10:30	<b>Coffee</b>	
10:30	<b>Biotechnological Approaches For The Metallurgical Sector</b> Ceas Buisman, WETSUS, The Netherlands	<b>Integrating Nutrient And Microconstituent Removal In Wastewater Treatment</b> Tanja Rauch-Williams, Carollo Engineers, USA
11:00	<b>An Innovative Approach To The Use Of Reverse Osmosis For The Treatment Of Coal Seam Gas Water</b> M. Taylor, M. Reid and J. Briggs, Australia	<b>Nanoparticles In Cities Of The Future: Monitoring And Treatment</b> A.L Bruchet, K. Glucina, P. Charles and M-L Janex-Habibi, France
11:15	<b>Simultaneous Biological Removal Of Sulfate, Nitrate And Carbon In A Newly Developed Cylinder-Shaped Anaerobic Baffled Reactor</b> W. Wang, C. Chen, Y. Yuan, X. Xu, N. Fang and A. Wang, China	<b>Integrating Advanced TiO<sub>2</sub> Photocatalytic Technology With Membrane Bioreactor (MBR) For The Removal Of Pharmaceutical Drugs From Recycled Wastewater</b> M.N Chong, G. Laera and B. Jin, Australia
11:30	Discussion	
12:00 - 13:00	<b>Lunch</b>	
13: 00-14:30	<b>Energy Recovery And Energy Efficiency Of Wastewater Systems</b> Moderators: Bruce Rittmann and Pedro Alvarez	<b>Resilient Technologies And Technologies For Disaster Recovery</b> Moderators: Takao Murakami and Philippe Gislette
13:00	<b>When Is Wastewater A Resource? A Life Cycle Perspective.</b> Francesc Castells, Universitat Rovira i Virgili, Spain	<b>Recovery Of Wastewater System From The Disaster</b> Takao Murakami, Japan Sewage Works Agency, Japan
13:30	<b>Denitrification With Dissolved Methane For Energy Efficient Wastewater Treatment</b> C. Kampman, T.L.G. Hendrickx, H. Temmink, G. Zeeman and C.J.N. Buisman, The Netherlands	<b>Novel Approaches To The Treatment And Disinfection Of Cholera Treatment Centre Wastewaters</b> E. Sozzi, J.F Fesselet and H.D Taylor, The Netherlands
13:45	<b>Development Of Nitrifying Granular Sludge For Urine Treatment In A Novel Decentralised BNR System</b> HR Mackey, M. van Loosdrecht and G-H Chen, Hong Kong, China	<b>MSABp; An Innovative Bioreactor With Function Of Excess Sludge Reduction</b> Asami Taniuchi, Japan
14:00	Discussion	Discussion
14:30 - 15:00	<b>Coffee</b>	
15:00	<b>Capturing Wastewater's Energy Potential – How Best To Do It?</b> Perry L. McCarty, Stanford University, USA and Inha University, Korea	<b>Innovative Technical Support For Accessing Water And Sanitation Solutions After Earthquake Disaster In Haiti</b> Alexandre Brailowsky, Suez Environnement, France
15:30	<b>Experience From Start-Up And Operation Of Two ANITA Mox MBBR Plants</b> R. Lemaire, S. Ekstrom, M. Christensson, E. Le Vaillant and J-C Schrotter, France	<b>Australia's First Cogeneration Facility With A Micro-Turbine</b> A. Davey and R. Howick, Australia
15:45	<b>Effects Of Changes In Temperature And Hydraulic Retention Time On Performance And Environmental Impacts Of Anaerobic Membrane Bioreactors For Domestic Wastewater Treatment</b> A. Lee Smith, N. Love, L. Raskin and S. Skerlos, USA	<b>Round Table Discussion</b> Panelists to include the moderators, authors of the papers, speakers from day one discussing how to prepare and how to react to natural disasters and emergency situations.
16:00	Discussion	



**Wednesday 6th June 2012**

	Room 1	Room 2
<b>08:30 – 10:00</b>	<b>From Resource Recovery To Wastewater Based Biorefineries</b> Moderators: Peter Cornel and Kartik Chandran	<b>Control And Mitigation Of Direct Greenhouse Gas (CH<sub>4</sub> And N<sub>2</sub>O) Emissions</b> Moderators: Mark van Loosdrecht and Zhiguo Yuan
<b>08:30</b>	<b>Wastewater As A Resource – Potentials And Recovery Options</b> Peter Cornel, Technische Universitat Darmstadt, Germany	<b>Methane And Nitrous Oxide Emissions From Urban Water Cycles</b> Zhiguo Yuan, The University of Queensland, Australia
<b>09:00</b>	<b>Self-Sufficient Wastewater Treatment: An Achievable Aspiration Within 5 Years!</b> A. Soares, V Mathioudakis, H Briers, I Martin-Garcia, B D Martin, M Pidou, E Wood, J Brigg, T Pearson, S A Parsons and B Jefferson, UK	<b>Methane And Nitrous Oxide Emissions From Municipal Wastewater Treatment</b> M.R. J. Daelman, U.G.J.M. van Dongen, E.M. van Voorthuizen, E.I.P. Volcke and M.C.M. van Loosdrecht, The Netherlands
<b>09:15</b>	<b>Large-Scale Practical Application Of Nutrient Recovery From Digested Sludge As Struvite</b> D. Antaklyali, V. Preyl, C. Meyer, W. Maier and H. Steinmetz, Germany	<b>Comparing Carbon Footprints Of Taste And Odor Treatment Technologies</b> A. Festger, S. Bindner, C. Hoover and M. Kuhns, Canada
<b>09:30</b>		Discussion
<b>10:00 – 10:30</b>	<b>Coffee</b>	
<b>10:30</b>	<b>Systematic Methology For The Synthesis Of Biorefinery Treatment Plants For Energy And Nutrient Plants</b> B. Chachuat, C. Puchongkawarin, C. Gomez-Mont and D. C. Stuckey, Imperial College, UK	<b>Metabolic Pathways And Factors Leading To N<sub>2</sub>O Production By Ammonia Oxidizing Bacteria In Engineered N-Removal Systems</b> Kartik Chandran, Columbia University, USA
<b>11:00</b>	<b>Isobutyraldehyde Production By Genetically Modified Ammonia Oxidizing Bacteria</b> W. Khunjar, A. Sahin, A. West, S. Banta and K. Chandran, USA	<b>Modelling N<sub>2</sub>O Emissions In Wastewater Treatment – State Of The Art</b> IWA Task Group on GHG Modelling Jose Porro, USA
<b>11:15</b>	<b>Performance Of A Sulfate-Reducing, Sulfide-Oxidizing Oxygen-Based Egsb Reactor</b> X Xu, C. Chen, A. Wang, N. Ren, N. Fang and D-J Lee, China	<b>Advanced Control System To Reduce N<sub>2</sub>O Emission In An SBR Treating N-Rich Effluent Via Nitrite Pathway</b> R. Lemaire, J. Chauzy, F. Veuillet and J-C Schrotter, France
<b>11:30</b>		Discussion
<b>12:00 – 13:00</b>	<b>Lunch</b>	





13:00–14:30	<b>Clean, Green, And Sustainable Water Technologies – Minimising Waste And Maximising Resource Utilization</b> <b>Moderators:</b> Johnathan Clement and Aik Num Puah	<b>Disinfection Byproducts In Drinking Water And Water Recycling</b> <b>Moderators:</b> Shane Snyder and Bram Martijn
13:00	<b>Zero Discharge Desalination (ZDD) Solves Concentrate Management Problems</b> Thomas A. Davis, University of Texas at El Paso, USA	<b>Emerging DBPs: Have We Been Looking Under The Wrong Street Light?</b> Phil Singer, University of North Carolina at Chapel Hill, USA
13:30	<b>Treatment Of Ion Exchange Brine With DVR</b> E. Vaudevire, The Netherlands	<b>Bromate Formation From Bromide Oxidation By The UV/ Persulfate Process</b> J-Y Fang and C. Shang, Hong Kong
13:45	<b>Zero Liquid Discharge Water Recycling Systems: Removal Of Foulants And Micropollutants From RO And NF Reject Streams By Granular Activated Carbon</b> C. Kazner, T. Wintgens and S. Vigneswaran, Australia	<b>The Use Of Hybrid Ceramic Membrane Process For Fouling Control During Water Treatment</b> B.I Harman, H. Koseoglu, N. Ozgu Yigit, M. Beyhan and M. Kitis, Turkey
14:00	Discussion	Discussion
14:30 –15:00	<b>Coffee</b>	
15:00	<b>Thermophilic Sludge Digestion And Advanced Nutrient Treatment: Perfect Match For Sustainable Sewage Treatment</b> S. E. Vlaeminck, D. Smet, J. Klok, W. Verstraete and J. Colsen, Belgium	<b>Application Of An In Vitro Bioassay And High Resolution MS To Quantify And Identify Novel EDCs In Wastewater</b> Merijn Schriks, KWR Water Cycle Research Institute, The Netherlands
15:15	<b>A Novel Two-Stage Process For Recovery And Recycling Of Ferric Phosphate Sludge From Wastewater Treatment</b> E. Mejia Likosova, Y. Poussade, S. Freguia and J. Keller, Australia	<b>Application Of An In Vitro Bioassay And High Resolution MS To Quantify And Identify Novel EDCs In Wastewater</b> Merijn Schriks, KWR Water Cycle Research Institute, The Netherlands
15:30	<b>Electrochemical Resource Recovery From Wastewater And Digestate Via Oxidation/Reduction And Transport Phenomena</b> J. Desloover and K. Rabaey, Belgium	<b>Advancing Indirect Potable Reuse In California</b> G. Wetterau, R.B. Chalmers, P. Liu, W. Pearce and T. Richardson, USA
15:45	<b>Quantifying The Contribution Of Nitric Oxide Production Pathways In Autotrophic Nitrogen Removal System</b> W. Khunjar, K. Chandran, D. Jiang and S. Murthy, USA	<b>Electrochemical Oxidation Of Reverse Osmosis Concentrates On Boron-Doped Diamond Electrodes</b> A.Y Bagastyo, D. Batstone, I. Kristiana, Y. Mu, W. Gernjak, C. Joll and J. Radjenovic, Australia
16:00	Discussion	Discussion
16:30	<b>Closing Remarks</b>	





## Technical Visits

### Option 1: Inghams Advanced Water Treatment Plant

Inghams Enterprises Pty Ltd is the key Australian poultry producer and one of the first private companies in Australia to make a multimillion dollar investment in water sustainability. Using water from an advanced water treatment plant creates a more environmentally sustainable system for the Murarrie facility, as well as contributing to the local community. The AWTP enables water use to be reduced by 70% using world class technology to treat the water used during processing in the factory, water is returned to be re-used in processing areas such as kill and evisceration and for wash down.

### Option 2: The Carlton United Brewers Yatala Brewery

The CUB Brewery at Yatala supplies approximately 25% of the beer consumed in Australia. In 2003 the brewery embarked on an upgrade program, investing over \$172 in the project to double the previous production capacity. This facility is now the world's most water-efficient major brewery with an average water consumption of only 2.3L per 1L of beer produced. During its expansion, the brewery worked with Gold Coast Water (now Allconnex) to reduce its impacts and to incorporate water reuse initiatives that complement the region's overall salinity, water and wastewater strategy. The innovative system has also resulted in significant reductions in salt discharge from the brewery and in the consumption of cleaning chemicals, while minimising energy and greenhouse gas impacts. On 16 May 2006 Foster's Australia (parent company) won the Industrial Eco-Efficiency Award in the inaugural Environmental Protection Agency Sustainable Industries Awards for recycling and reducing water use at the Yatala brewery.

### Option 3: Wivenhoe Dam and Bundamba Advanced Water Treatment Plant (AWTP)

The Bundamba AWTP is part of the Queensland Government's \$2.4 billion Western Corridor Recycled Water Project - the third-largest recycled water project in the world. It has the capacity to add 232 megalitres of purified water a day to the region's supply. The project includes more than 200 kilometres of pipeline and three advanced water treatment plants at Bundamba, Gibson Island and Luggage Point. The Western Corridor Recycled Water project provides purified recycled water to power stations, future industrial customers and potentially agricultural users. It will also supplement the regions drinking water supply through supplying Wivenhoe dam when dam levels fall to below 40%. Wivenhoe Dam is South East Queensland's major water supply. An interpretive centre and theatre is located at the dam information building that explains the Source Store Treat aspects of the South East Qld Water Grid and its role in providing water security to the population of South East Qld.

### Option 4: Hinze Dam and Desalination Plant

The Hinze Dam was originally constructed in 1976 and in December 2011 a \$395 million upgrade was opened. This upgrade saw the dam wall raised by 15 metres, doubling the dam's capacity and providing increased water security and flood mitigation. This tour will also visit the Gold Coast Desalination Project, which located at Tugun can provide up to 133 megalitres of water a day of new drinking water to residents and businesses in South East Qld. The desalination project includes a desalination plant, marine intake and outlet tunnels and a 25 kilometre pipe to connect the plant to the South East Qld Water Grid. The project employs the most advanced reverse osmosis process available in the world today.





Leading-Edge  
Technology

# 9th IWA Leading-Edge Conference on Water and Wastewater Technologies

3-7 June 2012  
Brisbane

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Leading-Edge  
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Platform presentations

ABSTRACTS



## 01 – Enabling The Uptake And Diffusion Of New Technology. The Political, Institutional And Social Contexts For Change

**R. Brown**

This presentation focuses on the social, institutional and political dynamics associated with the uptake and diffusion of more sustainable water technologies and practices, as part of the broader agenda of transitioning the Water Sensitive City. The social sciences, particularly the sociology of technology, transitions management and resilience literatures provide useful frameworks, and some empirically derived patterns of change, for understanding and potentially influencing these dynamics at the societal system level. The recent attention on actor-orientated analysis also provides a promising approach for unpacking and understanding the interplay between micro and meso-level processes of successful technological diffusion. This goes some way to explaining the distinct lack of mainstreaming (beyond demonstration projects) of many alternative sustainable water technologies which remains a significant and persistent problem that needs to be addressed.

Drawing on the above concepts, this presentation will present the outcomes of an empirically rich study of the current transition to sustainable stormwater management in Melbourne, Australia. While the technical transition appeared relatively obvious, the social transition was not. The research targeted the underlying dynamics and the role of actors, over the last 40 years, in relation to the speed and direction of the 'social dimension' of this transition. This city, with over 4 million people, is often credited by the international urban drainage community for hosting key scientific and technical innovators in the field, as well as being a leading city for managing to put these alternative processes and technologies into practice. Therefore, so far, Melbourne has seemingly been able to overcome many of the widely reported barriers and institutional entrapment effects observed elsewhere.

Essential to the transitioning was a critical and opportunistic interplay between niche actors (or champions) and the emergence of enabling context factors at different points in time. The significance of what a small group of niche actors can uniquely achieve collectively was revealed. While loosely networked across the public, private and community sectors, they had a shared agenda of the environmental protection of waterways. With common qualities, the characteristics of these champions included strong environmental values, a public good philosophy, active promotion of a best practice ideology, having a 'learning by doing' approach to their work, as well as being opportunistic, innovative and adaptive. The emergence of organisational champions mid way through the transitioning process was also instrumental to providing broader legitimacy to the activity and advocacy of niche actors.

While these champions were responsible for many of the on-ground successes in this transition to date, it has been their critical interplay with the 'enabling context' that has shaped, constrained and provided the opportunities for these champions' transitioning aspirations. For example, the fostering of local social capital for waterways protection, allowed for the creation of temporary bridging organisations that not only reduced transaction costs but provided nodal points for critical coordination processes between niche and

regime/institutional actors across each of the science, policy and private domains. The suite of enabling context factors included: local socio-political capital, formal coordinating accountabilities, trusted and reliable science, market receptivity with developers, multiple and temporary bridging organisations, binding systems-based targets, strategic funding injection intervals and on-ground demonstration projects. The key interplay ingredients within was the vehicle for addressing, and at times significantly minimising, many of the anticipated and experienced impediments to change.

These indicators of process dynamics may provide a guiding template for urban water strategists to identify current transitioning deficits and opportunities to improve the design, investment and outcomes of current policies and programs, and importantly the diffusion of innovative technologies.

**Rebekah Brown, Centre for Water Sensitive Cities, School of Geography and Environmental Science, Monash University AUSTRALIA** (rebekah.brown@monash.edu)

## 02 – Micropollutants And Transformation Products: What's New And What's Not

**S. A. Snyder**

The availability of safe freshwater is diminishing at an alarming rate globally. Increasing human population is stressing water supplies and contributing to water pollution. Urban density increases and climate changes, including epic droughts in certain parts of the world and catastrophic flooding in others, have led to the utilization of non-conventional water resources. Modern instrumental technologies for ultra-trace environmental analyses have rapidly become more sensitive, selective, efficient, and simultaneously, less expensive. At the same time, significant advances in genomics, proteomics, and metabolomics have led to major discoveries and allow complex aqueous mixture screening for potential human and environmental health impacts without the use of animals. In tandem, we now have powerful tools to detect essentially any imaginable environmental contaminants and concentrations easily less than one ng/L, and, to screen the complex mixtures of chemical contaminants in water to determine the potential for human health impacts for the mixture. However, what does this tell us about those chemicals which are most popular in current study, such as pharmaceuticals and EDCs? Also, what happens when we apply these modern instrumental and bioassay techniques to those chemicals that already have been regulated, controlled, or even banned? Lastly, we often assume that modern water treatment plants provide robust, reliable, and dependable disinfection for pathogenic bacteria and viruses. In water reuse, often we rely on vast "over-kill" to protect public health and perception. Yet, have we changed the water quality to a point where water-based pathogens thrive in distribution systems? Are we using the wrong surrogate species to track disinfection? This presentation will consider where we have come on emerging issues of the past years of LET and talk about the future in consideration of "what's new and what's not".

**Shane A. Snyder, University of Arizona USA**  
(snyders2@email.arizona.edu)



### 03 – Flow Cytometry In Microbiological Drinking Water Analysis – New Technology For An Old Problem

**T. Egli**

Throughout the world the microbiological quality of drinking water and recreational water is based on the analysis of two parameters: the heterotrophic plate count (HPC) and the search for the faecal indicator bacterium *Escherichia coli*. Both methods were developed originally more than a hundred years ago and have so far served their purpose fairly well. Although these methods were improved over the years they still have the disadvantage of being slow (*E. coli* and HPC) and insensitive (HPC). There is an urgent need for methods that allow a fast, reliable and cheap assessment of the hygienic state of water within 1-2 hours.

Flow cytometry is a method that has the potential to fill this gap because it allows detecting cells quickly after staining with fluorescent dyes. We have investigated several possible applications of flow cytometry for the fast detection of total cells, their viability, as well as for the fast screening for specific pathogenic microbes after immuno-enrichment and -staining. Application of these basic flow cytometric methods in drinking water production, disinfection and distribution will be illustrated. The FCM-based methods developed so far expand the range of easily accessible microbial parameters in drinking water analysis and may, on the long run, even replace some of the traditional methods.

**Thomas Egli, EAWAG, SWITZERLAND**  
(thomas.egli@eawag.ch)

### 04 – A Systems Approach For Mine Site Water Management And Its Analogy With Urban Water Management

**C. J. Moran & N. Kunz**

Over the last 8 years we have been formulating and testing a systems framework for improving water management in mining. The framework is a hierarchical representation from unit operations to mines within landscapes and ecosystems. The systems approach has facilitated clarification of a range of significant issues and provided a basis for developing a common language. The common language in turn has supported a formal and comprehensible approach to setting goals based on comparable benchmarks and reporting water performance. It has also been helpful in recognising and framing research challenges; both in applied systemic issues and more fundamental knowledge acquisition. Recently, we were exposed to a framework for representing an urban water research program at the Advanced Water Management Centre at UQ. This framework will be used as a grounding from which generalisation will be attempted. Via generalisation we hope to identify commonalities and differences in minerals water-related issues and those in the urban sector. As a final step, research topics that might be of interest will be identified and discussed.

**Chris Moran, The University of Queensland, Australia**  
(chris.moran@uq.edu.au)

### 05 – Disaster Management And Technologies

**T. Omura**

We experienced the tragic disaster with the unbelievable big tsunami caused by the Great East Japan earthquake on March 11, 2011. Almost wastewater treatment plants (WWTPs) located in the shore area where the tsunami attacked lost their function. This situation enforced people to live in the severe environment after the earthquake so that they could not sufficiently make access to the safe water from the viewpoints of water quantity and quality. This will attribute to the lacks of the knowledge on the disaster management and the preparation of logistic technology.

In the disaster management on the WWTPs, the Business Continue Plan (BCP) to reduce the damage from the earthquake had been established at most of the WWTPs but this did not work so much well because the damage was beyond the expectation and those who were engaged in operating the WWTPs came across the disaster. Moreover, both the electrical power and the spare power were lost by the tsunami, so the rehabilitation of the WWTPs was influenced.

In this situation, it is critical to show how we quickly rehabilitate the damaged WWTPs. This issues was discussed in the committee led by the Ministry of Land, Infrastructure, Transport and Tourism. In the discussion at this committee, in order to recover the abilities of the damaged WWTPs, the step rehabilitation was recommended so that the water environment would be improved so as to meet peoples' demand for the standard of water quantity and quality. And also, it was concluded that the rehabilitated or the newly constructed WWTPs should be converted to the facilities able to contribute to resolving the various global issues such as the smart circulations of energy and materials in the focus of the creation of sustainable world. I will introduce the detail of the report of committee in my presentation.

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## Platform Presentations

**06 – Resilient Technologies And The 2011 Flood In Brisbane/ South East Queensland**  
**P.Belz**

This presentation will outline the real life drama that unfolded through the 2011 floods. It will outline the emergency management process and the challenges associated with recovery. A significant challenge going forward for all utilities is incorporation of appropriate designs and risk mitigation measures to cover such extreme events.

**Paul Belz, Queensland Urban Utilities, AUSTRALIA**  
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**07- How To Create Successful Technology Solutions That Address All Sustainability Criteria – The New Zealand Journey**  
**J. Bradley**

With its legislative drivers, strong social agenda and commitments to the rights of indigenous Maori people, New Zealand is progressing with increased enthusiasm and momentum down a sustainable development path in which water and wastewater management are key parts. This path and the associated approach of the “Quadruple Four Well-beings” which is based on assessment of the Environmental, Social, Maori Cultural and Economic well-beings provides many challenges for the water and wastewater industry. Addressing these challenges within the framework of sustainability has created a number of successful and innovative technology solutions.

After setting the New Zealand national context and highlighting the key legislative sustainability drivers, the paper will traverse the practical challenges for the industry and using a selection of leading edge case history projects highlighting how these have been addressed.

These projects will include the Hastings District Council leading edge “paradigm shift” no sludge wastewater treatment project and the Hamilton City Council’s Securing Future Water Supply project. Both these projects received a number of highly coveted New Zealand industry awards each for their innovation and their approach to creating successful technology solutions addressing sustainability criteria.

**Jim Bradley, MWH New Zealand Ltd,**  
**New Zealand** (jim.w.bradley@nz.mwhglobal.com)

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## Innovative Water Technologies In Resource Industry

### 08 – Beneficial Use Of Produced Water From Coalbed Methane – Water Quality And Treatment Aspects

**J. Drewes, T. Y. Cath**

Contributions from unconventional gas resources to the nation's energy supply have grown significantly over the past 20 years and demand is expected to drive future growth. With an estimated 293 trillion cubic feet (TCF) of technically recoverable gas from gas shale, coal seams, and tight sands in the lower 48 states of the U.S., the resources are available to meet future demand. In order to meet this demand, solutions that reduce the amount of water produced are needed.

For proper gas well development in coalbeds water must be pumped out of the formation (dewatering) in order to reduce reservoir pressure and allow the methane to desorb. The co-produced water generated during these operations is by far the largest volume byproduct or waste stream associated with gas production. In contrast to conventional oil and gas production, the produced water from a coal bed methane (CBM) well is pumped in large volumes in the early stages of production and is typically at full pump capacity for up to two years. The quantity of water produced during the life of a well can be 1 to 3 bbl/mcf of gas. If an operator cannot sufficiently minimize water management costs, the CBM resource cannot be developed.

Where proper management of produced water cannot be cost effectively accomplished to meet regulations/permits or surface owner requirements, produced water issues can restrict current gas production or intended expansions.

This project developed an integrated guidance framework that linked the composition of produced waters to beneficial use applications and identified the most cost-efficient, most environmentally sound, and most beneficial strategies for management and treatment of produced water from CBM and gas shale operations by taking into account the conditions in place in the field ([http://aqwatec.mines.edu/produced\\_water/](http://aqwatec.mines.edu/produced_water/)). This was accomplished by cost-benefit analyses that considered both technical and non-technical factors.

This site-specific approach identified potential combinations of treatment processes, which can potentially minimize the volume of residual concentrated brines by considering both well-established and emerging desalination technologies. The project brought together gas producers, members of the water treatment industry, regulatory agencies, tribal interests, landowners, agricultural stakeholders and environmental groups to identify solutions to the institutional impediments to beneficial use of treated water. Input from industry, and particularly from environmental groups, was solicited, with suggestions being applied to the development of the integrated framework.

**Jörg E. Drewes Colorado School of Mines, USA,**  
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### 09 – Innovations In Produced Water Treatment – Case Studies

**M. Van Winden, Kevin P Molloy, C Hunter Nolen**

Natural gas is one of the world's fastest growing energy sources. Efficient and clean burning, with a carbon footprint smaller than coal when burnt, natural gas use is a key component of greenhouse gas reduction strategies. The development of unconventional sources, such as coal seam gas and shale gas, is set to grow dramatically due to vast basins in Australia, the United States, Europe, and around the world. These reserves are being tapped with new techniques for detection, hydraulic stimulation and extraction. One of these is hydrofracking, involving the injection of water, sand, and various compounds deep into oil- and gas-bearing rock to create fissures to release hydrocarbons from shale formations. Leveraging any natural resource requires environmental management, and proper shale gas development includes many protective measures, with special concern for water resources and water quality. There is considerable debate about environmental concerns related to hydrofracking. Our industry has a role to identify and apply robust, reliable and efficient scientific and engineering methods to help protect water supplies and the environment. Water management is often one of the biggest operating issues for resource developers. Drilling and hydrofracking require many megalitres of water and produce "flowback" water that must be managed. More liquid is produced throughout the gas well's lifecycle—all of which requires management through treatment or reuse. To protect fresh water resources and control treatment costs, more resource developers are seeking innovative water planning, sourcing, handling, treatment and reuse options.

**Marco van Winden, E3 Consult, Brisbane, AUSTRALIA,**  
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## Platform Presentations

**10 – An Innovative Process For Sulfate Treatment Of Membrane Concentrates From Mining Operations****K. Banerjee, S. Muddasani, C.D. Blumenschein, H. Buisson, and R. Zick**

A treatment process was developed to reduce sulfate from nanofiltration (NF) concentrate to less than 100 mg/l. The treatment system is comprised of a two-stage chemical precipitation process. The process recovers aluminum from the precipitated sludge for reuse. The impacts of sludge recirculation ratio, pH, chemical dosages including seed material were investigated. Calcium sulfate crystal growth kinetics was determined. Bench and pilot-scale studies were conducted to evaluate the performance of the system. The studies also evaluated the performance of an NF system for removing sulfate from water and wastewater. Using the ion chromatography (IC) method, the concentration of sulfate in water was analyzed. Membrane performance was evaluated at various flux rates, water recovery rates, and trans-membrane pressures.

**K. Banerjee, Veolia Water Solutions & Technologies, USA**  
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## Biotechnology Approaches For Mining/Mineral Processing Water Treatment

### 11 – Biotechnological Approaches For The Metallurgical Sector

**Cees J.N. Buisman, Roel J.W. Meulepas, Jan Weijma, Renata van der Weijden**

This paper identifies and reviews two recent biotechnological innovations that have the potential to improve the sustainability and affordability of metal-bearing mineral processing. One of these innovations is the bioelectrochemical recovery of metals from metallurgical process or waste streams. Another innovation is the biological-mediated production of scorodite from arsenate (oxidation state +5) or arsenite (oxidation state +3) from leachate, wastewater or roasting gas.

Global primary metal resources are dwindling and the mining and metallurgical industries are increasingly turning to lower grade minerals for metal extraction. This typically results in increased costs, chemical consumption, waste production and, energy consumption. Innovative metal recovery technologies are required to increase revenues and lower the impact on the environment. To achieve this, innovations should have a higher selectivity than state-of-the-art technologies, allow the recovery from lower grade streams or deposits, and require less secondary resources (e.g. electricity or lime stone). Biotechnology plays an increasing role in metallurgical operations, like sulphate reduction for metal recovery or bioleaching for metal liberation. The technologies addressed in this paper are two new examples.

**Cees Buisman, WETSUS, THE NETHERLANDS**  
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### 12 – An Innovative Approach To The Use Of Reverse Osmosis For The Treatment Of Cool Seam Gas Water

**J. Briggs, M. Taylor, M. Reid, Australia**

As part of their development of coal seam gas operations in Queensland, Santos identified a requirement to treat coal seam gas water and to dispose of the treated water within the strict requirements for the beneficial use/disposal of the water as imposed by DERM. The selected route for disposal was irrigation of local crops. In the early stages of developing the gas field, Santos constructed several containment ponds, where water from various gas wells was stored, awaiting the development of a suitable method of treatment/disposal. The ultimate disposal route was to be via the treatment facilities to be constructed as part of the future Gladstone Liquefied Natural Gas (GLNG) production facilities. Prior to the ultimate disposal facility being available, Santos required a 'temporary treatment and disposal methodology' and elected to have a portable treatment plant designed and installed, as a matter of urgency. This paper presents key aspects of the design development of the selected configuration (reverse osmosis in parallel with a Water Amendment Plant) to address the feed and product water quality requirements, challenges overcome through the commissioning period as well as water quality results.

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### 13 – Simultaneous Biological Removal Of Sulfate, Nitrate And Carbon In A Newly Developed Cylinder-Shaped Anaerobic Baffled Reactor

**W. Wang, Chuan Chen, Ye Yuan, Xijun Xu, Ning Fang, Aijie Wang**

This study proposed a newly developed cylinder-shaped anaerobic baffled bio-reactor to simultaneously remove sulfate, nitrate and COD from industrial wastewaters. The reactor was composed of four compartments to achieve the phase-separation for functional microbial groups. The seeding active sludge, was collected from WenChang Municipal Wastewater Treatment Plant (Harbin, China), and was inoculated before reactor startup. The temperature was maintained at  $30 \pm 1$  and HRT was controlled at 30 h. Synthetic wastewater consisting of 500 mg/L  $\text{SO}_4^{2-}$  and lactate made COD/ $\text{SO}_4^{2-}$  ratio of 2 in the influent medium. Phosphate was added at N/P ratio of 5, and bicarbonate was employed to maintain pH at  $7.5 \pm 0.2$ . To investigate the performance of the reactor, the operation scheme was divided into three stages: in the first stage, it took 20 days for reactor startup and sulfate reducing bacteria (SRB) enrichment. In the second stage, 130 mg/L  $\text{NO}_3^-$  ( $\text{SO}_4^{2-}$ -S/ $\text{NO}_3^-$ -N ratio of 2.5) was introduced to stimulate the growth of denitrifiers. In the third stage, the behavior of sulfate degradation in different compartments was tested without nitrate in the influent, and then added nitrate again into the third compartment. The experimental results indicated that SRB were mainly gathered in the first compartment, where 89.8% of sulfate was converted into sulfide, and the sulfide in the effluent from the first compartment was about 149 mg/L. Organic matters degradation, denitrification and sulfide oxidation were mainly happened in the last two compartments. In the second stage, the nitrate removal reached 98.7%. The COD removal was not so high, about 60%, possibly due to the low activity of methanogenesis inhibited by high level of sulfide. In the third stage, when adding nitrate into the third compartment, interestingly the sulfate reduction rate increased to 94.3% and sulfide in the effluent sharply decreased below 10 mg/L, also more than 99% of the nitrate was removed. Based on the analysis of sulfur balance, 82.3% of degraded sulfate was transformed into elemental sulfur, indicating that different functional microorganisms, such as SRB for sulfate removal, autotrophic and heterotrophic denitrifier for nitrate and sulfide removal, could be activated in different environmental space for their physiological requirements and transform sulfate, nitrate and COD into elemental sulfur, nitrogen gas and dioxide carbon with high efficiency.

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## Energy Recovery And Energy Efficiency Of Waste Water Systems

### 14 – When Is Wastewater A Resource? A Life Cycle Perspective

**F Castells**

Wastewater reuse is a procedure to avoid the use of new freshwater and consequently is generally an action for resource saving. In existing Waste Water Treating Plants, WWTP, there are always opportunities for materials or energy reduction: e.g. optimizing the gas production in biodigestors, it is possible to increase the energy recovery, or using sludges adequately in agriculture, less mineral fertilizer is needed. Nevertheless in certain occasions when the recovery process is complex and resource and energy demanding, the overall balance is negative, and the expense is higher than the expected saving.

Life Cycle Assessment, LCA, is the methodology that evaluates the environmental profile of a product, process or activity, all over their life cycle path, from its origin to its final destination. By using LCA in this work, applied to wastewater treatment facilities with materials and energy recovery, the value of calculated indicators as carbon footprint, depletion of abiotic resources will show how efficient is the system.

To illustrate the capabilities of LCA, and analyse the efficiency of resource saving in wastewater treatment, two case studies will be considered. Firstly, the analysis of the improvement of the operation of an existing WWTP, and secondly a comparison of different alternatives of wastewater reuse.

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### 15 – Denitrification With Dissolved Methane For Energy Efficient Wastewater Treatment

**C. Kampman, T.L.G. Hendrickx, H. Temmink, G. Zeeman and C.J.N. Buisman,**

Despite many advantages of anaerobic wastewater treatment over conventional activated sludge treatment, it has not yet been applied in temperate zones. This is mainly because effluent from anaerobic treatment still contains nitrogen and dissolved methane. A new concept for energy efficient anaerobic wastewater treatment at low temperatures is proposed, consisting of a UASB digester system and, for treatment of the anaerobic effluent, a reactor with denitrifying methanotrophic bacteria for nitrogen and dissolved methane removal and a nitrification reactor. Before application of the denitrification process, volumetric denitrification rates have to be increased.

In this research denitrifying methanotrophic bacteria, 'Candidatus Methyloirababilis oxyfera', were enriched in a membrane bioreactor, operated at 20 °C, inoculated with a mixture of wastewater treatment sludge and fed with medium containing effluent from municipal wastewater treatment as a source of potential growth factors. After a lag phase of 300 days, the volumetric consumption rate increased to 11 mg NO<sub>2</sub>-N/L-d at day 421. After spiking with denitrifying methanotrophic bacteria from another reactor, the rate increased to a new maximum of 36 mg NO<sub>2</sub>-N/L-d at day 655. These results indicate the potential applicability of the process for wastewater treatment, but still rates have to be increased by an order of magnitude.

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## 16 – Development Of Nitrifying Granular Sludge For Urine Treatment In A Novel Decentralised Bnr System

**G-H. Chen, H. R. Mackey, M. C. M. van Loosdrecht**

Conventional biological nutrient removal requires large footprints and suffers from dilution of the main nutrient stream, urine. The authors propose a novel urine based system incorporating urine separation, struvite precipitation, granular sludge urine nitrification and subsequent in-sewer denitrification. An extension incorporates seawater toilet flushing for freshwater savings and chemical free struvite precipitation. This system relies on a compact and efficient urine nitrification reactor. This paper reports on successful urine nitrification of both freshwater diluted urine and a high salinity, phosphorus-deficient urine-seawater mixture in a granular sequencing batch reactor. High nitrification rates of 1 kg-N/m<sup>3</sup> and fine granules with good settleability were observed. Notably, settleability appeared more dependent on feast-famine than on settling time.

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## 17 – Capturing Wastewater's Energy Potential. How Best To Do It?

**P. L. McCarty, J. Bae, J. Kim, and P. H. Lee**

Domestic wastewater is a resource for water, nutrients, and energy, all of which can best be captured when wastewater is used for irrigation. The energy resources are best obtained through complete anaerobic treatment in membrane bioreactors, which produce a high quality effluent, produce more energy than required for treatment, and also significantly reduce biosolids that further require costly treatment and disposal.

In seeking greater sustainability in water resources management, wastewater is now being considered more as a resource than as a waste – a resource for water, for plant nutrients, and for energy. What emerging processes offer most promise for capturing all of wastewaters resource potentials? Advanced wastewater treatment through reverse osmosis provides high quality water for domestic consumption, but sacrifices resources through higher energy consumption. The need to oxidize or to remove ammonia nitrogen for stream discharge also requires energy. However, if wastewater instead is used directly for crop or landscape irrigation, the largest users of water by humans, then such advanced treatment processes, including ammonia oxidation, are not necessary, resulting in energy savings. Here instead, using wastewater's nitrogen and phosphorus nutrients for plant fertilization, rather than wasting them, also helps offset the high-energy cost involved with making

synthetic fertilizer. All three of wastewater's valuable resources can then be captured. Energy in particular can be obtained from wastewater's organic as well as from its thermal content (McCarty et al., 2011). Two processes for capturing the organic energy content are anaerobic treatment and the much newer microbial fuel cells (MFCs). MFCs offer potential for direct biological conversion of wastewater's organic materials into electricity, although significant improvements are needed for this process to be competitive with anaerobic biological conversion of wastewater organics into biogas, a renewable fuel used in electricity generation. The current high voltage loss, which reduces energy capture significantly, plus the very high capital cost of MFCs significantly reduce their near-term potential for wastewater treatment.

Advancements in the anaerobic treatment of domestic wastewaters are growing rapidly, especially the use of the anaerobic membrane bioreactor, which produces energy in the form of biogas, and produces a well-treated effluent that is suitable for irrigation or can be purified further through reverse osmosis. Besides reducing or perhaps eliminating the high-energy requirements associated with conventional aerobic treatment, anaerobic processes also result in a considerable reduction in biosolids production, the disposal of which is often difficult and expensive. As in all membrane bioreactors, membrane fouling is an issue, generally requiring energy expenditure. A possible solution being developed at Inha University (Kim et al., 2011) is the staged anaerobic fluidized bed membrane bioreactor (SAF-MBR) in which fluidized particles of activated carbon within the reactor serve, not only as a media for the attachment of the anaerobic methane-producing culture, but also through constant motion next to the membrane, reduces fouling at greatly reduced energy expenditure. The result is a highly polished and membrane filtered effluent, which with normal disinfection should be able to meet normal requirements for agricultural reuse or reverse osmosis treatment. Laboratory-scale 20°C studies with this system on settled domestic wastewater have demonstrated that the biogas energy produced is more than sufficient to operate the treatment system. If nitrogen removal is required, addition of the anammox process to treat the effluent offers a very low energy and capital cost approach for accomplishing this. The anammox process is especially compatible with anaerobic wastewater treatment of domestic wastewaters.

**Perry L. McCarty, Inha University, REPUBLIC OF KOREA, Yang and Yamazaki Environmental & Energy Stanford, USA**

**18 – Experience From Start-Up And Operation Of Two ANITA Mox MBBR Plants**  
**R. Lemaire, S. Ekstrom, M. Christensson, E. LeVailant, JC. Schrotter**

ANITA Mox is a new 1-stage deammonification MBBR developed for autotrophic Nremoval (i.e. anammox) from N-rich effluents. An innovative seeding strategy, the "BioFarm concept" has been developed in order to decrease the start-up time of new ANITA Mox installations by seeding with typically 3-15% of carriers with already established anammox biofilm coming from the "BioFarm". The first ANITA Mox plant, started up in 2010 at Sjölanda WWTP in Malmö, proved this seeding concept, reaching an NH<sub>4</sub>-removal rate of 1.2 kgN/m<sup>3</sup>.d and 90% NH<sub>4</sub>-removal within 4 months from start-up with only 3% seeding carriers. Typical features of this first installation were low energy consumption (1.5 kWh/NH<sub>4</sub>-N removed), low N<sub>2</sub>O emissions, (0.2-0.9% of Nremoved) and a very stable and robust process towards variations in loads and process conditions. The second ANITA Mox plant, started up at Sundet WWTP in Växjö, reached full capacity within 2 months using 13% seeding carriers. By applying an N-loading strategy that matches the capacity of the seeding carriers, NH<sub>4</sub> and TNremoval efficiency of more than 90% and 80% could be obtained throughout the start up period. Specific anammox activity batch tests under non-limiting condition showed a maximum N-removal capacity of 12.5 gN/m<sup>2</sup>.d on the seeded Anox K5 carriers used to start-up Sundet ANITA Mox plant. Results from full scale ANITA Mox plants have proven this deammonification process to be a robust and stable sidestream process with high energy efficiency and low carbon footprint, and a key solution towards an energy neutral or even energy producing WWTP.

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**19 – Effects Of Changes In Temperature And Hydraulic Retention Time On Performance And Environmental Impacts Of Anaerobic Membrane Bioreactors For Domestic Wastewater Treatment**  
**A. L. Smith, N. G. Love, L. Raskin, and S. J. Skerlos**

Domestic wastewater (DWW) treatment design approaches need to progress toward energy neutral operations with lower residuals production, without compromising effluent quality. Anaerobic biological treatment of DWW has been proposed as a more sustainable alternative to traditional aerobic biological treatment due to lower energy requirements because aeration is unnecessary, reduced residuals production, and generation of methane-rich biogas, a renewable resource. However, conventional high-rate anaerobic bioreactor configurations typically cannot meet stringent effluent requirements without downstream aerobic treatment, and may experience performance deterioration at low temperatures common for DWW in most temperate climates. Anaerobic membrane bioreactors (AnMBRs), which combine anaerobic biological treatment and membrane separation, have the potential to improve or match the degree of treatment accomplished in current aerobic DWW treatment, while improving the sustainability of the process. The possibility of AnMBR DWW treatment at psychrophilic temperatures (2-20°C) has been proposed in a few studies and is a critical component for attaining process sustainability. Although a limited knowledge base on the feasibility of AnMBR treatment of DWW at low-temperatures exists, studies have yet to establish the lower limits of AnMBR DWW treatment in terms of temperature and hydraulic retention time (HRT). Furthermore, the claims of inherent benefits of AnMBR treatment such as reduced energy requirements, less sludge production, and biogas production have yet to be justified from a life cycle Assessment (LCA) perspective. This research assesses the feasibility of AnMBR technology for DWW treatment at a range of psychrophilic temperatures and HRTs through operation of a bench-scale AnMBR and compares AnMBR treatment with conventional activated sludge and aerobic MBRs through a comparative cradle-to-gate LCA.

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## From Resource Recovery To Wastewater Based Biorefineries

### 20 – Wastewater As A Resource – Potentials And Recovery Options

**P. Cornel, D. Lensch, K. Müller, C. Schaum**

Wastewater is ambivalent: It can be considered as harmful pollutant which needs treatment before discharge into water bodies or can be used as valuable resource for water, nutrients and energy. Wastewater consists of about 99.5 % pure water. Considering the nutrients especially phosphorus and nitrogen are of interest. Combining this makes wastewater to a convenient irrigation water substitute after adequate treatment where and whenever both nutrients and water is needed. Fit for purpose, defines what an adequate treatment is. Useful forms of energy are chemically bound energy, thermal energy and potential energy. Compared to the basic potential, there are different recovery options available, having in common efficiency limitations which will be presented.

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### 21 – Self-Sufficient Wastewater Treatment: An Achievable Aspiration Within 5 Years!

**A. Soares, V Mathioudakis, H Briers, I Martin-Garcia, B D Martin, M Pidou, E Wood, J Brigg, T Pearson, S A Parsons and B Jefferson,**

The self-sufficient wastewater treatment works represents a tangible aspiration to treat wastewater consistent with the challenges described above. Previous research has demonstrated that wastewater treatment utilising anaerobic process at its core, is a suitable pathway towards sustainable wastewater treatment but the debate remains on how to operate the anaerobic reactor towards achieving energy self-sufficiency and especially on the selection of the most appropriate secondary treatment to enable polishing of the effluent and nutrient removal. Research completed at Cranfield University demonstrated the benefits of replacing the biological nutrient removal processes with adsorption based units as a prerequisite for achieving energy neutrality, high effluent quality and for recovery of the nutrient resource for reuse. Since both phosphate and ammonia exist principally as ions in wastewater, they can be selectively removed and recovered through modern ion exchange adsorbers.

Two pilot-plants have been commissioned and are currently being operated at a full scale wastewater treatment works: a granular sludge anaerobic membrane reactor – that enables chemical oxygen demand (COD) and total suspended solids (TSS) removal and biogas production; and a second pilot plant designed for nutrient removal.

**Ana Soares, Cranfield University/Yorkshire Water UNITED KINGDOM** (a.soares@cranfield.ac.uk)

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**22 – Large-Scale Practical Application Of Nutrient Recovery From Digested Sludge As Struvite**

**D. Antakyali, V. Preyl, C. Meyer, W. Maier and H. Steinmetz,**

Struvite precipitation for nutrient recovery from wastewater and sewage sludge has been attracting interest, due to the remarkable fertilizer quality of the product. A method was developed in Stuttgart University to recover Struvite from digested sludge, involving the acidic dissolution of nutrients prior to the recovery. The application was first tested in a pilot scale plant and recently upscaled to a semi-industrial size by constructing a recovery plant at a municipal wastewater treatment plant. The study reports on the technical features and the operation of the large-scale plant with a short overview on the pathway leading to the construction, as well as quality of the product.

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**23 – Optimization-Based Methodology For The Synthesis Of Wastewater Facilities For Energy And Nutrient Recovery**

**B. Chachuat, C. Puchongkawarin, C. Gomez-Mont, D. C. Stuckey**

A paradigm change is currently underway from an attitude that considers wastewater streams as a waste to be treated to a proactive interest in recovering materials and energy from these streams. This talk is concerned with the development and application of a systematic, model-based methodology for the synthesis of wastewater resource recovery systems that are both economically attractive and sustainable. With the array of available treatment and recovery options growing steadily, a superstructure modelling and optimization approach based on rigorous mathematical optimization appears to be a natural approach for tackling these problems – see Figure opposite. The development of reliable, yet simple, performance and costing models is a central issue in this approach. It is argued here that commercial wastewater simulators can be used to derive such models. This methodology is illustrated for a simple resource recovery system, based on the commercial simulator GPS-X and the costing program CapdetWorks. We close this talk with a discussion of the merits and utilization of this methodology along with future research directions.

**Benoit Chachuat, Imperial College, UK**  
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**24 – Isobutyraldehyde Production By Genetically Modified Ammonia Oxidizing Bacteria**

**W. Khunjar, A. Sahin, A. West, S. Banta and K. Chandran, USA**

This work explores the use of genetically modified chemolithoautotrophic bacteria to produce biofuel precursors using ammonia and carbon dioxide as energy and carbon sources respectively.

Biosynthesis of organics like biomass and biofuels from renewable resources has traditionally been accomplished using photosynthetic organisms; however, biosynthesis by this approach is limited by the low energy efficiency of natural photosynthesis. An alternative is to exploit chemolithoautotrophic organisms, which utilize carbon dioxide and inorganic substrates as the primary carbon source and electron donor for biosynthesis. By using this strategy, biomass and/or biofuels can be produced without photosynthesis. In this work, we present evidence of biosynthesis of isobutyraldehyde (a biofuel precursor) using a genetically modified strain of a chemolithoautotrophic ammonia oxidizing bacteria (AOB) that propagates an enzyme required for non-fermentative production via the L-valine biosynthesis pathway. This work demonstrates that chemolithoautotrophic driven biosynthesis can be used to complement existing primary production strategies.

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## Clean, Green, And Sustainable Water Technologies – Minimising Waste And Maximising Resource Utilization

### 27 – Further Treatment Of Ion Exchange Brine With Dynamic Vapour Recompression E. Vaudevire, E.Koreman, G.Galjaard, R.Trommel, M.Visser

In the context of the development of the SIX© Ion exchange process, the Dutch water company (PWN) decided to investigate options for treatment of the brine arising from the regeneration of the resin. Main goals for the brine treatment are volume reduction and product recovery (water + NaCl). In this regard a biological denitrification (DNF) aiming at total nitrate removal followed by a nanofiltration (NF) aiming at ion separation (monovalent/bivalent) focused on NaCl re-use were implemented on a pilot scale recovering 80% of the total SIX brine (implying 80% recovery of NaCl). Further NF concentrate minimization and Sodium Chloride reclamation would allow a reduction of the disposal fees and chemical uses and therefore largely increase the overall process sustainability. During operation on a pilot scale with a capacity of 250l/h, the Dynamic Vapour Recompression (DVR) technology has proved itself to be capable to reduce the raw regenerate another 6 to 10 times reaching meanwhile the solubility limits of NaCl and other salts making their recovery on a solid stream possible. The condensate that resides after DVR treatment is low contaminated and is therefore suitable for re-injection upstream the SIX pre-treatment process. Laboratory scale evaporation tests showed that salts would precipitate according to the following order: BaSO<sub>4</sub> > BaCO<sub>3</sub> > MgSO<sub>4</sub> > MgCO<sub>3</sub> > CaCO<sub>3</sub> > CaSO<sub>4</sub> > Na<sub>2</sub>CO<sub>3</sub> > Na<sub>2</sub>SO<sub>4</sub> and NaCl. A sequenced thickening by DVR treatment leads to selective precipitation of BaSO<sub>4</sub>, BaCO<sub>3</sub>, MgCO<sub>3</sub>, CaCO<sub>3</sub> and CaSO<sub>4</sub> at concentration factor around 8 but beyond a CF of 10 it leads to a more or less simultaneous precipitation of NaCl, Na<sub>2</sub>CO<sub>3</sub> and Na<sub>2</sub>SO<sub>4</sub> without fouling/clogging problems of the DVR. A reuse of a heterogeneous (co)precipitate solid fraction is difficult; however this problem could be countered by further investigation on a temperature controlled precipitation of Na<sub>2</sub>CO<sub>3</sub> and Na<sub>2</sub>SO<sub>4</sub>. Cooling down the DVR brine saturated in dissolved sodium chloride, sulphate and bicarbonate to a temperature of 5°C increases solubility differences between sodium chloride and its two contaminants, making their separation possible.

**Elisabeth Vaudevire, PWN Water Supply Company**  
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### 28 – Zero Liquid Discharge Water Recycling Systems: Removal Of Foulants And Micropollutants From Ro And Nf Reject Streams By Granular Activated Carbon A.Kazner, T. Wintgens and S. Vigneswaran, Australia

High quality water reuse based on dense membrane treatment is expected to be progressively applied in many regions of the world to provide the additional water resources required for water scarcity mitigation. However, treatment and sustainable management of reject streams are still a critical issue of dual membrane treatment and limit the application of high quality water reuse, especially in inland locations. Various integrated reverse osmosis and nanofiltration membrane concentrate treatment concepts have been proposed to minimize waste and maximize the water recovery. A key issue in applying the Zero Liquid Discharge principle, is the removal of bulk and trace organics to provide a sink for organics and minimize fouling of the concentrate desalting system, consisting of e.g. electrodialysis or forward osmosis and a subsequent crystallizer. The focus of the study is on the optimum GAC treatment for the removal of micropollutants and foulants affecting the desalting system to allow a complete recycle of the treated concentrate to the upstream process, such as wastewater treatment.

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**29 – Thermophilic Sludge Digestion And Advanced Nutrient Treatment: Perfect Match For Sustainable Sewage Treatment**  
**S. E. Vlaeminck, D. Smet, J. Klok, W. Verstraete, J. Colsen**

Conventional communal sewage treatment plants (STP) offer few recovery potential and consume considerable amounts of energy. In this study, the concept feasibility of a new sewage sludge treatment train was elaborated according to the 'Cradle-to-cradle' (C2C) philosophy. The many STP installations in The Netherlands jointly produce ~346,500 ton sludge dry matter (DM) per year, or ~21 kg DM per inhabitant equivalent (IE) per year.

Current practices show that the greater part of sludge is dried and subsequently burned. However, the high overall operation costs involved makes sludge treatment an obvious candidate to investigate ways to exploit the inherent energy and nutrient content of STP sewage sludge. These potential energetic, environmental and economic advantages have lead to the development of the 'Energy Factory' and 'ZeroWasteWater' concepts. In this study, the concept feasibility of a new sewage sludge treatment train was elaborated based on thermophilic digestion and advanced nutrient treatment. For the technological, experimental aspect, a thermophilic pilot digester was operated for about 1 year, to demonstrate the performance and stability of thermophilic sludge digestion. Using these data, the energetic and economic balances were calculated to retrofit three existing Dutch STP.

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**31 – A Novel Two-Stage Process For Recovery And Recycling Of Ferric Phosphate Sludge From Wastewater Treatment**  
**E. Mejia Likosova, Y. Poussade, S. Freguia and J. Keller, Australia**

Phosphate removal in water and wastewater treatment represents a major cost to the water industry, due to the required addition of chemical and the disposal cost of the generated chemical sludge. In this work, a novel process was devised and tested at lab scale for the recovery of P and ferric from FePO<sub>4</sub> sludge. The process consists of a first stage whereby P is recovered by dosing sulfide to the sludge to produce colloidal FeS and separate it by precipitation. A second stage consists of an electrochemical cell, whereby ferric is regenerated at the anode, while sulfide is recovered at the cathode. The cost of the electrical power required to drive the process would be just a fraction of the cost to continuously dose fresh chemicals.

**E. Mejia Likosova, The University of Queensland, AUSTRALIA** (e.mejialikosova@uq.edu.au)

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## Platform Presentations

**32 – Electrochemical Resource Recovery From Wastewater And Digestate Via Oxidation/Reduction And Transport Phenomena****K. Rabaey, J. Desloover**

Electrochemical systems have the attractive feature that an oxidation process (anode) can be separated from a reduction process (cathode). In the context of wastewater treatment this leads to a number of interesting applications enabling recovery. Here, we present two approaches for the recovery of sulphide and ammonia from wastewater. Sulphide was recovered in a concentrate solution via alternating polarity switching. Ammonium was removed from an anodic fluid by transport to the cathode and subsequent stripping and capture. This is particularly useful for anaerobic digesters suffering from ammonia toxicity. In this presentation, we will present results from the ammonia and sulphide recovery, and in extension discuss similar recovery approaches from wastewater using bioelectrochemical systems.

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**33 – Quantifying The Contribution Of Nitric Oxide Production Pathways In Autotrophic Nitrogen Removal System****K. Chandran, W. Khunjar D. Jiang and S. Murthy, USA**

This work seeks to elucidate the enzymatic source of nitric oxide in ammonia oxidizing bacteria (AOB), nitrite oxidizing bacteria (NOB) and anaerobic ammonia oxidizing (Anammox) bacteria.

Current attempts to quantify nitrogen oxide emissions from autotrophic nitrogen (N) removal systems are hampered by a lack of understanding of the multiple pathways that are involved. Direct interrogations of cell extracts can identify the enzymes responsible for nitrogen oxide emissions. Structured models employing these rates can then be used to discriminate the sources of nitrogen fluxes, facilitating the development of strategies geared towards mitigating gaseous emissions. In this study, we quantify nitric oxide (NO) yield and production rates from cell extracts derived from three contributors to engineered autotrophic nitrogen removal systems, ammonia oxidizing bacteria (AOB), nitrite oxidizing bacteria (NOB) and anaerobic ammonia oxidizing (Anammox) bacteria.

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## Integrated And New Technologies For Cities Of The Future

### 34 – Reinventing America's Urban Water Infrastructure -Tailored Water For Distributed Non-Potable And Potable Reuse

**K. Nelson, J. Drewes, J. Benecke, J. Henkel, D. Vuono,  
T.Y Cath, R. Chaudry, P. Roa, B. Leinauer, J. Munakata-Marr,  
L. Johnson, T. Reid**

Cities worldwide are facing a mounting water crisis from climate change, population expansion, and deteriorating urban water infrastructure that threatens economic development, social welfare, and environmental sustainability. The current urban water paradigm, which was historically developed to assure the hygienic disposal of wastewater and its appropriate treatment to minimize adverse affects to publichealth and receiving water bodies, hardly makes any use of valuable substances such as nutrients (especially nitrogen and phosphorus) and of the purified water itself. Accordingly, wastewater should be considered as a resource rather than a waste stream. New strategies are needed for water/wastewater treatment and distribution that will reduce the need to pump water over long distances and provide opportunities to reclaim wastewater locally and tailor water to non-potable and potable reuse. Distributed wastewater treatment does not require extensive sewer systems and offers opportunities for a more sustainable management of local water resources. Reclaimed water quality could be tailored to local needs, such as landscape irrigation, groundwater recharge, streamflow augmentation, service water used in households (e.g., toilet flushing), or support point-of-entry treatment leading to potable reuse. These different uses will require treatment facilities that are capable and flexible of delivering different effluent qualities as a function of local demand or season. While many approaches involving contemporary treatment processes could be used to transition urban water infrastructure to this more sustainable state, their implementation currently is limited by uncertainties about their long-term performance, life cycle costs, institutional impediments, and public concerns regarding new technologies. The drawbacks of distributed wastewater treatment could be the higher specific cost of reclaimed water originating from economy of scale. These costs could be balanced through savings associated with the construction and maintenance of sewer systems, the need for a dedicated conveyance system to provide reclaimed water to end-users.

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### 35 – Intelligent Efficient Water Networks **A.Chapman, P. Guttman and J. Westcott, Australia**

This paper addresses where the greatest potential is for improving network efficiency for Cities of the Future from Integrated and new technologies. This paper is based on the findings of the Victorian Intelligent Water Network (IWN) Program which has been formed, as a partnership between the Victorian government, Australia, all 21 Victorian water corporations and the peak Victorian industry body Vic Water. The program's objective is to identify key current and emerging technology opportunities and develop strategies and programs that facilitate efficient and effective progress of these opportunities, to improve networks to deliver cost effective, flexible integrated networks for Cities of the Future. The network efficiency task of the IWN program has engaged the senior network managers and operators from all the 21 Victorian Water companies to identify and quantify where the greatest opportunities for network efficiency and reduce risk for a range of network sizes from small towns to dense inner city environments.

The water industry face significant challenges to maintain secure and reliable service provision in the context of climate change, ageing infrastructure, urban growth, irrigation demand and with investment capacity constrained by user affordability. Traditional urban water, sewer and drainage networks are essentially separate 'dumb networks', to operate in a preset mode, requiring manual intervention to change the mode of operation. Networks are also typically lazy civil assets designed for the extreme worst case events and 99.9% of the time the capacity is underutilised. At the same time the community is confronted by these challenges, the world is experiencing an explosion in technological innovation that presents an opportunity to transform 'dumb' separate networks into 'Intelligent Networks' to cater for the more complex integrated networks required for Cities of the Future.

Looking at recent advances and continuing trends of increasing, information technology power, data handling capacity, range of communication options, monitoring technology and smaller decentralised treatment technology. These advances have the potential to make water networks more intelligent in operation and enhance the network efficiency, manage risk of network integration, to cater for decentralised systems, to drive water networks to work harder and perform better – and to do so whilst continuing to provide a safe and reliable service to our community. Identified opportunity areas include:



## Platform Presentations

- Intelligent Alarms that analyse risk, prioritise alarms and required response for the operator
- Sweat the Assets that maximise use of existing capacity or prolong asset life
- In depth network knowledge that in-depth, accurate knowledge of network operations in real time enabling optimising decisions
- Integrated Water Systems to enhance risk control and operational efficiency in complex water environment
- Intelligent Customer Meters a potential range of operational data for customers and operators for a range of variables
- Leakage Detection in buried pipes out for water and in for sewer

The paper will provide to technology developers, and other water network managers understanding on where the biggest potential gains are for network managers and ultimately the customer from leading edge technology. Currently the focus of many technology providers is on water supply and leakage even though the sewer systems typically constitute 60% water industry asset value and capital expenditure. The paper will also quantify net system savings of some common efficiency variables including leakage and demand reduction, extending asset lives and energy reduction

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### 36 – The Future Is Now: First Application Of Integrated Dry And Wet Weather Water Reclamation Technology In An Indirect Potable Reuse Scheme

**J. Sandino, R. Boe, D. McKnight and B. Cole**

The North Texas Municipal Water District (NTMWD) has upgraded its indirect potable reuse scheme by incorporating in one of its water reclamation plants dual-purpose components providing in an integrated manner advanced tertiary treatment of dry weather flows using a high-rate clarification process, as well as biological treatment of all wet weather flows by converting the high-rate system into a biologically and chemically enhanced mode.

This is the first of its kind application of this technology in full-scale.

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### 37 – Integrating Nutrient And Microconstituent Removal In Wastewater Treatment

**T. Rauch-Williams, A. Salveson, R.W. Finch**

Many wastewater utilities in and outside of the U.S. are currently in the process of upgrading or planning to upgrade facilities to comply with nutrient TMDLs or more stringent nutrient criteria for nitrogen and/or phosphorus. Plant upgrades and expansions are occurring under financially constraint conditions and any major capital investments need to consider not only near-term, but medium and long-term regulatory requirements to be most cost effective long-term. Organic microconstituents, such as pharmaceuticals, personal care products, and other high production industrial chemicals are currently not regulated in the U.S., but are an important industry wide water quality issue and may become regulated in the future with detailed toxicological research underway. In anticipation of these requirements, several research foundations (e.g., Water Environment Research Foundation, Water Reuse Research Foundation) and public utilities have funded research on how to most cost-effectively treat the wide range of trace organic compounds. Design engineers, utilities, state and federal regulators, and the public will benefit from a better understanding on how nutrient removal processes effect organic microconstituents. This paper will synthesize the current state of knowledge on the removal efficiencies of organic microconstituent during conventional activated sludge treatment, biological nutrient removal (BNR), chemical precipitation and filtration, as well as disinfection.

The information provided in this paper is in part based on recent finding of research projects conducted for WERF and the Water Reuse Foundation that the authors were involved in. These projects focused on organic microconstituent removal during conventional and advanced activated sludge, filtration, and oxidation/ disinfection processes. The analysis is complimented by a literature review of related studies. The presentation will include the discussion of specific case study facilities in the U.S. that have in recent years undergone major capital improvements, for which organic microconstituent removal was a selection criteria. The presentation will also provide a brief overview of ongoing trends in the US, the European Union, and Switzerland related to these compounds.

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**38 – Nanoparticles In Cities Of The Future: Monitoring And Treatment**

**A.L Bruchet, K. Glucina, P. Charles and M-L Janex-Habibi**

With their growing use, nanoparticles will find themselves concentrated in cities of the future. Both adequate monitoring methods and water treatment technologies will be necessary to assess and avoid consumer exposure. This paper reports results in these two challenging areas both for organic and inorganic nanoparticles. Treatment experiments indicate that the best available technology for SiO<sub>2</sub> nanoparticles removal is lamellar settling. The use of 120 mg/L of Aqualenc coagulant without flocculant addition allows achieving 99% removal for an initial concentration of 1 g/L. On the other hand, dissolved air flotation process implemented under usual industrial conditions does not permit to remove SiO<sub>2</sub> nanoparticles. In this case SiO<sub>2</sub> removal occurs only by settling in the flocculator tank. Application of a high resolution LC/MS technique to a small selection of treated urban effluents indicates that C60 fullerenes are not widely spread in effluents yet, however non point sources cannot be entirely ruled out.

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**39 – Integrating Advanced TiO<sub>2</sub> Photocatalytic Technology With Membrane Bioreactor (MBR) For The Removal Of Pharmaceutical Drugs From Recycled Wastewater**

**M.N. Chong, G. Laera and B. Jin**

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The presence of pharmaceutical drugs and residues in wastewaters is of concern due to the potential health and environmental risks when the wastewater is recycled as an alternative water source. This study investigated the application of an integrated membrane bioreactor with titanium dioxide photocatalytic technology (MBR-TiO<sub>2</sub>), as a combined treatment barrier to remove Carbamazepine (CBZ) from pharmaceutical wastewater. A laboratory MBR-TiO<sub>2</sub> system was started-up, operated and monitored for its treatment efficiency with respect to CBZ concentration. Prior to the integration, the individual systems of MBR and TiO<sub>2</sub> photocatalytic technology were monitored separately, in order to distinguish the synergistic operational effects. Respirometric tests showed that the introduction of CBZ acts as a chemical stressor, influencing the biomass metabolism in the MBR and resulting in reducing sludge yield. Thereafter, the chemical stressor effects were alleviated when the combined MBR-TiO<sub>2</sub> system was operated in a 4:1 ratio. A maximum CBZ removal efficiency of 95% was observed, but the treatment efficiency was found to decrease with increasing number of treatment cycles possibly due to fouling by different organic and divalent ions found in wastewater.

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**40 – Recovery Of Wastewater System From The Disaster****T. Murakami**

Great disaster damages wastewater system as well as water supply system seriously. The huge tsunami which was caused by the Great East Japan earthquake on March 11, 2011 brought serious damage to northeastern Japan. Many wastewaters systems on the coastal region in the area were severely damaged and 48 WWTPs stopped operating after the tsunami struck. This caused great inconvenience to the citizenry, and moreover it exposed citizens to the danger of epidemic diseases. Therefore, the protection of wastewater system as well as water service from the disasters is very important. Since it is difficult to completely avoid damage caused by large-scale natural disasters, to minimize the damage and to secure the necessary minimum functionality for prompt restoration should be considered as a realistic policy. Among the necessary minimum functions, the drainage of wastewater from an urban area and disinfection before discharge are the basic functions to be secured in preparation for a disaster. For this purpose, to secure power supply is essential and greatly aids the early recovery of the wastewater system. It is essential to realize resilient wastewater system utilizing the lessons of the disaster to the maximum possible extent.

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**41- Novel Approaches To The Treatment And Disinfection Of Cholera Treatment Center Wastewaters****E. Sozzi, J.F Fesselet and H.D Taylor**

During the recent cholera epidemic in Haiti, the Médecins Sans Frontières (MSF) WatSan engineers had to find a way of safely treating and disposing of over 320,000 litres of hospital wastewater. In collaboration with Prof. Taylor from the University of Brighton they decided to use chemical methods to initiate coagulation and subsequent flocculation of contaminants, and through high or low pH levels, to destroy faecal bacteria, including *Vibrio cholerae*. During the course of two projects the entire quantity of hospital wastewater generated by two MSF Cholera Treatment Centres (CTC) has been safely treated and disposed, using two physicochemical treatment protocols. The clarified effluent presents a suspended solids removal greater than 90%, a significative reduction in terms of turbidity and an *E. coli* removal greater than 99.9%. The COD removal is greater than 99%. This effluent was subsequently discharged to controlled infiltration pits and the sludge transported to a controlled landfill operation.

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**42 – Design Of A Rapidly Deployable Sanitation Treatment System For Disaster Relief Situations****A. Taniuchi, S. Tange, T. Hashimoto, Y. Kawaguchi, H. Sato and Y. Watanabe**

The conventional activated sludge process (CAS), has satisfactory effluent quality but produces a large amount of excess sludge. Therefore, attention has recently been focused on reducing this sludge volume. In this report, we introduce the multistage activated biological process (MSABP), which uses a multistage bioreactor with fibrous microbial carriers, as an alternative to CAS. Organic contaminants are effectively degraded in the early stages of MSABP because of the high density of microbes on the fibrous carriers (average removal rate of S-CODcr is 82% and of SS is 93%). In later stages, the excess sludge is significantly reduced by autodigestion of the sludge (by more than 85% when compared to CAS). MSABP also has a higher sludge reduction coefficient than CAS. These phenomena are considered to arise from spontaneous food chain formation over the entire MSABP. We introduce equations for estimating the sludge reduction coefficient and the produced sludge volume and confirm good correspondence between the actual and estimated sludge reduction. Furthermore, we applied MSABP for interim sewage treatment at an earthquake-devastated sewage treatment plant. We conclude that MSABP is an advantageous sewage treatment technology capable of reducing excess sludge and also useful for emergency planning.

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**43 – Innovative Technical Assistance For Accessing Water And Sanitation Solutions After Earthquake Disaster In Haiti**

**A. Brailowsky, M. Vermersch, S. Ravet**

The situation of water and sanitation in Haiti was already alarming prior to the 2010 earthquake, but worsened after. Nevertheless, an ambitious sectorial reform had been approved in 2009, aiming in particular at reaching the MDGs in the country. In Port au Prince, after emergency assistance, and based on the reform of the sector, an innovative technical assistance contract has been set up in 2011 in order to move forward from earthquake emergency to reconstruction and development. It needed a specific approach regarding the bidding process, and the involvement of the partner. This alternative experience, and the challenges it is facing, will for sure lead to better practice for the four actors involved (public authority, operator, users and international financial institutions) in working and building the right solution together.

Haiti is one of the poorest countries in Latin America and, with regard to access to water and sanitation, it has the lowest ratio of the region. The country is currently emerging from two decades of major political and social crises, which have left the water and sanitation installations in poor condition and have heavily jeopardized economic and social development. And last but not least, the powerful earthquake which occurred on the 12 January 2010 resulted in the death of more than 300,000 people and destruction of most of the public facilities in the metropolitan area of the capital city of Port-au-Prince.

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**44 – Australia's First Cogeneration Facility With A Micro-Turbine**

**A. Davey and R. Howick, Australia**

Western Water is a Victorian water utility that services 135,000 people in the outer regions of Western Melbourne. While drought and water shortages in Australia have led to an increase in water recycling, equally an increase in energy prices has led to the emergence of a carbon industry and low emission technology. One of Western Water's core corporate values is to operate sustainably and the organisation has committed to being carbon neutral by 2017. The Melton Recycled Water Treatment Plant is a 10 ML/day activated sludge treatment plant with tertiary lagoon treatment. It services the townships of Melton, Melton South, Toolern and Eynesbury with both Class C recycled water and Class A recycled water. The sludge treatment process at Melton Recycled Water Treatment Plant incorporates an anaerobic digester. Anaerobic digestion remains one of the most important methods of treating sewage sludge and maximising benefits from bio-solids with the least impact on the environment. More importantly, clean energy can be derived from the bio-gas that is produced in this process. Western Water identified this available bio-gas as a means of reducing its greenhouse emissions and reaching the corporate target of carbon neutrality. Through Western Water's design and tender process different technologies for capturing bio-gas to produce energy and Capstone Micro turbine technology was identified as providing the best total life cycle cost. In an Australian first, Western Water partnered with Aquatec-Maxcon to design, supply and install a Capstone Micro turbine at the Melton Recycled Water Treatment Plant. The external heat recovery module also works in combination with the turbine exhaust to supply the process heat requirements of the Recycled Water plant onsite. The cogeneration facility takes the wastewater treatment plant at Melton a long way towards achieving Western Water target of energy self-sufficiency.

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## Control And Mitigation Of Direct Greenhouse Gas (CH<sub>4</sub> & N<sub>2</sub>O) Emissions

### 45 - Methane And Nitrous Oxide Emissions From Urban Water Cycles

**Z. Yuan**

Fugitive greenhouse gas emissions contribute significantly to the overall carbon footprint of water utilities. Methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O) are produced from various components of urban water systems including water storage systems (dams), wastewater collection systems (sewer networks), wastewater treatment plants and wastewater-influenced receiving water environments. CH<sub>4</sub> and N<sub>2</sub>O emissions from dams are strongly dependent on the catchment characteristics, with emission rates orders-of-magnitude different. CH<sub>4</sub> ebullition has been observed in dams or dam areas receiving high organic loading. CH<sub>4</sub> formation and emission from sewer networks can be significant, with rising mains already confirmed an important source of CH<sub>4</sub>. The contribution of sediments in gravity sewers is believed to be significant but detailed investigations are yet to be carried out. In sewers with poor ventilation, CH<sub>4</sub> can exceed its lower explosive limit (i.e. >5% v/v), causing safety concerns. Indeed, sewer explosion has been reported in various parts of the world. N<sub>2</sub>O emission from wastewater treatment plants performing biological nitrogen removal has been widely reported with emission factors up to a few percent of the total nitrogen load to the plant reported. The emission has been found to vary substantially between plants and also in time in the same plant. The design and operation of a treatment plant has a major influence on the emission rate, with plants performing higher level of total nitrogen removal emitting less N<sub>2</sub>O. This implies that there is a synergy between enhanced nitrogen removal and reduced N<sub>2</sub>O emissions. The understanding of the N<sub>2</sub>O production mechanism is being improved rapidly, which will lead to the development for effective mitigation strategies. CH<sub>4</sub> emissions from wastewater treatment plants have also been reported, with sewer networks (carryover) and anaerobic digesters as some of the identified sources. Wastewater treatment ponds are expected to be a significant source of CH<sub>4</sub>, but more work is needed to quantify these emissions. While limited research has been done investigating the impact of the discharge of raw and partially treated wastewater to receiving waters on CH<sub>4</sub> and N<sub>2</sub>O emissions from these water bodies, evidence is emerging showing that the impact can be substantial.

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### 46 - Methane And Nitrous Oxide Emissions From Municipal Wastewater Treatment

**M.R. J. Daelman, U.G.J.M. van Dongen, E.M. van Voorthuizen, E.I.P. Volcke and M.C.M. van Loosdrecht, The Netherlands**

Methane and nitrous oxide emissions from a fully covered municipal wastewater treatment plant were measured on-line during sixteen months. At the plant under study, nitrous oxide contributed for three quarters to the plant's carbon footprint, while the methane emission was slightly larger than the indirect carbon dioxide emission related to the plant's electricity and natural gas consumption. This contrasted with two other wastewater treatment plants, where more than 80 % of the carbon footprint came from the indirect carbon dioxide emission. The nitrous oxide emission exhibited a seasonal dynamic, of which the cause remains unclear. Three types of air filters were investigated with regard to their effectiveness to remove methane from the off-gas.

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### 47 - Evaluating Carbon Footprint Of Water Treatment Technologies Used For Treatment Of Taste And Odor

**S. Bindner A.Festger, C. Hoover and M. Kuhns**

A comparative life cycle analysis (LCA) study was carried out to evaluate the carbon footprints of various water treatment technologies commonly utilized for the removal of the taste and odor (T&O) molecules, MIB and geosmin. The analysis involved calculating the inherent carbon footprint of unit processes associated with such T&O treatment systems including the production of raw material and equipment, transportation, and operation over a 20 year facility life. T&O treatment technologies utilizing advanced oxidation technologies such as UV-oxidation and ozone were evaluated to have the lowest carbon footprint. In contrast, the use of granular and powdered activated carbon (GAC and PAC) was shown to have a higher inherent carbon footprint. Specifically, an over two-fold and an over four-fold larger carbon emission totals were observed for GAC and PAC respectively when compared to the emissions associated with advanced oxidation technologies.

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**48 - Metabolic Pathways And Factors Leading To N<sub>2</sub>O Production By Ammonia Oxidizing Bacteria In Engineered N-Removal Systems**

**K. Chandran**

There is now a rejuvenation in research related to the elucidation of metabolic pathways in chemolithoautotrophic ammonia oxidizing bacteria, especially with a focus on the production of gaseous nitrogen oxides such as nitric oxide (NO) and nitrous oxide (N<sub>2</sub>O). While it was believed that these gaseous oxides were produced and emitted mostly in response to factors such as limiting oxygen concentrations or even anoxic conditions, new information suggests that the pathways and triggers are far more intricate. This presentation summarizes the state of the knowledge on the mechanisms and factors relating to NO and N<sub>2</sub>O by chemolithoautotrophic ammonia oxidizing bacteria, with a specific emphasis on engineered biological nitrogen removal (BNR) systems. The approach is to first acknowledge the genomic potential and complexity of the constituent pathways and then re-construct them metabolically within the context of the configurations and operating conditions of engineered BNR processes, using lab-scale and full-scale measurements.

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**49 - Modelling N<sub>2</sub>O Emissions In Wastewater Treatment - State Of The Art**  
**J. Porro, Ingmar Nopens, H. Li, A. Shaw, Z. Yuan, B. Wett, M. Kampschreur, K. Chandran, and S. Murthy**

Although robust modeling tools exist for predicting wastewater treatment plant (WWTP) carbon dioxide (CO<sub>2</sub>) emissions (direct and indirect), there is still a gap in understanding and incorporating nitrous oxide (N<sub>2</sub>O) emissions into the carbon footprint from a process perspective. Researchers have made significant strides in the last two years to expand the knowledge base on N<sub>2</sub>O pathways from both nitrification (specifically ammonia oxidation) and denitrification, and develop supporting model structures that can help fill this gap. For the ammonia oxidizing bacteria (AOB), several metabolic pathways can lead to N<sub>2</sub>O formation, as predicted by genome-wide data mining and experimental data. However, there is little consensus yet on a model based description of these pathways and processes. For the heterotrophic denitrification pathways, a better understanding exists. The Hiatt and Grady ASMN model has served as a common base; however adjustments, particularly with electron transfer, are required for certain conditions. A thorough review and validation of each of these models is currently underway and will be discussed. The Task Group objective is to help arrive at a unified N<sub>2</sub>O model from both autotrophic ammonia oxidation and heterotrophic denitrification.

**IWA Task Group on GHG Modelling, Sudhir Murthy, USA**

**50 - Advanced Control System To Reduce N<sub>2</sub>O Emission And Improve Performance Of An SBR Treating N-Rich Effluent Via Nitrite Pathway**

**R. Lemaire, J. Chauzy, F. Veuillet and JC. Schrotter**

N-removal via the nitrite pathway is an attractive process to treat N-rich effluent such as anaerobic digestion liquors. Costs saving could be achieved due to less oxygen and carbon substrate requirement. However it has been reported that under certain operating conditions these nitrite pathway processes could generate large amount of N<sub>2</sub>O which is a strong greenhouse gas and therefore off-set the promising energy and costs savings. In this study, a new nitrite pathway SBR process called ANITA™ Shunt was developed to reduce the N<sub>2</sub>O emission. A 500L SBR Pilot was operated for 18 months to treat digested sludge filtrate, more than 90% of N-removal was achieved via the nitrite pathway and N<sub>2</sub>O emission was less than 0.7% of the N-removed. The patented SBR cycle control system is based on the use of free nitrous acid (FNA) concentration set-point, calculated in real time by using pH, temperature and NO<sub>2</sub>- on-line measurement, in order to stop the aeration phase and limit the N<sub>2</sub>O emission. This works demonstrate that N<sub>2</sub>O emission during nitrification stage under low DO condition by AOB is not directly linked to high nitrite level as reported in the literature but mainly to FNA level. Under non limiting DO level, N<sub>2</sub>O emission from AOB denitrification pathway is strongly reduced but long-term nitrite pathway condition will likely be affected.

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### 51 - Emerging DBPs: Have We Been Looking Under The Wrong Street Light? P.C. Singer

Most of the research on disinfection byproduct (DBP) formation for the past 35 years has focused on reactions between chlorine and dissolved organic carbon (DOC). The associated reactions between chlorine and the nitrogenous moiety of natural organic matter (NOM) have been largely overlooked. As a result, there has been little effort to date to characterize the removal effectiveness of enhanced coagulation on dissolved organic nitrogen (DON), and its impact on subsequent formation of nitrogen-containing DBPs (N-DBPs). These N-DBPs have been demonstrated to exhibit a greater degree of toxicity than the more conventional regulated DBPs. Accordingly, the principal objectives of this study were to evaluate the formation potential of selected N-DBPs before and after enhanced coagulation in a variety of raw drinking waters across the U.S., to compare DON removal and DOC removal by enhanced coagulation, and to compare the formation of N-DBPs with the formation of trihalomethanes.

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### 52 - Bromate Formation From Bromide Oxidation By The UV/Persulfate Process J-Y Fang and C. Shang,

Bromate is classified as a B2, possible human carcinogen, and is currently regulated at a maximum contamination level of 10 µg L<sup>-1</sup> worldwide. It is well known as a common disinfection byproduct generated from ozonation of bromide-containing waters. In recent years, novel sulfate radical-based advanced oxidation processes have found their superiority to conventional hydroxyl radical-based processes in destruction of some micropollutants. However, we recently discovered that, in bromide-containing ultrapure water, bromate could also be formed in significant quantity from the UV/persulfate process that primarily generates sulfate radicals. The formation was thus likely driven by sulfate radicals. The conversion from bromide to bromate was found to be even higher than that driven by ozone or hydroxyl radicals. To our best knowledge, the phenomenon of bromate formation from bromide oxidation by sulfate radicals has never been reported in any literature. In this study, bromate formation from bromide oxidation by the UV/persulfate process was thus systematically investigated, with changes of pH, persulfate dosages, concentrations of bromide, chloride, bicarbonate and natural organic matter in synthetic water and in filtered natural water.

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### 53 - The Use Of Hybrid Ceramic Membrane Process For Fouling Control During Water Treatment

**M. Kitis, B.I Harman, H. Koseoglu, N. Ozgu Yigit, M. Beyhan and M. Kitis**

A hybrid membrane process, hydrogen peroxide/iron oxide-coated ceramic UF membrane (HPCUF), was investigated in lab-scale for natural organic matter (NOM) removal and fouling control in raw water filtration. Iron oxide coating of the ceramic UF membrane increased NOM rejections. Addition of hydrogen peroxide to membrane feed water did not enhance NOM rejections, indicating that catalytic NOM oxidation did not occur in the hybrid process. However, hydrogen peroxide in the hybrid process increased the raw water flux values and flux recovery and reduced flux declines and the extent of irreversible fouling during operations. Long term filtration tests with the hybrid process showed that sustainable raw water flux values close to those of clean water can be achieved with very low fouling level. The results indicated the membrane surface cleaning and iron oxide regeneration capabilities of hydrogen peroxide for the iron oxide-coated ceramic UF membrane. Hydrogen peroxide may provide a self, continuous cleaning ability to the hybrid process. Thus, even though peroxide did not provide extra NOM oxidation, it may keep iron oxide surfaces clean and partially unloaded. The results overall suggested that hybrid (HPCUF) process may be effective for NOM removal and organic fouling mitigation in drinking water filtration.

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**54 - Application Of An In Vitro Bioassay And High Resolution MS To Quantify And Identify Novel EDCs In Wastewater**  
**M. Schriks, J.A. van Leerdam, Sander C. van der Linden, B. van der Burg, A. P. van Wezel, Pim de Voogt**

In the past two decades much research effort has focused on the occurrence, effects and risks of estrogenic compounds. However, increasing emission of new emerging compounds may also affect the action of other hormones. Recently, a suite of novel CALUX® bioassays has become available that enables to look further than estrogenic effects only. By employing these bioassays, we recently showed high glucocorticogenic activity in wastewaters collected at various sites in The Netherlands. However, since bioassays provide an integrated biological response, the identity of the responsible biological compounds remained unknown. Therefore, our current objective was to elucidate the chemical composition of the wastewater extracts used in our previous study by means of LC-high resolution Orbitrap® MS/MS and to determine if the compounds quantified could account for the observed glucocorticoid responsive (GR) CALUX bioassay response. The mass spectrometric analysis revealed the presence of potent glucocorticoids such as triamcinolone acetonide and dexamethasone in the ng/L range. In hospital wastewater extracts several glucocorticoids were identified (cortisol, cortisone, prednisone, prednisolone, triamcinolone acetonide) which are used to treat a great number of human pathologies. A potency balance calculation based on the instrumental analyses and relative potencies (REPs) of the individual glucocorticoids, supports the conclusion that triamcinolone acetonide, dexamethasone and prednisolone are the main contributors to the glucocorticogenic activity in the investigated wastewater extracts. The action of these compounds is concentration additive and the overall glucocorticogenic activity can be explained to a fairly large extent by their contribution.

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**56 - Advancing Indirect Potable Reuse In California**  
**G. Wetterau, R.B. Chalmers, P. Liu, W. Pearce and T. Richardson, USA**

While indirect potable reuse (IPR) has been used in southern California (USA) since the 1970s, the commissioning of the 265-megalitre-per-day Groundwater Replenishment System (GWRS) in Orange County (California) showed the region's commitment to utilizing reuse as a major source of potable water augmentation. The treatment process used at GWRS has become the benchmark on which California regulations were based and which other IPR facilities are measured against. As the cities of Los Angeles and San Diego move forward with their own IPR programs, they have commissioned pilot-scale and demonstration-scale projects to build on the lessons learned at the GWRS and to aid in developing future projects that are efficient, effective, and publicly supported. This paper will discuss the technical approaches being evaluated in these projects and the lessons learned in the operation of the existing full-scale facilities.

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**57 - Electrochemical Oxidation Of Reverse Osmosis Concentrates On Boron-Doped Diamond Electrodes****A.Y Bagastyo, D. Batstone, I. Kristiana, Y. Mu, W. Gernjak, C. Joll and J. Radjenovic**

Electrochemical treatment is an emerging method for the degradation of organic contaminants present in chloride-containing wastewater streams, including reverse osmosis concentrate (ROC). In this study, the application of boron-doped diamond (BDD) electrodes for the electrochemical oxidation of ROC generated in water recycling plants was investigated, focussing on the removal of chemical oxygen demand (COD) and dissolved organic carbon (DOC). A high overpotential for O<sub>2</sub> evolution on BDD electrodes enables the generation of hydroxyl radicals (OH<sup>•</sup>), thus enhancing the performance of electrochemical oxidation. The experiment was performed at controlled pH 6-7 and without any pH adjustment (pH 1-2) in order to investigate the effect of operating pH on the competition between electro-generated OH<sup>•</sup> and active chlorine (HClO/ClO<sup>-</sup>) for the electrochemical oxidation, and on the scavenging of OH<sup>•</sup> by chloride ions. Complete removal of COD observed at acidic and circumneutral pH was after 5.2 and 6.6 Ah L<sup>-1</sup>, respectively, yet the corresponding DOC removal was only 48% and 59%, respectively. Although enhanced mineralisation of organic matter seemed to obtain at pH 6-7, the formation of adsorbable organic halogen (AOX) and low molecular weight by-products, such as trihalomethanes (THMs) and haloacetic acids (HAAs), was still observed. Nevertheless, THMs and HAAs were further degraded at higher specific electrical charge to final concentrations of 4 and 22 μM at circumneutral pH, and to 1 and 12 μM at acidic pH, respectively. The overall results suggest the necessity for the removal of chloride ions prior to electrochemical oxidation to avoid the formation of chlorinated by-products.

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## Contents

Poster Presentations

ABSTRACTS



### A Holistic View Of Sludge Treatment Processes – The Linkage Between Digestion And Dewatering

**D Lensch, C. Zeig, C.Schaum, P. Cornel**

Via anaerobic sludge digestion methane can be produced due to generate heat and electricity. Though, nowadays many digesters are not used to capacities which can be used as additional input material to gain more energy. Of interest are easy degradable material and material high in organic matter such as food waste. But the utilization of co-substrate does not only affect the digester the following treatment steps are affected, too. Furthermore dimensioning approaches based on sewage sludge as input material have to be adapted to the material. In order to examine the linkage between sludge treatment procedures with the focus on co-digestion combined digestion and dewatering tests have been conducted at the Technical University of Darmstadt. Test results indicated that a holistic view of the sludge treatment procedure is indispensable, especially when adding co-substrate: Since the organic matter of sewage sludge and co-substrate (e.g. food waste) differs significantly the specific substrate characterization has to be considered and it has been shown that the COD is essential for an adequate digester dimensioning and operation. Additionally digesters temperature as well as dewatering including processwater quality have to be considered.

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### A Novel Free Nitrous Acid (FNA) – Based Technology For Improving Sludge Biodegradability

**Q. Wang, M. Pijuan, L. Y., Zhiguo Yuan**

This study presents a novel free nitrous acid (FNA) – based method to improve sludge biodegradability. A series of experiments were conducted to assess the biocidal effect of FNA on a denitrifying sludge. Both cell viability and biomass activity were reduced significantly after 8 – 48 h treatment at FNA levels of 0-2.0 mg N/L. The degradability of FNA-treated sludge was also enhanced substantially compared to the untreated sludge, revealed by aerobic digestion with a full-scale activated sludge. The method can potentially be used to reduce sludge production and enhance biogas production.

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### Ammonia Recovery From Wastewater Using A Microbial Electrolysis Cell

**G. Ho, R. Cord-Ruwisch, K.Y. Cheng, R.Flavigny**

Microbial Electrolysis Cell (MEC) was utilised as a novel process to recover ammonium in the form of ammonia gas from medium concentrated ammonium wastewater stream (50 mM). Such process has the advantage of removing organics and producing a current that enables the migration of ammonium against its concentration gradient to the cathode. The maximum ammonium accumulation was against a concentration gradient of 1 M ammonium in the catholyte. The energy requirements for this novel process are similar to traditional activated sludge process. However MEC is not proposed as a replacement for current technology, but as an alternative to recover ammonium and remove organics from specific industrial wastewaters.

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### A Preliminary Study On Aspergillus Flavus Soft Pellets (AfSP) As A Biological Coagulant For Water Treatment

**A. H. Rajab, M.Bin Musa, B.S.U Ibn-Abubakar, Aldris**

*Aspergillus flavus* link-44 is a fungus with yellow-green mold in culture. In this study, the coagulation property of *A. flavus* Soft Pellets (AfSP) was investigated. Synthetic turbid water samples were used to evaluate the coagulation performance of AfSP using jar test. The effects of coagulant concentration, pH, initial turbidity and combination of AfSP and alum on coagulation performance were also investigated. The results showed AfSP coagulant was able to remove up to 66% of initial turbidity 188 NTU. More importantly, the used of combined coagulant (AfSP+alum) produced water with turbidity lower than 3 NTU from the initial 160 NTU. Therefore, application of combined coagulant (AfSP+alum) could be promising alternative to reduce cost of treatment.

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## A Study On GHG Footprint For The Environmental Performance Index Of A Sewage Treatment Plant

**T. Fukushima I. Somiya**

We developed an index for sewage treatment plant GHG footprint to evaluate plant environmental performance. Calculations were made to determine GHG footprint from environmental load removal (organics, nitrogen, phosphorus) and GHG emissions, and an evaluation of volume reduction using various advanced treatment methods and digestion was made at a model plant with a treatment capacity of 48,000m<sup>3</sup>/day. GHG footprint was low in the case of an advanced treatment method intended for removal of phosphorus and was improved to 1.56 by introducing power generation with digester gas and high temperature incineration in case of Anaerobic-Anoxic-Oxic processes. The improvement of GHG footprint was led by the reduction of sludge and the removal of phosphorus.

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## An Innovative Tool For Waste Water Treatment Alternatives Delection Integrating Knowledge Based Methodologies And Life Cycle Assessments

**M. Garrido, A. Hospido, R. Reif1, M.T.Moreira, G. Feijoo, M. Poch**

Nowadays, new challenges and regulations in the field of water sanitation are leading towards a paradigm shift. The concept of wastewater treatment is evolving from facilities where solids and conventional pollution are removed at a high cost towards a plant conceived for the reuse and resource recovery from treated wastewater, minimizing energy requirements and operational costs: the sewage treatment plant of the XXI century. In this context, innovative technologies and tools must play a major role, in order to achieve a more sustainable and integrated plant design. EDSSs (Environmental Decision Support Systems) are useful tools which may help, during the decision-making process, the selection of the most adequate treatment for wastewater. In this work, an innovative EDSS methodology (Novedar\_EDSS) has been applied to select the most feasible WWTP incorporating crucial parameters towards sustainability based on Life Cycle Analysis (LCA). In particular, four impact categories will be considered: Eutrophication Potential (EP), Global Warming Potential (GWP) and Fresh Water and Terrestrial Ecotoxicity Potential (FTP and TTP). In addition to the environmental vector, the EDSS considered many

additional criteria in the decisionmaking process: fate of produced effluent, space availability, cost-benefit analysis and the use of innovative technologies. The applicability of this approach (EDSS) will be illustrated with different case studies. Six typologies of wastewater treatment plant will be selected and the environmental performance achieved by the implementation of the EDDSS will be validate through real data. The selected alternative will need to minimize the environmental impact categories defined at the same time that complies with the limits fixed by the regulator. The results will show how the different plant typologies have different impacts in the selected categories, and which alternative maximizes the degree of satisfaction of all the objectives.

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## Anaerobic Digestion Of Pretreated Meat Processing Wastes Reference

**M. Othman**

The aim of this study was to assess biogas production potential (BPP) from the co-digestion of the wastewaters and a solid waste (paunch) generated at a meat processing plant in Melbourne. The effect of ultrasonic and thermal pretreatment of both wastewater and paunch on the BPP was also investigated. Wastewater and homogenized paunch samples were subjected to thermal treatment at 70°C for 30 and 90 min, respectively. Similarly, the samples were subjected to ultrasonic treatment, each for 10 min. The codigestion of untreated and pretreated wastewater, and paunch samples was investigated in anaerobic digestion batch reactors at mesophilic conditions. The organic loading in the reactors that were fed with wastewater and homogenized paunch (50:50 V/V) was 0.95 gCODt added/gVS inside reactor. Screening tests to assess the effectiveness of the pretreatment processes and the optimum exposure time were carried out. The changes in total solids (TS), volatile solids (VS), total COD (CODt) and soluble COD (CODs) were monitored. It was observed that ultrasonic pretreatment of paunch raised its CODs by 25%, 42% and 92% after 5, 10 and 15 min exposure, respectively, whereas, the CODs for wastewater increased by 15%, 25% and 35% after 5, 10 and 15 min, respectively.

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## Autotrophic And Heterotrophic Denitrification In Saline

**Feng Jiang\***, **Guo-Liang Peng\***, **Jin Qian\*\***, and **Guang-Hao Chen\*\***

Urine contains over 80% of the nitrogen in municipal sewage. Urine source-separation could be cost-effectively conducted in densely-populated high-rise residential buildings in Hong Kong. In order to beneficially dispose of collected urine, we have developed low-cost urine phosphorus removal (Mackey *et al.* 2011), followed by discharging nitrified source separated urine into sewers in order to achieve in-sewer denitrification for downsizing centralized treatment (Jiang *et al.* 2011). Due to large-scale seawater toilet flushing practice in Hong Kong, sulfate originating from 20-30% of seawater in sewage tends to be reduced to sulfide in some sewers where anaerobic conditions prevail. Sulfide may induce autotrophic and heterotrophic denitrification in anaerobic condition (Chen *et al.* 2009, Reyes-Avila *et al.* 2004), when nitrate and carbon source are available. It could occur in sewers, when nitrified urine is discharged. The relationship between the autotrophic and heterotrophic denitrifiers could be commensalism, i.e. autotrophic nitrate-reducing sulfide-oxidizing bacteria (NR-SOB) reducing nitrate to nitrite, while heterotrophs reducing nitrite to N<sub>2</sub> (Reyes-Avila *et al.* 2004). The overall denitrification in the sewers would be affected by either of or both rates, which are unclear. This study was therefore to determine the nitrogen removal rates by autotrophic and heterotrophic denitrification as well as the sulfide oxidation rate in the sewer through laboratory batch tests and a real sewer investigation.

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## Bacterial Strain Dependent Silver Nanoparticle Adsorption And Toxicity: Effect Of Bacterial Cell Surface Hydrophobicity

**E. Jeong, S. Kang, S. Chae, H. Shin**

Wastewater treatment plants are considered to be key intermediate stations in a recent risk assessment of Ag NPs, and a high degree of Ag NPs removal is associated with the adsorption onto sludge biomass. Here we carried out a series of Ag NPs adsorption tests using four different bacterial species to compare adsorption capacity and to find out affecting factors. *P. putida* showed the highest Ag NPs adsorption followed by *E. coli*, *B. subtilis*, and *S. aureus*. The biosorption of the Ag NPs onto each bacterium fitted well with the Langmuir model. Calculations of Derjaguin-Landau-Verwey-Overbeek (DLVO) interaction energy predicted the presence of a substantial attractive energy to Ag NPs

deposition in saline solution (0.85% NaCl). Different bacterial adsorption of Ag NPs in solution tested in this study, therefore, is not controlled by physical-chemical interaction and caused by biological interaction. Since the first step of adsorption of NPs is to EPS or the cell surface, EPS production of each bacterium was analyzed and compared. The Ag NPs adsorption capacity is correspondent with the amount of total EPS production. Among two compartments of EPS, protein EPS showed a more important role in Ag NPs adsorption.

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## Beneficial Concentrate Disposal Of Inland RO Systems By The Use Of Halophyte Plant

**M.H.Naser Moaddeli**

Concentrate disposal of desalination plants is major concern in especially inland systems and could comprises one of the major costs of this type of water treatment system. There are some well known disposed methods, including surface water discharge, sewer discharge, deep well injection, evaporation ponds, zero liquid discharge. All these method focus on two major objectives: 1) reduce concentrate volume and 2) direct discharge to water bodies. Many concentrate streams are toxic to marine and freshwater organisms. In inland areas, concentrate disposal is especially challenging because any discharge to surface water would contaminate the fresh water resources. Thus, concentrate disposal is a major obstacle preventing the implementation of desalination in inland area. One attractive solution to the concentrate disposal issue is to construct halophyte forests as a beneficial use of concentrate. Halophyte is group of tree which is capable to tolerate high content of salinity. Carbon sequestering advantage, possible economical usage, job creation, and generating new ecosystem can be of major advantageous of this solution. Thermal desalination concentrate disposal systems are not concerned in this paper and the major focus will be on natural disposal system in RO concentrate disposal. The concept of constructed forests of a group of salt tolerant plants generally named Halophytes and some important factors to be considered in their selection, besides their possible effects on the environment will be discussed in this paper.

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Biological Phosphorous And Nitrogen Removal In Sequencing Batch Reactors: Effects Of Cycle Duration, Dissolved Oxygen Concentration And Influent Particulate Matter

**M. Ginige, A. S. Kayaalp, K.Y. Cheng, J. Wylie, A.H Kaksonen,**

Municipal wastewater treatment plants (WWTPs) often use chemical precipitation to remove phosphorus (P) from wastewaters. However, this conventional method is usually costly due to excessive chemical usage and sludge production. Enhanced biological phosphorus removal (EBPR) could be a cheaper alternative for P removal, but often, it is difficult to achieve without the availability of sufficient volatile fatty acids (VFAs). This study aims to explore ways to make maximum use of the available VFAs in wastewater by investigating the effects of exposure time to anoxic / anaerobic and aerobic conditions and dissolved oxygen concentrations on EBPR and nitrogen removal. A bench-scale sequencing batch reactor was operated under sequential anoxic-anaerobic-aerobic conditions for a period of 1.5 years (SRT= 20 d; HRT= 13 h). The SBR received influent wastewater subjected to primary sedimentation. The effects of cycle time (6 vs. 8 h) and dissolved oxygen (DO) concentrations (0.8 vs. 2 mg/L) on EBPR performance and nitrogen removal were quantified. The results indicated that 6 h cycles significantly increased P removal compared to 8 h cycles. Denitrification largely via nitrite pathway was observed at a low DO (0.8 mg L<sup>-1</sup>) on a 6 h cycle and a 83% removal of influent P was observed. Nitrification was complete in the 8 h cycle and with an extra demand on COD for denitrification, only 31% of P was biologically removal took place in the 8 h cycle. Overall, this study suggests that both biological phosphorus and nitrogen removal can be facilitated from municipal wastewaters provided steps are taken to conserve already available wastewater COD.

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Comparative Methanogenic Activity Of Thermophilic Anaerobic Digestion Of Waste Activated Sludge On Formate And Acetate

**D.Ho, P. D. Jensen, D.J. Batstone**

series of anaerobic batch experiments were carried out to determine the degradation kinetics and specific activities of methanogenic pathways in a lab scale anaerobic digester operated at thermophilic conditions. The results showed that hydrogenotrophic methanogenesis occurred much faster than acetoclastic methanogenesis, indicating the significance of hydrogenotrophs in the community. Molecular analysis found that the methanogenic population was dominated by Methanosarcina, which can utilise either acetoclastic or hydrogenotrophic pathways under specific conditions. The increased hydrogenotrophic capacity suggests syntrophic acetate oxidation as a key pathway at elevated temperatures, a finding which needs to be verified via stable isotope analysis

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Current Driven Bioelectrosynthesis Of 1,3-Propanediol From Glycerol

**M. Zhou, A.Wise, J.Keller, K.Rabaey**

1,3-propanediol (1,3-PDO), a commodity chemical, can be naturally produced from glycerol fermentation. However, the yield was restrained by the accessibility of reducing equivalents. In this study, we provided electrical current via bioelectrochemical system (BES) to glycerol fermentation. The results indicated that current led to faster glycerol consumption as well as higher 1,3-PDO yield. At 100 mA cell current, the yield was 0.57 mol PDO mol<sup>-1</sup> glycerol relative to 0.27 mol PDO mol<sup>-1</sup> at 10 mA and 0.22 mol PDO mol<sup>-1</sup> glycerol in the absence of current.

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**Darling Quarter Water Treatment Plant: Integrating Innovative Technologies To Improve Reliability, Robustness And Sustainability For Water Recycling**

**I. Fernandez Rousselot, J.C. Schrotter, C. Grech, K. Shaw**

This paper presents performance testing results of an innovative water treatment plant combining Moving Bed Biofilm Reactor/Ultrafiltration/Reverse Osmosis technologies. Key features of this plant will be presented and compared to a more conventional Membrane Bioreactor/Reverse Osmosis reuse plant.

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**Degradation Of Endocrine Disrupting Chemicals In Water Using A Hybrid Photocatalytic-Membrane Reactor**

**H. M. Coleman, C. Marquis, R. Amal**

Photocatalysis and photolysis (using UVA and UVC radiation) were investigated for the removal of endotoxins in water. The Limulus Amebocyte Lysate (LAL) assay was used to monitor the endotoxicity. Results showed that photocatalysis is effective for the degradation of endotoxins in water and was much more effective than UV light alone, with rates up to 7 times faster for photocatalysis.

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**Delayed Aeration Of Activated Sludge For Time-Shifting Of Power Consumption**

**Wei. Shi, H. Satoh, T. Mino**

In order to reduce power consumption for aeration of activated sludge processes during daytime, the authors investigated the possibility to introduce "delayed aeration". The authors' idea is to reduce aeration during day time and remove organic pollutants by the capability of microorganisms to accumulate temporal carbon storage materials such as polyhydroxyalkanoate (PHA), and oxidize it during night time. The authors operated sequencing batch reactors with 6 cycles/day with synthetic wastewater, and reduced aeration in one of the cycles. One-cycle experiments to see short term effects of one cycle aeration reduction and a long term experiment were conducted. Removal of DOC was not affected with aeration reduction of up to 50%.

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**Effect Of A Long Anaerobic Reaction Time On Phosphorus Removal And N<sub>2</sub>O Production In A Denitrifying Phosphorus Removal System**

**Y Wang**

**Effect Of Acclimatization And Bioaugmentation On A Submerged Membrane Bioreactor Treating Recalcitrant Pharmaceutical Wastewater**

**R. Saravanane**

Extensive laboratory investigations were carried out using a commercially available membrane (ZENON make; pore size – 0.04 μm and made of a polymeric material) for studying the treatment efficiency of an industrial pharmaceutical wastewater (obtained from a company manufacturing 'analgesic' drug). Chemical Oxygen Demand (COD) removal (%) was obtained by operating the MBR under various organic loading rates (OLRs) ranging between 0.277 to 36.57 Kg.COD/m<sup>3</sup>.d, hydraulic retention times (HRTs) ranging from 24h to 4h. COD removal efficiency achieved in this study (i.e., with bioaugmentation) is qualitatively comparable to the efficiencies reported so far using the MBR process for various pharmaceutical wastewaters.

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**Effect Of Anions On The Degradation Of Hexabromocyclododecane (HBCD) With The Stabilized Ni/Fe Particles**

**C.P. Tso, Y.H. Shih**

Extensive laboratory investigations were carried out using a commercially available membrane (ZENON make; pore size – 0.04 μm and made of a polymeric material) for studying the treatment efficiency of an industrial pharmaceutical wastewater (obtained from a company manufacturing 'analgesic' drug). Chemical Oxygen Demand (COD) removal (%) was obtained by operating the MBR under various organic loading rates (OLRs) ranging between 0.277 to 36.57 Kg.COD/m<sup>3</sup>.d, hydraulic retention times (HRTs) ranging from 24h to 4h. COD removal efficiency achieved in this study (i.e., with bioaugmentation) is qualitatively comparable to the efficiencies reported so far using the MBR process for various pharmaceutical wastewaters.

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### Effect Of Combined Ultrasonic And Microwave Treatment On Sludge Biodegradability And Anaerobic Digestion Performance

**A.M.Yeneneh, S. Chong, T. Sen, H. M.Ang and A. Kayaalp**

Though anaerobic digestion is the most effective means for the stabilization of sludge, it has a very slow rate limiting sludge hydrolysis step which is associated to low biodegradability of cell walls and the presence of extracellular biopolymers. Treatment, handling and disposal of excess sludge amounts to 60% of the total operating cost. This necessitates the enhancement of biogas production and sludge disintegration process by sludge pretreatment and process improvement techniques. This particular study aims at investigating the effect of ultrasonic, microwave and combined microwaveultrasonic treatment on biogas production, solid removal, COD reduction and dewaterability of anaerobically digested sludge.

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### Effect Of Stripping With CO<sub>2</sub> On Biological Hydrogen Production By Molasses In Large Lab-Scale

**I.Mariakakis, C.Meyer, H.Steinmetz**

This work aimed at the examination of the effect of stripping with CO<sub>2</sub> on bio-hydrogen production by dark fermentation of molasses. The experimental investigations were carried out in complete mixed reactors in large lab-scale (40 L). In all cases, the hydrogen yield was improved when stripping was applied independently of the stripping frequency and the gas volume. Microbial population analyses showed a predominance of hydrogen producing bacteria (Clostridium and Coprococcus) species together with lactic acid (Sporolactobacillus, Olsenella and Prevotella) and hydrogen consuming microorganisms (Sutterella, Ralstonia, C.ljungdahlii and Archaeon Methanobrevibacter).

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### Effect Of Water Chemistry On The Aggregation And Sedimentation Of Commercial TiO<sub>2</sub> Nanoparticles In Water

**Y.H.Shih**

Nanomaterials released into the environment could cause a threat to our ecosystem and human health. Titanium dioxide, TiO<sub>2</sub>, is one of widely used nanoparticles (NPs) found in a large number of consumer products. This study aims to evaluate the mobility of commercial stabilized TiO<sub>2</sub> NPs in aquatic environment. The properties of TiO<sub>2</sub> NPs were characterized using X-ray diffraction (XRD), transmission electron microscopy (TEM) and dynamic light scattering (DLS). The main crystalline structure of the TiO<sub>2</sub> NPs is anatase. From FTIR spectrum, organic capping agents on commercial TiO<sub>2</sub> NPs could contribute its stability. The point of zero charge (PZC) of the commercial TiO<sub>2</sub> NPs we used was about pH 6.5. The stability of commercial TiO<sub>2</sub> NP is independent on its concentration. TiO<sub>2</sub> NP tended to settle down when the aqueous pH near its pHPzc, and remained stable when the solution pH away from its pHPzc. In stable suspensions, TiO<sub>2</sub> NPs settled down obviously at NaCl concentrations higher than 100 meq/L. It was attributed to the surface charge of TiO<sub>2</sub> neutralized by Cl<sup>-</sup> anions. In the presence of low concentrations of Suwannee river humic acid (SRHA), TiO<sub>2</sub> NPs did not settle down until SRHA concentration increased to 20 mg/L, which were stabilized again in the presence of SRHA of 50 mg/L. In the four aqueous conditions designed by the Taguchi method, TiO<sub>2</sub> NPs did not settle down in 5 hrs only under an aqueous condition with 200 meq/L NaCl and 10 mg/L SRHA at pH 7.1. These better understandings can facilitate the prediction of NP removal and fate in the aquatic environment.

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## Fate Of Pharmaceuticals And Personal Care Products Through A Membrane Bioreactor Treatment System

**T. Trinh, B. Akker, H.M. Coleman, R.M. Stuetz P. Le-Clech, J. E. Drewes, S.J. Khan**

This study provides a comprehensive insight into the levels and fate of 20 pharmaceuticals and personal care products (PPCPs) through a package membrane bioreactor (MBR) in New South Wales, Australia. The results of this study showed that the removal of most of the studied PPCPs through the package MBR was high with removal efficiencies above 95%. However, diclofenac was only partially removed through the MBR with average removal efficiencies of 44.7% and carbamazepine had negative removal. This may be due to the enzymatic cleavage of the glucuronic conjugate of carbamazepine and release of the parent compound during the treatment process. Removal mechanisms were shown to depend upon the physical-chemical properties of the specific pharmaceuticals. However, biodegradation/transformation was the dominant removal mechanism overall. This knowledge can be used to optimise the performance of MBRs in removing PPCPs to achieve the best possible effluent quality for specific water reuse applications.

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## Sidestream Treatment In Wastewater Treatment Plant With Respect To Global Energy Efficiency

**L Graveleau, N Landes, A. Kaldate, Martin L Graveleau**

Improving energy efficiency for wastewater treatment plant (WWTP) is the priority for new wastewater treatment. In large scale WWTP, anaerobic digestion (AD) is widely used to produce onsite renewable energy source. The tendency is to increase the biogas production by promising technologies (pre-treatment, co-treatment and post-treatment). However, the supernatant from digester is highly concentrated in ammoniac nitrogen, the contribution from the recycled of this sidestream to the plant influent may represent up to 20% of the total nitrogen load. This value is even higher for the sidestream from AD with enhancing digester. In consequence, an intense nitrogen load increases considerably the energy consumption link to aeration during biological treatment and decreases the ratio COD/NTK in raw water, leading to more often external carbon addition for denitrification (especially in case of biofilter).

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## Greater Understanding Of Microbial Processes In Wastewater Treatment Reactors Is The Key To Develop Resilient Wastewater Treatment Technologies

**C. Ehlers, S. Turner**

Understanding the triggers of microbial aggregation is essential to the operation of wastewater treatment plants since it plays a fundamental role in the maintenance of communities in activated sludge (AS) reactors. In addition, it is an essential step in bioflocculation. The development of strategies to support solid-liquid separation is instrumental to minimize the impact disaster events such as floods have on treatment processes during dramatic changes in nutrient conditions. Laboratory bioreactors were operated under changing nutrient conditions to simulate feast and famine environments. Studies were also conducted on a model AS bacterium, *Acidovorax*, to determine triggers of aggregation. The investigation indicated the possibility to configure a reactor that incorporates early detection of polymer accumulation which can occur due to shifts in nutrients and remediate aggregation failures during floods by artificially altering nutrient conditions. This may aid in retaining microbes when AS reactors are under stress.

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## Improvement Of Virus Rejection By Fouling Of Membrane

**Ryota Nakagawa, and Naoyuki Kamiko**

Various problems concerning chlorination have been pointed out. From these reasons, membrane treatment is attracting attention. However, the knowledge about the relationship between fouling and virus rejection is not enough. In this study, virus rejection during UF (ultrafiltration) membrane processes was examined by a dead-end filtration method using coliphage MS2. For different kinds of hollow fiber ultrafiltration membranes were used: polysulfone (PS) and polyacrylonitrile (PAN) ultrafiltration membrane from Asahi Kasei Chemicals Corporation. The relationship between fouling caused by cake layer and the removal rate of coliphage was analyzed from the data of each experiment. The results of experiments clearly showed that the removal rate by ultrafiltration membrane (PS) was decreased with the progress of filtration and there was possible relationship between pressure increase and the volume of filtrated water. On the other hand, the removal rate of ultrafiltration membrane (PAN) was increased with the progress of filtration and membrane resistance was kept constant approximately  $50 \times 10^{11} \text{ m}^{-1}$ . From these investigations, ultrafiltration membrane (PAN) was indicated constant performance for a long time and backwashing may not be required to obtain high removal of virus.

**Ryota Nakagawa, Ritsumeikan University**



### Interactive Effects Between Hardness, Alkalinity, And NOM In Reverse Osmosis Concentrate On Nano Zero Valent Iron Reactivity Reference

**Y-H Hwang, H-S Shin**

The water reuse offers attractive solutions for global water shortage. The disposal and management of desalination process by-product water (i.e., concentrate) is often a major issue. Nano zero valent iron (NZVI) was known as suitable material for nitrate reduction and organic transformation by redox reaction and precipitation. However, high concentrations of hardness, alkalinity, and organic matter in RO concentrate would have significant effect on NZVI reactivity. In this study, the influence of hardness, alkalinity, and organic matter on NZVI reactivity was evaluated by response surface method (RSM). The average diameter of prepared NZVI was 31.3 nm, while the BET surface area was 18.3 m<sup>2</sup>/g. The hardness (Ca<sup>2+</sup>) showed positive effect on NZVI reactivity by acceleration of iron corrosion. On the other hands, alkalinity (HCO<sub>3</sub><sup>-</sup>) and organic matter (HA) showed negative effect on NZVI reactivity by morphology change to carbonate green rust and competitive adsorption of HA, respectively. The validity of the statistical prediction model derived by RSM was confirmed by additional confirmation experiment. The experimental result exists within 95% confidential interval. Therefore, it could be said that the model derived by RSM is statistically significant. Department of Civil and Environmental Engineering,

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### Membrane Fouling As Revealed By Advanced Autopsy In A UF/Coagulation Pilot Trial For Enhanced Removal

**A Keucken , B.C.Donose, B.C.**

In the southern part of Sweden a general tendency of browning of the lakes has been noticed. On-going climate change has also increased the risk of surface water contamination with pathogens, due to increased combined sewer overflows, and increased run-off from land. In the light of these changes, VIVAB has decided to evaluate ultrafiltration membranes for improvement of drinking water quality with respect to NOM removal and microbiological barrier effect. A fully automated pilot plant with pre-programmed operating modes has been in operation since June 2010 (14 month trial period). Advanced NOM characterizations have been conducted

from water source to tap and beyond by using Liquid Chromatography – Organic Nitrogen Detection (LC-OCD). The strategy of using UF with pre-coagulation proved to be successful in removing humic fractions of NOM. Advanced autopsy methods, involving Scanning Electron Microscopy/ Energy Dispersive X-Ray Spectroscopy/ Atomic Force Microscopy (SEM/EDS/AFM), revealed the topography and elemental composition of the fouling layer. It was found that the coagulant, calcium and manganese silicates were the most abundant compounds found on the surface of the fibres. These results, in combination with the feed characterisation, establish the baseline of a future optimisation strategy. The application at full scale of UF/coagulation could meet the requirements for multiple microbial safety barriers as well as preparedness for future deterioration of raw water quality by enhanced NOM-removal. This concept also minimizes the risk of formation of disinfection byproducts during the treatment process.

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### Microfiltration Of Municipal Secondary Effluent For Water Reuse

**F Roddick S. Nguyen,**

The flux performance and colour rejection of a polymeric membrane and a ceramic membrane in microfiltration (MF) of a dark yellow secondary effluent for water reuse was investigated. The two membranes gave similar performance when the polymeric membrane was operated in dead-end mode and the ceramic membrane was run at a crossflow velocity of 1.8 m/s. Increasing the crossflow velocity improved the flux performance of the ceramic membrane. However, this also significantly increased the energy consumption. Coagulation of the feed reduced fouling on both membranes and increased the overall colour rejection. However, neither MF alone nor the combination coagulation-MF was able to address the yellow colour issue which may limit customers' willingness to reuse the treated effluent.

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### Monitoring And Modelling Nitrous Oxide Emissions From A Full-Scale Wastewater Treatment Plant Reference

**Y. Y. Law, B-J. Ni, L. Ye, C. Byers, K. de Jong, P. Lant, Z. Yuan**

A mathematical model is developed based on three metabolic pathways of nitrous oxide ( $N_2O$ ) production by ammonia-oxidising bacteria (AOB) proposed thus far. This model, in conjunction with the four-step denitrification model that describes  $N_2O$  production and consumption by denitrifiers, is implemented in Activated Sludge Model No.1 (ASM1). The model describes well the dynamic  $N_2O$  emission data collected online from the Woodman Point wastewater water treatment plant (WWTP), which is a sequencing batch reactor (SBR) system. The modelling results suggest that different  $N_2O$  production pathways may be dominating in different periods of the SBR cycle.

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### Nitrifying Bacterial Community Succession In A DHS Reactor With Salinity Control For Enhancement Of Nitrification

**T. Natori, Y. Takemura, K. Abe, M. Kimura, A. Ohashi, T. Yamaguchi, H. Harada, S. Uemura,**

The effect of salinity on nitrification in a Down-flow hanging sponge (DHS) reactor was evaluated in a continuous long-term experiment for more than 1400 days. The DHS reactor was fed with artificial wastewater containing 100 mg-N/L of ammonium nitrogen. The salinity of the influent was controlled by adding NaCl at concentrations of 0 – 25 g-Cl/L. The effluent nitrite increased with increasing salinity, i.e., the nitrite increased to approximately 90% of the total nitrogen in the effluent at 25 g-Cl/L. As salinity increased, the nitrifying bacterial community in the reactor changed markedly at the species level. In particular, the dominant nitrite-oxidizing bacteria changed from Nitrospira-sublineage I at 0 g-Cl/L to Nitrobacter spp. at 15 g-Cl/L. At 25 g-Cl/L, no nitrite-oxidizing bacteria were detected.

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### Novel Fertilizer Drawn Forward Osmosis (FDFO) For Fertigation: Application To Tomato

**H. K. Shon**

Fertilizer drawn forward osmosis (FDFO) desalination is a novel low energy desalination concept for fertigation of crops. In this particular study, we evaluate the FDFO desalination for fertigation of a tomato plant in terms of nutrient concentrations that can be achieved using various feed water qualities. Draw solution (DS) was assumed to be a mixed fertilizer of grade 17:3:20 (N (nitrogen):P (phosphorus):K (potassium) in %) prepared using four different types of fertilizers. Our evaluation indicates that, FDFO desalination is more suitable for low salinity feed water. If high salinity feed water is used, the final FDFO product water require substantial dilution before making it suitable for dilution. Options available for achieving acceptable nutrient concentrations are also briefly discussed.

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### Oxygen-Limited Autotrophic Nitrification/ Denitrification Maximizes Net Energy Gain In Technology Schemes With Anaerobic Digestion

**S Vlaeminck, H. De Clippeleir, E. Courtens, E. W. Verstraete W. and N. Boon**

Due to the increasing energy prices and the 'climate change' focus on sustainability and renewable energy, anaerobic digestion is increasingly applied on high-strength organic wastestreams to recover energy. In practice, energy recovery is the main goal from separately collected organic waste applied in dedicated biogas plants, but in several industrial and municipal wastewater treatment plants (WWTP) energy efficiency is also becoming more important. However, the removal of nitrogen through conventional nitrification/denitrification is very energy-intensive and decreases the potential net energy gain due to the oxidation of energy-rich organic matter. Over the past decade, full-scale applications of partial nitrification/anammox have been established. Oxygen-limited autotrophic nitrification/denitrification (OLAND) is a one-stage realization of this process, which removes nitrogen with a 60% lower aeration energy requirement and 100% lower biodegradable organic carbon need. Given these features and the decimated sludge production, OLAND costs can be cut by 30-40% compared to conventional nitrification/denitrification, resulting in a treatment cost of about 2.5 EUR  $kg^{-1}$  N. In this conceptual study, the impact of implementing OLAND in a WWTP is investigated on the plant's energy balance. Overall, this study provides insights in application domains in which OLAND can significantly improve the energy balance.

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### Ozonation Of Secondary Effluent: Impact On Biodegradability F Roddick

**P. Puspita, F.Roddick, N. Porter**

The impact of different pH conditions and the presence of hydrogen peroxide on the ozonation of the organic components of a highly coloured municipal secondary effluent was investigated. The effect on biodegradability and molecular size distribution, and the kinetics of the reduction of the colour, humic acid- and fulvic acid-like matter (the source of the colour), A254, COD and DOC were also determined.

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### PVC Pipes – A Review Of PVC Pipes Sustainability And Performance In Water Infrastructure

**N. Jones**

One of the fundamental differences that define the developed world compared to developing nations is the delivery of clean, safe drinking water to the population and the removal of wastewater. And an absolute key, integral part of that process is a pipeline in which to transport the water. Over the past 50 years, PVC has achieved great success as a dominant material used to produce pipes in most parts of the world. Originally, installed cost, ease of installation and longevity were the prime reasons for the adoption of PVC pipes. More comprehensive sustainability issues have since evolved and the paper describes how PVC pipe manufacturers have responded to these changes.

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### Raising The Bar On Best Practice For Environmental Management Of Sewage Rising Mains

**J. Theobald**

South East Water has a robust program in place to manage the risks associated with managing the sewerage system. The National Water Commission National Performance Report 2009 -10 identifies South East Water as one of the highest performing organisations regarding minimising sewer spills to the environment. Additionally South East Water has focussed on innovative solutions to reduce the impact of sewer spills. For example the organisation was one of the first Australian water companies to introduce surcharge monitoring (Blok-Aids) in its sewerage network. However, sewage spills to the environment still occur and South East Water has worked with EPA Victoria to develop a program to reduce the likelihood and impact from sewer spills.

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### Real Plant Of Co-Digestion Of Food Waste Leachate, Sewage Sludge And Swine Manure Using Up-Flow Anaerobic Sludge Blanket Reactor For Methane Production

**S-K Cho, H.S. Park, M. Y. Lee, K. W. Jung, Y. Choung, E. Jeong, S-K. Cho**

The objective of this study was to evaluate the performances of co-digestion technology using up-flow anaerobic sludge blanket (UASB) reactor and CHP (Combined Heat and Power Generator) in series. The real plant was operated and monitored continuously fed with co-substrate of food waste leachate (25ton/d), sewage sludge (25ton/d) and swine manure (50ton/d). The effect of HRT and OLR was firstly investigated. The results suggested that the optimal operational condition for acid fermenter was around 60days of total HRT, and the methane production was ranged from 80% at over 60days of total HRT to 71% at below 20days of total HRT. The methane fermentation was good and stable as shown by 75% of methane contents and 14.0 m<sup>3</sup>/m<sup>3</sup>.d of biogas production, but a continuous increase of the OLR caused an instant drop in the gas production. During the operation, the average power production ratio of the CHP engine was 2.3 kWh/Nm<sup>3</sup>, and the methane had a calorific value of approximately 8,900 kcal/Nm<sup>3</sup>, as the average methane contents of about 75% was observed. These results strongly suggest that co-digestion technology using UASB reactor is a highly reliable and promising technology for waste treatment and methane production.

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## Removal Of Endotoxins In Water Using Titanium Dioxide Photocatalysis

**H. M. Coleman, C. Marquis, R. Amal**

Photocatalysis and photolysis (using UVA and UVC radiation) were investigated for the removal of endotoxins in water. The *Limulus Amebocyte Lysate* (LAL) assay was used to monitor the endotoxicity. Results showed that photocatalysis is effective for the degradation of endotoxins in water and was much more effective than UV light alone, with rates up to 7 times faster for photocatalysis.

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## Seasonal And Spatial Variations Of Trihalomethanes And Haloacetic Acids In Drinking Water In Seoul, Korea

**K-D. Zoh, J. Lee**

The concentrations of trihalomethanes (THMs) and haloacetic acids (HAAs) were measured in tap water samples passing through water distribution systems of six water treatment plants in Seoul, Korea. The concentration ranges for total THMs (TTHMs) and HAA5 were 3.9–53.5 µg/L and < LOD–49.5 µg/L, respectively. Concentrations (mean ± standard deviation) of total organic carbon (TOC), free chlorine residual, and pH in water samples were 0.95 ± 0.41 mg/L, 0.40±0.17 mg/L, and 7.2±0.2, respectively. Among DBPs, chloroform, bromodichloromethane, dichloroacetic acid, and trichloroacetic acid were the most frequently detected compounds. The highest concentrations of TTHMs and HAA5 were detected in summer due to higher chlorine doses, warmer water temperatures, and higher TOC levels in the summer, whereas the lowest concentrations were detected in winter. Spatial variations in median concentrations of TTHMs and HAA5 in the six water distribution systems were significant ( $P < 0.001$ ). The statistical analysis shows that there were moderate negative correlations between TTHMs and HAA5, with correlation coefficients of  $r = -0.31$  to  $-0.56$  ( $P < 0.001$ ) in five of the six water distribution systems.

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## Sedimentation Of Commercial ZnO Nanoparticles In Different Aqueous Conditions

**Ch Shiung, Y- C Tsai, F-Y. Lin, Y-F .Su, Y-H Shih,**

The aggregation and sedimentation of commercial stabilized zinc oxide (ZnO) nanoparticles (NPs) were investigated to evaluate the mobility of ZnO NPs in aquatic environment because ZnO NPs, one of widely used NPs, could threaten the health of ecosystem and human. The properties of ZnO NPs were characterized using X-ray diffraction (XRD), transmission electron microscopy (TEM) and dynamic light scattering (DLS). The main crystalline structure of the ZnO NPs is wurtzite. From FTIR spectrum, organic capping agents on commercial ZnO NPs could contribute its stability. The point of zero charge (PZC) of the commercial ZnO NPs we used was about pH 10.3. The stability of commercial ZnO NP is independent on its concentration. ZnO NPs trended to settle down when the aqueous pH near its  $pH_{pzc}$ , and remained stable when the solution pH away from its  $pH_{pzc}$ . In stable suspensions, ZnO NPs settled down obviously at NaCl concentrations higher than 10 meq/L. It was attributed to the surface charge of ZnO neutralized by Cl<sup>-</sup> anions. In the presence of low concentrations of Suwannee river humic acid (SRHA), ZnO NPs did not settle down until SRHA concentration increased to 1 mg/L, which were stabilized again in the presence of SRHA of 10 mg/L. In the four aqueous conditions designed by the Taguchi method, ZnO NPs did not settle down in 2 hrs only under an aqueous condition with 5 meq/L NaCl and 1 mg/L SRHA at pH 10.3. These better understandings can facilitate the prediction of NP removal and fate in the aquatic environment.

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### Sensitivity Of Viruses And Bacteria Against UV Light Emitted By Excimer Lamps Reference

**T. Jogi, N. Kamiko, R. Abe, Y. Morimoto, S. Kameda, K. Kasagi**

UV disinfection is generally a low pressure mercury lamp 254nm (LP) is used. In this study, we used excimer lamp which has particular single wavelength like 222nm to compare effect of disinfection with 254nm of LP. We analyzed effect of inactivation against coliphage and E.coli by using 222nm and 254nm. We used three coliphage (MS2, Q, x174) and E.coli (K12) as indicator microorganisms. In addition, photoreactivation of E.coli were examined using a UV lamp 222nm and 254nm. 222nm can be effective inactivation by small UV dose compared to 254nm. Photoreactivation occurred when used E.coli inactivated by 254nm. However, photoreactivation did not occur when exposed to visible light to E.coli inactivated by 222nm. This result suggests that 222nm may have potential as new application of UV disinfection.

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### Sidestream Treatment In Wastewater Treatment Plant With Respect To Global Energy Efficiency

**Laure Graveleau**

Improving energy efficiency for wastewater treatment plant (WWTP) is the priority for new wastewater treatment. In large scale WWTP, anaerobic digestion (AD) is widely used to produce onsite renewable energy source. The tendency is to increase the biogas production by promising technologies (pre-treatment, co-treatment and posttreatment). However, the supernatant from digester is highly concentrated in ammoniac nitrogen, the contribution from the recycled of this sidestream to the plant influent may represent up to 20% of the total nitrogen load. This value is even higher for the sidestream from AD with enhancing digester. In consequence, an intense nitrogen load increases considerably the energy consumption link to aeration during biological treatment and decreases the ratio COD/NTK in raw water, leading to more often external carbon addition for denitrification (especially in case of biofilter). Therefore, a dedicated technique for sidestream treatment is indispensable with respect to energy efficiency. The technique should not only treat the nitrogen load but also have to adapt the particularity of sidestream: high concentration in ammonium, low BOD, chargeable flow and loading. This article presents an evaluation of strategy of sidestream management towards a energy positive WWTP, in particular the sludge digestate treatment process.

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### Sonication For Cleaning Microfiltration Membranes Fouled With Biologically Treated Municipal Effluent

**F. Roddick Y. Hakata, L. Fan**

Sonication and backwashing were compared for restoring the flux of microfiltration membranes fouled with treated municipal effluent. Sonication was shown to be more effective for single and multiple fouling cycles. The components causing hydraulically irreversible fouling were proteinaceous and polysaccharide-like, and sonication effectively detached the fouling layer from the surface as well as loosened the foulants blocking the membrane pores.

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### Sorption Of Bisphenol A And Phenol On Rice Straw Ash In Water

**Yang-hsin Shih, Feng-Yi Lin, Yang-hsin Shih, Ph.D. Taiwan University**

To concern the fate and bioavailability of organic pollutants such as phenolic compounds in the aquatic environment, the sorption behaviors of those chemicals in natural adsorbents like black carbon (BC) play an important role. In this research, the sorption isotherms of phenol and bisphenol A (BPA) on one of BCs, rice straw ash (RSA), were investigated. The sorption amount of BPA on RSA is higher than phenol due to its higher hydrophobicity. As compared to Freundlich model, Langmuir isotherm is a better representative model for phenol on RSA; however, Freundlich model is better for BPA on RSA. For competitive experiments, sorption of phenol on RSA was enhanced by BPA could be due to the bilayer sorption; however, phenol cannot compete with BPA on RSA. These findings could facilitate the prediction of the transport and fate of these organic contaminants in the aquatic environment.

**Yang-hsin Shih, Taiwan University**

## Strategies To Mitigate N<sub>2</sub>O Emissions From Biological Nitrogen Removal Systems: A Review

**S Vlaeminck, J. Desloover, P. Clauwaert, W.Verstraete, N. Boon**

Joachim Desloover, Siegfried E. Vlaeminck, Peter Clauwaert, Willy Verstraete and Nico Boon N<sub>2</sub>O emissions from the biological treatment of nitrogenous liquid waste streams comprising sewage, manure, landfill leachates and industrial effluents have gained considerable interest among policy makers and environmental scientists. Estimated global emissions rates from these sources contribute up to 10% of the anthropogenic N<sub>2</sub>O emissions. Particularly at the level of a treatment plant, the N<sub>2</sub>O impact can be very significant and reach up to 80% of the operational CO<sub>2</sub> footprint. Imperfect nitrification by an imbalance in the two-step nitrification metabolism of ammoniaoxidizing bacteria is considered as the main contributor to N<sub>2</sub>O production with hydroxylamine and particularly nitrite as key precursors, and monitoring of these compounds is warranted to understand and abate N<sub>2</sub>O emissions. In this review poster, the focus is on mitigation strategies, which should comprise optimisations of the process parameters as well as bio-augmentative approaches empowered to restore the functional capacity and to deal with unwanted accumulation of intermediates. For BNR plant operators, the ultimate output of the ongoing N<sub>2</sub>O research is a clear overview of guidelines aiming at minimal N<sub>2</sub>O emissions. Therefore, possible mitigation measures are discussed. The main focus of N<sub>2</sub>O mitigation is prevention of its emission, which can be accomplished by minimizing N<sub>2</sub>O production and, if it is formed, maximizing *in-situ* N<sub>2</sub>O consumption.

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## The Effect Of H<sub>2</sub>S On N<sub>2</sub>O Accumulation During Denitrification

**Yuting Pan, Liu Ye, Zhiguo Yuan**

A series of batch experiments were conducted to assess the potential inhibitory effects of sulfide on nitrate, nitrite and N<sub>2</sub>O reduction by a methanol utilizing denitrifying culture. Hydrogen sulfide was found to be strongly inhibitory to N<sub>2</sub>O reduction, with 50% inhibition observed at an H<sub>2</sub>S concentration of 0.02 mg H<sub>2</sub>S-S/L. In comparison, nitrite reduction was inhibited by 34% at 1.5 mg H<sub>2</sub>S-S/L, while nitrate reduction was not affected by H<sub>2</sub>S at up to 2 mg H<sub>2</sub>S-S/L (the highest concentration studied). N<sub>2</sub>O accumulation was observed during nitrite and nitrate reduction at 0.23 and 1.0 mg H<sub>2</sub>S-S/L, respectively. The results also showed that hydrogen sulfide (H<sub>2</sub>S), rather than sulfide, was the true inhibitor.

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## Water Purification And Hydrogen Generation Using Novel Visible-Light Activated Ag<sub>3</sub>PO<sub>4</sub>-Pt Photocatalyst

**L Liu, J. Liu, D. D. Sun**

Ag<sub>3</sub>PO<sub>4</sub> was recently reported to be a new and high efficient visible-light photocatalyst for water splitting and dye decomposition. In this work, we have developed a novel photocatalyst in terms of Ag<sub>3</sub>PO<sub>4</sub> and platinum nanoparticles (Ag<sub>3</sub>PO<sub>4</sub>-Pt). The new Ag<sub>3</sub>PO<sub>4</sub>-Pt composite exhibited high photocatalytic activity towards the removal of organic dye under visible light irradiation, 100% removal within 3 min, which was higher than that of bare Ag<sub>3</sub>PO<sub>4</sub>. The disinfection results showed that this novel composite could accelerate the bacteria decomposition under visible light irradiation. Moreover, this novel composite was supposed to achieve water splitting and hydrogen generation under visible light irradiation. All these make Ag<sub>3</sub>PO<sub>4</sub>-Pt a promising photocatalyst in the fields of water purification and clean energy production.

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**PENTAIR**

# MAXIMIZE WASTE-TO-ENERGY WITH MEMBRANES

## **X-FLOW** ANAEROBIC MBR

Pentair X-Flow supplies membrane technology for anaerobic MBR systems that maximize the renewable energy production from wastewater while producing superb quality effluent that can be reused or discharged directly to the sewer. With an efficiency of 98 - 99 percent, the combination of anaerobic biological treatment and membrane separation offers the highest waste-to-energy ratio on the market.

### **KEY FEATURES**

- Increased biogas production
- Compact and flexible design
- Reduced discharge costs
- Reduced post treatment costs
- Easiest membrane cleaning and maintenance
- Long membrane life



[WWW.X-FLOW.COM](http://WWW.X-FLOW.COM)





## Leading-Edge Technology

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