INTERNATIONAL OZONE ASSOCIATION

European African Asian Australasian Group

INTERNATIONAL CONFERENCE & EXHIBITION

EA3G2016

26 – 28 October 2016, Swansea, United Kingdom

OZONE AND ADVANCED OXIDATION FOR THE WATER – ENERGY – FOOD – HEALTH NEXUS

Host

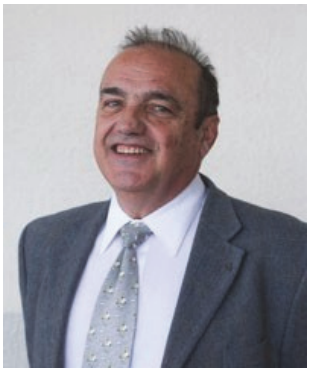
Swansea University
Prifysgol Abertawe

General sponsor

suez

PROGRAMME
BOOK OF ABSTRACTS

WELCOME ADDRESS



The European African Asian Australasian Group of the International Ozone Association presents its 2016 International Conference & Exhibition on Ozone and Advanced Oxidation for the Water – Energy – Food – Health Nexus.

This event was organised to be held in Swansea thanks to the collaboration with the College of Engineering, Swansea University, UK.

EA3G2016 continues a long series of successful conferences organised to provide an international forum for all concerned with fundamental, engineering and applied aspects of oxidation techniques involving ozone and related oxidants.

Although the water sector remains the largest user of ozone and related oxidants, other applications in the food, industry and health sectors are also growing. Advances in ozone and related oxidants address conventional and emerging water and environmental issues (e.g. DBPs, emerging contaminants, pharmaceuticals, EDCs) as well as air & soil remediation. Research in these areas continues to advance and new applications continue to emerge. We wish to address in this conference the question how ozone and advanced oxidation can play a significant role in the nexus water-energy-food-health.

This event will provide an overview of the current state of knowledge and latest advances regarding the use of Ozone and Advanced Oxidation for providing sustainable solutions to a range of significant societal issues related to water, food, health, and the environment. The conference will also focus on innovative applications of ozone and AOPs.

We would like to express our gratitude and thanks to all of you who contributed to make this event possible:Swansea University staff under the leadership of Dr. Chedly Tizaoui, authors, exhibitors, sponsor, Association' members, chairpersons and members of the Committees.

We wish you a very enjoyable and fruitful Conference.

On behalf of the IOA-EA$_3$G Organising Committee

Santiago Esplugas
IOA-EA$_3$G President

> The Organizer

IOA

The International Ozone Association is a non-profit organization dedicated to the development of educational and scientific activities to respond at the best to the needs of industry and research community in the field of ozone and derived oxidants. Since its foundation in 1973, the IOA is at the forefront in connecting professionals around the globe involved and interested in ozone-related issues including scientists, researchers, engineers, system designers, technologists, equipment manufacturers, consultants, users and members of governmental agencies. Typical topics covered in the activities program are ozone generation, secondary oxidant generation, gas mass transfer, chemical reactions of ozone in gas and liquid phases, engineering aspects, water treatment for disinfection and pollutants removal, oxidation for food processing, for pulp bleaching, for products manufacture and conditioning, development of analytical procedures and materials, development of equipments for ozone use, development and applications of advanced oxidation processes, safety and health effects. The EA$_3$G group of IOA manages IOA membership in Europe, Africa, Asia and Australasia.

For more information, please visit www.ioa-ea3g.org/

> The Host

Swansea University

Swansea University is a research-led university that has been making a difference since 1920. The University community thrives on exploration and discovery, and offers the right balance of excellent teaching and research, matched by an enviable quality of life. The University has enjoyed a period of tremendous growth, and we have achieved our ambition to be a top thirty research University, soaring up the 2014 Research Excellence Framework league table to 26th in the UK from 52nd in 2008. Additionally, an ambitious Campus Development Programme is well underway – one of the largest knowledge economy projects in the UK and within the top five in Europe. It involves the creation of the Bay Campus, a brand new £450 million development on the eastern approach to the city, together with the transformation of our existing Singleton Park Campus. Swansea's multicultural dual-campus community provides a global perspective and opportunities to gain skills that last a lifetime.

For more information, please visit http://www.swansea.ac.uk/

COMMITTEES

> Programme Committee

Pr. Michel Roustan | Emeritus Professor, INSA Toulouse, France
Dr. Sylvie Baig | Head of scientific innovation, Suez, France)
Prof Latifa Bousselmi | CERTE, Tunisia
Pr. Santiago Esplugas | University of Barcelona, Spain
Pr. Nigel J.D. Graham | Imperial College London, UK
Mr. Mickael Oneby | Project manager, MWH Global, USA
Dr Nigel Parker | Onnic International, UK
Dr. Jean-Stéphane Pic | Assistant Professor, INSA Toulouse, France
Dr. Achim Ried | Chief engineer, Xylem, Germany
Dr Chedly Tizaoui | Swansea University, UK
Dr. Frédéric Violleau |Teacher Researcher, Ecole d'Ingénieurs de Purpan, France
Dr Hector Valdes | University of Concepcion, Chile

> Organising Committee

Alain Lasalmonie, France | IOA-EA3G Secretary-Treasurer
Dr. Sylvie Baig | Head of scientific innovation, Suez, France)
Pr. Santiago Esplugas | University of Barcelona, Spain
Dr Chedly Tizaoui | Swansea University, UK

SPECIAL ACKNOWLEDGEMENTS AND CONTRIBUTIONS

The success in the organization of this event results from the strong and faithful involvement of many individuals, from the support of companies and from the generous contribution of Suez as general sponsor of the conference.

The Organizers would like herewith to acknowledge the support given by the following partners:

Swansea University
Prifysgol Abertawe

University of Swansea
Conference host

www.swansea.ac.uk/

suez

www.ozonia.com
www.suez-environnement.fr/

SUEZ (Ozonia)
General Sponsor / Exhibitor

SUEZ's ozonia® ozone technology portfolio includes products from laboratory scale units to the largest ozone systems ever built. From our company's roots in Switzerland, we have been the ozone industry pioneer for over 25 years. Suez uses our extensive ozone technology experience to provide the industry's most reliable and robust products. Our unique ability to deliver systems with the highest operational and safety standards is why thousands of customers in every part of the world have chosen ozonia® ozone systems.

AirSep
A Chart Industries Company

www.airsep.com

AirSep Corp. –A chart Industries company
Exhibitor

AirSep Corporation – A Chart Industries Company, offers innovative, non-cryogenic oxygen supply solutions as an alternative to cylinder or liquid supplies. By providing an unlimited supply of oxygen on-location, an AirSep Oxygen Generator eliminates regular oxygen deliveries. AirSep offers a large selection of systems including, standard oxygen generators, self-contained oxygen generators, packaged systems and VPSA oxygen plants. AirSep's products maximize ozone generator performance and can be used in a wide range of applications such as water and wastewater treatment.

ET enviro technology services

www.et.co.uk

Enviro Technology Services
Exhibitor

Enviro Technology Services are leading suppliers of Air Quality Monitoring equipment including analysers for the measurement of Ozone in Ambient Air and for Process Control Applications.

STATIFLO

Exhibitor

www.statiflo.com

Statiflo is the world's leading company for the development and application of static mixing technology for the water industry. Products include pipeline mixers, channel mixers and gas dispersion systems which have been proven to be the premium system for dissolving large volumes of Ozone into water. Applications include: disinfection, pesticide removal, colour, taste & odour removal and iron oxidation. Numerous site tests have shown Ozone transfer efficiency to be typically 98% and with the minimal power requirements of the system, this technology offers a very rapid return on investment.With increasing demands on water resources, reuse of municipal effluents has drawn considerable attention and tertiary treatment by ozone is widely accepted as an effective treatment. Statiflo has been fully involved in this development by adapting the successful Statiflo GDS gas dispersion system to transfer large dose rates of ozone at various treatment stages to wastewater plants. The effectiveness of the side stream system combined with the all important contactor mixer in the main stream has resulted in high ozone transfer efficiencies. The side stream flow rates are considerably less than venturi systems and with the low headloss static mixers the overall energy requirements are less resulting in energy savings and greater overall mass transfer efficiencies.

Xylem

Exhibitor

www.xyleminc.com

Wedeco was founded in 1975 in Herford, Germany to develop chemical-free and environmentally friendly water treatment technologies, including ultraviolet light and ozone systems. There are more than 250,000 installed Wedeco systems for UV disinfection and ozone oxidation globally in private, public utility and industrial locations. Wedeco introduced ozone technology in 1988 and has been expanding internationally ever since. UV disinfection systems have a number of applications including water treatment and aquaculture. Ozone disinfection systems have applications in drinking water, wastewater, process water, product polishing, bleaching, ozonolysis / synthesis and deodorization.

About Xylem

Xylem (XYL) is a leading global water technology provider, enabling customers to transport, treat, test and efficiently use water in public utility, residential and commercial building services, industrial and agricultural settings. The company does business in more than 150 countries through a number of market-leading product brands, and its people bring broad applications expertise with a strong focus on finding local solutions to the world's most challenging water and wastewater problems. Xylem is headquartered in Rye Brook, N.Y., with 2013 revenues of $3.8 billion and more than 12,500 employees worldwide. Xylem was named to the Dow Jones Sustainability World Index for the last two years for advancing sustainable business practices and solutions worldwide.

The name Xylem is derived from classical Greek and is the tissue that transports water in plants, highlighting the engineering efficiency of our water-centric business by linking it with the best water transportation of all — that which occurs in nature.

GENERAL INFORMATION

> Language

The official language will be English.

> Conference venue

The Conference venue will be the new Bay Campus, College of Engineering, Swansea University.

Swansea University
Bay Campus
Fabian Way
Crymlyn Burrows
Swansea SA1 8EN
Wales, UK

Tel. +44 (0)1792 205678 Minicom +44 (0)1792 513100
Web: www.swansea.ac.uk/

> Registration categories

There are 8 categories of registration with associated fees as follows:

- IOA Member - Full registration
- Non-member - Full registration
- Member Student - Full registration
- Non-member Student - Full registration
- One-day registration – Member, 26 or 27October
- One-day registration - non-Member, 26 or 27October
- Conference dinner
- Technical Tour

The full registration fee covers scientific sessions, electronic proceedings, abstracts book, lunches and refreshments.
A special discount rate is available for IOA members. Valid student ID is required for student registration. Additional registration is required for the Conference dinner and technical tour. This is opened to accompanying person.

> Welcoming desk

It will be opened during the conference as follow:

- • Wednesday, October 26 07:00 – 18:00
- • Thursday, October 27 08:30 – 18:00

> Badges

The wearing of a badge is compulsory during the conference. They are necessary to access all scientific sessions, exhibition and lunch room.

> Coffee breaks & Lunch

Complimentary coffee and drinks will be available at the scheduled break times.
Each day, lunch will be offered in the same building as the conference.

> Liability and insurance

Registration for the Conference implies that the delegate agrees that neither the Organizers assume any liability whatsoever. Delegates are requested to make their own arrangements for medical, travel and personal insurance.

> Disclaimer

The Organizers may at any time, with or without giving notice, in their absolute discretion and without giving any reason, change the Conference programme and withdraw any invitation to attend. In any case, neither the organizers nor any of their officers employees, agents, members or representatives shall be liable for any loss, liability, damage or expense suffered or incurred by any person, nor will they return any money paid to them in connection with the Conference unless they are satisfied not only that the money in question remains under their control, but also that the person who paid it has been unfairly prejudiced (as to which the decision shall be in their sole and unfettered discretion, and when announced, final and conclusive).

GENERAL PROGRAMME

The conference will include:

- 2-day scientific and technical sessions including keynote lectures, oral presentations, poster with 1-slide presentations, and discussions,
- Key lectures and speakers
  - Water Energy Food and Health Nexus by Prof. Geoff Maitland Imperial College London
  - Ozone and Advance Oxidation Processes to Provide Sustainability for Water Systems by Dr. Saad Y. Jasim, P.Eng., Manager, Utilities, City of White Rock, British Columbia, Canada
  - Ozone as active substance under the Biocidal Products Regulation by Bernhard Paolini, Chairman of EurO3zon
- 2-day exhibition of ozone related products and services,
- 1-day technical tour,
- Conference dinner and Awards ceremony for delegates and their guests.

Wednesday 26 October		
7h00-9h00	Registration	
9h00-10h00	Opening session	
10h00-11h00	Session 1. Focus Water	
11h00-11h30	Coffee break	
11h30-12h50	Session 1 Cont'd. Focus Water	
12h50-14h00	Lunch	Exhibition
14h00-15h40	Session 2. Focus Food and Health	
15h40-16h10	Coffee break	
16h10-17h00	Session 2 Cont'd. Focus Food and Health	
17h00-17h50	Session 3. Focus Energy	
20h00	Conference dinner at The Morgans Hotel	
Thursday 27 October		
9h00-11h00	Session 4. In Water Treatment System	
11h00-11h30	Coffee break	
11h30-11h45	Session 4 Cont'd. In Water Treatment System	
11h45-12h25	Session 5. Ozone and Advanced Oxidation Process	
12h30-14h00	Lunch	Exhibition
14h00-15h40	Session 5 Cont'd. Ozone and Advanced Oxidation Process	
15h40-16h10	Coffee break	
16h10-17h10	Session 5 Cont'd. Ozone and Advanced Oxidation Process	
11h30-12h00	Closing session and Award Ceremony	
Friday 28 October		
9h00-18h00	Technical tour Steanbow Farm, Pilton, Shepton Mallett , Somerset Lunch in a local pub Centre for Sustainable Aquatic Research (CSAR), Bay Campus Centre	

> Publications and scientific awards

To encourage young researchers, the Programme Committee will select and award a prize to the best paper presented by a doctorate student during the Conference.

All accepted papers will be printed in the conference proceedings that will be handed out to participants at registration. After the conference, the editors of the Ozone: Science & Engineering Journal will make the final selection among the papers presented for possible publication in this IOA peer-reviewed journal.

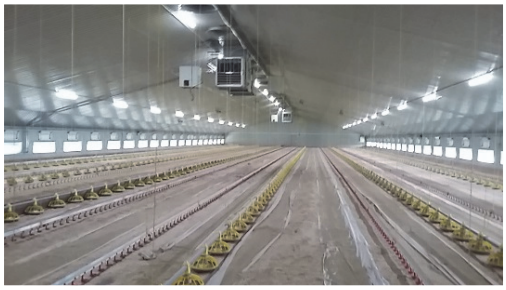
> Conference dinner and show - Wednesday 26, 20h00

A conference dinner & drinks reception with local entertainment will be proposed to delegates on Wednesday 26 October at the Morgans Hotel.

Morgans Hotel is now a luxurious boutique hotel located in the beautiful maritime quarter only moments away from the city centre and stunning Mumbles & Gower coastline. Housed in a grade II* listed building previously home to the port authority Morgans used to be the heart of Swansea's thriving harbour industry.

> Technical Tour at – Friday 28, full day

Steanbow Farm, Pilton, Shepton Mallett, Somerset



The Steanbow Farm hosts over 50,000 chicks. The farm uses the Airedox purification processes to deliver ozone to purify the feed, air and water supplies.

The ozone treatment lowers the pathogenic bacterial contamination, which reduces the need for antibiotics, and improves the feed conversion ratio.

This visit will demonstrate ozone use in chicken farming and will provide an excellent opportunity to see yet another fascinating application of ozone.

Lunch in a local pub

Centre for Sustainable Aquatic Research (CSAR), Bay Campus Centre

The Centre for Sustainable Aquatic Research, CSAR, provides research and technological development in the aquaculture sector with areas of specialty overarching themes of: food and fuel security, low carbon technologies, climate change research and blue biotechnology.

CSAR operates from state-of the-art, controlled environment facilities in Swansea University equipped with modern, fully programmable recirculating aquaculture systems and benefitting from a modern ozone-sterilised water intake and discharge.

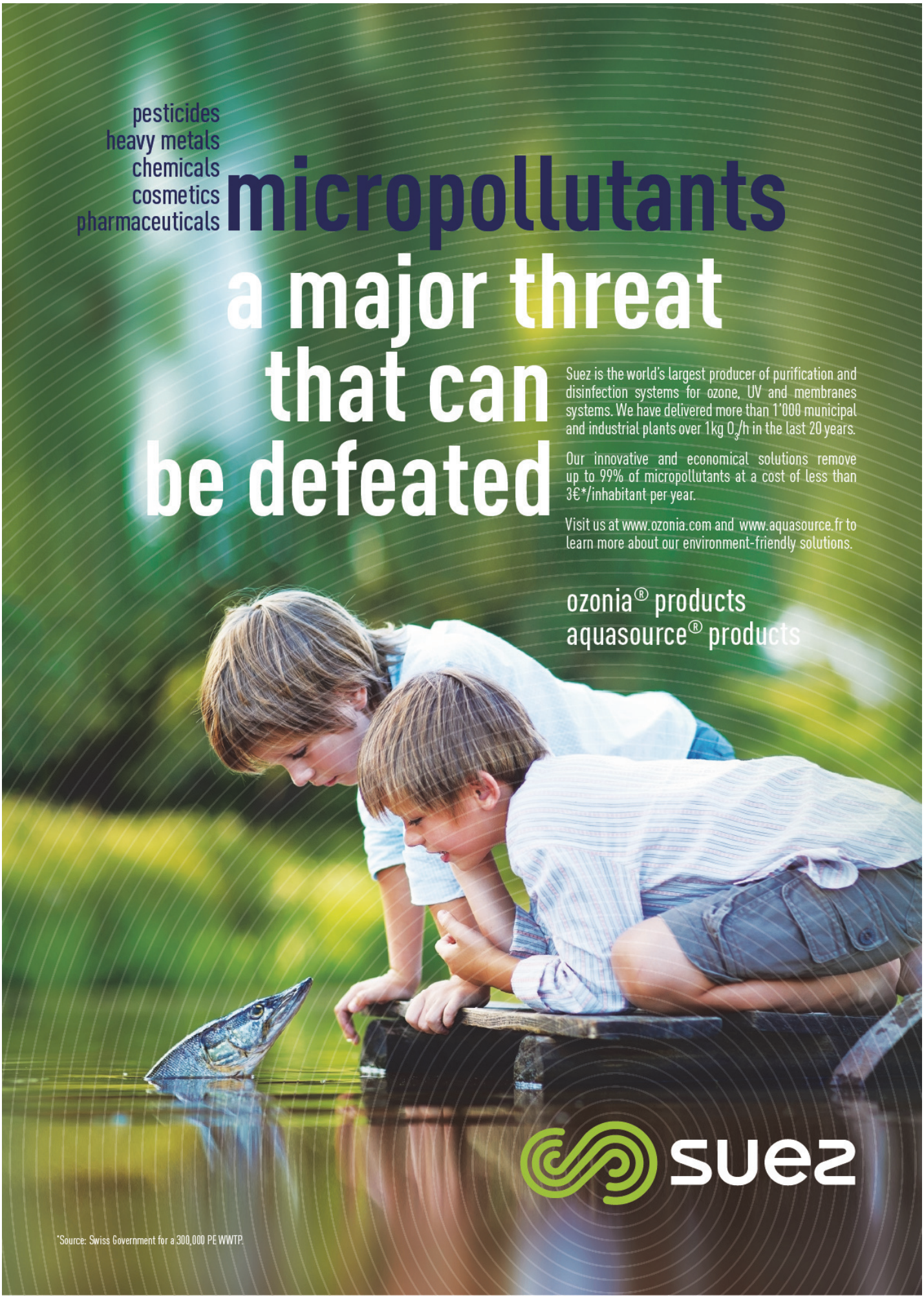
> Enjoy your stay in Swansea

Swansea is Wales' Waterfront City, second largest city and the twenty-fifth largest city in the UK. It sits on the sandy 5 mile stretch of Swansea Bay beach and is a great base for exploring the best of South-West Wales, UK. Swansea lies within the historic county boundaries of Glamorgan. The county area includes the Gower Peninsula and the Lliw uplands. The City Centre is a vibrant hub offering numerous attractions, over 230 shops and a fabulous market that's home to all sorts of local delicacies.

Places to visit particularly include:

- The Dylan Thomas Centre, Swansea Museum and the National Waterfront Museum, Swansea Castle,
- Many parks and gardens (Clyne Gardens, Singleton Botanical Gardens, Victoria Park, Cwmdonkin Park and Brynmill Park),
- And Swansea Bay, Mumbles and Gower.

The organizing Committee encourage conference participants to discover Swansea and its area. Many opportunities of sightseeing tours can be found at www.visitswanseabay.com/destinations/swansea/


pesticides
heavy metals
chemicals
cosmetics
pharmaceuticals
micropollutants
a major threat
that can
be defeated
Suez is the world's largest producer of purification and disinfection systems for ozone, UV and membranes systems. We have delivered more than 1'000 municipal and industrial plants over 1kg O_3/h in the last 20 years.
Our innovative and economical solutions remove up to 99% of micropollutants at a cost of less than 3€*/inhabitant per year.
Visit us at www.ozonia.com and www.aquasource.fr to learn more about our environment-friendly solutions.
ozonia® products
aquasource® products
suez
*Source: Swiss Government for a 300,000 PE WWTP.

SCIENTIFIC AND TECHNICAL PROGRAMME

Wednesday 26 October

7h00-9h00	**Registration, exhibition**	
9h00-10h00	**Opening session**	
9h00-9h20	**Welcome and opening address** *Prof. Santiago Esplugas, IOA-EA$_3$G President* **Ozone for Water Energy Food and Health** *Dr. C. Tizaoui, Swansea University*	
9h20-10h00	**Key note lecture** **Water Energy Food and Health Nexus** *Prof. Geoff Maitland, Imperial College London*	
10h00-11h00	**Session 1. Focus Water**	
10h00-10h40	**Key note lecture** **Ozone and Advance Oxidation Processes to Provide Sustainability for Water Systems** *Saad Y. Jasim (Canada)*	
10h40-11h00	**Influence Of Secondary Effluent Quality On Micropollutants Removal At Full-Scale Ozonation Tertiary Treatment** *Ywann Penru, Cécile Miège, Matthieu Masson, Clement Cretollier, Amandine Roussel-Galle, Amélie Guillon, Mar Esperanza, Sylvie Baig, Samuel Martin Ruel, Marina Coquery, Jean Marc Choubert (France)*	
11h00-11h30	**Coffee break, poster session and exhibition**	Exhibition
11h30-12h50	**Session 1 Cont'd. Focus Water**	
11h30-11h50	**Advances of catalytic ozonation and engineering applications in water treatment** *Da Wang, Xinwang Liu, Jun Ma (China)*	
11h50-12h10	**The ozone process in potable water reuse applications** *Michael Oneby, Erin Mackey, Wendy Broley (USA)*	
12h10-12h30	**Ozone for micropollutants control and disinfection within indirect water reuse management: Lausanne WWTP** *Sylvie Baig, Sylvain Donnaz, Christophe Mechouk, Gregor Maurer, Olivier Français, Adriana Gonzalez Ospina, Jean-Michel Grenaingaire, Jéromine Albertini (France, Switzerland)*	
12h30-12h50	**The role of Soil Aquifer treatment (SAT) for effective removal of organic matter, micropollutants and micro-organisms from ozonated secondary effluents** *Anat Lakretz, Haim Chikurel, Elena Gelman, Inbal David, Ines Zucker, Dror Avisar, Hadas Mamane (Israel)*	
12h50-14h00	**Lunch, poster session, exhibition and networking**	
14h00-15h40	**Session 2. Focus Food and Health**	
14h00-14h40	**Ozone as active substance under the Biocidal Products Regulation** *Bernhard Paolini, Tim Pühmeier, Jörg Mielcke, Matthias Rothe, Matthias Hoffmann, Jaak Ryckeboer (Switzerland, Germany)*	
14h40-15h00	**Closing three vectors of poultry disease by controlled oxidation** *Martyn Jutsum, Tristan Cogan (UK)*	
15h00-15h20	**Ozone as final facility sanitizer in Parma Ham processing** *Gabriele Fortini, Claudia C. Cardoso, Fabio Senese (Italy)*	Exhibition
15h20-15h40	**Ozonation degree of vegetable oils as the key factor of their anti-inflammatory and wound healing effectiveness** *Pamela Guerra Blanco, Arizbeth Pérez Martínez, Yolanda Gómes y Gómes, Ma. Esther Bautista, Tatyana Poznyak, Isaac Chairez (Mexico)*	
15h40-16h10	**Coffee break, poster session and exhibition**	
16h10-17h10	**Session 2 Cont'd. Focus Food and Health**	
16h10-16h30	**Ozonized sunflower oils properties: influence of water addition during ozonolysis** *Sophie Moureu, Frédéric Violleau, Djamila Ali Haimoud-Lekhal, Anne Calmon (France)*	
16h30-16h50	**Greenhouses for food production and the environment** *Abdeen Mustafa Omer (UK)*	
16h50-16h55	**Ozone generators for bubbling of physiological solutions** *Tatiana Barkhotkina, Roman Tomashevskyi, Mykola Makhonin (Ukraine)*	Exhibition
16h55-17h00	**Gaseous ozone abatement using transition metal modified natural zeolite** *Francisco Ulloa, Héctor Valdés, Víctor Solar, Manuel Cepeda (Chile)*	

17h00-17h50	**Session 3. Focus Energy**	Exhibition
17h00-17h20	**Cooling conditions of ozone generators** *Nicole Brueggemann, Tim Puehmeier, Ralf Fiekens, Franz-Josef Richardt, Manfred Salvermoser (Germany)*	
17h20-17h40	**Adding years to your existing ozone equipment** *Nick Burns, Troy Hall (USA)*	
17h40-17h45	**A new oxidation process using ozone to regenerate coked catalysts** *Romain Richard, Carine Julcour, Marie-Hélène Manero (France)*	
17h45-17h50	**A microbubble plasma reactor for pretreatment of lignocellulosic biomass** *Junchen Ren, Matteo Taglioli, Alexander Wright, Hemaka Bandulasena, Felipe Iza (UK)*	
20h00	**Conference Dinner**	

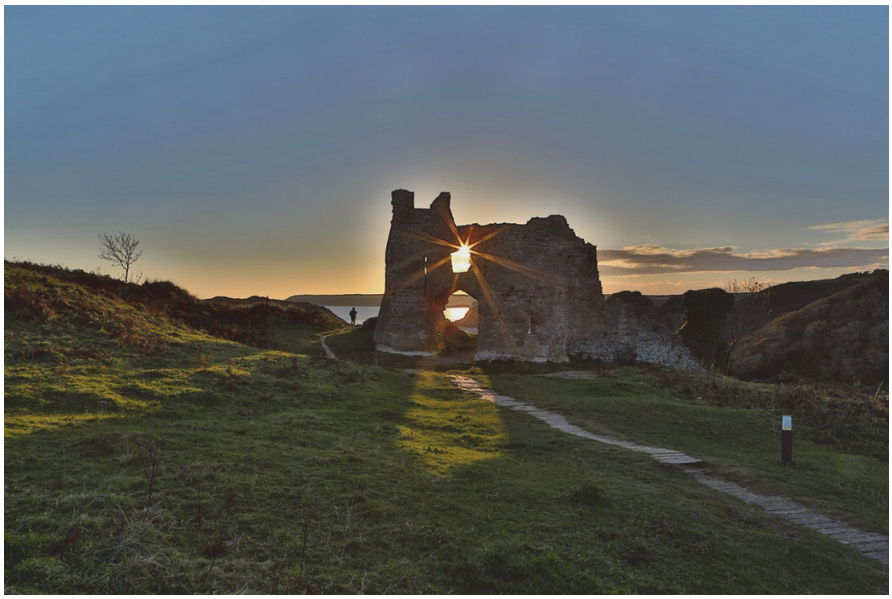
Thursday 27 October

9h00-11h00	**Session 4. In Water Treatment System**	Exhibition
9h00-9h20	**Integration of ozonation and biological treatment of industrial wastewater from dye house** *Stanislaw Ledakowicz, Renata Zylla, Katarzyna Pazdzior, Julita Wrębiak, Jadwiga Sójka-Ledakowicz (Poland)*	
9h20-9h40	**Synergetic biological and chemical ozone oxidation for micropollutants removal from wastewater** *Bruno Domenjoud, Adriana Gonzalez Ospina, Emmanuelle Vulliet, Sylvie Baig (France)*	
9h40-10h00	**Advanced online control for ozone-enhanced biologically active filtration system for municipal water reuse** *Tony Zhang, Dean Berkebile, Achim Ried, Keel Robinson (Germany)*	
10h00-10h20	**Application of ozone assisted membrane cleaning for nom fouled graphene enhanced polyvinylidene fluoride membranes** *Regina Khayrullina, Chedly Tizaoui, Chris Spacie (UK)*	
10h20-10h40	**Ozone cleaning of natural organic matter fouled hybrid poly(vinylidene) fluoride/carbon nanotubes membrane** *Jono Suhartono, Chedly Tizaoui (UK)*	
10h40-11h00	**Ozonation as part of integrated water management system in petrochemical plant** *Sarah Chéret, Sylvie Baig (France)*	
11h00-11h30	**Coffee break, poster session and exhibition**	
11h30-11h50	**Session 4 Cont'd. In Water Treatment System**	Exhibition
11h30-11h35	**Basic batch reactor ozonation experiments and modelling of non-porous ozone resistant membranes for water treatment** *Caitlin M. Taylor, Matthew J. Berry, William King, Davide Mattia, Y.M. John Chew, Jannis Wenk (UK)*	
11h35-11h40	**Extending the range of micro-pollutants removed using a continuous process of adsorption coupled with electrochemical regeneration** *N.W. Brown, M.A. Nabeerasool, B.E. van Dongen, D.A. Polya, N. de las Heras, M. Conti-Ramsden, K. Nkrumah-Amoako (UK)*	
11h40-11h45	**Application of advanced oxidation processes and membrane technologies for tertiary treatment of domestic sewage** *Tatiane Benvenuti, Caline Gally, Carolina Bittencourt, Andréa M. Bernardes, Jane Zoppas-Ferreira (Brazil)*	
11h45-12h25	**Session 5. Ozone and Advanced Oxidation Process**	Exhibition
11h45-11h50	**Advanced oxidation of phenylphenol isomers in O_3/UVC system** *Magdalena Olak-Kucharczyk, Stanisław Ledakowicz (Poland)*	
11h50-11h55	**Kinetic study of nitrate removal on bipolar boron doped diamond (bdd) electrode** *Mouna Ghazouani, Hanene Akrout, Seifeddine Jomaa, Salah Jallali, Latifa Bousselmi (Tunisia, Germany)*	
11h55-12h00	**Impacts of suspended solids, water temperature and dilution on TROC elimination and UVA254 reduction by laboratory scale ozonation of secondary effluent** *Michael Stapf, Inga Hilbrandt, Ulf Miehe, Martin Jekel (Germany)*	
12h00-12h05	**Using advanced oxidtion proceses to remove coffee stains from porous flooring** *Rhys Lewis, Chedly Tizaoui (UK)*	
12h05-12h10	**Ozone treatment of indigo carmine dye wastewater in a plug flow reactor** *Edward Lester-Card, Chedly Tizaoui (UK)*	
12h10-12h15	**Towards the optimal process configuration for emerging pollutant and enhanced nitrogen and phosphorus removal** *M.J.C. van den Braak, S.M. Scherrenberg, J.D. Boorsma*, (The Netherlands)	

11h50-12h25	**Session 5 Cont'd. Ozone and Advanced Oxidation Process**	Exhibition
12h15-12h20	**Pyrite as iron source for polymeric dye decolourization by electro-fenton process** *Bakhta Bouzayani, Jessica Meijide, Sourour Chaâbane Elaoud, Marta Pazos, María A. Sanroman (Spain, Tunisia)*	
12h20-12h25	**Non thermal plasma for pharmaceuticals removal in water** *Kay Tor, Chedly Tizaoui (UK)*	
12h30-14h00	**Lunch, poster session, exhibition and networking**	
14h00-15h40	**Session 5 Cont'd. Ozone and Advanced Oxidation Process**	Exhibition
14h00-14h20	**Inactivation of bacteria in final sewage treatment work effluents** *A. Wright, B. Uprety, M.Mach, F. Iza, G Shama, H. Bandulasena (UK)*	
14h20-14h40	**Two-phase ozonation of for the removal of estrone, 17β-estradiol and 17α-ethinylestradiol in water using ozone-loaded Decamethylcyclosiloxane** *S. Ben Fredja, R.T. Novarovskib, C. Tizaouic, L. Monsera (Tunisia)*	
14h40-15h00	**Application of ozone on Activated Sludge: Micropollutant removal and sludge quality** *M. Marce, O. Palacios, A. Bartolomé, J. Caixach, S.Baig, S.Esplugas (Spain, France)*	
15h00-15h20	**Enhancement of micropollutant removal in urban wastewater using catalytic ozonation** *C. Crousier, J.-S. Pic, J. Albet., S.Baig, M.Roustan (France)*	
15h20-15h40	**Effect of SO_4^{-2} and Cl^- ions on the catalytic ozonation of phenolic compounds in the presence of the CeO_2 film and suspension** *Ivette C. Gúzman, Julia L. Rodríguez S., Tatiana Poznyak, Isaías Hernández P., Isaac Chairez (Mexico)*	
15h40-16h10	**Coffee break, poster session and exhibition**	
16h10-17h10	**Session 5 Cont'd. Ozone and Advanced Oxidation Process**	Exhibition
16h10-16h30	**A comparative study on the performance of different advanced oxidation processes for diethyl phthalate removal** *Lobna Mansouri, Sven-Uwe Geissen, ChedlyTizaoui, Latifa Bousselmi (Tunisie, Germany, UK)*	
16h30-16h50	**Cost estimation of AOP to remove a priority pollutant: 1,4-dioxane** *Helen Barndõk, Daphne Hermosilla, Noemi Merayo, Carlos Negro, Ángeles Blanco (Spain)*	
16h50-17h10	**Pyridinium-based ionic liquid degradation by heterogeneous electro-Fenton process** *Jessica Meijide, Marta Pazos, María A. Sanroman (Spain)*	
17h10-17h30	**Closing session and Winners announced**	

Friday 28 October

9h00-18h00	**Technical tour with lunch** **Steanbow Farm, Pilton, Shepton Mallett , Somerset** **Lunch in a local pub** **Centre for Sustainable Aquatic Research (CSAR), Bay Campus**



KEY NOTE SPEAKERS

Dr Tizaoui (PhD, CEng, FICHEME, FHEA) has research interests in the development of novel water and wastewater treatment technologies based on oxidation and advanced oxidation processes (AOPs). This includes ozonation, UV radiation, non-thermal plasma, photocatalysis and catalytic processes. He researches and applies these processes to eradicate potentially hazardous contaminants such as emerging contaminants and endocrine disrupting chemicals (EDCs) (e.g. pharmaceuticals, personal care products, hormones, etc.), landfill leachates, pesticides, textile dyes, heavy metals etc. As a Chemical Engineer, he is particularly interested in the analysis and design of these treatment technologies, looking at fundamental understanding of reaction kinetics, mass transfer, and the performance of various reactor designs. His research also spans over a range of physical water treatment processes including membranes, nanotechnology, filtration and coagulation/flocculation and have been working on the development of novel chemical-free treatment processes and hybrid ozone/membrane systems for water production. He has also applied ozone in areas beyond water treatment including food, to increase the shelf life of produce, and wound healing, to develop an ozone-based wound dressing. Dr Tizaoui's research has been widely published in peer-reviewed scientific journals and conferences.
URL: http://www.swansea.ac.uk/staff/academic/engineering/tizaouic

Geoff Maitland is Professor of Energy Engineering at Imperial College London and a Past President of the Institution of Chemical Engineers (2014-15). His career has spanned academia and industry, spending 20 years in oil and gas with Schlumberger and over 20 years at Imperial, first as a young lecturer from 1974 and then from 2005 in his current post. His work is centred on how we can continue to use fossil fuels for most of this century without causing catastrophic climate change. Geoff was awarded the Hutchison Medal by the Institution of Chemical Engineers in 1998 and served as President of the British Society of Rheology from 2002-2005. In 2006 he was elected a Fellow of the Royal Academy of Engineering. He was awarded the IChemE Chemical Engineering Envoy Award in 2010 for his media work explaining the engineering issues involved in the Gulf of Mexico oil-spill. He chaired the post-Macondo review of the UK Offshore Oil and Gas Regulatory Regime in 2011 ('The Maitland Report') and in 2012 received the Rideal Lecture Award from the Royal Society of Chemistry. He is the Founding Director of the Qatar Carbonates and Carbon Storage Research Centre, a $70M 10 year programme funded by Qatar Petroleum, Shell and Qatar Science and Technology Park, based at Imperial College London, and is currently Director of the Shell-Imperial Digital Rocks Lab.

Dr. Saad Jasim, P.Eng. is Manager, Utilities for Engineering and Municipal Operations, City of White Rock, British Columbia, Canada.He served as an Acting Research Director and Principal Investigator at the Qatar Environment and Energy Research Institute (QEERI). Before joining QEERI, Dr Jasim was the President of SJ Environmental Consultants (Windsor) Inc. (1993-2005 and 2013-2015) and Adjunct Research Professor at the University of Western University, Canada from 2009. He is also Adjunct Professor, University of Windsor since 1996 and serves on the Editorial Board of Ozone Science and Engineering Journal and on the Editorial Board for Water Process Engineering. He also worked on the Editorial Board of the Desalination Journal from 2009 to 2012. Dr. Jasim served as Director of the Great Lakes Regional Office-International Joint Commission. He managed the operation of the Scientific and Technical programs, initiated strategic partnerships and alliances with the stakeholders. Served as the Founding CEO for the Walkerton Clean Water Centre, developing it to be one of the leading research and training institutes for water treatment in Canada. As Director of Water Quality & Production for the City of Windsor, Canada, following successful pilot scale research he proposed, and successfully implemented Ozone for drinking water treatment, Windsor, Ontario, the first application in that scale in Ontario. He was also the past president of the International Ozone Association-PAG. Saad Jasim received his masters and Ph.D. degrees on Chemical Engineering from the University of Wales in Swansea, UK, and is the recipient of several awards such as the recognition award from the International Network for the Advancement of Water & Wastewater Education (2013) and the Harvey Rosen Award for Best Publication (2011) about Ozone. He supervised PHD and masters students and has many papers in peer reviewed journal publications and international conferences.

Bernhard Paolini
Studies in Process Engineering and later in economy
Before joining the „ozone family" working for three companies in the field of research & development of absorbtion processes, electronics (soft- and hardware) and implementation of new manufacturing technologies.
2001 Start at Suez-Ozonia Switzerland as Vice President Technology
Main successes:

- Development of Ozonias CFV family
- Development of the Ozonia IGS technology
- Development of full IGBT Power supply Units

2009 Joining the Global Management Team of Suez-Ozonia Group as CTO
2013 Chairman of Ozone Registration Group (ORG)
2014 CEO of Suez-Ozonia Switzerland and EMEAI
2015 Chairman of EurO3zon

ABSTRACTS OF PRESENTATIONS

Opening session

Welcome address
Pr. S. Esplugas, IOA-EA3G President

Ozone for Water Energy Food and Health
Dr. C. TIZAOUI, Swansea University (UK)

Ozone for Water Energy Food and Health
Prof. G. MAITLAND, Imperial College London (UK)

Session 1. Focus Water

1.1. Ozone and Advance Oxidation Processes to Provide Sustainability for Water Systems

Dr. S. Y. JASIM (Canada)

The Sustainability of water infrastructure is critical to providing the public with clean and safe drinking water. Sustainability means preparing for future growth, and potential environmental impacts. Climate change is a fact of life, and the current changes in weather and precipitation trends are clear indications. The sustainability of the communities served depends on sustainability planning. There is a need to have an understanding to the value of the investment needed to maintain the sustainability of water infrastructure. Economic growth depends on economic planning and development of robust water and wastewater systems to be able to address the impacts of urban growth, climate change, and development of reasonable risk assessment and risk management plans. Sustainability includes investment in people. The importance of developing and maintaining the capacity in the technical and managerial skills for the water systems authorities and operators is a strategic factor in ensuring long sustainability planning. Acquiring financial assistance for developing water systems should be linked to sustainability planning. Developing partnerships and collaborations with academia, government, industry and the private sector are well defined approaches that proven successful.
The City of White Rock, BC, Canada is in the process of upgrading the water system to include two water treatment plants for arsenic and manganese reduction. An intensive water quality sampling and analysis procedure has started and the City of White Rock is in discussion with the University of British Columbia, Vancouver, BC to start a bench and pilot scale testing which will include different technologies (to be used individually and on a hybrid setup) such as but not limited to; Ozone, Membrane filtration, and Green SandPlus. The research findings will provide the City of White Rock a unique opportunity to select the most effective technologies and water treatment system to meet the goals of the treatment required.

1.2. Influence Of Secondary Effluent Quality On Micropollutants Removal At Full-Scale Ozonation Tertiary Treatment

Y. PENRU, C. MIEGE, M. MASSON, C. CRETOLLIER, A. ROUSSEL-GALLE, A. GUILLON, M. ESPERANZA, S. BAIG, S. MARTIN RUEL, M. COQUERY, J.M. CHOUBERT (France)

Dissemination of chemical substances in the environment is becoming a major issue and wastewater effluents are one the main point sources. The goal of the present work was to determine the performances on micropollutants removal of a recently developed process consisting in ozone contactor followed by a post-denitrification submerged biofilter and the impact of the secondary effluent quality (especially organic matter and nitrite concentration). A full-scale tertiary ozonation unit (600 m^3/h) built at Sophia-Antipolis WWTP was operated under various ozone doses and secondary effluent chemical composition. The groups of micropollutants monitored include pharmaceuticals, hormones and pesticides (domestic uses) with different reactivity toward ozone. Main results show that ozone transfer of 0.4 gO_3/gDOC, achieved high removal of micropollutants with high reactivity toward ozone (carbamazepine, diclofenac for example) when transfer of 0.7 gO_3/gDOC was required to achieve 70% removal of micropollutants with the lowest reactivity toward ozone. Nitrite presence in secondary effluent at concentration up to 0.7 mg NO_2-N/L was demonstrated to have an influence on removal of micropollutants with lowest reactivity toward ozonation when it has no influence on micropollutants with the highest reactivity.

1.3. Advances of catalytic ozonation and engineering applications in water treatment

D. WANG, X. LIU, J. MA (China)

The paper reviewed the advances in catalytic ozonation for the refractory pollutants removal in aqueous solution and its full scale applications in China in the last decade. A summary on catalysts development for ozonation of pollutants in simulated waters in lab is presented. Different types of catalysts have been developed: such as metal oxide, metal or metal oxide on support. The catalytic activities of various catalysts were evaluated on the ozonation of organic pollutants (such as pesticides, EDCs and pharmaceuticals) compared with ozonation alone. The paper also reviewed the effectiveness of catalytic ozonation for treating practical raw waters or wastewaters, including lab experiments, pilot scale and full scale applications.

1.4. The ozone process in potable water reuse applications

M. ONEBY, E. MACKEY, W. BROLEY (USA)

The ozone process, broadly applied in water treatment, has application in the reuse of tertiary effluent from domestic wastewater treatment plants. A powerful oxidant and disinfectant, ozone improves water quality by oxidizing organic and inorganic contaminants. In combination with other unit processes, ozone provides additional treatment train alternatives that meet water quality objectives for potable reuse. There are several bases for using reclaimed water as a potable water supply, including drought, contamination, and population growth. Reuse of wastewater effluent is a viable source of supply if public health can be insured. To date, most advanced treatment of wastewater for potable reuse applications employs full advanced treatment (FAT). FAT is centered on the reverse osmosis (RO) process followed by an advanced oxidation process (AOP). The effluent from an FAT facility is highly pure and free of most constituents. The disadvantages are the cost and biochemical instability of the water. The capital, operating and maintenance cost of FAT is substantial, and the high effluent quality not always necessary to insure public health. Alternative treatment trains employing ozone provide a cost-effective alternative while protecting public health. Regulation and public perception are key factors in determining the treatment objectives from which the treatment train is designed.

1.5. Ozone for micropollutants control and disinfection within indirect water reuse management: Lausanne WWTP

S. BAIG, S.DONNAZ, C. MECHOUK, G. MAURER, O. FRANÇAIS, A. GONZALEZ OSPINA, J.M. GRENAINGAIRE, J. ALBERTINI (France, Switzerland)

The Federal Government of Switzerland has recently addressed a pioneer regulation's program in mid-2014 with regards to the need of treating micro-pollutants to protect water resource in surface waters. The original Swiss ordinance for water protection (October

28th 1998, OEaux; RS 814 201) has been amended to integrate a stage of micro-pollutants in wastewater treatment plants. The Léman's lake, this natural water treasure has always represented a main water resource to supply the Drinking Water Plants (DWP) as early as 1933, in Lausanne for instance. The City of Lausanne, located near the Léman's lake, is producing 73% of its drinking water production from the lake (surface water), with an annual production of 30 million of m^3/year. Around 87 towns and 360,000 inhabitants are supplied by the City water service through 7 drinking water plants. 2 main drinking water plants are using water resource from the lake (fresh water is pumped at around 70 m water depth). As Lausanne wastewater treatment plant does discharge treated water to the Léman's lake, in respect to its interaction with the water resource cycle, Lausanne WWTP is directly concerned by the Swiss ordinance amendment of 2014. At Saint-Sulpice Drinking Water Plant, the nearest plant to Lausanne Vidy WWTP, the bacteriological performance indicator (UFC/mL) does highlight the interaction between the WWTP, the Lake and the sewage treatment works, as well as other parameters studied since decades by the City of Lausanne and the CIPEL association. Therefore, indirect water reuse has historically been a key mechanism in the city of Lausanne to ensure the protection of the environment and the drinking water supply of the population. As part of the main cities around the Léman's lake, the City of Lausanne has been one of the first, since 2009, to implement an ambitious R&D program with regards to micro-pollutants wastewater process removal. These trials were the consequence of the Swiss national scale program called "Stratégie Micropoll" initiated by the Federal government in 2006. In April 2015, after several years of R&D pilot scale testing, the City of Lausanne decided to invest a total of 300 million CHF for the extension and refurbishment of its major WWTP, the biggest WWTP (400,000 PE) to treat micropollutants for a total investment of 60 million CHF.

1.6. The role of Soil Aquifer treatment (SAT) for effective removal of organic matter, micropollutants and micro-organisms from ozonated secondary effluents

A. LAKRETZ, H. CHIKUREL, E. GELMAN, I. DAVID, I. ZUCKER, D. AVISAR, H. MAMANE (Israel)

Soil Aquifer Treatment (SAT).is a well known natural treatment which uses the favorable characteristics of soil, subsoil and aquifer for further treatment of infiltrated effluents for agricultural irrigation or even for Indirect Potable Reuse (IPR). This treatment has been considered to be an efficient and cheap polishing method for secondary or tertiary wastewater effluents used for unrestricted irrigation for around 40 years. Removal of organic matter is a critical parameter in SAT since it also influences the removal of other contaminants like nitrogen compounds, micropollutants and microorganisms. Most of the oxidation processes of organic compounds as well as of nitrogen compounds take place in the unsaturated zone (vadose zone) and for the Shafdan (Israel) SAT system (3-12 months r.t.) that treats 140 MCMY, at intermittent natural aeration of the vadose zone (1 day infiltration and 2 days drying), the consumption of oxygen is 42.5 ± 12 mg/L. This very high oxygen consumption agreed well with the high purification efficiency (around 90% removal of DOC and complete removal of ammonia) in the Shafdan SAT. Besides, the SAT provides efficient physical pathogen removal due to long retention times. In the course of the infiltration of secondary effluents through the bioactive upper SAT layer and the vadose zone, most of the available oxygen is depleted which causes anoxic conditions and mobilization of dissolved manganese from the soil. An additional emerging concern if the water is to be also used for IPR is the removal of persistent trace organic compounds (TrOCs) that may be in small amounts in the reclaimed water. In that case advanced tertiary treatments like (membrane processes, reverse osmosis, advanced oxidation process - ozonation) are recommended. Lately, an innovative hybrid process based on bio-filtration, ozonation and short SAT (sSAT, 22-30 days r,t,) as compared to the above mentioned conventional SAT was proposed for treatment of the Shafdan secondary effluent to overcome limitations of the existing system and to reduce the SAT's physical footprint.

Session 2. Focus Food and Health

2.1. Ozone as active substance under the Biocidal Products Regulation

B. PAOLINI, T. PÜHMEIER, J. MIELCKE, M. ROTHE, M. HOFFMANN, J. RYCKEBOER (Switzerland, Germany)

Ozone is declared an active substance under the EU Biocidal Products Regulation No 528/2012 (BPR) starting as of September 1st, 2013. In effect the BPR is considerably extending scope compared with the prior existing directive. Due to this, the active substance ozone and the ozone generated by a specific piece of equipment need to be authorized. EurO3zon has submitted as of June 5, 2015 an active substance dossier for ozone covering applications defined under biocidal product-types (PT) 2, 4, 5 and 11. The deadline for submitting active substance dossiers was September 1, 2016. Three other parties have submitted ASDs for ozone too. The filing of in minimum one ASD for ozone secures that ozone can be brought to the EU market in the future. However, any party doing so needs to be in accordance with the BPR. Hence it is the main target of EurO3zon to achieve that ozone is approved as active substance and listed in the EU "List of approved active substances". As soon as this is the case – somewhere second half of 2018 to our best estimation - it is then required to apply also for the product authorization of ozone, a biocidal product which is generated on-site. It is important to understand that the word "product" does not mean the ozone generating equipment but the ozone generated by a specific piece of equipment. Only ozone with a product authorization can be brought legally correct to the EU market. This allows the further use of ozone in treatment processes in agreement with the EU law. The product authorization can possibly most effectively be done by the actual manufacturer of such ozone equipment. However also an operator of ozone generating equipment can apply for it. In order to apply for a product authorization an approved active substance dossier must be either owned or legally accessed by a letter of access (LoA). EurO3zon will make Letters of Access (LoA) available to everyone who needs it. One other party, called EUOTA, which has submitted an ASD for ozone too, is known to offer LoAs too.
The ASD from EurO3zon is now under evaluation by the CA of Germany, called BAuA. During this evaluation process it is realized more and more that all the detailed regulation within the approval process are made for stable and less reactive substances. As a consequence EurO3zon is now in a situation to adapt procedures of regulations to ozone in coordination with the CA BAuA. The difficulty here is that all CAs from all EU member states have to agree on this procedure because they have to apply it too.
In addition to the BPR ozone is no also discussed under REACH and it may up that also a REACH approval could necessary in the future. And not only Europe is regulating the use of ozone. We know that also in the US and in China is work in progress, which could also cover the use of ozone.

2.2. Closing three vectors of poultry disease by controlled oxidation

M. JUTSUM, T. COGAN (UK)

Further to clinical trials carried out under a UK Home Office licence at The School of Veterinary Sciences, Langfoed College, University of Bristol during summer 2015, it was decided to follow recommendations to continue and possibly expand treatments across the three perceived vectors of disease infection: To study the effect of the prescribed treatments of controlled multi-phased oxidative treatment to air, feed and drinking water supplies, to gastrointestinal microflora of conventionally hatched (Ross 308) poultry, from day old chicks through a 40 day growth cycle. The chicks are hatched from the same parent stock (aged approximately 40 weeks) and placed in modern designed commercial scale poultry growing houses (barns) approximately 80 Metres by 30 Metres each housing around 42,000 chicks. The ventilation as supplied by draperVENT, air handling units (AHUs) heating incoming air by biomass wood chip fuel, distributing even flowing treated air over the birds giving a constant background concentration of O_3 not exceeding 50 parts per billion (ppb). Ozone systems from draperBIOTECH: A single hub O_3 unit supplying sanitation to both the AHUs and feed lines with a third line supplying the bore hole water both pre-filtration and post-filtration. The process of harvest triggers a natural response in grain to 'bleed' amounts of humic and fulvic acids. These acids provide nutrients for the otherwise

dormant fungal spores. In turn, these spores shed bacteria onto the surfaces of the grain, producing mycotoxins and causing serious infections through livestock consumption. We predict that early treatment will retard the production of the nutrients and immobilise the fungal spores to a point where colonisation of the grain husks becomes unviable.

2.3. Ozone as final facility sanitizer in Parma Ham processing

G. FORTINI, C. C. CARDOSO, F. SENESE (Italy)

The use of chemical disinfectants in the food industry can contribute to their accumulation in the environment. Ozone is a strong antimicrobial agent that safely decomposes to oxygen. It does not leave residues or stimulate pathogen resistance. It can be used in controlled atmosphere to reduce populations of foodborne bacteria, including *L. monocytogenes*. In Parma ham processing, surface sanitation and air purification are very important, mainly in the boning and slicing rooms. The ideal procedure should reach all surfaces and critical points in a homogenous form. Ozone in the gaseous state can be a good alternative but care must be taken regarding its pulmonary toxicity so inhalation must be avoided. During the first steps of ozone sanitation several aspects were considered to select the correct treatment. A concentration of 1,2 ppm was chosen for the five night hours when the rooms are certainly empty and there are no hazards for the operators' health. Some environmental conditions were monitored like temperature, humidity, time to achieve treatment concentration and ozone decay time in the boning area (Figure 1) as well as the ozone concentrations during and after treatment (Figure 2) and, the evaluation of ozone effect on reducing the Total Viable Count (UFC/ml) in several points of the room and the equipment (Figure 3). The results of a test carried out in an atypical and extreme situation without the cleansing phase showed ozone ability to control microbiological load. The routine microbiological follow up guarantees efficiency and reliability of the process.

2.4. Ozonation degree of vegetable oils as the key factor of their anti-inflammatory and wound healing effectiveness

I. C. GUZMAN, P. GUERRA BLANCO, A. PEREZ MARTINEZ, Y. GOMES Y GOMES, M. ESTHER BAUTISTA, T. POZNYAK, I. CHAIREZ (Mexico)

The aim of this paper is to study the effect of the ozonation degree of vegetal oils on two clinical tests, such as anti-inflammatory and wound healing. These tests were evaluated in mice with two oils grape seed (GS) and sunflower (SF). The ozonation degree of oils was quantified by the total unsaturation method (TU) that was used to determine the oxidizable substrate contained in oils. The evaluation of the anti-inflammatory effect was carried out by the measurement of DB-index of the lipid extracts of the tissues the skin from of the pavilion of the ear, and by the weighing of the skin (5 mm) to determine the inflammation inhibition of each of the anti-inflammatory agents (grape seed and sunflower oils with the different ozonation degree, ozonated physiological solution and indomethacin). The DB-index has been used as an indicator of biochemical changes in the tissue. The wound healing was carried out with four different agents: ozonated GS and SF oils, furacin ointment (nitrofurazone 2%) and the combination of furacin ointment with ozonated oil. In experiments were used mice with diabetes mellitus induced by the artificial application of oxytocin. The results obtained confirm that the better anti-inflammatory effect was correlated with the increasing of the DB-index value: from 0.1700mmol/g for negative control up to 0.2714mmol/g and 0.2317mmol/g for the application of GS and SF oil, respectively (both ozonated 46%). Furthermore, the DB-index was correlated with the inflammation inhibition that was better for the oils partially ozonated up to 24%. In general, the inflammation inhibition was 23% for SF and 29% for GS. The complete wound healing, without the observation of infection signs of diabetic mice treated with ozonated oils was obtained during the time reported for wound healing of no diabetic mice.

2.5. Ozonized sunflower oils properties: influence of water addition during ozonolysis

S. MOUREU, F. VIOLLEAU, D. A. HAIMOUD-LEKHAL, A. CALMON (France)

The ozone-enhanced biologically active filtration (O3-BAF) process plays an important role in the investigated water reuse concepts. The treatment train incorporating O3-BAF has been shown to be more cost-effective since it minimizes or eliminates the need for reverse osmosis. Ozone oxidizes trace organic contaminants and provides pathogen disinfection credit while BAF provides additional polishing effect for residual by-products and organic (e.g., COD). Controlling the ozone dosage is crucial to achieve treatment goals while minimizing overdosing to reduce energy usage and formation of by-products, bromate and NDMA. Operators usually determine the ozone dose based on historic data and a worst case design basis, which is usually conservative and leads to overdosing in real-time conditions. An online monitoring and control system reduces the operational cost by using the ozone more effectively and avoiding overdosing. In this study, a pilot system was integrated with an ozone generator, an ozone contactor, two parallel biologically activated filters (BAF), three UV-VIS sensors, and a master programmable logic controller (PLC) system. A comprehensive pilot study was conducted for 4 month at the Western Butler County Authority (WBCA), in Zelienople, PA. The impact of applied ozone dose, BAF Empty Bed Contact Time (EBCT) and filter media type were evaluated in terms of organic removal. Results show 1 mg of ozone can generally eliminate 0.6 mg of COD under tested conditions (Ozone dose from 0 to 15 mg/L), and subsequent BAF treatment can further eliminate 8 – 12 mg/L of COD, depending on the EBCT. The pilot was also equipped with online sensors to monitor the environmental parameters such as COD, TOC and Ultraviolet Transmittance (UVT) for influent, ozonized and effluent samples. An advanced multi-loop on-line control system, which trims the applied ozone dose based on influent and effluent TOC (or COD), can automatically adjust the process to achieve treatment goals while optimizing ozone consumption. The performances of the O3-BAF system with and without online control are compared under different test conditions to determine its process and economic benefits.

2.6. Greenhouses for food production and the environment

A. MUSTAFA OMER (UK)

A greenhouse is essentially an enclosed structure, which traps the short wavelength solar radiation and stores the long wavelength thermal radiation to create a favourable microclimate for higher productivity. The sun's radiation incident on the greenhouse has two parts: direct radiation and an associated diffuse sky radiation. The diffuse part is not focused by the lenses and goes right through Frensel lenses onto the surface of the absorbers. This energy is absorbed and transformed into heat, which is then transported via the liquid medium in copper pipes to the water (heat) storage tanks or, if used, open fish tanks. In this way, an optimal temperature for both plant cultivation and fish production can be maintained. Stable plant growth conditions are light, temperature and air humidity. Light for the photosynthesis of plants comes from the diffuse radiation, which is without substantial fluctuations and variation throughout most of the day. The air temperature inside the greenhouse is one of the factors that have an influence on the precocity of production. The selective collector acts in a more perceptible way on extreme air temperatures inside the greenhouse. Hence, the system makes it possible to avoid the excessive deviation of the temperature inside the greenhouse and provides a favourable microclimate for the precocity of the culture. Sediment and some associated water from the sediment traps are used as organic fertiliser for the plant cultivation. The present trend in greenhouse cultivation is to extend the crop production season in order to maximise use of the equipment and increase annual productivity and profitability. However, in many Mediterranean greenhouses, such practices are limited because the improper cooling methods (mainly natural or forced ventilation) used do not provide the desired micro-climatic condition during the summer of a composite climate. Also, some of these greenhouses have been built where the meteorological conditions require some heating during the winter, particularly at night. The worst scenario is during the winter months when relatively large difference in temperature between day and night occurs. However, overheating of the greenhouse during the day is common, even in winter, requiring ventilation of the structure. Hence, several techniques have been proposed for the storage of the solar energy received by the greenhouse during the day and its use to heat the structure at night. Reviews of such

techniques are presented in this chapter. Air or water can be used for heat transport. The circulating water is heated during the day via two processes. The water absorbs part of the infrared radiation of the solar spectrum. Since the water is transparent in the visible region, they do not compete with the plants that need it. Alternatively, the water exchanges heat with the greenhouse air through the walls. At night, if the greenhouse temperature goes down below a specified value, the water begins to circulate acting as heat transfer surfaces heating the air in the greenhouse. This chapter describes various designs of low energy greenhouses. It also, outlines the effect of dense urban building nature on energy consumption, and its contribution to climate change. Measures, which would help to save energy in greenhouses, are also presented. It also enabled the minimisation of temperature variation and, hence avoided the hazard of any sudden climatic change inside the greenhouse.

2.7. Ozone generators for bubbling of physiological solutions

E. Sokol, T. BARKHOTKINA, R. TOMASHEVSKYI, M. MAKHONIN (Ukraine)

There are many different methods of medical use of ozone. The west-european school adheres to application of ozone-oxygen mixture in a gaseous form (external use, rectal and injection administration of ozone, minor and major autohemotherapy). Also, the application of ozonated oil is widely used in practice. The east-european school of ozone application in medicine, in addition to all the above methods, often uses ozonated saline solutions. For obtaining such ozonated solution is carried its bubbling by ozone-oxygen mixture. Given method of ozone therapy is a simple and affordable, has a positive effect efficient and low side effects. For ozonation is usually used normal saline solution of sodium chloride. The ozone-oxygen mixture is passed through it to reach the required ozone concentration in the solution. Intravenous drip infusion of ozonated saline solution - the most commonly used method of ozone therapy among Ukrainian ozone therapists. The positive results of the use of ozonated saline solutions have led to the fact that this method became interested to west-european ozone therapists. However, the majority of medical ozone generators, with which they work, cannot provide the necessary dosage of saline solution by ozone. Firstly, the ozone concentration and flow rate of the ozone-oxygen mixture in the output tract of the ozone generator change when appeared the pneumatic resistance by bubbling of saline solution. Second, bubbling requires a long maintenance of high concentration of ozone in the ozone-oxygen mixture.

2.8. Gaseous ozone abatement using transition metal modified natural zeolite

F. ULLOA, H. VALDÉS, V. SOLAR, M. CEPEDA (Chile)

Ozone at tropospheric level poses serious environmental and occupational health hazards. Ozone can increase sensitivity to bronchoconstrictors and allergens, and may facilitate the development of asthma. In working environments ozone is formed due to the use of laser printers, photocopiers, sterilization apparatus and ozone generators for air and water treatment [1]. Cars and power plant emissions are precursors of ozone outdoor formation [2]. Ozone decomposition has been reported over metal oxide catalysts [3-9]. However, the high investment costs, become a major obstacle for full-scale application, and alternative materials should be found. Recently, low cost stable natural zeolites have been used as alternative materials [10-12]. Lewis acid sites were claimed as the main responsible for ozone gaseous elimination, using outgassed natural zeolite at 550ºC [10]. Transition metal modified natural zeolites could act as an alternative and low cost catalyst to effectively abate ozone, exhibiting greater activities than the parent natural zeolite. This work provides experimental basis for scaling up and design a catalytic process to remove ozone emissions from working environments, using transition metal modified natural zeolites at low temperature. In particular, the impact of the structure, framework composition, and identity of the transition metal modified natural zeolites on the catalytic activity in the ozone gaseous abatement are established. Finally, a surface reaction mechanism that represents ozone catalytic removal by transition metal modified natural zeolite is proposed

Session 3. Focus Energy

3.1. Cooling conditions of ozone generators

N. BRUEGGEMANN, T. PUEHMEIER, R. FIEKENS, F.J. RICHARDT, M. SALVERMOSER (Germany)

Cooling of ozone generators is necessary for efficient ozone formation. The intention of the paper is to show the influence of the cooling of the ozone generation process and how to “turn the screw” to optimize the whole system.

3.2. Adding years to your existing ozone equipment

N. BURNS, T. HALL (USA)

Ozonation systems originally installed in the mid-1990’s are now seeing upgrades in both generation technology and application and monitoring methods to better utilize ozone cost-effectively. The City of Fargo is expanding the Fargo WTP from 30 to 45 mgd (113 to 129 MLD). The Fargo WTP is a softening facility and ozone is applied downstream from recarbonation at a pH of approximately 9.5. The system consisted of two 835 ppd (380 kg/day) Ozonia ozone generators installed in 1997, two ozone contactors with diffusers capable of adding ozone at two locations, supplemental air blowers, and destruct units. Given the increase in plant capacity and the difficulty procuring spare parts, a study was performed to determine the feasibility of updating the power supply units (PSU) to include IGBT technology, new circuit boards and high voltage transformers and replacing the dielectrics with newer more efficient ones. The outcome from the study was that ozone could be produced more cost effectively through an improvement in specific energy and ozone could be generated at higher concentration reducing the use of LOX. These improvements allowed an increase in generator capacity from 835 ppd (380 kg/day) to 1,200 ppd (545 kg/day), a 44% increase in capacity. The generator shells were in good condition and the plant staff had maintained the ancillary systems to the extent that very few additional modifications to the system were required. These improvements resulted in an updated system that will continue to serve the City of Fargo for many years into the future. The presentation will provide an overview of the original and updated ozone system at the Fargo WTP; the mechanical improvements that staff performed during the nearly two decades of operation including replacement of instruments, actuators, pipe, etc.; detailed discussion on the modifications to the ozone generator, PSU, control system; and the performance data for the original and existing equipment. This presentation will be valuable to those utilities interested in updating their existing equipment to extend the usable life or those considering novel approaches to maximizing the capacity of existing ozonation systems.

3.3. A new oxidation process using ozone to regenerate coked catalysts

R. RICHARD, C. JULCOUR, M.H. MANERO (France)

Approximately 80% of industrial processes currently use heterogeneous catalysts because of their various advantages. Chief among them is the possible reuse of these solid catalysts, either immobilized in the reactor or easily separated from the reaction medium by filtration. They are used in various application fields such as air/wastewater treatment, petrochemicals and fine chemicals. However, one major drawback is their unavoidable deactivation which can occur over variable time scales (from seconds to several years). This phenomenon can be generated by several mechanisms: poisoning (chemisorption of impurities or by-products on active sites), fouling (carbon or coke deposition which blocks the porosity) and/or degradation (chemical, physical or mechanical). Our work focuses on the regeneration of an industrial zeolite catalyst which has been deactivated by fouling with coke deposition. The most common process to remove coke is combustion, generally carried out with air or oxygen under severe conditions (400°C - 600°C). The aim of our work is to study the possibility of replacing this high energy consuming process by an oxidation process with milder conditions. As previous works have been led in our lab team on solid/gas reactions and on regeneration of zeolites by ozone [5], such a process was worth investigating.

3.4. A microbubble plasma reactor for pretreatment of lignocellulosic biomass
J. REN, M. TAGLIOLI, A. WRIGHT, H. BANDULASENA, F. IZA (UK)

Biofuels production has received growing attention due to the rising concern over depletion of fossil fuel and increased greenhouse gas emissions from fuel combustion. Currently, world leading producers of bioethanol use food crops such as corn and sugarcane as the main raw material. However, use of food sources for biofuel production is not sustainable as most countries are struggling to feed their population. As a result, research efforts are now shifting to lignocellulosic biomass as a renewable source that does not compete with food production. In converting lignocellulosic material to ethanol, one of the main challenges is the accessibility of enzymes to cellulose that is shielded by lignin. To facilitate this access, biomass needs to be pre-treated to degrade the lignin structure prior to enzyme exposure.

Session 4. In Water Treatment System

4.1. Integration of ozonation and biological treatment of industrial wastewater from dye house
S. LEDAKOWICZ, R.ZYLLA, K. PAZDZIOR, J. WRĘBIAK, J. SÓJKA-LEDAKOWICZ (Poland)

The textile industry demands huge amounts of water which after a production cycle becomes environmentally burdensome wastewater, loaded with contaminations – dyes, textile auxiliaries, salts and other chemicals. An environmentally sustainable development policy in textile industry requires development of new technologies to reduce water consumption as well as negative environmental impact of discharged wastewater. Therefore, closing of the water cycle within the factories is a promising method of decreasing its environmental impact as well as operational costs. Among the many processes which can be applied to textile wastewater treatment the biological one is recognized as environmental friendly and ecological, however it is not sufficient to remove or degrade the recalcitrant pollutants. Therefore, the biodegradation is coupled with chemical oxidation mostly by ozone. The goal of present project was to develop an innovative technology combining chemical and biological methods allowing for effective treatment of wastewater and the closure of technological water in textile plants. In combined chemical-biological treatment, first was ozonation while biodegradation was a second stage. Furthermore, to examine the progress of degradation, measurements of organic carbon compounds content (BOD_5, COD, TOC), colour and toxicity towards *Vibrio fisheri* have been done.

4.2. Synergetic biological and chemical ozone oxidation for micropollutants removal from wastewater
B. DOMENJOUD, A. GONZALEZ OSPINA, E. VULLIET, S. BAIG (France)

The environmental and human health risks induced by the presence of trace contaminants on the environment are nowadays of general acceptance among the scientific community as well as for the public authorities. Urban wastewater treatment plants (WWTP) were not conventionally designed to deal with trace organic contaminants. They are perceived as a continuous and major source of emission of micropollutants. Tertiary ozonation has demonstrated high performances covering a wide range of contaminants elimination and to be economically suitable. This is supported by a growing number of serious studies and by the fact that national strategies usually opt for a solution including an ozonation step. Nevertheless, the implementation of tertiary ozonation on site supposes an ozone contactor that has a substantial footprint in regard to the available space on most of the existing WWTP. In addition, a subsequent biological step is frequently seen to limiting the emission of some undesired by-products, whose formation mainly depends on the application conditions of ozone. Ozone oxidation reactions with nucleophilic organic substances are highly selective. Based on this characteristic of ozone reactions, an innovative approach was designed. It consists in evaluating the performances of ozone oxidation integrated to conventional activated sludge (CAS) treatment for the removal of pharmaceuticals. Applications of ozone upstream the biological treatment and on the sludge recycling loop, both at a same time or separately, were tested. Integrating ozone before or into the biological treatment results in a much lower footprint than tertiary ozonation in contact chambers and makes use of the possible synergistic effect of the biological and chemical oxidations. This configuration also presents the advantage of making use of the biological activity to deal with the possible undesired ozonation by-products.

4.3. Advanced online control for ozone-enhanced biologically active filtration system for municipal water reuse
T. ZHANG, D. BERKEBILE, A. RIED, K. ROBINSON (Germany)

The ozone-enhanced biologically active filtration (O3-BAF) process plays an important role in the investigated water reuse concepts. The treatment train incorporating O3-BAF has been shown to be more cost-effective since it minimizes or eliminates the need for reverse osmosis. Ozone oxidizes trace organic contaminants and provides pathogen disinfection credit while BAF provides additional polishing effect for residual by-products and organic (e.g., COD). Controlling the ozone dosage is crucial to achieve treatment goals while minimizing overdosing to reduce energy usage and formation of by-products, bromate and NDMA. Operators usually determine the ozone dose based on historic data and a worst case design basis, which is usually conservative and leads to overdosing in real-time conditions. An online monitoring and control system reduces the operational cost by using the ozone more effectively and avoiding overdosing. In this study, a pilot system was integrated with an ozone generator, an ozone contactor, two parallel biologically activated filters (BAF), three UV-VIS sensors, and a master programmable logic controller (PLC) system. A comprehensive pilot study was conducted for 4 month at the Western Butler County Authority (WBCA), in Zelienople, PA. The impact of applied ozone dose, BAF Empty Bed Contact Time (EBCT) and filter media type were evaluated in terms of organic removal. Results show 1 mg of ozone can generally eliminate 0.6 mg of COD under tested conditions (Ozone dose from 0 to 15 mg/L), and subsequent BAF treatment can further eliminate 8 – 12 mg/L of COD, depending on the EBCT. The pilot was also equipped with online sensors to monitor the environmental parameters such as COD, TOC and Ultraviolet Transmittance (UVT) for influent, ozonized and effluent samples. An advanced multi-loop on-line control system, which trims the applied ozone dose based on influent and effluent TOC (or COD), can automatically adjust the process to achieve treatment goals while optimizing ozone consumption. The performances of the O3-BAF system with and without online control are compared under different test conditions to determine its process and economic benefits.

4.4. Application of ozone assisted membrane cleaning for nom fouled graphene enhanced polyvinylidene fluoride membranes
R. KHAYRULLINA, C. TIZAOUI, C. SPACIE (UK)

The membrane technology has many applications that range from food to pharmaceutical industries. However, one of the most important applications of this technology is development of membranes for water and waste water filtration. Depending on the type (UF, MF, NF, RO), membranes are capable of exhibiting high levels of selectivity for the removal of desired contamination as well as maintaining high water flux. Despite the great relationship between selectivity and flux, membranes have tendency to accumulate particles on the surface and in the pores which in turn reduces water permeation. This process can be identified as fouling, where one of the main fouling materials is natural organic matter (NOM) that is typically present in raw water. Many researchers investigated the effects of ozone treatment for membrane cleaning using various methods and membrane materials. Although most organic membranes fail to withstand the ozone treatment, polymeric polyvinylidene fluoride (PVDF) membranes show high ozone resistance due to high crystallinity of PVDF. As well as excellent ozone resistance, PVDF membranes exhibit good mechanical strength, thermal stability and chemical resistance. Hybrid ozone/PVDF membrane system has many advantages including: achievement of efficient separation with stable flux under low filtration pressures; simplified, reliable and low cost process with minimal required space;

improved water quality with limited pre-treatment steps; instant ozone cleaning of contamination on membrane surface and disinfection of Cryptosporidium (microscopic parasites) by ozone in concentrate as well as in filtrate

4.5. Ozone cleaning of natural organic matter fouled hybrid poly(vinylidene) fluoride/carbon nanotubes membrane
J. SUHARTONO, C. TIZAOUI (UK)

This research studied the ability of ozone in cleaning composite carbon nanotubes (CNTs)/polymeric membrane fouled by natural organic matters (NOM). The polymer used was polyvinylidene fluoride (PVDF) whilst two types of impregnated CNTs were used, pristine and oxidized, in matrix CNTs/polymer with composition of 0.3 %mass. Three different methods were investigated for cleaning the membrane, those were cleaning by water without ozonation, water followed by ozonated water, and by full ozonated water. It is found that application of full ozonated water for 10 minutes was very effective and able to reinstate the flux to almost its value of fresh membrane flux. However, flux recovery obtained by oxidized-CNTs (CNTs-O) and pristine CNTs (CNTs-P) provided a different phenomenon.

4.6. Ozonation as part of integrated water management system in petrochemical plant
S. CHERET, S. BAIG (France)

The intent of the whole study is to develop a new water management system based on the application of the most promising technologies and their combination for water recycling and reuse with the major objective to reduce freshwater withdrawal by 40% and discharge pollutants for better compliance with environmental policy. Thanks to pilot trials, the optimized water management system is defined at the industrial site scale, for recycling and reuse within cooling water make up and/or in other operation/production processes. It involves ozonation stages for cooling water recycling and for advanced treatment of the wastewaters as part of the Low Liquid Discharge System developed.

4.7. Basic batch reactor ozonation experiments and modelling of non-porous ozone resistant membranes for water treatment
C.M. TAYLOR, M.J. BERRY, W. KING, D. MATTIA, Y.M. JOHN CHEW, J. WENK (UK)

Ozone is an important disinfectant and oxidant in water treatment that is being increasingly used as an alternative for chlorine[1]. However, ozonation, in particular the production of ozone, is a highly energy intensive process. Traditionally ozone is dispersed by bubbling ozone gas through the water column via bubble diffusors or using static mixers. These processes are often inefficient because the mass transfer across the gas phase to the liquid phase is not optimal resulting in a higher ozone demand[2]. Membrane contactors are a potential solution to improving the mass transfer efficiency in ozone treatment processes. While they are well established in the industrial separation of gases, the application of membrane contacting to water treatment is limited. Furthermore, the mass transfer characteristics of ozone in non-porous membranes are not well known in comparison to traditional, dispersive, ozone contacting processes. In this study the performance of non-porous polydimethylsiloxane (PDMS) membranes for bubble-less transfer of ozone gas into the aqueous phase was investigated. The conducted work included both experimental and computational aspects. The overall aims of the experimental part of the study was to design, build and test a simple membrane batch reactor to carry out ozonation experiments. The aim of the computational part was to understand the mass transfer of ozone in non-porous membrane systems by exploring the effects of different parameters using computational fluid dynamics modelling and comparison to experimentation.

4.8. Extending the range of micro-pollutants removed using a continuous process of adsorption coupled with electrochemical regeneration
N.W. BROWN, M.A. NABEERASOOL, B.E. VAN DONGEN, D.A. POLYA, N. DE LAS HERAS, M. CONTI-RAMSDEN, K. NKRUMAH-AMOAKO (UK)

Cost effective removal of organic micro-pollutants has proven to be one of the most significant challenges facing the water industry. This research presents a different approach to removal and destruction of these micro-pollutants using a continuous process of adsorption coupled with simultaneous electrochemical regeneration. Initial trials have shown it can achieve the EU pesticide standard for Metaldehyde of < 0.1 µg/l, with high removals of a range of other micro-pollutants (typically greater than 95%). The energy for regeneration has been calculated as 0.17 kWh/m^3, based on these un-optimised initial trials. However the system is currently adsorption limited and the data shows that on-going work should obtain a significant reduction in energy requirements.

4.9. Application of advanced oxidation processes and membrane technologies for tertiary treatment of domestic sewage
T. BENVENUTI, C. GALLY, C. BITTENCOURT, A. M. BERNARDES, J. ZOPPAS-FERREIRA (Brazil)

The discharge of industrial and domestic waste water containing a high load of contaminants affects the ecosystems and the human healthy. In order to minimize the environmental pollution and the necessity to solve the problems related to water scarcity periods, the environmental laws are becoming more stringent. This fact stimulates the development and the application of alternative technologies, more efficient, to produce water from different wastewater for reuse. Membrane separation processes are used in water and waste water treatment, having different specific properties and applicability (Bernardes, 2013). Electrodialysis (ED) is based on the selective migration of ions in an aqueous solution through ion exchange membranes under the influence of an electric field between two electrodes, resulting in at least two solutions: one concentrated in ions and other substantially composed of water (Rodrigues et al., 2008, Strathmann, 2004). Nevertheless, ED does not remove non-ionic organic compounds. For these contaminants, the advanced oxidation processes (AOPs) are the most promisor alternatives. The aim of these processes is the degradation and mineralization of organic compounds in aqueous phase, through oxidation reactions by hydroxyl-radicals (HO•) (Rodrigues et al., 2008). Among the AOPs, the photoelectrooxidation (PEO) uses electric current and UV radiation on a dimensionally stable anode (DSA) in order to generate HO• to degrade organic compounds (Da Silva et al, 2015). At the present work, electrodialysis and photoelectrooxidation was evaluated separately and associated, as a tertiary treatment for an effluent from a domestic sewage treatment plant in South of Brazil, aiming to produce water with quality for industrial uses.

Session 5. Ozone and Advanced Oxidation Process

5.1. Advanced oxidation of phenylphenol isomers in O_3/UVC system
M. OLAK-KUCHARCZYK, S. LEDAKOWICZ (Poland)

Removal of micropollutants and persistent contaminants from aquatic environment is nowadays a very important issue. The objects of these research were phenylphenols (*ortho*-, *meta*- and *para*-phenylphenol), which are preservative agents widely used in many branches of industry (Paris et al., 2002; Coelhan et al., 2009). These compounds were detected in surface water, riverine sediments, sewage sludge (Bolz et al., 2001; Peng et al., 2008) and marine sediments (Aguera et al., 2003). The purpose of the present work was to study the advanced oxidation of phenylphenol isomers in the aqueous solution under UVC radiation in the presence of ozone. The influence of different reaction parameters, such as ozone and phenylphenol isomers concentration, pH and temperature of the reaction mixture on the phenylphenols degradation rate was determined. Our aim was also identification of major transformation products and toxicity assessment of the reaction solutions.

5.2. Kinetic study of nitrate removal on bipolar boron doped diamond (bdd) electrode

M. GHAZOUANI, H. AKROUT, S. JOMAA, S. JALLALI, L. BOUSSELMI (Tunisia, Germany)

Nitrate electro-reduction is an extremely complex process because of the production of ammonia and nitrite as unfavorable by-products. However, many anode materials are tested and found effective for nitrite and ammonia oxidation to nitrogen gaseous and nitrate such as DSA (O_2-Dimensionally Stable Anodes) and BDD (Boron-Doped Diamond) anodes. But until now, the mechanisms are not clear for nitrate elimination. The main objective of this work was to study the cathodic reduction of nitrate and the simultaneous anodic oxidation of electrogenerated by-products (ammonia and nitrite) in a bipolar BDD cell. The effect of chloride on kinetic rates is also undertaken in order to propose a nitrate removal mechanism.

5.3. Impacts of suspended solids, water temperature and dilution on TROC elimination and UVA254 reduction by laboratory scale ozonation of secondary effluent

M. STAPF, I. HILBRANDT, U. MIEHE, M. JEKEL (Germany)

The suitability of an advanced treatment of secondary effluent with ozone as measure for trace organic compounds (TrOC) elimination was shown by several pilot studies. To decide if ozonation is a suitable option as an upgrade of a certain WWTP, ozonation experiments in laboratory-scale and decision tools as proposed by Wildhaber et al. can help to avoid the operation of expansive and labour intensive pilot plants. Such laboratory experiments should be conducted at similar conditions and by the same methods in order to achieve a better comparability of results. Water quality parameters such as DOC, nitrite and pH and experimental conditions, which have a significant impact on the results, have to be identified and taken into account. In this study, the effects of potential impact factors such as dilution of the sample, water temperature during the ozonation and the concentration of suspended solids, on the achieved TrOC elimination and the UVA_{254} reduction (as a possible surrogate parameter for monitoring or a closed-loop process control) were investigated.

5.4. Using advanced oxidtion proceses to remove coffee stains from porous flooring

R. LEWIS, C. TIZAOUI (UK)

This study investigated whether advanced oxidation processes could be optimised to remove brown coloured staining caused by coffee spillages on bricks. Photocatalysis using TiO_2 was optimised by applying 1g/L suspensions of TiO_2 in water in small volumes at frequent intervals. Ozonation, which performed the best overall, was optimised by applying larger volumes of water saturated with ozone and allowing the brick to dry naturally. Treatment with hydrogen peroxide was optimised using a concentration of 800mg/L H_2O_2 in water. No noticeable improvement in decolourisation was observed when H_2O_2 was added to the ozonation process.

5.5. Ozone treatment of indigo carmine dye wastewater in a plug flow reactor

E. LESTER-CARD, C. TIZAOUI (UK)

This research studied the treatment of the dye, indigo carmine, in a wastewater treatment pilot plant using ozone gas. A plug flow reactor model was used to describe the chemical reactions between ozone and indigo carmine. The wastewater flowrate was varied from 0.25 to 0.35L/min; this was done to understand if this operational parameter would have any effect on the kinetics of the reactions. The kinetics of ozone degradation along the length of the reactor were also studied using a first order reaction model. A second order model for the ozone reaction with the dye was used and a good correlation between the experimental data and the model was found.

5.6. Towards the optimal process configuration for emerging pollutant and enhanced nitrogen and phosphorus removal

M.J.C. VAN DEN BRAAK, S.M. SCHERRENBERG, J.D. BOORSMA, (The Netherlands)

The world population is increasing to an estimated total of 9.7 billion people by 2050.This increase, together with an overall improvement of living standards, results in a growing demand for water, raw materials and energy. For these reasons, Delfland waterboard has set the aim to close the loops for water, raw materials and energy. In order to close the loop for water, the waterboard has chosen to develop a water factory. With this initiative, the waterboard aims at improving the quality of Wastewater Treatment Plant (WWTP) effluent in such a way that it can be used as surface water for fragile biotopes instead of being discharged into the North Sea. Furthermore the reuse of wastewater contributes to recreational and nature values. Previous research has proven that (WWTP) effluent can fulfill a role in fresh water supply. However, standards regarding nutrients, macro and emerging parameters have to be med. To ensure a stable water quality, the European water framework directive was implemented in 2000. In this directive, European nations agreed to provide a chemically and ecological balance in there surface waters before 2027. This research contributes to reach the set goals by providing the optimal process configuration including data on the removal of emerging pollutants, by conducting a research on pilot scale. The objective of the full paper is to discuss the optimal process configuration, using a combination of different filter techniques and ozonation for emerging pollutants and enhanced nitrogen (N) and phosphorus (P) removal. For emerging pollutants, the objective is to endeavor an effluent quality that will contribute to the goals set by the European water framework directive. For N and P, the objective is respectively reach concentrations below 2.0 and 0.3mg l^{-1}.

5.6. Pyrite as iron source for polymeric dye decolourization by electro-fenton process

B. BOUZAYANI, J. MEIJIDE, S. CHAÂBANE ELAOUD, M. PAZOS, MARÍA A. SANROMAN (Spain, Tunisia)

The release of dye-containing effluents into aquatic environment leads severe pollution problems worldwide owing to the presence of toxic, carcinogenic or mutagenic products such as polyaromatic compounds with the concomitant aesthetic effect. Electrochemical Advanced Oxidation Processes (EAOPs) are considered an suitable alternative to remove these recalcitrant compound from wastewater. One of the most popular EAOPs is electro-Fenton process; however, the use of soluble iron instead of heterogeneous catalyst presents numerous operational problems. Pyrite, the most abundant sulphide mineral in the Earth's crust, has been successfully used as heterogeneous catalyst for several processes based on Fenton's reaction. Its capacity to regulate the iron ions into the solution in the presence of O_2 enhances the degradation and mineralization effectiveness compared to classical Fenton's process. Therefore, the goal of this study was to evaluate the applicability of electro-Fenton-pyrite process for decolourization and degradation of a polymeric dye such as Poly R-478 and to optimize different operational parameters such as pyrite dosage and applied current intensity.

5.7. Non thermal plasma for pharmaceuticals removal in water

K. TOR, C. TIZAOUI (UK)

Numerous methods exist for the treatment of wastewater containing pharmaceuticals such as TiO_2 photocatalytic processes and UV radiation treatment which are often energy intensive or otherwise consisting of infrastructures which are difficult or expensive to implement. Furthermore, pilot and full-scale studies have deduced that conventional biological treatment plants are not effective to degrade pharmaceuticals to lower levels acceptable for discharge into the environment (e.g. the Environmental Quality Standard for 17-α ethinylestradiol, found in birth control pills, is suggested to be as low as 35 pg/L). This is because conventional wastewater treatment works were not specifically designed to remove this new type of emerging contaminants. Hence there is need for new efficient and cost-effective treatment technologies. This research searches for new ways to remove contaminants in wastewater, specifically those which result in antimicrobial resistance (AMR); it aims to impede the dissemination of antimicrobial resistant genes by identifying common anti-microbial resistant causing pollutants in water and develop methods/ systems of removing such pollutants. AMR which was declared by the WHO in 2012 as "*a complex problem driven by many interconnected factors; single,*

isolated interventions have little impact", is also regarded as a new serious type of environmental pollutant due to its potential to be transmitted from the environment to human pathogens as well as its negative impact on the environmental microbiota.

5.8. Inactivation of bacteria in final sewage treatment work effluents

A. WRIGHT, B. UPRETY, M.MACH, F. IZA, G SHAMA, H. BANDULASENA (UK)

It is well documented that bacteria are dispensed into bodies of surface water downstream of waste water treatment plants and although the full environmental impact is unclear, studies have suggested these bacteria can negatively impact the nearby eco-system. A reactor has been developed to address this problem by inactivating bacteria before water is realised from the treatment plant. The reactor uses a dielectric barrier discharge to produce highly oxidative, but short-lived species that are encapsulated in microbubbles produced by a combination of a fluidic oscillator and a microporous nickel membrane. Three operating regimes were identified by modulating the plasma ON time. This enabled strong control over the gas plasma chemistry (O_3, OH, etc) and the pH of the liquid. Operating at 45% on-time, the reactor consumes 13W and it is able to reduce the concentration of *E. coli*, a bacterium commonly found in waste water, by 4.5 logs in 20 min.

5.9. Two-phase ozonation of for the removal of estrone, 17β-estradiol and 17α-ethinylestradiol in water using ozone-loaded Decamethylcyclosiloxane

S. BEN FREDJA, R.T. NOVAROVSKI, C. TIZAOUI, L. MONSER (Tunisia, UK)

Although ozonation has been proven effective for the destrucation of endocrine disrupting chemicals (EDCs), single-phase ozonation system is still limited by low ozone solubility and stability in water. These limitations may be overcome by mixing a prior ozone-loaded non-polar solvent with the aqueous solution. Decamethylpentacyclosiloxane (D5) has been chosen as the solvent to be charged with ozone for its non-toxicity, reusability, high ozone solubility (10 times higher than ozone solubility in water) and ozone stability. The experiments were carried out in a concurrent column reactor for a simultaneous removal of three endocrine disrupting compounds (EDCs) in water: Estrone (E1), 17β-estradiol (E2) and 17α-estradiol (EE2). Our results show that 98% of a 1 mg L^{-1} solution of EDCs can be degraded effectively along the reactor. The efficacy of the degradation depends of ozone dose, of D5/water volume ratio and of the column feeding flow rate.

5.10. Application of ozone on Activated Sludge: Micropollutant removal and sludge quality

M. MARCE ESCALE, O. PALACIOS, A. BARTOLOME, J. CAIXACH, S.BAIG, S.ESPLUGAS (Spain, France)

Ozone has been applied conventionally at the end of the treatment chain. However, some benefits have been reported after ozone application in the conventional activated sludge (CAS). Indeed, it promotes changes in the sludge matrix, increasing the COD solubilisation until the IOD completion and decreasing the SVI. Moreover, significant pharmaceutical removals have been achieved with low transferred ozone doses (TODs), reaching removals up to 99% depending on the compound.

5.11. Enhancement of micropollutant removal in urban wastewater using catalytic ozonation

C. CROUSIER, J.S. PIC, J. ALBET., S.BAIG, M.ROUSTAN (France)

Micropollutants can cause negative effects on the environment and on human health, even at low concentrations. Conventional urban wastewater treatment plants are not efficient enough to eliminate all of these compounds. The use of tertiary processes such as advanced oxidation processes seems therefore to be a promising alternative. This thesis aimed to study the application of catalytic ozonation according to TOCCATA® process to urban wastewaters treatment in order to control micropolluant emissions. Investigations were carried out on specific micropollutants in water (carbamazepine, diuron, ketoprofen, diclofenac, naphtalene) as well as on a large set of organics detected in real urban wastewaters. Most of the compounds were eliminated with low dose ozonation by the catalytic ozonation system. The properties of the micropollutants and their affinities with the catalytic ozonation system were studied in order to explain their behaviours.

5.12. Effect of SO_4^{-2} and Cl^- ions on the catalytic ozonation of phenolic compounds in the presence of the CeO_2 film and suspension

I. C. GÚZMAN, J. L. RODRÍGUEZ S., T. POZNYAK, I. HERNÁNDEZ P., I.CHAIREZ (Mexico)

In the present work, the effect of SO_4^{-2} and Cl^{-1} ions on the conventional and catalytic ozonation of phenolic compounds (phenol, 4-chlorophenol and 4-phenolsulfonic acid) was studied. Catalytic ozonation was carried out with the CeO_2 suspension (commercial) and film. The CeO_2 film ($CeO_{2\,(f)}$) was synthesized by the ultrasonic spray pyrolysis technique. Both catalysts were characterized by the different techniques (DRX, XPS and AFM). For phenol (Ph), the effect of ions was modeled by adding NaCl and Na_2SO_4 (100 mg L^{-1}). In the case of 4-chlorophenol (4-CPh) and 4-phenolsulfonic acid (4-PhSA), the chloride and sulfate ions were accumulated in ozonation due the dechloration and desulfonation processes in the initial stage of ozonation. The studied systems were O_3, O_3-Na_2SO_4, O_3-NaCl, O_3-$CeO_{2\,(S)}$, O_3-$CeO_{2\,(F)}$, O_3-Na_2SO_4-$CeO_{2(S)}$, O_3-NaCl-$CeO_{2\,(S)}$, O_3-Na_2SO_4-$CeO_{2(F)}$, O_3-NaCl-$CeO_{2\,(F)}$ in the decomposition of phenol, while in the case of 4-CPh and 4-PhSA degradation only conventional and catalytic processes (O_3, O_3-$CeO_{2\,(S)}$ and O_3-$CeO_{2(F)}$) were employed. The presence of the catalyst had no significant effect on the 4-CPh and 4-PhSA decomposition profiles, nonetheless, its effect was observed in the formation-decomposition of byproducts and the accumulation of oxalic acid, as a final product. $CeO_{2(F)}$ catalyst has a lower activity than $CeO_{2(S)}$ in almost all studied processes. To evaluate the global efficiency of all studied systems, the removal of chemical oxygen demand (COD) was also determined. In general, the presence of SO_4^{-2} and Cl^- ions causes an inhibition of both catalysts ($CeO_{2(S)}$ and $CeO_{2(F)}$) due to the adsorption of ions in the catalyst surface. However, the CeO_2 film was more resistant to the inhibition by ions.

5.13. A comparative study on the performance of different advanced oxidation processes for diethyl phthalate removal

L. MANSOURI, S.-U. GEISSEN, C.TIZAOUI, L. BOUSSELMI (Tunisie, Germany, UK)

The occurrence of substances in the aquatic environment that cause disruption of the endocrine system is becoming a major concern due to their toxic and hazardous effects on human health. Phtalates have been found to cause endocrine disruption and tend to have high resistance to conventional treatment processes and tend to accumulate in the aquatic environment.Of those phthalates, diethyl phthalate (DEP) is often detected at high concentrations levels in living environments, and was found to resist to the biological and photochemical treatment. Thus, efficient and reliable technologies are extremely required to degrade and remove these substances from the aquatic media. This study on DEP removal from aqueous solution was an attempt to enlarge the existing knowledge Advanced Oxidation Processes (AOPs) application for phthalates esters decontamination. Several AOPs including: O_3, O_3/H_2O_2, O_3/TiO_2,O_3/Activated carbon (AC), O_3/Al_2O_3, $O_3/Fe^{2+}/H_2O_2$ and photocatalysis, have been studied in earlier works for the degradation of diethyl phthalate (DEP)in water. This work compares the performance of these techniques in removing DEP through the evaluation of the effects of several operating parameters (pH, DEP concentration, catalysts dosage, and inlet ozone concentration).

5.14. Cost estimation of AOP to remove a priority pollutant: 1,4-dioxane

H. BARNDÕK, D. HERMOSILLA, N. MERAYO, C. NEGRO, Á. BLANCO (Spain)

1,4-Dioxane is considered a priority pollutant persistent to biological treatments and bio-accumulative. 1,4-dioxane removal is crucial to prevent its accumulation along conventional wastewater treatment plants (WWTP). Various common AOPs have been assessed for 1,4-dioxane removal; nevertheless, it is of great interest to search for more cost-effective and less residues-producing techniques. Heterogeneous photo-Fenton oxidation with zero valent iron (Fe^0) at neutral pH , CDEO on boron doped diamond (BDD) electrodes [4] and basic ozonation (O_3/OH^-) have proved technical feasibility for 1,4-dioxane degradation in real industrial wastewaters.

However, combination of AOPs to increase the biodegradability, with biological process is the preferred option. Sufficient biodegradability enhancement determines the size and the oxidant requirements of the AOP, and, thus, its total cost. Therefore, the objective of this study was to compare, technically and economically, basic ozonation, CDEO and heterogeneous Fe^0-based photo-Fenton (UV and solar), as possible pre-treatments to increase the biodegradability of a wastewater containing 1,4-dioxane.

5.15. Pyridinium-based ionic liquid degradation by heterogeneous electro-Fenton process
J. MEIJIDE FERNANDEZ, M. PAZOS, M. A. SANROMAN (Spain)

The ionic liquids have been widely used as green solvents over the past decades owing to their negligible vapour pressure and non-flammability. However, their high thermal and chemical stability suggest potential environmental pollution. Thus, several studies have reported their toxicological effects and distribution in environmental matrices such as soil and water. Therefore, the development of new technologies for ionic liquid removal is required. Advanced oxidation processes (AOPs) can be an alternative in the treatment of these complex substances. AOPs and more specifically electro-Fenton are based on hydroxyl radical generation and may be a potential treatment to remove ionic liquids from wastewater owing to their resistance to biodegradation. However, few studies have reported the application of oxidation process involving Fenton's reagents (Fe^{+2}/H_2O_2) to remove pyridinium cation from aquatic environments. The use of homogeneous electro-Fenton catalyst has several operational limitations that can be overcome by use of heterogeneous catalyst. Previous studies have reported the use of a mixture of poly (vinyl alcohol) (PVA) and alginate as carrier material for metal immobilization. The combination of both hydrogel polymers PVA/AL contributes to increase the strength and high crosslinking ability and reduces the agglomeration trend due to the presence of alginate. The aim of this study was to synthesize hydrogels beads containing goethite as iron source (FeOOH-PVA/AL) as heterogeneous electro-Fenton catalyst and to evaluate the influence of key parameters such as pH solution and catalyst dosage on the degradation rate of 1-butylpyridinium chloride (C_4pyr Cl).

Closing session and Award Ceremony

Conference Conclusions
Special Prize of the Programme Committee

FOR ANY FURTHER CONTACT

> IOA-EA$_3$G Secretariat

7 rue Marcel Doré, Bât. B16
86000 POITIERS – France

Fax: +33 (0)549 454 060
Phone: +33 (0)549 454 454
E-mail: ioa@esip.univ-poitiers.fr

> IOA-EA$_3$G website

www.ioa-ea3g.org

SAVE THE NEXT DATES

> Conference, Shanghai March 2017

> Workshop within Wasser Berlin, 28-31 March 2017

> 23rd IOA World Congress and Exhibition, 13 – 17 August, 2017– Washington D.C.

It will be held at the Gaylord National Resort & Convention Center in National Harbor, Maryland. This world congress will showcase leading edge technologies for Aquarium use, Municipal water, Municipal wastewater and Industrial process applications with special attention to both Ozone and AOP Technologies.

The IOA is a non Profit educational association focused on the safe and effective use of these beneficial technologies to protect public health, and the environment. Attend this conference to learn more about the multiple benefits Ozone technologies deliver and what exciting new applications and benefits are emerging.

INTERNATIONAL OZONE ASSOCIATION

Water Treatment
Science and Technology
Members Publications
Advances Knowledge
Food Processing
Ozone and Related Oxidants
Events
Industry News
Field application
Awards Standards Fundamentals
Engineering
Ozone Therapy
Agriculture Worldwide