The International Ozone Association and
The International Ultraviolet Association
are pleased to present their

2011 Joint World Congress & Exhibition

20th IOA World Congress - 6th IUVA World Congress

Ozone and UV
Leading-edge science and technologies

Attending any IOA and IUVA World Congress & Exhibition is the most effective way to keep current within the research and industry and to establish contact.

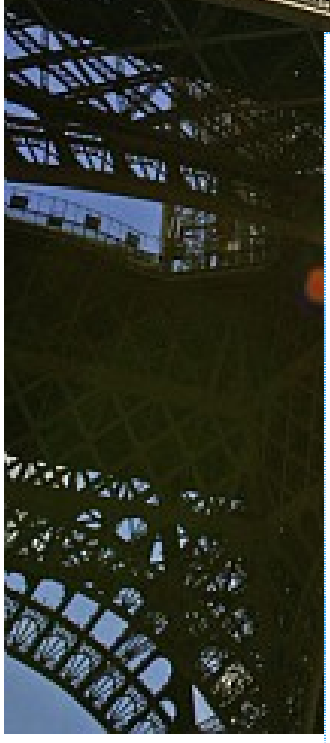
No other event delivers the sound science plus a showcase for new products, new services, new applications, and new solutions for ozone & related oxidants technologies and/or UV techniques.

1973 Washington
1975 Montréal
1977 Paris
1979 Houston
1981 Berlin
1983 Washington
1985 Kyoto
1987 Zurich
1989 New York
1991 Monte Carlo
1993 San Francisco
1995 Lille
1997 Kyoto
1999 Dearborn
2001 London
2001 Washington
2003 Las Vegas
2003 Vienna
2005 Strasbourg
2005 Whistler
2007 Los Angeles
2009 Tokyo
2009 Amsterdam

23-27 May 2011
Paris, France

IUVA
2011 WORLD CONGRESS & EXHIBITION

Programme
Book of Abstracts



Ozone and UV
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WELCOME ADDRESS

Following a long series of successful congresses organized every two years, it gives us great pleasure to welcome you to the joint IOA IUVA World Congress & Exhibition in Paris, France's prestigious capital city.

Paris is the world's leading tourist destination with 27 millions visitors each year. Visiting Paris is indeed a fashion dream for everyone. The arts as well as education, entertainment, science and the latest trends in personal pleasures are prevalent in very numerous places of this city - a city where something is always happening and as such an excellent venue for the 20th IOA World Congress and 6th IUVA World Congress.

With the ambition to reproduce the success of the first Congress held in Los Angeles in 2007, the International Ozone Association and the International Ultraviolet Association have designed a second joint congress with the aim of providing a very unique forum for all concerned with fundamental, engineering and applied aspects of oxidation techniques involving ozone and related oxidants and/or UV techniques:

- To interface with scientists, researchers, students, engineers, users, technical experts, representatives of leading organizations from various disciplines,
- To share the latest information on research topics, current issues, technologies under development, new applications, full-scale experiences and equipments and products,
- To consider and discuss directions able to deliver innovative, competitive and sustainable solutions which address current and next challenges.

Under the Co-Chairmanship of Professor Michel Roustan and Doctor Michael Templeton, the Scientific Committee has produced a highly integrated programme from the large number of abstracts submitted. This scientific programme will include numerous high quality scientific presentations, whether oral or posters, complimented by keynote lectures. It will cover three major application fields: environmental and human health protection, industrial manufacture and conditioning and medical therapy.

The tremendous answer to the call for papers and exhibitors as well as the further support received through sponsorships and finally the attendance level already proved the "uniqueness" of this event. This uniqueness is not only about the joint congress organization, but primarily reflects the dynamism of international research and industry in developing and implementing processes and technologies based on UV, ozone or related oxidants – this is the scope of the IOA and the IUVA Associations. There is no doubt that this congress will meet our expectations, as delegate or organizer.

Enhancing an excellent technical and scientific programme, you will have many opportunities to discover the beautiful Paris city.

We would like to express our gratitude and thanks to all of you who contributed to make this event possible: authors, exhibitors, sponsors, Associations' members, chairpersons and the local organizing Regional Group of the IOA.

On behalf of the Board of Directors of the International Ozone Association,
On behalf of the Board of Directors of the International Ultraviolet Association,
We wish you, delegate, guest, accompanying person a very enjoyable and fruitful Congress.

Sylvie BAIG,

IOA President

Bertrand DUSSERT,

IUVA President

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THE ORGANIZERS: IOA & IUVA

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

IUVA

Advancing the sciences, engineering & applications of ultraviolet technologies to enhance the quality of human life & protect the environment.
The International Ultraviolet Association (IUVA) was established to serve the following aims and objectives:

- To provide a forum for the discussion of all scientific and technological issues that relate to the use of ultraviolet light;
- To provide a common voice for the interests of companies using ultraviolet technologies and manufacturing ultraviolet lamps or equipment;
- To organize periodic international and national conferences focused on ultraviolet technologies;
- To publish a regular Newsletter (IUVA News) to keep members informed of new developments in the applications of ultraviolet technology;
- To encourage the establishment of rational terms, units and nomenclature in the fields of ultraviolet technology;
- To encourage research into the advancement of the applications of ultraviolet technologies;
- To encourage the adoption of rational environmental regulations that would encourage the use of ultraviolet technologies.

For more information, please visit http://www.iuva.org/.

IOA-EA_3G

The EA_3G group of IOA manages IOA membership in Europe, Africa, Asia and Australasia.
Among usual activities, it is over years the local organizer of all IOA Congresses held under the Presidency of one of its member.
It initiated and carried out the organization of the Paris Congress.

FOR FURTHER CONTACT

> **IOA-EA_3G Secretariat**
Address : ESIP – Plate-Forme Eaux, 40 avenue du Recteur Pineau, 86022 POITIERS CEDEX – France
Fax: +33 (0)549 454 060 - Phone: +33 (0)549 454 454 - E-mail: ioa@esip.univ-poitiers.fr

> **IUVA**
International Ultraviolet Association Inc. PO Box 28154, Scottsdale AZ 85255
Phone: 480-544-0105 (Tel) – Fax: 480-473-9068 (Fax) – E-mail: ask@iuva.org

COMMITTEES

Co-chairs

- Sylvie BAIG, France - IOA President
- Bertrand DUSSERT, USA - IUVA President

Organizing Committee

- Sylvie BAIG, France | IOA President, IOA-EA$_3$G Past President
- Bertrand DUSSERT, USA | IUVA President
- Alain LASALMONIE, France | IOA-EA$_3$G Secretary-Treasurer
- Paul OVERBECK, USA | IUVA Executive Director
- François MAUVAIS, France | IOA-EA$_3$G Secretary-Treasurer
- Achim RIED, Germany | IOA-EA$_3$G President
- Chris SCHULZ, USA | IUVA Treasurer
- Jeff NEEMANN, USA | IOA Treasurer and President Elect

Scientific Committee

Co-chairs

- Michel ROUSTAN Michel, Emeritus Professor, INSA Toulouse, FR
- Michael TEMPLETON, Lecturer, Imperial College London, UK

- Heinz ANDERLE, Baxter BioScience, AU
- Sylvie BAIG, Dr., Degrémont, FR
- Margarete BUCHELI, Dr., Gas Wasser Abwasser, CH
- Stéphane BROSILLON, Professor, University of Montpellier, FR
- Eric CHAUVEHEID, Dr, VIVAQUA, BE
- Hubert DEBELLEFONTAINE, Professor, INSA Toulouse, FR
- Zdravka DO-QUANG, Dr, CIRSEE-Suez Environnement, FR
- Jean-Pierre DUGUET, Dr, Veolia, FR
- Santiago ESPLUGAS, Professor, Uninversity Barcelona, SP
- Nigel GRAHAM, Prof., Professor, Imperial College London, UK
- Nathalie KARPEL VEL LEITNER, Dr. CNRS, University of Poitiers, FR
- Florencio MARTIN, Veolia Environnement RI, FR
- Maria ORTA DE VELASQUEZ, Dr, Instituto de Ingeniera, UNAM, MX
- Achim RIED, Dr., ITT W&W Herford GmbH, DE
- Geraldo SANT'ANNA, Emeritus Professor University Rio de Janeiro, BZ
- Michael SIEVERS, Professor, CUTEC-Institut, Leibeizsfr, DE
- Renate VIEBAHN-HANSLER, Dr., Dr.J.Hänsler GmbH, DE
- Urs VON GUNTEN, Professor EAWAG, CH

Ozone and UV
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SPECIAL ACKNOWLEDGMENTS AND CONTRIBUTIONS

The success in the organization of this congress results from the strong involvement of many individuals and from the generous contributions of sponsors, exhibitors and plant managers. The Organizing Committee would like herewith to acknowledge the support given by the following partners:

- **2B Technologies, Inc** | Exhibition
- **ABIOTEC UV** | Exhibition
- **AIRSEP Corporation** | Exhibition and Coffee break sponsoring
- **ATI Analytical Technologies** | Exhibition
- **Calgon Carbon Corporation** | Exhibition
- **Chart Industries** | Coffee Break sponsoring
- **Degremont Technologies Ozonia** | Platinum and Monday Lunch sponsoring, Exhibition
- **Dr. J. Hänsler GmbH - OZONOSAN** | Exhibition
- **Eau de Paris** | Technical tour
- **HERAEUS Noblelight GmbH** | Congress Bag sponsoring, Exhibition
- **IN USA, Inc.** | Exhibition
- **ITT Water & Wastewater Herford GmbH** | Platinum and Congress Bag sponsoring, Exhibition
- **NEDAP Light Controls** | Exhibition
- **OAS Sweden AB** | Exhibition
- **OSTI, Inc** | Exhibition
- **PCI** | Exhibition
- **Philips Lighting B.V.** | Silver sponsoring
- **STATIFLO International Limited** | Exhibition
- **SEDIF** | Technical tour
- **SUEZ Environnement - CIRSEE** | Welcome Reception sponsoring
- **SVAROG** | Exhibition
- **Syndicat Intercommunal Assainissement Côte de Nacre** | Technical tour
- **TROJAN Technologies** | Congress Lanyards sponsoring, Exhibition
- **Union des Industries de l'Eau et de l'Environnement** | Press partner

GENERAL INFORMATION

Language
English will be the official language.

Congress Venue
Congress venue will be CAP 15 International Center of Businesses and Congress, located close to the Eiffel Tower in the France's prestigious capital city of Paris.

Address : 1 / 13 Quai de Grenelle, F-75015 PARIS
Phone [+33] (0) 1 44 37 42 00

Registration categories
The main categories of registration and associated fees are as follows.

Full registration: IOA/IUVA Member	Cover scientific sessions, electronic proceedings, abstracts book, exhibits, welcome reception, lunches, refreshments and 3-day subway pass*
Full registration : Non-member	
Student registration: IOA/IUVA Member	Cover scientific sessions, electronic proceedings, abstracts book, exhibits, workshops, welcome reception, lunches, refreshments and 3-day subway pass*. Copy of valid student ID is required.
Student registration : Non-member	
T1 - Choisy le Roi and Méry sur Oise	Technical tours. Include bus transfer and lunch and entrance fees for T2. Minimum number of 30 registrations is required per visit. Copy of valid ID card or passport is required.
T2 - Côte de Nacre and D-Day Museum	
T3 - Orly and Joinville	
Congress dinner	Number of registrations is limited to 280.
Accompanying person registration	Covers welcome reception, lunches and congress dinner.
Cultural tour C1 Giverny	Opened to accompanying persons and delegates. Minimum number of 20 registrations is required per visit. Cover bus transfer, guide, entrance fees and lunch only for C2 and C3.
Cultural tour C2 Paris	
Cultural tour C3 Versailles	
Electronic proceedings and abstracts book IOA/IUVA member rate	Additional copies available can be purchased during and after the Congress at discounted rate for IOA/IUVA member.
Electronic proceedings and abstracts book Non member rate	

* upon reservation only

Cancellation policy

Notification of cancellation must be received by the Congress Secretariat in writing. Full refunds will be provided if notified by April 4, 2011. A 50 % refund will be provided if notified by May 2. No refund will be provided after May 2.
Each cultural or technical tour can be cancelled if the number of registrations required is not met. Full refund will then be provided.

Liability and insurance

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

Disclaimer

The organisers may at any time, with or without giving notice, in their absolute discretion and without giving any reason, cancel or postpone the Congress, change its venue or programme and withdraw any invitation to attend. In any case, neither the organisers 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 Congress 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).

Registration desk

It will be opened during the Congress as follows:

- Sunday, May 22 16:00 – 20:00
- Monday, May 23 07:00 – 18:00
- Tuesday, May 24 08:30 – 18:00
- Wednesday, May 25 08:30 – 18:00

Badges

The wearing of badges is compulsory inside the Congress Centre. They are necessary to access all scientific sessions, exhibits, social events and other Congress services and functions.

Coffee breaks

Each morning and afternoon complimentary coffee and drinks will be available in the exhibition area at the scheduled break time.

Lunch break

Each day, lunch will be offered on board of a “bateau-mouche” on the Seine river. Lunch ticket is required and punctuality is essential.

Speaker room

A room is available for final check of the speaker’s presentations.

Meeting point

The meeting point for all tours is at the entrance of the Congress Centre CAP15.

Internet access

The Organizers offer to delegates a free internet access with wifi connection within the Congress Centre CAP15. Password will be provided at the registration desk upon request.

Paris

Paris has something for everyone in a multifaceted, magical, mythical and sometimes surprising capital that is always exciting. People come to Paris to admire its exceptional architectural and cultural heritage, which makes it one of the world's most beautiful cities.

This dynamic heritage is constantly being updated and enriched. Paris is also the capital of gastronomy, fashion and shopping.
It is committed to the notions of quality of life and sustainable development and offers its inhabitants and visitors a particularly pleasant setting.

Innovative, audacious and vibrant, Paris has leapt boldly into the 21st century.

Enjoy your stay.

Ozone and UV
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GENERAL PROGRAMME

This event features 5 full days. Here's a snapshot of what it ioffers:

- Attendance by top specialists and the brightest student minds alike, all working on technologies based on ozone, UV and related oxidants and all interested in environmental and human health protection, industrial manufacture and conditioning, medical therapy – 500 delegates from 50 countries from past experience, already over 400 registrations,
- 3-day Technical and Scientific Programme with close to 270 scientific presentations arranged in 15 sessions in 4 parallel tracks. All topics of current or future interest are covered. Half of the sessions are devoted to transverse topics,
- A large industry leading Exhibition of all space offered sold out in less than 30 days – Discover the Exhibition floor,
- 2-day exclusive plant tours to the 5 most advanced ozone and UV plants – Méry sur Oise and Choisy le Roi, Bernières sur Mer, Orly and Joinville le Pont,
- And social and cultural events for the enjoyment of the delegates and their guests: welcome reception, celebratory Congress Dinner, Awards Ceremony, 3 tours to discover the prestigious places Giverny, Paris City, Versailles,

All in the France's world-famous environment and hospitality.

SCHEDULE

May 22	Hour	May 23	May 24	May 25	May 26	May 27
	07h00	Registration				
	8h30 10h00	Opening	S1 S6 S4 S5 E	S11 S8 S9 S10 E C3	T1	T2 T3
	10h30 12h30-45	S1 S2 S4 S5 E	S1 S7 S9 S5 E C2	S11 S12 S13 S3		
	12h30-45 14h30	Lunch	Lunch	Lunch		
14h00 Stand assembling	14h30 16h00	S1 S3 S4 S5 E C1	S1 S8 S9 S10 E	S12 S12 S14 S15 E		
17h00 Registration Poster panels	17h00 18h30	S1 S3 S4 S5	S1 S8 S9 S10	Awards and Closing		
19h00 Welcome Reception				20h00 Congress Dinner		

With S: Scientific Session; E: Exhibition; C: Cultural tour; T: Technical tour

Rooms: Newport, Newport I, Newport II, Pacific, Beach

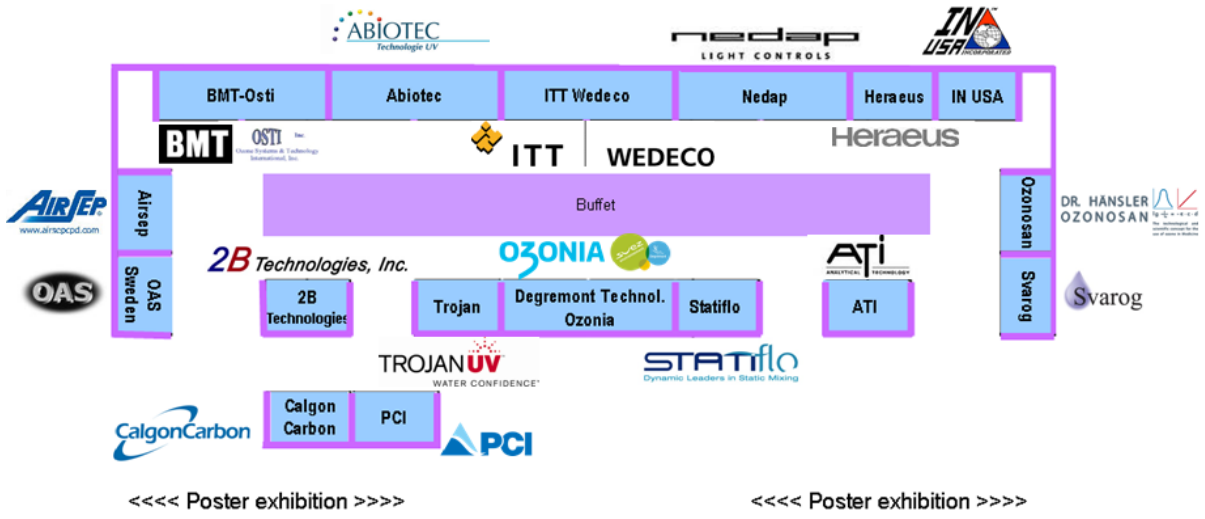
Scientific Sessions

S1	Advanced Oxidation Processes	S6	Ozone for Agrifood	S11	Reaction study and modelling
S2	Ozone reactor design	S7	IOA review of industry and technical news	S12	Applications in Natural waters
S3	Industrial applications	S8	Applications in Wastewaters	S13	UV lamps
S4	UV reactor design and validation	S9	Full scale applications	S14	UV for Aquatics
S5	Ozone in Medicine	S10	Process development and optimization	S15	Ozone generation

EXHIBITION

Monday May 23 to Wednesday May 25

Leading companies supplying equipment for ozone application display new and standard products. Enough time will be available to go in the exhibition space and see the exhibits.



The list of exhibitors includes equipment suppliers for Ozone application | UV application

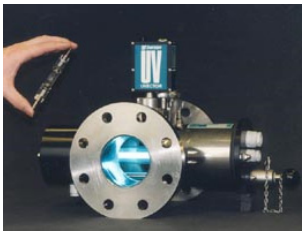
2B Technologies, Inc (USA) - www.twobtech.com

2B Technologies, Inc.

2B Technologies is dedicated to the development and commercialization of new analytical instruments for atmospheric and environmental measurements. We specialize in miniaturized, portable instruments for measurements of ozone (O3), nitric oxide (NO), nitrogen dioxide (NO2) and other chemical species in air. Our light-weight, low-power instruments are now used for atmospheric, ambient, and industrial measurements in many diverse applications. Our products are currently operating in such extreme and remote sites as Antarctica, Death Valley, the Galapagos Islands, the Greenland ice sheet, the summit of Mont Blanc, the Amazon rain forest, the Arctic Ocean, many U.S. National Parks and numerous other locations throughout the world. We look forward to helping you achieve your monitoring needs!

ABIOTEC UV (France) - www.abiotec.fr

ABIOTEC
Technologie UV



Since its creation in 1985, **Abiotec** the UV technology specialist, with Berson UV (Nederlands) has installed over 2000 systems in France and on all five continents.
Its three locations (a triangle comprising Ile-de-France, the Southwest and the Southeast) ensure effective coverage of the whole of France, both in terms of marketing and in terms of commissioning the various installations and after-sales service.
In addition to the services provided, the Abiotec's network of installation engineers ensures that each and every customer is given real technical assistance: advice and a consultancy facility designed to optimise the customer's return on investment.

AIRSEP Corporation (USA) - www.airsepcpd.com

For over 23 years **AirSep** PSA & VPSA Oxygen Generators are used in over 100 countries offering customers the freedom and independence from gas suppliers in many ozone related applications. AirSep systems lower oxygen costs while providing customers with a dependable source of oxygen, simply by compressing atmospheric air that is produced by an air compressors and separating the oxygen from the nitrogen.
Highly engineered, safe, reliable, economical and virtually maintenance free, AirSep PSA & VPSA Oxygen Plants offer a superior alternative to conventional liquid or gas oxygen supply. Available in standard and custom design with oxygen flow rates from 0.3 to 2600 Nm^3/hr. AirSep Oxygen Generators…the most efficient way to MAXIMIZE ozone production. AirSep Corporation is awarded a Duplex 39 TPD (1025 Nm3/hr) VPSA Oxygen Plant for project "Melbourne Water" for installation in 2011.
Contact: Angelo Barberic, ph. 716-691-0202 ext. 266 - fax 716-691-1255 - abarberic@airsep.com.

ATI Analytical Technologies (USA) - www.analyticaltechnology.com

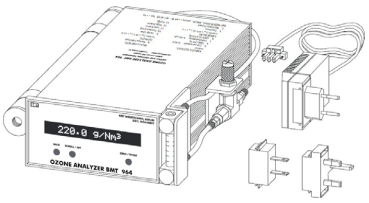
Analytical Technology is a U.S. based manufacturer of water quality monitoring instruments and toxic gas detection systems. Our products are widely used in high purity water systems, drinking water facilities, and a variety of industrial water treatment application.

For the IOA/IUVA World Congress Exhibition, we will display:

- Dissolved Ozone Monitors
- Ozone Gas Leak Detectors
- Dissolved Hydrogen Peroxide Monitors
- H_2O_2 Gas Detection Systems

BMT - OSTI, Inc (Germany) - www.bmt-berlin.de / www.osti-inc.com

Since more than 25 years **BMT** is specialized on photometric measurement of ozone in air, in oxygen, and in water. BMT is a technology leader in the measurement of ozone in moist off-gas and moist vent-gas, and ozone in water. An exhaustive range of accessories is offered to support single source design. And we are supplying small but advanced air cooled ozone generators for ozone experiments and for small scale ozone systems. Our ozone instruments are used worldwide in many kinds of ozone applications such as: semiconductor, pharmaceutical, medical, and chemical. For ozone treatment of water and waste water we are offering complete solutions for all points of ozone measurement in the plant.



Calgon Carbon Corporation (USA) - www.calgoncarbon.com/uv

Calgon Carbon is a leader in ultraviolet treatment solutions with more than 25 years of experience. We have installed over 500 UV systems sized to treat over 15 billion litres per day. Product offerings include the following:

- **Sentinel®** for drinking water offers EPA validated reactors ranging from 12 inch (300 mm) flange to the industry leading 48 inch (1220 mm) flange that are able to treat up to 200 million litres per day.
- **Sentinel® AOP** for advanced oxidation applications with and without hydrogen peroxide. Available in a 24" (600 mm) and 48" (1220 mm) flange. Both products are third-party validated.
- **C^3 Series™** for wastewater and reuse applications utilizes high-efficiency 500W lamps and a patent-pending design that increases the germicidal efficiency of the reactor. The **$C^3$500™D** has fewer lamps than other LPHO UV systems, smaller footprint, decreased installation and O&M costs and is third-party validated per NWRI guidelines.

Email: uvtechnologies@calgoncarbon-us.com Pittsburgh, PA 724.218.7000

Degrémont Technologies - OZONIA (Switzerland)

www.degremont-technologies.com

OZONIA: "Innovative technologies for a clean world"

OZONIA is the world leading supplier in ozone and UV technologies. OZONIA provides equipment and systems for municipal and industrial disinfection as well as oxidation solutions. Its product range includes for example turn key plants and standard ozone equipment, horizontal and vertical UV lamps systems.
In addition, thank to more than 20 years of expertise and innovation, OZONIA is able to provide tailor-made solutions for any applications with the highest level of know-how, engineering, and service.

Dr. J. Hänsler GmbH - OZONOSAN (Germany) - www.ozonosan.de

Hänsler OZONOSAN is for more than 40 years the leading company in ozonetechnology for ozonetherapy and hygiene, research and development in application systems for medical ozone with a multitude of patented systems, documentation of research and clinical trials, recommendations in applications and dosages. Certification according to ISO 9003, EN 46003 and MDD is standard. All products are marked with the CE symbol. Products developed are based on the medical ozone concept for the application of O_3 in preventive and complementary medicine – as tested in basic research and confirmed by empirical medicine; for all systemic and topical ozone treatment forms, i.e. such as reinfusion of ozone-treated blood, local application in subatmospheric systems, and topical application of ozonized water: OZONSAN alpha plus, OZONOSAN photonic, OZONOSAN boardcase, Hygiene - Set with Micro - Bubble – System.

HERAEUS Noblelight GmbH (Germany) - www.heraeus-noblelight.com/en

Heraeus Noblelight GmbH gehört weltweit zu den Markt- und Technologieführern bei der Herstellung von Speziallampen. Das Unternehmen entwickelt und fertigt UV-Lichtquellen und kundenspezifische Lösungen für industrielle Anwendungen.

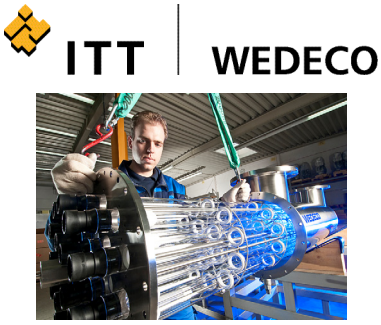
Heraeus Noblelight GmbH is one of the technology and market leaders in the production of specialty UV lamps. The organisation develops and manufactures UV light sources and customized solutions for industrial applications.

IN USA, Inc. (USA) - www.inusacorp.com

IN USA, Inc. is a leading manufacturer of industrial grade OZONE analyzers for the water treatment industry utilizing state-of-the-art UV Light Absorption measurement technology. Our wide range of analyzers are tailored for the following applications:
- Ozone generator output measurement
- Off-gas ozone measurement
- Dissolved ozone in water measurement
- Ambient ozone measurement for workplace safety
- Portable Spot checker for locating ozone leaks

All our Instruments are CE compliant and available in NEMA Enclosures.

ITT Water & Wastewater Herford GmbH (Germany) - www.ittwww.com



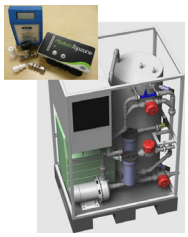
The **WEDECO** success story began 1975 with the establishment of the first production facilities in Herford, Germany. From the very beginning, the company's business policy was shaped by the vision of chemical-free and environmentally friendly water treatment.
Today with an installed base of over 250,000 units for UV disinfection and ozone oxidation in numerous private, municipal and industrial areas of application worldwide, WEDECO stands for energy-efficient and forward-looking technology, combined with first-class technical and engineer services.
As part of ITT Water & Wastewater, WEDECO maintains the industry's most extensive sales and service organization, operating both locally and globally to meet the needs of customers. And by combining its world-class products and engineering expertise, ITT can offer integrated and multi-discipline solutions including full process design, equipment selection and supply, installation, commissioning and operator training.

NEDAP Light Controls (Netherlands) - www.nedaplightcontrols.com

Nedap Light Controls is World's leading company for UV lamp Drivers.
Nedap develops and produces intelligent, dimmable electronic lamp drivers (electronic ballasts) for gas discharge light sources, for Ultra Violet (UV) disinfection, curing and general lighting applications.
Nedap lamp drivers offer many advantages: energy saving, easy-to-use, high-quality, improved lamp life, best performance and high reliability.
Also the possibility for long lamp cable length (between lamp driver and lamps) is one of the interesting features.
The new Uvineo product line will be presented during the IOA/IUVA exhibition. This technology for low pressure UV lamps combines high efficiency power conversion with intelligent controls and communication protocols allowing the best UV systems at the lowest total costs.

OAS Sweden AB (Sweden) - www.oas.se

OAS Sweden AB has been designing and manufacturing advanced Ozone generators and systems for two decades. Our systems are used in professional and light industrial environments. We work closely with customers integrating Ozone into both water treatment and gaseous applications, providing simplified installation, efficient Ozone generation, with the addition of clear user interfaces for control and monitoring. The unique design features found in OAS products also allow engineers and end users the ability to update or view system parameters, locally or remotely over internet as required. In addition to our Ozone generating systems we supply a comprehensive range of ancillary components from oxygen concentrators, feed gas filtration devices, connectors, valves and fittings to complete palletised water systems. OAS Sweden AB is pleased to welcome you to our exhibition stand to discuss your requirements.

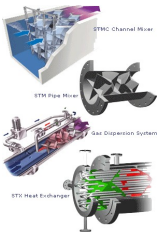


PCI (USA) - www.pcigases.com

PCI was founded in 1984 to manufacture cryogenic air separation devices for operation in extreme and remote environments. Since then, PCI has continually expanded its technology platforms to include membrane and adsorption (VSA) technology. PCI manufactures ruggedized onsite liquid and gaseous oxygen and nitrogen generators for a variety of markets; including Military, Medical, Water & Wastewater Treatment, Industrial, and Oil & Gas markets.
Based on existing technology used in its military oxygen generators, PCI has developed a commercial line of on-site oxygen generators, known as DOCS. To produce oxygen, these systems utilize a proprietary Vacuum Swing Adsorption (VSA) process. This technology offers the lowest operating cost and most reliable oxygen generator in its class, with outputs ranging from 280 pounds per day to 10 tons per day at 93% purity. Oxygenation using an on-site oxygen concentrator can yield significant cost savings over conventional aeration methods.

STATIFLO International Limited (United Kingdom) - www.statiflo.net

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 manganese 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.
Correctly designed static mixers produce "plug flow" which have been used by several UV equipment suppliers to enhance the performance of their reactors to condition the inlet flow to improve reactor efficiency. This technology has been applied to both pipeline and channel installations.



SVAROG (Russia) - www.svarog-uv.org

JSC"**SVAROG**" produces water treatment equipment utilizing advantages of combine action of the ultraviolet and ultrasound disinfection. The equipment is successfully employed for variety applications including municipal / residential drinking water, water recycling and sewage treatment.
UV water disinfection strengthened by ultrasound (US) action.
The water disinfection technology "Lazur" based on simultaneous application of UV radiation and ultrasound action developed by JSC"SVAROG" is the most effective contemporary method for complete inactivation of pathogenic microorganisms for a variety of water sources. JSC "SVAROG" offers the highest equipment performance along with lowest energy consumption at competitive price for variety applications including municipal/residential drinking water, water recycling and sewage treatment.
Tel: +7(495) 6171945, fax: +7(495) 6171946 - E-mail: enquiries@lazur-uv.org

TROJAN Technologies Deutschland GmbH (Germany) - www.trojanuv.com

Trojan Technologies designs, manufactures, and sells UV systems for municipal wastewater and drinking water facilities, as well as for the industrial, commercial and residential markets.

The company also provides UV treatment for the removal of chemical contaminants from water. With over 7,000 municipal facilities in more than 80 countries using its technology, Trojan has the largest installed base of UV systems in the world.

Headquartered in London, Ontario, Canada, the company also has offices in the U.K., Germany, China, France, Australia, Italy, Spain, and the U.S.

SOCIAL EVENTS

Welcome reception

Sunday 22 May, 19h00

All delegates, partners and sponsor and exhibitor staff are invited to attend the welcome reception on Sunday 22 May evening.

Congress dinner

Wednesday 25 May, 20h00

The scientific programme of the congress will close with an unforgettable gala dinner at the Restaurant La Bonne Franquette.

In the heart of Montmartre, you will find this old house, more than four centuries.

It was here, while the last century, the meeting point of artists : Pissarro, Sisley, Cézanne, Toulouse-Lautrec, Renoir, Monet, Zola et Vincent Van Gogh...

" Aimer, manger, boire et chanter"

"Love, eat, drink and sing" written at the entrance of the restaurant evokes the philosophy of the restaurant.

SPECIAL EVENTS

Awards ceremony

Wednesday 25 May, 17h00

Numerous awards will be presented during the closing session, for recognition of:

- Special contributions to the Associations IOA and IUVA,
- Major contributions to advances in science and technologies
- The quality of presentations made by Doctorate Students.

CULTURAL TOURS

The organizing Committee designed sightseeing tours especially for congress participants, spouses and partners: Giverny, Paris and Orsay Museum, Versailles. Special registration is required. All tours will include transport by bus with pick up and return at the Congress center CAP15. Information on time for departure will be available at the registration desk.

Cultural Tour C1 - Giverny

Monday 23 May –Afternoon Half day tour

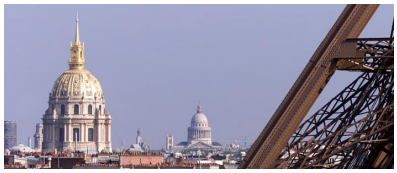


While driving you along the Seine river valley to the village in Normandy where Claude Monet lived from 1883 to 1926, your guide will retrace the painter's life and his sources of inspiration. You will then visit his house and studio and the gardens he created as a subject for his paintings. See the ponds and the Japanese bridges built with a lock on the tiny Epte river for the Water Lilies series. Drive back on a scenic road overlooking the Seine river valley and cross beautiful landscape and charming villages.

Cultural Tour C2 - Paris

Tuesday 24 May – Full day tour





Sightseeing tour. Panoramic drive showing you all the main sites and neighborhoods.
You will see: Arc de Triomphe, Champs Elysées, Trocadéro, Tour Eiffel, Invalides, Concorde, Madeleine, Opéra, Vendôme, Louvre, Notre-Dame and Montmartre. From the ancient Lutetia to the medieval town (Cluny, Cité, Notre-Dame). From Classical Paris (Vendôme, Invalides, Concorde) to the Great works of Baron Haussmann (Opera-Garnier, the Boulevards). From the 19th century (Eiffel tower, Orsay, Sacré-Coeur) to modern Paris (Pompidou centre, Glass pyramid of the Louvre) you will travel through 2000 years of history and architecture. Your city tour includes time to go up the Eiffel tower or go shopping and lunch in a very Parisian brasserie or follow our guide's suggestion according to your tastes and an inside visit of the Orsay museum.
A must for the first-time visitor. If you are a regular visitor your guide will suggest next visits of many less familiar places such as the musée de La Vie Romantique, Cognac Jay, the house of Balzac, Zadkine, Gustave Moreau, Maillol...

Cultural Tour C3 - Versailles

Wednesday 25 May Morning – Half day visit



Half day visit and lunch at the Restaurant "La Flottille" located in front of the Grand Canal.
The Château and the gardens of Versailles count among the most prestigious monuments of the world's artistic heritage, a finest and most complete achievement of 17th century French art and the sumptuous theatre of history from Louis XIV to Louis XVI. Versailles was the creation of one of French history's main figures, King Louis XIV, who reigned from 1661 to 1715. The royal dream house that many European Kings envied and tried to duplicate exemplified the splendid image of the Sun King. Guided tour of the State Apartments, the Hall of Mirrors and the 250-acre gardens designed by André Lenôtre.

TECHNICAL TOURS

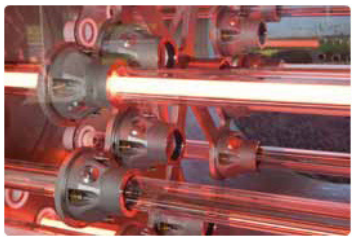
Upon proposals of IOA and IUVA corporate members and by kind permission of the operator companies (Degrémont Technologies-Ozonia, Eau de Paris, Lyonnaise des Eaux, SEDIF, Trojan Technologies, Veolia) three visits have been arranged for the Congress delegates.

- Choisy le Roi and Méry sur Oise Drinking Water Plants
- Côte de Nacre WasteWater Treatment Plant and D Day Museum of Arromanches
- Orly and Joinville Drinking Water Plants

Each one lasts the day with picturesque stretch of the area with possible stops. All tours depart from and return to the Congress center CAP15. Special registration is required. The fee includes bus transfer and lunch.

Technical Tour T1 - Choisy le Roi and Méry sur Oise Drinking Water Plants

Thursday 26 May - Full day tour



SEDIF (Syndicat des Eaux d'Ile de France) founded in 1923, is a public establishment covering 144 municipalities spread over seven departments in the Paris area, and is responsible for the production and distribution of drinking water for 4 million customers. The raw water comes mainly from three surface water resources: The rivers Seine, Marne and Oise which are respectively treated in the Choisy-le-Roi WTP, Neuilly sur Marne WTP and Méry sur Oise WTP.

The **Choisy-le-Roi plant** on the Seine river, serves approximately 1.65 million inhabitants It is amongst the major water treatment plants in Europe, designed for a 600 000 m^3/d nominal capacity. The water treatment line was initially including coagulation, sand filtration, ozonation, GAC filtration onto granular activated carbon and final chlorination. Considering the effectiveness of the current process for Cryptosporidium removal (< 4 log) and the risk which would result from a filtration failure, SEDIF has made the decision to secure the treatment process in Choisy le Roi plants by inserting recently a UV disinfection step between the GAC adsorption and final chlorination.

The **Méry-sur-Oise plant**, serves 39 districts in the northern suburbs of Paris, totaling 800,000 inhabitants with 370 000 m^3/d nominal capacity. The plant has two independent treatment trains. The biological train includes settling, sand filtration, ozonation, activated carbon adsorption and chlorination. The membrane train applies lamellar sedimentation, dual-layer filtration, microfiltration and nanofiltration. It produces 80 % of the water distributed.The Méry-sur-Oise plant, serves 39 districts in the northern suburbs of Paris, totaling 800,000 inhabitants with 370 000 m^3/d nominal capacity. The plant has two independent treatment trains. The biological train includes settling, sand filtration, ozonation, activated carbon adsorption and chlorination. The membrane train applies lamellar sedimentation, dual-layer filtration, microfiltration and nanofiltration. It produces 80 % of the water distributed.

Technical Tour T2 - Côte de Nacre WasteWater Treatment Plant and D-Day Museum of Arromanches

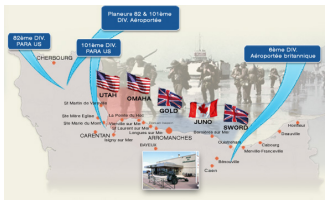
Thursday 26 May - Full day tour

The **Joint Association of Côte de Nacre of the Normandie coast** was created in 1992 in order to manage and control the wastewater treatment for seven towns: Courseulles-sur-Mer, Bernières-sur-Mer, Saint-Aubin-sur-Mer, Langrune-sur-Mer, Luc-sur-Mer, Douvres-la-Délivrande et Cresserons. The wastewater treatment plant is located at Bernières sur Mer, twenty kilometers of Caen,, regional capital, and 270 kilometers from Paris.

The sewage treatment plant has a capacity of 97 000 population equivalent (based on seasonality). The raw sewage collected undergoes a full pre-treatment including mechanical screening, degreasing and desanding, biological treatment using activated sludge within two stages for carbon and nitrogen removal. At the outlet of the clarifier, the purified water is further treated using tertiary sand filtration and final ozonation for disinfection purpose. After the treatment, the effluent is discharged according to the tides. The rejection is made at 15 meters depth and at 2.5 km of coastline.

Visiting Normandy is the opportunity for you to discover its lanscape, the medieval architecture of the Caen area and the landing beaches. Bernières-sur-Mer offers to the walkers two and a half kilometres of bank lined with a cordon dunaire on the West, of a dike walk along the town, and along a cliff in the East. The sea, in low tide, lets discover the sandy estran, rocks and islands which make the happiness of fishers.

The church and the big properties in their case of greenery encircled by walls in stones make the charm of Bernières and are the witnesses of rich past. Bernières was formerly an active port in the mouth of Seulles. The church Notre-Dame with imposing dimensions and the high stone arrow drawn up between ground, sea and sky - is a beautiful example of the medieval architecture of the Plain of Caen and Bessin. Bernières is a high place of the unloading of the allied armed forces. Numerous Anglo-Saxon and Canadian soldiers walked on the beach of Juno Beach to free Bernières and Europe, some left it the life. The still visible vestiges of the Atlantic Wall became a place of memory.



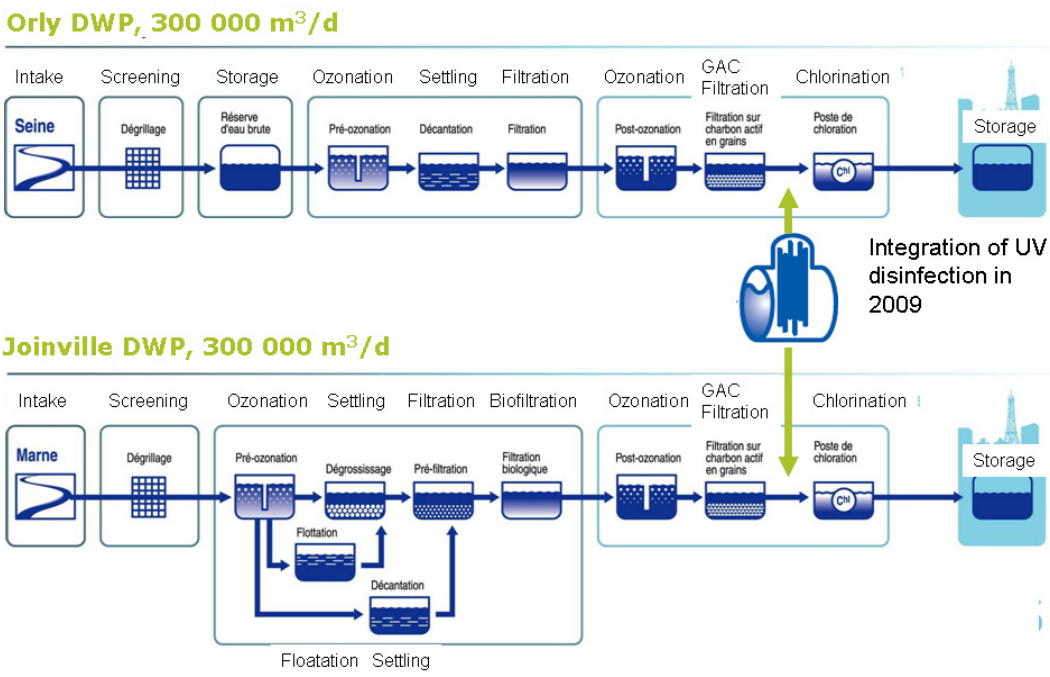
The tour includes stop and visit of the D-Day Museum of Arromanches that is the battle of Normandy main highlight. It is the first museum to be built in commemoration of June 6th 1944 and the Normandy Campaign. It overlooks the very spot where one of the Mulberry Harbours was constructed and where its remains can still be seen today, just a few hundred metres from the shore

Technical Tour T3 - Orly and Joinville Drinking Water Plants

Friday 27 May - Full day tour

Eau de Paris is the unique public institution of the City of Paris in charge of the management of the water service in Paris, from collection, production to distribution of 550 000 m^3/d of drinking water to users and subscribers. The city of Paris has four plants fed with groundwater at Longueville (77), Sorques (77), Saint-Cloud (92) and L'Hay-les-Roses and two plants treating the waters of the Seine and Marne rivers at Orly and Joinville. Half of the drinking water supplied comes from the plants of Orly and Joinville, which withdraw water, respectively, in the Seine and the Marne.

Each of Orly and Joinville plants has a capacity of 300 000 m^3/d. The treatment lines are shown below. To comply with new regulations on pathogens and bromate restrictions, the ozone drinking water treatment plants in Joinville and Orly are now equipped with UV reactors.



Ozone and UV
Leading-edge science and technologies

SCIENTIFIC AND TECHNICAL PROGRAMME

The Scientific Programme includes:

Close to 270 presentations

Keynote lecture (KN) / Long oral presentations (LP) / Short oral presentation for poster introduction (SP) / Poster exhibition (PE)

Organized in 15 sessions

Half of the sessions are devoted to transverse topics.

Colours stand for: Combined Ozone and UV sessions - Ozone focused sessions - UV focused sessions

S1	Advanced Oxidation Processes	Ozone-based AOPs, UV-based AOPs, Ozone and UV-based AOPs, other AOPs
S2	Ozone reactor design	Hydrodynamics and mass transfer, Reactor design / Modeling / Validation, Multiphase reactors, Gas diffusion devices
S3	Industrial applications	Gas treatment and odor control, Soil remediation, Biosolids treatment, Application in agricultural and industrial processes, Decontamination/Modification of materials and surfaces
S4	UV reactor design and validation	New techniques and findings in UV reactor design and validation
S5	Ozone in Medicine	Medical applications, Ozone effects, Therapy methods, Clinical studies
S6	Ozone for Agrifood	Application in agriculture and food processing
S7	IOA review of industry and technical news	Market and applications growth, scientific and technical trends, control methods, publication highlights
S8	Applications in Wastewaters	By-product formation and control, Water disinfection, Emerging contaminants - occurrence and treatment, Pollutants removal, Wastewater treatment for reuse or discharge, Competitiveness of technologies
S9	Full scale applications	Operation studies, Regulatory requirements, Ozone and UV synergy, Competitiveness of technologies
S10	Process development and optimization	Process development and optimization, control tools, Measurement and on-line monitoring
S11	Reaction study and modelling	Chemical reactions, Biochemical reactions, Photochemical reactions, Photobiological reactions , Reaction mechanisms, Reaction kinetics and modelling
S12	Applications in Natural waters	By-product formation and control, Water disinfection, Emerging contaminants - occurrence and treatment, Pollutants removal
S13	UV lamps	UV source technologies
S14	UV for Aquatics	Application of UV for treating water in swimming pools / recreational waters
S15	Ozone generation	Generator development, ozone cost

Monday, May 23

Plenary session. Opening

Room Newport

Hour	
08:30	**Opening Addresses**, Sylvie BAIG, IOA President & Bertrand DUSSERT, IUVA President
08:45	**Congress introduction**, Michel ROUSTAN & Michael TEMPLETON, Co-chairs of the Scientific Committee, Renate VIEBAHN
09:00	**Challenges in Water Supply and Sanitation: WSSTP Vision and Related Strategy** *Durk Kroll (WSSTP Treasurer), Mike Farrimond (WSSTP Chair)* **Successful Implementation of Efficient Oxygen/Ozone Installation in Los Angeles Inspires, Promotes and Encourages Ozonation in North America and Worldwide** *Kervin Rakness, Pierre-André Liechti* **Advancing Large-Scale UV Implementation in New York City** *Gary R. Kroll, Richard Fahey, Paul D. Smith*
09:45	**IOA General Assembly**
10h00	***Break***

Session 1. Advanced Oxidation Processes – Part 1

Room Newport II

Hour	Presentation	Title and authors	Country	ID
10:30	LP	**Catalytic Ozonation of para-Chlorobenzoic acid (pCBA) in Municipal Wastewater Effluent using Nano-structured Titanium Dioxide in a Packed Bed Configuration** *Paul K. Westerhoff, Michelle C. Barry, Jennifer Elton, Kiril Hristovski*	USA	214
10:50	LP	**Catalytic ozonation of organic micropollutant in water with ordered Mn-MCM-41 mesoporous molecular sieves as catalyst** *Minghao Sui, Jia Liu, Li Sheng, Lingmin Wu*	P.R. China	218
11:10	LP	**Catalytic ozonation and its full scale application in China in the last decade (2000-2010)** *Zheng-Qian Liu, Bang-Jun Han, Jun Ma, Ren-Guang Zha, Hai-Tao Zhu, Li-Ping Shen, Wei-Ping Guan, Sheng-Jun Wang, Lei Zhao*	P.R. China	260
11:30	LP	**Efficient photodegradation of paracetamol using Fe modified TiO_2 meoporous nanoparticles under visible light irradiation** *Ya Hsuan Liou, Szu-Ying Chen*	Taiwan	280
11:50	LP	**TiO_2-based enhanced photocatalytic degradation and disinfection of water under solar light irradiation** *Miguel Pelaez, Polycarpos Falaras, Erick R. Bandala, Patrick Dunlop, John Byrne, Armah A. de la Cruz, Dionysios D. Dionysiou*	USA, Greece, México, UK	308
12:10	LP	**Coupling photocatalysis with non-thermal plasma for removal of odorous pollutants** *Alina Maciuca, Catherine Batiot-Dupeyrat, Jean-Michel Tatibouët*	France	110
12:30	***Lunch***			

Session 2. Ozone reactor design

Room Pacific

Hour	Presentation	Title and authors	Country	ID
10:30	LP	**Optimizing Ozone Transfer Through Pipeline, Multi-Jet Gas Mixing** *James R Jackson, Michael Oneby P.E., Celia M. Mazzei, Michael G. Priest P.E.*	USA	22
10:50	LP	**Static Mixers for Ozonation of Water** *Rein Munter*	Estonia	32
11:10	LP	**Basics and Engineering of a Bubble Column** *Pierre-André Liechti*	Switzerland	143
11:30	LP	**Considering Options to Refurbish and Replace an Aging Ozonation System** *Jeff Neemann, Bryan Townsend, Mario Francucci, Kathy Moriarty, Weston Haskell, Rick Pershken, Kevin Pottle*	USA	182
11:50	LP	**Reengineering for improving the operation of wastewater treatment plants by using ozone** *Robert Hausler, Pierre-André Liechti*	Canada, Switzerland	189
12:10	LP	**Design of oxygen and ozone systems for large scale advanced tertiary treatment plant** *John Mieog, Jon Bates, Andrew Nelson, Nick Burns*	Australia	207
12:30	***Lunch***			

Session 4. UV reactor design and validation – Part 1

Room Newport I

Hour	Presentation	Title and authors	Country	ID
10:30	LP	**New York City UV system validation by Lagrangian actinometry using dyed microspheres** *Chengyue Shen, O. Karl Scheible, Ernest R. Blatchley III, Eric Cox, Matthew Valade*	USA	155
10:50	LP	**Comparison of CFD, biodosimetry and Lagrangian actinometry to assess UV reactor performance** *Bas A. Wols, Roberta C.H.M. Hofman-Caris, Danny J.H. Harmsen, Erwin F. Beerendonk, Johannis C van Dijk, Po-Shun Chan, Ernest R. Blatchley III*	Netherlands, USA	122
11:10	LP	**Is the REF of UV-Plants for Drinking Water Disinfection Proportional to Lamp Power and Flow Rate?** *Alexander Cabaj, Regina Sommer, Georg Hirschmann, Thomas Haider*	Austria	311
11:30	LP	**Demonstrating 4-log Adenovirus Inactivation in a Medium Pressure UV Reactor** *Karl G. Linden, Karl Scheible, Chengyue Shen, Charles Gerba, Akrum Tamimi, Phyllis Posy*	USA, Israel	318
11:50	LP	**UV System Checkpoint Bioassays: Proof of Scale-Up, Challenges from the Field, and Comparison Methodology** *Brian Petri, Ji An, Victor Moreland*	Canada	307
12:10	LP	**Yikes! What the UVDGM Does Not Address on UV Disinfection** *Harold Wright, Mark Heath, Jeff Bandy*	USA	319

Session 5. Ozone in Medecine – Part 1 — Room Beach

Hour	Presentation	Title and authors	Country	ID
10:30	LP	**Ozone as a medical drug. Toxicity versus therapeutic benefit. Guidelines and treatment strategies.** *Renate Viebahn-Hänsler*	Germany	29
10:45	LP	**Ozone Oxidative Postconditioning protects against the injury associated to Alcohol Withdrawal Syndrome** *Olga S. León Fernández, Maria T. Díaz-Soto, Angela Fraga, Jaqueline Dranguet, Mayté Casanova, Renate Viebhan, Silvia Menéndez*	Cuba, Germany	30
11:00	LP	**Effects of Medical Ozone as an Anti Cancer Agent in Hepatocellular Carcinoma in Rats (A Histopathological Study)** *M.N. Mawsouf, M.A. Fadel*	Egypt	338
11:15	LP	**The role of O_3/O_2-Pneumoperitoneum in a cardiac allograft survival study in rats** *Aline Henriquez Santana, Siegfried Schulz, Harald Tillmanns, Thomas Stadlbauer*	Germany	51
11:30	LP	**Cardioprotective Effects of Ozone Oxidative Preconditioning in an in Vivo Model of Ischemia/Reperfusion Injury** *Azza M. Agha , Amina S. Attia, Mohamed N. Mawsouf, Hesham A. Salem, Lamiaa A. Ahmed*	Egypt	337
11:45	LP	**Comparative analysis of the effect of small dozes of ozone and doxorubicin on the therapeutic pathomorphism of an experimental tumor** *C.N.Kontorshchikova, A.V.Alyasova, B.E.Shakhov, I.G. Terentiev, S.N. Tzybusov, S.N.Kuznetzov, S.S.Sazanov*	Russia	105
12:00	LP	**Ozone and the periodontal health and diseases** *Judit Martinez Abreu, Mark T. Weiser, Eduardo Llanes Llanes, Silvia Menéndez Cepero*	Cuba, USA	80
12:15		**Discussion**		
12:30	***Lunch***			

Session 1. Advanced Oxidation Processes – Part 2 — Room Newport II

Hour	Presentation	Title and authors	Country	ID
14:30	LP	**Impact of Combined Coagulation-UV/H_2O_2 Treatment on Biological Stability of Water** *Mahdi Bazri, Madjid Mohseni*	Canada	114
14:50	LP	**Control of TCE Using UV Combined with Hydrogen Peroxide or Chlorine** *Ding Wang, Tim Walton, Leigh MacDermott, Ron Hofmann*	Canada	266
15:10	LP	**Application of UV/H_2O_2 as post-treatment of WWTP secondary effluents for water reuse** *Bruno S. Souza, Renato F. Dantas, Angel Cruz, Santiago Esplugas, Carme Sans, Márcia Dezotti*	Brazil, Spain	278
15:30	LP	**A method for quantifying the assimilable organic carbon in water treated with UV/H_2O_2 and biological activated carbon filtration** *Mihaela I. Stefan, Siva R. Sarathy*	Canada	294
15:50	LP	**International project on new concepts of UV/ H_2O_2 oxidation** *C.H.M. Hofman-Caris, D.J.H. Harmsen, E.F. Beerendonk, M. Heringa, A.H. Knol, K. Lekkerkerker-Theunissen, J. Geboers, M. Meyer, D. Metz*	Netherlands	287
16:10	LP	**Removal of Antibiotics from Urban Sludge: A Comparison of Ozonation and Fenton Processes** *L.Elif Acar, Nalan Bilgin Öncü, Isıl Akmehmet Balcıoglu*	Turkey	208
16:30	***Break***			

Session 3. Industrial applications – Part 1 — Room Pacific

Hour	Presentation	Title and authors	Country	ID
14:30	KN	**Economic, environmental and microbiological benefits of ozone laundering systems** *Rip G. Rice, Marc DeBrum, Jacqueline Hook, Dick Cardis, Cameron Tapp*	USA, UK	54 55
15:10	LP	**UV irradiation for the manufacturing of viral vaccines: state-of-the-art and perspectives in modern vaccine processing** *Ines Mayerhofer, Heinz Anderle, Otfried Kistner, M. Keith Howard, Thomas R. Kreil, P. Noel Barrett*	Austria	283
15:30	LP	**Effects of dissolved ozone in internal and external fish body systems** *Cathy Shuk-wun Fong, Grace Ka-yan Man, Wo-wing Cheng, Gilbert Yuk-sing Chan*	Hong Kong	148
15:50	LP	**Application of O_3 and UV for disinfection of seawater in Ballast water treatment** *Joon-Wun Kang, Yeojoon Yoon, Yumi Jung*	Republic of Korea	123
16:10	LP	**Effect of Low Pressure Ultraviolet Irradiation on Barnacle Growth under Open Sea Conditions** *XIE, Rongjing*	Singapore	150
16h30	***Break***			

Session 4. UV reactor design and validation – Part 2 — Room Newport I

Hour	Presentation	Title and authors	Country	ID
14:30	LP	**Impact of advanced validation techniques and dose-monitoring strategies on UV reactor operating efficiency** *Bryan Townsend, Bob Hulsey, Jeff Neemann, Xi Zhao*	USA	293
14:50	LP	**On-Site Testing Extends Validated Range for Year-Round Operation of a Medium Pressure UV Disinfection System** *Mark Heath, Harold Wright, Jeff Bandy, Irfan Gehlen, Mark Forsyth*	USA	303
15:10	LP	**Development, Challenges and Validation of a High Efficiency UV Unit for Title 22 Reuse** *Keith Bircher, Bill Sotirakos, Andy Salveson*	USA	298

Hour	Presentation	Title and authors	Country	ID
15:30	LP	**Drinking Water UV Operation Without On-Line UVT Monitoring: The Default UVT and Sensor Setpoint Approaches to Validation** *Jeff Bandy, Harold Wright, David Gaithuma, Oliver Lawal, Steve Larner*	USA, UK	274
15:50	LP	**Sensor-Based Control - THE Way for Safe, Energy-Efficient UV System Operation** *Mike Newberry, Paul Ropic*	USA	74
16:10	LP	**Reflections cause measureable error when calculating UV dose in a collimated beam apparatus** *Shawn Verhoeven, Harold Wright, Conrad Odegaard, Jessica Shaw, Keith Bircher*	Canada, USA	149
16:30	***Break***			

Session 5. Ozone in Medicine – Part 2 Room Beach

Hour	Presentation	Title and authors	Country	ID
14:30	LP	**Effect of ozone on TGFβ1, VEGF, FAS and TIMP2 in chronic hepatitis C patients (An immune histochemistry study)** *Sadek A, Abd El Hady A M, Hammam O, Abdel Hady A A, Mansy S, Elbasha H, Alawam H.*	Egypt	47
14:40	LP	**Effect of Rectal Ozone Gas on Viral Kinetics liver functions and Liver Histopathology, in Hepatitis C Patients: A Phase II Clinical Study** *Sadek A, Kamal E, Abd El Hady A M, Aashour M, Hammam O, Shalaby S, Abd El Hady A A*	Egypt	46
14:50	LP	**Application of Ozone Therapy in the Vestibulocochlear Syndrome** *Silvia Menéndez, Alejandro del Cerro, Tania Alvarez*	Cuba	28
15:05	LP	**CT-guided Oxygen-Ozone Nucleolysis for the Treatment of Degenerative Spinal Disease – the Role of Age, Gender, Disc Pathology and Multi-Segmental Changes** *B. Oder, S.A. Thurnher*	Austria	339
15:20	LP	**Results of combined intradiscal and periganglionic injection of medical ozone and periganglionic administration of steroids and anesthetic for the treatment of lumbar disk herniation: effects on disk size and lumbar radiculopathy in 283 patients** *Thomas Lehnert, Nagy Naguib, Thomas J. Vogl*	Germany	58
15:35		**Discussion**		
16:00	LP	**Correlation of plasma interleukin-1 levels with disease activity in rheumatoid arthritis with and without ozone** *Ziad Fahmy*	Germany	334
16:15	LP	**Application of ozone therapy in patients with knee osteoarthritis** *José Luis Calunga, Silvia Menéndez, Rodolfo León, Soulien Chang, Dailen Guanche, Alberto Balbín, José Zayas, Pedro García*	Cuba	31
16:30	LP	**Role of intra-articular Ozone gas injection in the management of internal derangement of the temporomandibular joint** *Emad T Daif*	Egypt	23
16:45	***Break***			

Session 1. Advanced Oxidation Processes – Part 3 Room Newport II

Hour	Presentation	Title and authors	Country	ID
17:00	SP	**Efficiency and mechanism of catalytic ozonation on metal oxide catalysts** *Roberto Rosal, Soledad Gonzalo, Javier Santiago, Antonio Rodríguez, José Antonio Perdigón-Melón, Eloy García-Calvo*	Spain	38
17:05	SP	**Influence of catalyst synthesis method of Ni/TiO_2 on the 2,4-dichlorophenoxyacetic acid decomposition by ozone in water** *J.L. Rodríguez S, T. Poznyak, M.A. Valenzuela, F. Pola H*	México	75
17:10	SP	**A Comparison between catalytic ozonation and activated carbon adsorption of aqueous dyes solutions in a semi batch reactor** *S. Faleh, M. Guiza, A. Ouederni*	Tunisie	107
17:15	SP	**Ozonation of sulfamethoxazole promoted by MWCNT** *Alexandra Gonçalves, José Órfão, Manuel Pereira*	Portugal	136
17:20	SP	**Catalytic ozonation of organic pollutants using nanocarbon materials grown on a macro structured support** *João Restivo, José J.M. Órfão, Manuel F.R. Pereira, Sabino Armenise, Enrique Garcia-Bordeje*	Portugal, Spain	172
17:25	SP	**Petrochemical Effluent Treatment By Zeolites Combined To Ozone** *Marie-Hélène Manero, Jean-Stéphane Pic, Stéphan Brosillon, Julie Mendret, Anne Galarneau, Nicolas Lesage*	France	225
17:30	SP	**The method of eliminating bromate in catalytic ozonation in treating drinking water** *Ping Dong, Xiangdong Kong*	P.R. China	246
17:35	SP	**Heterogeneous catalytic ozonation of diethyl phthalate** *Chedly Tizaoui, H M Mohammed, L Mansouri, N Hilal, L Bousselmi*	UK, Tunisia	159
17:40	SP	**The Application of Catalytic Ozonation by Combining with Goethite and UV on the Oxidation and Recirculation of Swimming Pool Water** *Jerry J. Wu, Gang-Juan Lee*	Taiwan	162
17:45	PE	**Poster exhibition & Discussion with authors**		

Session 3. Industrial applications – Part 2 Room Pacific

Hour	Presentation	Title and authors	Country	ID
17:00	SP	**Natural zeolite reactivity towards ozone: the role of compensation cations** *Héctor Valdés, Serguei Alejandro, Claudio. A. Zaror*	Chile	11

Hour	Presentation	Title and authors	Country	ID
17:05	SP	**Synergistic Effect of Hydrogen Peroxide and Ozone in a Gaseous Environment** *Simon Robitaille, Marie-Christine Gagné, Sylvie Dufresne*	Canada	217
17:10	SP	**Quantification of the microbiological efficacy of the JLA Ltd ozone diffusion laundering system** *Kyle Allison, Jacqueline Hook, Dick Cardis, Rip G. Rice*	UK, USA	56
17:15	SP	**Removal of phosphorus from iron mineral using ozone** *F. R. Carrillo-Pedroza, M. J. Soria-Aguilar, R. Perales Cárdenas*	México	209
17:20	SP	**Metallic nanoparticles obtained from cyanidation solutions treated with ozone** *Ma. de Jesús Soria-Aguilar, F. Raúl Carrillo-Pedroza, L.A. García-Cerda, Marco Sanchez-Castillo, Damáris M. Puente-Siller, Delia M. Valdéz Zavala*	México	210
17:25	SP	**Ozone disintegration on waste sludge: enhanced biogas production and energy balance in wastewater treatment plant** *Albert Canut, Begoña Ruiz, Mireia Fiter, Carlos Ferrer, Andrés Pascual*	Spain	224
17:30	SP	**Purification of grease trap by ozonation and sonication** *Michal Piotr Kwiatkowski, Satoshi Ihara, Chobei Yamabe, Saburoh Satoh, Masanori Nieda*	Japan	261
17:35	SP	**Advances in UV irradiation technology for biopharmaceuticals to enhance process robustness** *Heinz Anderle, Ines Mayerhofer, H. Peter Matthiessen, Manfred Reiter, Wolfgang Mundt*	Austria	284
17:40	SP	**Effects of temperature on the synergistic disinfection of biofilms in the combination use of ozone water followed by hydrogen peroxide water** *Mariko Tachikawa, Kenzo Yamanaka*	Japan	328
17:45	SP	**Innovative O_3/O_2 reactive flotation for paper deinking** *Nathalie Marlin, Filipe Almeida, Davide Beneventi, Marc Aurousseau*	France	344
17:50	PE	**Poster exhibition & Discussion with authors**		

Session 4. UV reactor design and validation – Part 3 Room Newport I

Hour	Presentation	Title and authors	Country	ID
17:00	LP	**Application of UV Disinfection to achieve Enterococci - Removal at a Trickling Filter Plant** *Gary Hunter, Amy Kliewer, Bob Hulsey, Charlie Klinger, Manuel Carrera*	USA	275
17:20	SP	**Technology limitations of UV-validations** *Paul Buijs, Willem Bakermans, Andrew Clark*	Netherlands	289
17:25	SP	**Updating the Approaches in the NWRI/AwwaRF UV Guidelines: The Impacts of Water Quality and Recirculation Mode Testing on UV Validation** *Brian Petri, Chengyue Shen, O. Karl Scheible, Stephen Tang*	Canada, USA	305
17:30	SP	**Constrained regularization for Lagrangian actinometry** *Eric Cox, Ernest R. Blatchley III*	USA	12
17:35	SP	**Defining UV Dose Monitoring Equations** *Harold Wright, Jeff Bandy, Mark Heath, Keith Bircher*	USA	320
17:40	SP	**Another Intense UV Dose of Fluence – Musing on Photons and the Vector Properties of Light** *Harold Wright*	USA	321
17:45	PE	**Poster exhibition & Discussion with authors**		

Session 5. Ozone in Medicine – Part 3 Room Beach

Hour	Presentation	Title and authors	Country	ID
17:15	LP	**Ozone as oxidative detoxication factor in early period of burn disease** *Peretyagin S.P., Struchkov A.A., Kostina O.V., Martusevich A.K., Lusan A.S., Kontorschikova K.N., Atyasov I.N., Pogodin I.E.*	Russia	194
17:30	LP	**Antimicrobial effectiveness of ozonated vegetable oils controlled by their total unsaturation** *Arizbeth Pérez, Jesús Rodríguez, Tatyana Poznyak, Isaac Chairez, Susana Mendoza*	México	65
18:00	SP	**Importance of the Toxicological Tests in the Application and Safety of Ozone Therapy** *Silvia Menéndez, Zullyt Zamora, Frank Hernández*	Cuba	16
18:05	SP	***In vivo* antimicrobial activity of ozonized theobroma oil vaginal suppositories against *candida albicans*** *Rosa I. Meneau, Maritza F. Díaz, Irán Fernández, Yaíma Sánchez, Dayana Gil, Bárbara M. Manet, Gastón García*	Cuba	18
18:10	SP	**Antioxidant effects of an ozonized oil formulation on damaged-inflammatory rat skin** *Yaíma Sánchez, Maritza F. Díaz, Frank Hernández, Dayana Gil, Gastón García*	Cuba	19
18:15	SP	**Ozone Therapy Immunomodulatory Effect in Children with Selective Immunoglobulin A Deficiency** *Jacqueline Díaz Luis, Silvia Menéndez Cepero, Consuelo Macías Abrahan*	Cuba	27
18:20	SP	**Effect of Ozone Gas With and Without Anti-Oxidants on Viral Kinetics and Liver Histopathology, in Hepatitis C Patients: A Phase II Clinical Study** *Sadek A, Abd El Hady A M, Hammam O, Elbasha H, Abd El Hady A A*	Egypt	44

Hour	Presentation	Title and authors	Country	ID
18:25	SP	**Is Ozone antifibrotic? An electron microscopic study on chronic Hepatitis C patients** *Sadek A, Mansy S, Abd El Hady A M, Hammam O, Abdel Hady A A, Elbasha H.*	Egypt	45
18:30	SP	**Effect of ozone/oxygen gas mixture on bilharzial hepatic fibrosis induced in infected mice** *Sadek A, Alawam H, Kasem M, Abd El Hady A M, Hammam O, Mahmoud S, Abd El Hady A A, Diab T*	Egypt	48
18:35	PE	**Poster exhibition & Discussion with authors**		

Tuesday, May 24

Session 1. Advanced Oxidation Processes – Part 4

Room Newport II

Hour	Presentation	Title and authors	Country	ID
08:30	LP	**OH-Radical Yield in the Peroxone Process (H_2O_2 + O_3)** *Alexandra Jarocki, Myint Sein, Justus von Sonntag, Alfred Golloch, Torsten C. Schmidt, Clemens von Sonntag*	Germany	175
08:50	LP	**Combined O_3/ H_2O_2 and UV for multiple barrier OMP treatment and bromate formation control – One year pilot plant research** *K. Lekkerkerker-Teunissen, J. Scheideler, A.H. Knol, A. Ried, J.Q.J.C. Verberk, J.C. van Dijk*	Netherlands, Germany	8
09:10	LP	**Degradation of atrazine by sulfate radical anions. Reaction rate constants and mechanistic aspects** *Holger Lutze, Stephanie Bircher, Clemens von Sonntag, Torsten C. Schmidt*	Germany, Switzerland	173
09:30	LP	**Efficient Degradation and Decomposing Mechanism of Perfluoro Compounds in Water Using Discharge Plasmas** *Koichi Yasuoka, Ryuichi Hayashi, Nozomi Takeuchi*	Japan	97
09:50	LP	**Degradation of pesticides and taste and odour compounds using a flow-through Vacuum-UV reactor** *Gustavo E. Imoberdorf, Madjid Mohseni*	Canada	171
10:10	PE	**Poster exhibition & Discussion with authors**		
10:30	***Break***			

Session 6. Ozone for Agrifood

Room Pacific

Hour	Presentation	Title and authors	Country	ID
08:30	KN	**Ozone Clean in Place in Food Industries - Industrial validation of an Ozone Clean in Place system in a dairy industry** *A. Canut, I.Llorca, V.Martínez, A. Pascual*	Spain	42 43
09:10	LP	**Some ozone applications in seafood** *Walter J. Blogoslawski, Mary E. Stewart*	USA	242
09:30	LP	**Ozone applications in the postharvest of papaya (*Carica papaya l*): an alternative to *Amistar* fungicide** *Mayra Bataller, José E. González, Eliet Veliz, Lidia A. Fernández, Dariem Nápoles, Caridad Álvarez, Silvia Menendez*	Cuba	15
09:50	LP	**Plague Elimination and Ozone Effects on Types Stored Corn** *Jose G. LLanes O, Miguel Angulo*	México	204
10:10	LP	**Effects of ozone and UV treatment on biomass, chlorophyll and antioxidant production in wheatgrass** *Emmanuelle Mansier, Gilbert Yuk-sing Chan, Sarah Kam-lan Yeung*	Hong Kong, France	125
10:30	***Break***			

Session 9. Full scale applications – Part 1

Room Newport I

Hour	Presentation	Title and authors	Country	ID
08:30	LP	**12-Month UV Fouling Study on Unfiltered Source Water** *Chad Talbot, Mark Heath, Harold Wright, David Peters*	USA	119
08:50	LP	**UV Disinfection in Germany: Results of a Field Study in Drinking Water Treatment Plants** *Jutta Eggers, Burkhard Wricke*	Germany	132
09:10	LP	**Design and Operation of UV Equipment for Large Scale Municipal Wastewater Disinfection: City of Moscow** *Sergey Kostychenko, Sergey Volkov, Andrey Tkachev, Olga Petrova, Pavel Parilov*	Russia	276
09:30	LP	**City of Winnipeg Water Treatment Program. Deacon UV Disinfection Facility – Lessons Learned from a Large Scale Installation** *S.R. (Ray) Bilevicius, A.Weremy, D. Taylor*	Canada	345
09:50	LP	**An improved control of the microbiological health risk of drinking water quality for Parisian consumers – the new implementation of UV disinfection on the surface water drinking water treatment plants of Eau de Paris** *B. Welté, M. Joyeux, V. Pilmis, S. Baig*	France	304
10:10	LP	**Biodosimetry of a Full-Scale Wastewater UV Disinfection System Using Multiple Surrogate Microorganisms** *Bruno Ferran, Wei Yang*	USA	295
10:30	***Break***			

Session 5. Ozone in Medicine – Part 4 — Room Beach

Hour	Presentation	Title and authors	Country	ID
08:30	LP	**Workshop on medical ozone therapy: How to successfully integrate ozone therapy into other clinical treatments** *Michael Schreiber*	Germany	236
08:50	LP	**Ozone therapy for viral hepatitis** *Heinz Konrad*	Brazil	87
09:10	LP	**Role of ozone therapy as an adjuvant in management of the childhood asthma** *M.N.Mawsouf, A.Gomaa*	Egypt	336
09:25	LP	**Ozone therapy as a valuable component in the treatment of chronic inflammatory diseases of the female internal genital organs** *Chandra-D'Mello Rajani, Grechkanev Gennady, Peretyagina Natalia, Grechkaneva Olga*	Azerbaijan, Russia	145
09:40		**Special applications in practice: wound cleaning, disinfection, bagging, ozonized water/topical injections** *M. Schreiber, S. Tiron*	Germany, Romania	
10:30	***Break***			

Session 1. Advanced Oxidation Processes – Part 5 — Room Newport II

Hour	Presentation	Title and authors	Country	ID
11:00	SP	**Photodegradation of glyphosate acid and its commercial formulations in water by the UV/ H_2O_2 process** *Silvana Neder, Antonio Negro, Alberto Cassano, Cristina Zalazar*	Argentina	98
11:05	SP	**Kinetics studies of n-butylparaben degradation in H_2O_2/UV system** *Dorota Błędzka, Jacek S. Miller, Stanisław Ledakowicz*	Poland	103
11:10	SP	**Advanced Oxidation Process (UV/H_2O_2) applied to study the inactivation of pseudomonas aeruginosa** *Maria Franciosi, Rodolfo Brandi, Alberto Cassano, José Di Conza, Marisol Labas*	Argentina	181
11:15	SP	**Triazine herbicides removal by UV/H_2O_2 in water and secondary effluent** *Samanta Pereira, Renato F. Dantas, Santiago Esplugas, Carme Sans, Márcia Dezotti*	Brazil, Spain	277
11:20	SP	**Prediction of advanced oxidation performance in pilot UV/H_2O_2 reactor systems with MP- and LP-UV lamps** *C.H.M. Hofman-Caris, D.J.H. Harmsen, E.F. Beerendonk, A.H. Knol, D. Metz, B.A. Wols*	Netherlands	286
11:25	SP	**Destruction of cyanotoxins by UV/H_2O_2 Advanced Oxidation Process** *Xuexiang He, Armah A. de la Cruz, Dionysios D. Dionysiou*	USA	309
11:30	SP	**H_2O_2/UV oxidation of Arsenic and Terbuthylazine in drinking water** *Sabrina Sorlini, Mihaela Stefan, Francesca Gialdini*	Italy, Canada	323
11:35	SP	**Photochemical oxidation of arsenic (III) using hydrogen peroxide and UVC radiation** *Maia Lescano, Cristina Zalazar, Alberto Cassano, Rodolfo Brandi*	Argentina	99
11:40	SP	**Elimination and mineralization of sulfonated organic compounds by ionizing radiation: Effect of hydrogen peroxide (H_2O_2) and persulfate ions ($S_2O_8^{2-}$)** *Turki S. Alkhuraiji, Nathalie Karpel vel Leitner*	France	50
11:45	SP	**Enhanced Degradation of Polychlorinated Biphenyls in Soil by Hydrogen Peroxide, Persulfate and Ozone** *Marika Viisimaa, Jelena Veressinina, Anna Goi*	Estonia	37
11:50	PE	**Poster exhibition & Discussion with authors**		
12:30	***Lunch***			

Session 7. IOA review of industry and technical news — Room Pacific

Hour	Presentation	Title and authors	Country	ID
11:00	LP	**Ozone-How much is that really?** *Joseph Drago, Glenn Hunter, Robert Jarnis, Susan Neal, Mike Oneby, Kerwin Rakness, Neal Spivey*	USA	49
11:20	LP	**Worldwide Ozone Capacity for Treatment of Drinking Water and Wastewater: A Review** *Barry L. Loeb, Craig M. Thompson, Joseph Drago, Hirofumi Takahara, Sylvie Baig*	USA, Japan, France	142
11:40	LP	**Accuracy of High Concentration Ozone Photometry** *Ralph Christopher*	Germany	36
12:00	LP	**Ozone: Science & Engineering - Thirty Three Years and Growing** *Barry L. Loeb*	USA	141
12:20	SP	**Ozone in Food Processing – A Forthcoming Book** *Colm O'Donnell, B.K. Tiwari, P.J. Cullen, Rip G. Rice*	UK, Ireland, USA	52
12:25	SP	**The Ozone Laundry Handbook. A Comprehensive Guide for the Proper Application of Ozone in the Commercial Laundry Industry** *Rip G. Rice, Marc DeBrum, Dick Cardis, Cameron Tapp*	USA, UK	53
12:30	***Lunch***			

Session 9. Full scale applications – Part 2 — Room Newport I

Hour	Presentation	Title and authors	Country	ID
11:00	SP	**San Francisco Begins Operation of a 315-MGD UV Disinfection Facility** *Michael L. Price, Bijan Ahmadzadeh, Jamal Awad*	USA	60
11:05	SP	**Implementation of UV reactors for cryptosporidium inactivation at two major plants of Paris suburban** *Gérard Chagneau, Alain Neveu, Stewart Tattersall, Jean-Claude Laffitte*	France, UK	133

Hour	Presentation	Title and authors	Country	ID
11:10	SP	**UV Water Disinfection Systems for Canberra's Water Security Programme** *Iain F. Johnson*	Australia	262
11:20	SP	**UV-chlorine synergy in Ukraine: case studies** *Sergey Malyshko, Alla Muskeyeva, Alexander Shavrov, Sergii Ovcharenko, Leonid Vorobiov, Paul Buijs*	Ukraine, Netherlands	290
11:25	SP	**Energy optimization of the Seymour-Capilano UV disinfection facility** *Bryan Townsend, Mark Ferguson, Sharon Peters, Timothy Phelan, Alistair Wardlaw*	USA, Canada	292
11:30	SP	**Twenty Years and Nearly One Billion Dollars Later, UV and Ozone are an Integral Part of Metro Vancouver's Water Treatment System** *Inder Singh, Mark Ferguson*	Canada	312
11:35	PE	**Poster exhibition & Discussion with authors**		
12:30	***Lunch***			

Session 5. Ozone in Medicine – Part 5 — Room Beach

Hour	Presentation	Title and authors	Country	ID
11:00		**Systemic application: extracorporal blood treatment, rectal insufflation** *Michael Schreiber/Heinz Konrad*	Germany, Brazil	
12:00	SP	**Treatment with ozone in diabetic patients with periodontal abscess** *Judit Martinez Abreu, Mark T. Weiser, Eduardo Llanes Llanes, Silvia Menéndez Cepero*	Cuba, USA	81
12:05	SP	**Ozonated saline influence on lipid and protein metabolism in patients with metabolic syndrome** *J.R.Efremenko., C.N. Kontorshchikova, E.F. Koroleva*	Russia	104
12:10	SP	**The usage of ozonized physiologic saline in gynecologic patients after surgery** *O.S. Yanchenko, E.U. Kontorschikova, C.N. Kontorshchikova, T.V. Kotelnikova, T.C. Kachalina, V.V. Novikov*	Russia	106
12:15	SP	**State of Auditory Analyzer in Modern Human and Its Correction Using Medical Ozone** *Barkhotkina Tetiana*	Ukraine	140
12:20	SP	**Ozone using in treatment of rosacea** *Bitkina O.A., Kontorchirova K.N., Kopytova T.V.*	Russia	195
12:25	SP	**Ozone therapy in diseases associated with atherosclerosis** *Oleg V. Maslennikov, Irina A. Gribkova, Claudia N. Kontorschikova, Elena U. Kontorschikova*	Russia	219
12:30	SP	**Ozone Therapy in the oncology (experimental research)** *Tatiana Scherbatyuk, Mahir Abdul, Victor Selemir*	Russia	243
12:35	SP	**Retinitis Pigmentosa patients treated with ozone therapy during 20 years. Cuban experiences** *Mirta Copello, Silvia Menéndez*	Cuba	346
12:40	***Lunch***			

Hour	Room Newport I
14:00	**IUVA General Assembly**

Session 1. Advanced Oxidation Processes – Part 6 — Room Newport II

Hour	Presentation	Title and authors	Country	ID
14:30	SP	**Benchmark / Comparison of Energy consumption of established and emerging Advanced Oxidation Technologies** *F.-J. Spiess, A. Hauser, C. Garcia, C. Sichel*	Germany	249
14:35	SP	**Antimicrobial Removal from Environmentally Relevant Matrices by Advanced Oxidation Processes** *Nalan Bilgin Öncü, Isil Akmehmet Balcioglu*	Turkey	199
14:40	SP	**2,4 - Dichlorophenoxyacetic acid degradation in Aqueous Media: Ozonation and Ozonation combined with Ultraviolet Radiation** *María Eugenia Lovato, Carlos A. Martín, Alberto E. Cassano*	Argentina	187
14:45	SP	**Use of Advanced Oxidative Processes for degradation of organic refractory pollutants** *Kátia F. Streit, José L.N. Xavier, Marco A.S. Rodrigues, Andréa M. Bernardes, Jane Zoppas Ferreira*	Brazil, Spain	180
14:50	SP	**The degradation of endocrine disruptors estrone (E1), 17β-estradiol (E2) and 17α-ethinylestradiol (EE2) with UV-based systems and ozone** *Chedly Tizaoui, Khaled Mezughi, Hadj Benkreira*	UK	160
14:55	SP	**Application of ozone involving advanced oxidation processes to remove some pharmaceutical compounds from urban wastewaters** *Fernando J. Beltrán, Almudena Aguinaco, Juan F. García-Araya*	Spain	151
15:00	SP	**Oxidation effect on the Helminth's eggs *Toxocara canis* with ozone and ozone-peroxide** *Clementina Rita Ramírez-Cortina, Juan Diego Cruz-Bautista, Benjamin Nogueda-Torres, Maria Soledad Alonso-Gutiérrez, Gabriela Ibáñez-Cervantes*	México	72
15:05	SP	**Effect of high concentration of chloride ion on ozonation and O_3/ H_2O_2 process** *Hiroshi Tsuno, Fumitake Nishimura, Eri Hasegawa, Kensuke Okuda, Yuki Nishida*	Japan	244
15:10	SP	**Application of advanced ozone oxidation to the treatment of refractory petrochemical dry-spun acrylic fiber wastewater** *Zhiyong Tian, Yonghui Song, Qi Qiao*	P.R. China	343

Hour	Presentation	Title and authors	Country	ID
15:15	SP	**Design and performance of a mobile pilot plant for the evaluation of Advanced Oxidation Processes (AOP) in waste water treatment** *Daniel M. Meier, Walter Uttinger, Sylvie Baig, Marijan Romancuk, Sven Bressmer, Fabio Krogh, Bernhard Paolini*	Switzerland, France	24
15:20	SP	**Formation of toxic by-products in advanced oxidation processes of organic pollutants in aqueous environments** *Roberto Rosala, Javier Santiago, Soledad Gonzalo, Ana Agüera, María del Mar Gómez, Amadeo R. Fernández-Alba, Antonio Rodríguez, Eloy García-Calvo*	Spain	39
15:25	SP	**Phenol Degradation by H_2O_2, O_3, UV, H_2O_2-O_3 and H_2O_2-O_3-UV Systems** *Clementina Rita Ramírez Cortina, Isaías Hernández Pérez, Raúl Suárez Parra, Ricardo Luna Paz, Maria Soledad Alonso Gutiérrez. Carlos Eduardo Ortiz Lozoya*	México	67
15:30	SP	**Removal of hazardous substances present in treated municipal effluents by Advanced Oxidation Processes based on ozone** *Judith Sarasa, Isabel García, Rosa Mosteo, Maria P. Ormad, José Luis Ovelleiro*	Spain	89
15:35	SP	**Removal of 1,4-dioxane from water with ozonation** *Rominder Suri, Tony Singh, Sagar Vattikonda, Marianne Curran*	USA	79
15:40	SP	**Application of advanced oxidation technologies for propoxycarbazone-sodium degradation** *Aleksandr Dulov, Niina Dulova, Yelena Veressinina, Marina Trapido*	Estonia	203
15:45	PE	**Poster exhibition & Discussion with authors**		
16:30	***Break***			

Session 8. Applications in Wastewaters – Part 1 Room Pacific

Hour	Presentation	Title and authors	Country	ID
14:30	KN	**Ozonation versus adsorption for organic matter removal and micropollutants control in urban wastewater** *S. Esplugas, B. Domenjoud, S. Baig*	Spain, France	232 233
15:10	LP	**Elimination of micropollutants and pathogens and formation of byproducts during wastewater ozonation: effect of wastewater matrix** *Yunho Lee, Urs von Gunten, Daniel Gerrity, Shane Snyder*	Switzerland, USA	9
15:30	LP	**Treatment of secondary municipal effluent with ozone and ultrafiltration** *María Teresa Orta L. de Velasquez, Juan Fernando Muñoz Paredes, Ignacio Monje-Ramírez*	México	84
15:50	LP	**Influence of wastewater quality on disinfection efficiency and reliability of operation of UV disinfection and ozonation** *Valentina Lazarova, Bruno Ferran, Philippe Savoye*	France, USA	147
16:10	LP	**UV disinfection of Waste water effluent: Goals and requirements** *Regina Sommer, Alexander Cabaj, Georg Hirschmann, Thomas Haider, Alexander Kirschner*	Austria	324
16:30	***Break***			

Session 9. Full scale applications – Part 3 Room Newport I

Hour	Presentation	Title and authors	Country	ID
14:30	LP	**UV: not just for *Cryptosporidium* anymore** *Paul Swaim, Anthony Myers, Todd Elliott, Lisa Voytko, Bruce Jacobs, James Malley, Jr.*	USA	68
14:50	LP	**Filtration and UV-irradiation for ships' ballast water management – water quality challenges and UV-dose requirements** *Helge Liltved, August Tobiessen, Stephanie Delacroix, Harald Heiaas, Ingun Tryland*	Norway	211
15:10	LP	**Balancing Risk versus Benefit in the Selection of Equipment for Portland's Bull Run UV Disinfection Facility** *Bryan Townsend, Chad Talbot, Harold Wright, David Peters, Timothy Phelan*	USA	77
15:30	LP	**Scale up of UV AOP reactors from bench tests using CFD modeling** *Keith Bircher, Mai Vuong, Brad Crawford, Mark Heath, Jeff Bandy*	Canada, USA	299
15:50	LP	**An Australian perspective of ozone and biological filtration for drinking water treatment** *Yaode Yan, Paul Thompson, Peter Dennis*	Australia	120
16:10	LP	**Los Angeles Aqueduct Filtration Plant UV Disinfection Plant: Preparing for the Future** *Christine Cotton, Steve Ott, Kurt Wells, Pankaj Parekh, Ben Kuhnel, Patrick Carlson, James Collins*	USA	252
16:30	***Break***			

Session 10. Process development and optimization – Part 1 Room Beach

Hour	Presentation	Title and authors	Country	ID
14:30	LP	**Ozone Residual Meter Calibration Protocol and Results** *Kerwin L. Rakness, Glenn F. Hunter*	USA	70
14:50	LP	**Evaluating Impacts of Inlet Piping Configuration on UV Dose Delivery** *Christopher R. Schulz, Mike Hyland, Mark Allen, David Werth, Inder Singh*	USA	237
15:10	LP	**Application of Real-time RT-PCR for Measuring High UV Dose** *Takeyoshi Naruse, Naoyuki Kamiko*	Japan	282
15:30	LP	**Disinfection Treatment Performance Defines Ozone Automation** *Kerwin L. Rakness*	USA	21
15:50	LP	**A New Tool for Optimizing Pretreatment for UV Disinfection of Wastewater** *Katherine Y. Bell, Juan Sanez, Martha J.M. Wells*	USA	267

Hour	Presentation	Title and authors	Country	ID
16:10	LP	**Assessment of the ozonation process under continuous flow in sewage wastewater reclamation** *Antonio Rodríguez, Ivan Muñoz, Jose A. Perdigón, Roberto Rosal, Jose. B. Carbajo, Alice Petre, Maria. J. Martínez, Amadeo R. Fernández-Alba, Eloy García-Calvo*	Spain, UK	111
16:30	***Break***			

Session 1. Advanced Oxidation Processes – Part 7 Room Newport II

Hour	Presentation	Title and authors	Country	ID
17:00	SP	**Assessment of the ozonation and Fenton process as a pretreatment of a subsequent biological treatment based on respirometric measurements** *Pieter Van Aken, Jan Luyten, Jan Degrève, Sven Liers*	Belgium	196
17:05	SP	**Heterogeneous photo-Fenton processes for disinfection of treated urban wastewater** *Jorge Rodríguez-Chueca, Rosa Mosteo, Mª Peña Ormad, Natividad Miguel, José Luis Ovelleiro*	Spain	102
17:10	SP	**Remediation of petroleum contaminated soil by photo-Fenton process applying germicidal light** *Otidene Rossiter Sá da Rocha, Marta Maria Menezes B. Duarte, Renato F. Dantas, Marcia Maria Lima Duarte, Valdinete Lins da Silva*	Brazil	325
17:15	SP	**Oxidative Degradation of Amantadine by the Fenton Processes** *Ping Zeng, Yonghui Song, Johanna Dresely, Liang Duan, Shuhu Xiao, Yincheng Ma, Chenhao, Wang, Erhard Hoffmann*	P.R. China, Germany	340
17:20	SP	**Influence of the aqueous matrix in photocatalytic process: degradation of pesticides** *Natividad Miguel, María P. Ormad, Rosa Mosteo, Judith Sarasa, José L. Ovelleiro*	Spain	90
17:25	SP	**Removal of endocrine disrupting compounds from secondary treated wastewater by heterogeneous photocatalysis** *Zacharias Frontistis, Vassileia M.Daskalaki, Nikolaos P. Xekoukoulotakis, Despo Fatta-Kassinos, Dionissios Mantzavinos*	Greece, Cyprus	230
17:30	SP	**Photocatalytic oxidation of phenol under UV irradiation on a combined TiO_2-AC Tissue** *Elham F. Mohamed, Caroline Andriantsiferana, Henri Delmas*	France	63
17:35	PE	**Poster exhibition & Discussion with authors**		

Session 8. Applications in Wastewaters – Part 2 Room Pacific

Hour	Presentation	Title and authors	Country	ID
17:00	SP	**Oxidation processes for reuse of treated wastewater** *Juan Fernando Garcia-Araya, Azahara Espejo, Fernando Beltrán, Pedro Álvarez*	Spain	154
17:05	SP	**Comparative Evaluation of Ozonation and UV Disinfection in Municipal Wastewater Treatment Plants for Reuse Applications** *Serkan Evcimen, Bugra Alpak, Aslihan Kerc*	Turkey	163
17:10	SP	**Characterization of the ozonation process in the municipal wastewater treatment for reuse** *Eliet Véliz Lorenzo, José G. Llanes Ocaña, Lidia Asela Fernández García, Mayra Bataller Venta*	Cuba, México	205
17:15	SP	**Effect of Alginic acid, Peptone, NOM and Alkalinity on the O_3 Process: Degradation of Cyclophosphamide** *Yaal Lester, Dror Avisar, Hadas Mamane*	Israel	86
17:20	SP	**Required ozone doses for controlling pharmaceutical in Swedish WWTP effluents** *Maria G. Antoniou, Per Falas, Gerly Moradas, Jerker Fick, Mats Tysklind, Anna Ledin, Jes La Cour Jansen, Henrik Rasmus Andersen*	Denmark, Sweden	128
17:25	SP	**Degradation of emerging pharmaceuticals in water/wastewater matrix with advanced oxidation processes: a comparative study** *Irina Epold, Polina Barajeva, Yelena Veressinina, Marina Trapido*	Estonia	152
17:30	SP	**Identification of ecotoxicity caused by O_3 and ClO_2 treatment of wastewater** *Maritha Hörsing, Sara Furuhagen, Anna Ledin, Magnus Breitholtz, Henrik R. Anderssen*	Denmark, Sweden	165
17:35	SP	**Monitoring and Oxidative Removal of EDCs in Istanbul Wastewater Treatment Plants** *Zehra Semra Can, Aslihan Kerc, Serkan Evcimen, Melike Firlak*	Turkey	191
17:40	SP	**Characterization and treatment of leachates from municipal solid waste landfill** *Lidia Asela Fernández, Ma. del Carmen Espinosa, Eliet Véliz, Matilde López, Mayra Bataller, Yalexmi Ramos*	Cuba	13
17:45	SP	**O_3/UV treatment of a wastewater consisting of an organic compound (phenol, xylene or t-butanol) and sodium acetate** *Wim Van de Moortel, Jan Degrève, Jan Luyten*	Belgium	213
17:50	SP	**Influence of Activated Carbon on Ozonation of Phenolic Wastewater** *Oliver Järvik, Vardo Saarik, Irina Osadchuk, Andres Viiroja, Inna Kamenev*	Estonia	164
17:55	PE	**Poster exhibition & Discussion with authors**		

Session 9. Full scale applications – Part 4 Room Newport I

Hour	Presentation	Title and authors	Country	ID
17:00	SP	**A Collaborative Design of a 600 MGD Drinking Water UV Facility** *Ben Kuhnel, Christine Cotton, Kurt Wells*	USA	186
17:10	SP	**Removal of Trichloroethylene (TCE) and Tetrachloroethylene (PCE) in a full scale ozone/H_2O_2/GAC plant in Switzerland** *D. Urfer, P. Houlmann, N. Landoz, J. Gigandet, M. Meyer, G. Voirol*	Switzerland	34
17:15	SP	**Optimization of the Ozone Dosage at the Drinking Water Treatment Plant of Kluizen** *Jan Cromphout, Walter Neirynck, Stijn Mortier, Jos Boonen, Liesbeth Verdickt*	Belgium	85

Hour	Presentation	Title and authors	Country	ID
17:20	SP	**Livestock Wastewater Treatment by Biological Sequencing Digestion/Dissolved Ozone Floatation/Biological Filtration** *Moonki Park, Joon-Wun Kang*	Rep. of Korea	124
17:25	SP	**Converting a Large Water Treatment Plant to Enhanced Coagulation and Biological Filtration** *Mark Simon, Michael Mikeska, Peter Stencel, Jennifer Cottingham, Jeff Neemann, George Budd, Randy Romack*	USA	183
17:30	PE	**Poster exhibition & Discussion with authors**		

Session 10. Process development and optimization – Part 2 Room Beach

Hour	Presentation	Title and authors	Country	ID
17:00	SP	**Ozone Monitoring Applications with semiconducting gas sensors** *Nicolas Moser*	Switzerland	234
17:05	SP	**The use of polymerase chain reaction - denaturing gradient gel electrophoresis to detect the survival of foodborne microorganisms after UV treatment** *Alexa A. Isaks, Pieter A. Gouws*	South Africa	100
17:10	SP	**Evaluation of the Keitz Equation for Quantifying the Total UV Output of Medium Pressure Mercury Lamps** *Farnaz Daynouri, Jim Robinson*	Canada	115
17:15	SP	**Effect of preozonation on ultrafiltration of meat industrial waste water** *Angéla Szép, Szabolcs Kertész, Gábor Szabó, Cecilia Hodúr, Zsuzsanna László*	Hungary	129
17:20	SP	**Ozonated Constructed wetland for Tibetan hog sewage treatment** *Joanne Chung Yan Ho, Zhi Chong Lee, Gilbert Yuk Sing Chan*	P.R. China	134
17:25	SP	**Hybrid degradation of alkyl-phenol ethoxylate by ozonation and biodegradation** *Tetsuji Okuda, Daisuke Okajima, Masashi Hirosaki, Tomoyuki Takeda, Kenji Oda, Satoshi Nakai, Wataru Nishijima, Mitsumasa Okada*	Japan	317
17:30	SP	**Biological denitrification of drinking water in a sand filter followed by ozonation** *Sabrina Sorlini, Francesca Gialdini*	Italy	216
17:35	SP	**Suspended Ultraviolet Irradiation for Algae Eradication in Reservoir Water** *R.J. Xie, M. Gomez*	Singapore	238
17:40	SP	**Disinfection of water and wastewater by solar, UV-A and UV-C irradiation: application of real-time PCR method** *Efthalia Chatzisymeon, Maria S. Gonzalo, Roberto Rosal, Nikos Xekoukoulotakis, Dionissios Mantzavinos, Danae Venieri*	Greece, Spain	239
17:45	PE	**Poster exhibition & Discussion with authors**		

Wednesday, May 25

Session 11. Reaction study and modelling – Part 1 Room Newport I

Hour	Presentation	Title and authors	Country	ID
08:30	LP	**Research to reassess the low dose risks of bromate in drinking water** *Joseph Cotruvo, Richard Bull, Brian Cummings, Don Delker, Jeffrey Fisher, Zhongxian Guo, Choon Nam Ong, Shane Snyder, Oscar Quinones*	USA	35
08:50	LP	**Ultraviolet Genomic Modeling: Current Research and Applications** *Wladyslaw J. Kowalski*	USA	61
09:10	LP	**Antibiotic Activity of Pre-Ozonated Ciprofloxacin and Sulfamethoxazole** *Temesgen Garoma, Melissa Allen*	USA	117
09:30	SP	**Kinetic and hypothetical mechanism of the OH• radical reaction with cisplatin** *Yalexmi Ramos, Carlos Hernández, Lidia Asela Fernández, Mayra Bataller, Eliet Veliz, Silvia Menendez*	Cuba	14
09:35	SP	**A simplified analytical method for ozone born radicals monitoring** *Jean-Stéphane Pic, Laura Fuller, Marie-Hélène Manéro, Hubert Debellefontaine*	France, UK	241
09:40	SP	**Impact of Ultraviolet Irradiation on Growth of Chlorellapyrenoidis** *Meiting Guo, Hongying Hu, Jian Chen, Xiaobin Liu*	P.R. China	76
09:45	SP	**Degradation of biocide *o*-phenylphenol in water solutions by ozone** *Magdalena Olak, Jacek S. Miller, Stanisław Ledakowicz*	Poland	78
09:50	SP	**The molecular products of ozone decomposition in water solutions** *C.N. Kontorchshikova, A.A.Sibirkin, L.M. Obukhova, O.Yu. Chernova*	Russia	82
09:55	SP	**Methanol Decomposition by the Combination of Ozone/Activated Carbon** *Iliana Fuentes Camargo, Tatiana Poznyak*	Mexico	95
10:00	SP	**Ozonation of atrazine** *Rafaela Cristina Landeiro da Silva, Roberto José de Carvalho*	Brazil	116
10:05	SP	**Ozonation of imidacloprid in aqueous solutions: Reaction monitoring and identification of degradation products** *Marc Bourgin, Frédéric Violleau, Laurent Debrauwer, Joël Albet*	France	201
10:10	PE	**Poster exhibition & Discussion with authors**		
10:30	***Break***			

Session 8. Applications in Wastewaters – Part 3 Room Newport II

Hour	Presentation	Title and authors	Country	ID
08:30	LP	**Performance of ozone for EDC removal from sewage effluent** *John Churchley, Brian Drage, Emilie Cope, Yvonne Narroway, Achim Ried, Tony Swierk, Ken Alexander, Rakesh Kanda*	UK	41
08:50	LP	**Oxidation of Mixed Active Pharmaceutical Ingredients in Biologically Treated Wastewater** *Gerly Moradas, Jerker Fick, Anna Ledin, Jes la Cour Jansen, Henrik Rasmus Andersen*	Sweden, Denmark	94
09:10	LP	**Comparison of the Advanced Oxidation Processes for antibiotic wastewater treatment (UV, UV/ H_2O_2 and O_3)** *Andrzej K. Bi, Sylwia Sobera-Madej*	Poland	254
09:30	LP	**Chemical and toxicological evaluation of by-products during oxidative tratment of waste water treatment plant effluents** *Jochen Tuerk, Jessica Richard, Claudia vom Eyser, Andrea Boergers, Kai Bester, Elke Dopp*	Germany, Denmark	177
09:50	LP	**Removal of 1,4-dioxane from landfill leachate by O_3 and O_3/ H_2O_2 process** *Fumitake Nishimura, Hiroshi Tsuno, Eri Hasegawa, Kensuke Okuda*	Japan	245
10:10	LP	**Monitoring of EfOM fractions along ozonation of conventional and MBR secondary effluents by LC-OCD** *Oscar González, Ana Justo, Jordi Bacardit, Enrique Ferrero, Jorge Juan Malfeito, Carme Sans*	Spain	139
10:30	***Break***			

Session 9. Full scale applications – Part 5 Room Pacific

Hour	Presentation	Title and authors	Country	ID
08:30	LP	**Reconstruction of the largest WTP plant in the Czech Republic – ozone treatment system** *Radka Hušková, Jiri Benes, Philip Page, Florian Axt*	Czech Republic, UK, Germany	222
08:50	LP	**Full-scale Test of a Static Mixer Ozone Dissolution System** *Michael A. Oneby, Michael Price, Michael G. Priest*	USA	215
09:10	LP	**Retrofit of Intermediate Ozonation for Taste and Odour and Cyanotoxin Removal** *Craig Jakubowski, Paul Thompson, Mike Brooks*	Australia	33
09:30	LP	**Ozone implementation for drinking water in the Great Lakes basin** *Saad Jasim, Michael Oneby, Gord Devine, Bill Mundy*	Canada, USA	167
09:50	LP	**Successful Ozone System Operation at San Diego's Largest Water Plants with State-of-the-Art Controls** *William O'Neil, Ben Kuhnel, Chris Schulz, Kerwin Rakness, Iraj Asgharzadeh*	USA	188
10:10	LP	**Effects of ozone on the removal and formation of Tastes and Odors in drinking waters: case studies** *A. Bruchet*	France	197
10:30	***Break***			

Session 10. Process development and optimization – Part 3 Room Beach

Hour	Presentation	Title and authors	Country	ID
08:30	LP	**Ozone disinfection: main parameters for process design in wastewater treatment and reuse** *Valentina Lazarova, Marie-Laure Janex, Philippe Savoye*	France	146
08:50	LP	**Biodegradation of pre-ozonated chlorophenols using acclimated microorganisms** *P. Guerra, T. Poznyak, A. García, I. Chairez, I. García-Peña*	Mexico	96
09:10	LP	**Ozone-enhanced biological treatment of landfill leachates** *Claudio Di Iaconi, Antonio Lopez, Achim Ried*	Italy, Germany	112
09:30	LP	**Textile wastewater treatment by ozone integration in a Sequencing Batch Biofilter Granular Reactor** *Adriana Maria Lotito, Claudio Di Iaconi, Umberto Fratino, Annalisa Mancini*	Italy	170
09:50	LP	**Revealing the Secrets Inside UV Oxidation Reactors: Mapping the Reactor Performance** *Fariborz Taghipour, Siamak Elyasi*	Canada	259
10:10	LP	**Measurement of the Fluence rate distribution in a UV reactor using a micro fluorescent detector: Influence of different reactor walls** *Mengkai Li, Zhimin Qiang, Tinggang Li, James R. Bolton*	P.R. China, Canada	268
10:30	***Break***			

Session 11. Reaction study and modelling – Part 2 Room Newport I

Hour	Presentation	Title and authors	Country	ID
11:00	SP	**Efficiency and Mechanism on Decomposition of Diethyl Phthalate by Ozonation** *Gang Wen, Jun Ma*	P.R. China	235
11:05	SP	**Effect of wavelength on UV-degradation of *N*-Nitrosodimethylamine (NDMA)** *Hiroshi Sakai, Koji Kosaka, Satoshi Takizawa*	Japan	270
11:10	SP	**Calculation of UV-flux emitting by a Medium Pressure Mercury lamp** *Alex Voronov*	Germany	83
11:15	SP	**Mathematical Modelling of Aqueous Ozonation Processes** *Alexey Ignatev, Alexey Pryakhin, Valery Lunin*	Russia	108
11:20	SP	**ESVERA: A novel finite-volume-based UV lamp emission model** *J. Esteban Duran, Fariborz Taghipour, Madjid Mohseni*	Canada, Costa Rica	113

Hour	Presentation	Title and authors	Country	ID
11:25	SP	**Use of "large volumes" in Collimated Beam for study of byproduct formation in UV and UV/H_2O_2 processes** *C.H.M. Hofman-Caris, D.J.H. Harmsen, B.A. Wols, E.F. Beerendonk, L.L.M. Keltjens, M. Heringa*	Netherlands	288
11:30	SP	**Different ozone damages in *Escherichia coli* and *Salmonella enterica var. thyphimurium* applying low ozone concentrations in aqueous media** *Irán Fernández, Mayra Bataller, Carlos Hernández, Elaine Sánchez, Yamelis Morales*	Cuba	26
11:35	SP	**Effect of pH on phenol ozonation and its toxicity in *Lactuca sativa* seeds** *Clementina Rita Ramírez-Cortina, María Guadalupe Pérez-Ramirez, María Soledad Alonso-Gutiérrez*	México	25
11:40	SP	**Physicochemical characterization of ozonated sunflower oil obtained by different procedures** *Maritza F. Díaz, Yaima Sánchez, Magali Gómez, Márcia C. da C. Veloso, Pedro A. da P. Pereira, Antonio S. Mangrich, Jailson B. de Andrade*	Cuba, Brazil	17
11:45	PE	**Poster exhibition & Discussion with authors**		
12:50	***Lunch***			

Session 12. Applications in Natural waters – Part 1 — Room Newport II

Hour	Presentation	Title and authors	Country	ID
11:00	KN	**State of the Art - Removal and Production of Tastes and Odors by Drinking Water Ozonation** *I. H. (Mel) Suffet, K. Weisenthal, G. Crozes, T. Chen, K. Z. Atasi, A. Bruchet*	USA, P.R. China, France	190
11:30	LP	**Controlling the efficiency of ozone disinfection for the production of drinking water from surface water: can aerobic spore forming bacteria be a tool?** *Eric Chauveheid, Julie Vancoppenolle, Claude Houbrechts*	Belgium	169
11:50	LP	**Kinetics and Mechanisms of *N*-nitrosodimethylamine formation upon ozonation of *N,N*-dimethylsulfamide-containing waters: Bromide catalysis** *Urs von Gunten, Elisabeth Salhi, Carsten K. Schmidt, William A. Arnold*	Switzerland, Germany, USA	10
12:10	LP	**Disinfection of seawater- application of UV and ozone** *Ywann Penru, Andrea Raquel Guastalli, Santiago Esplugas, Sylvie Baig*	Spain, France	231
12:30	SP	**Minimization of chlorinous odor and bromate ion formation by ozonation and Advanced Oxidation Process (O_3/H_2O_2 process) with an ozone bubble contactor** *Songkeart Phattarapattamawong, Satoshi Ishihara, Shinya Echigo, Sadahiko Itoh*	Japan	121
12:35	SP	**Oxidation of taste and odor compounds and bromate formation during ozonation and the advanced oxidation process O_3/ H_2O_2** *Holger Lutze, Andreas Peter, Hans-Peter Kaiser, Urs von Gunten*	Germany, Switzerland	176
12:40	SP	**Characterization of by-products issued from ozonation of Acetochlor** *Yasmine Souissi, Sophie Bourcier, Michel Sablier, Véronique Boireau, Valérie Ingrand, Pascal Roche, Stéphane Bouchonnet*	France	347
12:45	SP	**Ozonation of benzotriazoles** *Holger Lutze, Andreas Peter, Urs von Gunten, Walter Giger, Hans-Peter Kaiser, Clemens von Sonntag, Torsten C. Schmidt*	Germany, Switzerland	174
12:50	***Lunch***			

Session 13. UV source technologies — Room Pacific

Hour	Presentation	Title and authors	Country	ID
11:00	LP	**Comparison of different long life coating technologies in low pressure mercury lamps** *A. Voronov, B. Jung, V. Adam*	Germany	313
11:20	LP	**Some observations concerning the efficiency testing of low pressure and low pressure high output UV lamps** *Michael J. Santelli, James R. Bolton, William Lubarsky*	USA, Canada	296
11:40	LP	**Microwave UV comes to Texas?** *Meera Victor, Andrew Salveson, Dolan McKnight, Ken Wesson*	USA	258
12:00	LP	**Inactivation of pathogenic and heat resistant microorganisms in milk by a non thermal UV treatment system** *Rudean van Wyk, Pieter A. Gouws*	South Africa	88
12:20	SP	**Considerations in the design and competitive bidding of electrical systems for UV units** *Arne Fareth, Jae Kim, Jami Walsh, Eduardo Amaba, Robert Jarnis, Edward Barbo*	USA	327
12:25	SP	**Influence of quartz sleeve type on medium pressure UV system performance** *Christian Bokermann, Ronnie Bemus, Harold Wright*	Germany, USA	272
12:30	SP	**Method for measuring the UVC-output of low pressure germicidal lamps** *Sobur Denis, Sergey Kostuchenko, Dmitry Sokolov, Leonid Drozdov, Michiel van der Meer, Hans Maes, Fred van Lierop*	Russia, Belgium	101
12:35	PE	**Poster exhibition & Discussion with authors**		
12:50	***Lunch***			

Session 3. Industrial applications – Part 3 — Room Beach

Hour	Presentation	Title and authors	Country	ID
11:00	LP	**Nitrogen oxides ozonation as a method for NO_x emission** *Stanisław Ledakowicz, Kinga Skalska, Jacek S. Miller, Marcin Wilk*	Poland	40
11:20	LP	**Powerful impulse UV irradiation for purification of airflows containing bacterial spores** *V.I. Sigaev, S.G. Shashkovsky, V.P. Arkhipov, I.A. Zhelaev, S.N. Uspenskaya, A.N. Varfolomeev, E.V. Zvyagina*	Russia	62
11:40	LP	**Smog in Hong Kong: Statistical analysis on historical database** *Jane Wei-Zhen Lu, Xiekang Wang*	Hong Kong, P.R. China	202

Hour	Presentation	Title and authors	Country	ID
12:00	LP	**Ozone - From Pen and Paper to Bubbles in Water** *Ben Kuhnel, Jeremy Metts, Robert Hoffman, Ed Fordan, Iraj Asgharzadeh*	USA	185
12:50	***Lunch***			

Session 12. Applications in Natural waters – Part 2 — Room Newport I

Hour	Presentation	Title and authors	Country	ID
14:30	KN	**Can UV Protect the Public from Adenovirus in Drinking Water?** *Karl G. Linden, Karl Scheible, Phyllis Posy*	USA	316
15:10	LP	**Sustainability Analysis for the Implementation of an Ultraviolet Disinfection System in a Low-Income Community** *Mario A. Zapata, James R. Bolton, Mohamed Gamal El-Din*	Canada	178
15:30	LP	**Photocatalytic Reduction of Nitrate in Water Using Commercial Titanium Dioxides** *Paul Westerhoff, Kyle W. Doudrick*	USA	310
15:50	SP	**Advanced Treatment for Impaired Water Supplies: When AOPs are the Best Option** *James Collins, Christine Cotton*	USA	251
15:55		**Poster exhibition & Discussion with authors**		
16:30	***Break***			

Session 12. Applications in Natural waters – Part 3 — Room Newport II

Hour	Presentation	Title and authors	Country	ID
14:30	LP	**Influence of applied extraction method and genotoxicity test on detection of genotoxic by-products after UV-oxidation treatment of water** *Minne B. Heringa, Erwin F. Beerendonk, Roberta H.M. Hofman, Leo.L.M. Keltjens*	Netherlands	297
14:50	LP	**Byproduct formation and advanced genotoxicity testing to characterize the potential harmful side effects of chemical oxidation and disinfection** *Bram J. Martijn, Joop C. Kruithof*	Netherlands	69
15:10	LP	**UV Disinfection of Stormwater Overflows and Low UVT Wastewaters** *Jennifer Muller, Wayne Lem*	Canada	64
15:30	SP	**Establishment of a model system for control and prevention of biofouling by UV radiation in water flow systems** *Hadas Mamane, Liron Friedman, Eli Margalit, Tali Harif, Eliora Z. Ron*	Israel	273
15:35	SP	**Genotoxicity of drinking water treated with different disinfectants and effects of disinfection conditions detected by umu test** *Liu Wenjun, Liu Qing, Zhang Liping, Nie Xuebiao, Sun Wenjun, Cui Lifeng*	P.R. China	315
15:40	SP	**A study of by-product formation and toxicity due to LP UV disinfection of ballast water** *Liu Wenjun, Sun Wenjun, Liu Che*	P.R. China	279
15:45	PE	**Poster exhibition & Discussion with authors**		
16:30	***Break***			

Session 14. UV for Aquatics — Room Pacific

Hour	Presentation	Title and authors	Country	ID
14:30	KN	**Effects of UV_{254} Irradiation on Residual Chlorine and DBPs in Chlorination of Model Organic-N Precursors in Swimming Pools** *ShihChi Weng, Ernest R. Blatchley III*	USA	301
15:10	LP	**Nitrogen trichloride levels in air in chlorinated indoor swimming pools treated by medium-pressure UV radiation** *Delphine Cassan, Béatrice Mercier, Françoise Castex, André Rambaud*	France	127
15:30	LP	**Validation of UV reactors for recreational waters** *O. Karl Scheible, Chengyue Shen, Ernest R. Blatchley III*	USA	302
15:50	SP	**UV Technology in Aquatics Applications** *Ismail Gobulukoglu, Ken Haagsma*	USA	179
15:55	PE	**Poster exhibition & Discussion with authors**		
16:30	***Break***			

Session 15. Ozone generation — Room Beach

Hour	Presentation	Title and authors	Country	ID
14:30	LP	**Revolutionary Pinnacle Ozone System Design – Compact, Efficient, Reliable, Intelligent** *Charles E. Bud Leffler, Bud Francis, Chuck Smith, David Carpenter*	USA	223
14:50	LP	**High Efficient Ozone Production with Excimer Lamps** *Rainer Kling, PhD.; Mark Paravia, PhD., Markus Roth, PhD.*	Germany	161
15:10	LP	**Inhomogeneous Feed Gas Processing for Cost Effective Ozone Generation** *Fabio Krogh, Daniel Meier, Bernhard Paolini, Alfred Freilich, Jose Lopez*	Switzerland, USA	92
15:30	SP	**Microwave Powered Ozone Generator – Concept and Initial Test results** *Jaromir Bilek, Richard Little, Russel Sion*	UK	247
15:35	SP	**Ozone Cost Implications from Oxygen Supply – Advantages of VSA Technology** *David Schneider, Soeren Schmitz*	USA	192
15:40	PE	**Poster exhibition & Discussion with authors**		
16:30	***Break***			

Plenary session — Room Newport

Hour	Agenda
17:00	**Awards Ceremony**
18:00	**Synthesis and Conclusions - Announcements**

ABSTRACTS OF ORAL PRESENTATIONS

Monday, May 23

Plenary session. Opening

Opening Addresses

Sylvie BAIG, IOA President & Bertrand DUSSERT, IUVA President

Congress introduction

Michel ROUSTAN & Michael TEMPLETON, Co-chairs of the Scientific Committee, Renate VIEBAHN

Introductory conferences

1. Challenges in Water Supply and Sanitation: WSSTP Vision and Related Strategy

Durk Kroll (WSSTP Treasurer), Mike Farrimond (WSSTP Chair)

WssTP is the Water supply and sanitation Technology Platform. It was initiated by the European Commission in 2004 to promote coordination and collaboration of Research and Technology Development in the water industry. www.wsstp.eu

2. Successful Implementation of Efficient Oxygen/Ozone Installation in Los Angeles Inspires, Promotes and Encourages Ozonation in North America and Worldwide

Kervin Rakness, Pierre-André Liechti

Until oxygen-fed ozone generation was proven “worthy” in Los Angeles, water utilities considered air-fed ozone as their only “ozone-system” option. Air-fed ozone systems could be successful when they were designed conservatively and well maintained, but capital and O&M budgets were relatively large and maintenance was relatively intense. In the late 1980’s, oxygen-fed ozone produced at “medium-high-concentration” (6 %wt) proved to be cost efficient at the 2270 MLD (600 MGD) water treatment plant operated by the City of Los Angeles. This was a major milestone in the industry. Suddenly, liquid oxygen (LOX) systems were cost competitive with air-fed ozone. Other benefits were supplemental and significantly important, including improved controllability (better automation), less maintenance, lower capital cost, less equipment, and other. In the mid-1990’s, even higher concentration ozone (10 %wt) systems were introduced that effectively removed air-fed ozone as a design consideration. Oxygen-fed ozone has since been installed at plants ranging from 4 to 2900 MLD water flow and 8 to 16,000 kg/day ozone production. Large and small water plants have won local and national best-tasting water awards after ozone was installed. Prior to ozone, these same plants had significant customer complaints of bad-tasting and bad-smelling water. In addition, after ozone, plants have met more stringent water quality treatment objectives for improved disinfection and reduction of disinfection by-products. Challenges have been overcome, such cost-efficient Bromate mitigation techniques for the ozone DBP, namely Bromate. Los Angeles took the bold step to “prove” oxygen-fed ozone in a big way. Other large and many, many smaller water utilities have benefited thereafter.

3. Advancing Large-Scale UV Implementation in New York City

Gary R. Kroll, Richard Fahey, Paul D. Smith

At 7,650 mega liters per day (2,020 million gallons per day), the New York City Department of Environmental Protection’s (DEP) new Catskill and Delaware Ultraviolet (UV) Light Disinfection Facility will be the world’s largest, serving more than 9 million people. UV will provide enhanced disinfection of the raw water supply, resulting in 2-log inactivation of Cryptosporidium. This paper will detail New York City’s massive UV disinfection project, including the evaluation and selection of UV for enhanced disinfection, the value of computational fluid dynamics in designing and optimizing efficiency of the plant, and the role of technology in addressing issues associated with constructing large-scale facilities. The paper will also discuss the challenges created by the magnitude of this project, including validation of the largest UV units ever made. Finally, the paper will provide an update on construction progress and plans for full-scale operation.

Session 1. Advanced Oxidation Processes – Part 1

1. Catalytic Ozonation of para-Chlorobenzoic acid (pCBA) in Municipal Wastewater Effluent using Nano-structured Titanium Dioxide in a Packed Bed Configuration

Paul K. Westerhoff, Michelle C. Barry, Jennifer Elton, Kiril Hristovski

Nano-TiO_2 has been shown to act as an effective catalyst for ozone destruction of several organic compounds. In comparison to bulk size TiO_2, nano-TiO_2 offers advantages such as increased surface area and number of reactive surface sites. However, the size of nano-TiO_2 limits its use to continuously stirred tank reactors (CSTR) or batch reactors. The use of nano-TiO_2 in a packed bed configuration is not feasible due to large headloss across a packed bed and ineffective retention of nanomaterials in the reactor. To address these challenges, while still taking advantage of the large surface area of nano-TiO_2, a novel media was synthesized. This media, highly porous nano-structured TiO2 spheres, was tested for catalytic effect on the ozonation of the model pollutant para-chlorobenzoic acid, (pCBA), in a packed bed configuration. pCBA has been used as a model pollutant in ozonation studies based on its slow reaction kinetics with molecular ozone and its rapid kinetics with hydroxyl radicals. Both pCBA spiked ultrapure water and municipal wastewater effluent were used as a model water matrix to provide a comparison of effects in real world conditions. The performance of the novel media was compared against ozonation through a packed bed reactor containing glass beads, which exhibit non-catalyst properties. Batch kinetic testing was also conducted and removal of pCBA occurred within 2-3 minutes of initial ozone dosing. The packed bed reactor configuration provided a means to evaluate catalytic effect within the first 30 seconds of contact time. Results showed similar removal of pCBA for ozone, ozone-hydrogen peroxide, and ozone-TiO_2 at pHs of 5 and 7.5 in ultrapure and wastewater matrices for both kinetic tests and PBR testing indicating a need to further investigate conditions at which catalytic ozonation provides a commercial advantage to ozonation alone.

2. Catalytic ozonation of organic micropollutant in water with ordered Mn-MCM-41 mesoporous molecular sieves as catalyst

Minghao Sui, Jia Liu, Li Sheng, Lingmin Wu

Heterogeneous catalytic ozonation (HCO) has been a promising advanced oxidation method to remove synthetic organic micropollutants from water in the last past decades due to its potentially higher effectiveness in the degradation and mineralization of refractory organic compound. The exploitation of novel catalysts is the key to improve the efficiency of HCO process. The object of this study is to introduce ordered Mn-MCM-41 mesoporous molecular sieves as catalyst into ozonation system. The ordered MCM-41 mesoporous molecular sieves were synthesized by hydrothermal synthesis method using cationic surfactant of cetyltrimethylammonium bromide as template agent, ethyl silicate as silicon source. Manganese oxides were successfully loaded on MCM-41 with manganese nitrate as manganese source and ammonia as alkaline medium by synchronous and asynchronous impregnation methods. The ordered channel arrays of parallel lines were observed clearly along the direction of the pore arrangement for the prepared MnOx/MCM-41s. Choosing nitrobenzene as model toxic and refractory organic matter, the catalytic activity of MnO_x/MCM-41s was evaluated. Under the same reaction conditions, the presence of MnO_x/MCM-41s enhanced the degradation and mineralization efficiencies of ozonation on nitrobenzene. The electron spin resonance (ESR) determination results show that the generation of hydroxyl radicals was promoted in the presence of MnO_x/MCM-41s.

3. Catalytic ozonation and its full scale application in China in the last decade (2000-2010)

Zheng-Qian Liu, Bang-Jun Han, Jun Ma, Ren-Guang Zha, Hai-Tao Zhu, Li-Ping Shen, Wei-Ping Guan, Sheng-Jun Wang, Lei Zhao

This paper reviews the advancement in catalytic ozonation for the refractory pollutants removal in aqueous solution and its full scale applications in China in the last decade (2000-2010). In the first part of this paper, a brief summary on catalysts development for ozonation of pollutants in simulated waters in lab is presented. Many kinds of catalysts have been developed: (1) metal oxide, metal or metal oxide on support (such as MnO_2, FeOOH, Co_3O_4, TiO2, $Co(OH)_2$, CuO, ZnOOH, NiO, CeO_2, La_2O_3, Al_2O_3, Co-Mn-Fe_2O_3, bismuth titanate, Ce-RuO_2/Al_2 O_3, Ru-CuO/Al_2 O_3, and iron silicate polymer); (2) carbon and its supported catalysts (such as AC, AC fiber, carbon nanotube, MnO_x/AC, CuO/AC, Fe_2O_3/AC, TiO_2/AC, RuO_2/AC, CeO_2/AC, NiO/AC, Mn/carbon xerogels and Pt/graphite); (3) mineral and its supported catalysts (such as ceramic honeycomb and its supported catalysts, zeolite, CuO/zeolite, ZnO/clay, and TiO_2/attapulgite). The catalytic activities of the various catalysts were evaluated on the ozonation of organic pollutants (such as pesticides, EDCs, pharmaceuticals and dyes) compared with ozonation alone. The second part of this paper reviews the effectiveness of catalytic ozonation for treating practical raw waters or wastewaters, including lab experiments, pilot scale and full scale applications. Ozonation of practical raw waters in the presence of catalysts can increase the removal efficiency of TOC and/or CODMn and the biodegradability of the effluent compared with ozonation alone. Activated carbon used as catalysts or catalyst supports gained much attention in ozonation of practical wastewaters. The third part of this paper shows the results obtained in a full scale application of heterogeneous catalytic ozonation for a highly polluted raw water treatment. The elimination of CODMn, NH_4^+-N, and turbidity by bio-pretreatment, sedimentation, catalytic ozonation, BAC and filtration were investigated in twenty-three months. It is observed that the removal efficiency of CODMn by heterogeneous catalytic ozonation is about 10-20% and this removal efficiency is independent with the CODMn concentration of influent and water temperature.

4. Efficient photodegradation of paracetamol using Fe modified TiO_2 meoporous nanoparticles under visible light irradiation

Ya Hsuan Liou, Szu-Ying Chen

TiO_2-m and Fe-TiO_2-m with high surface area and crystallized frameworks were prepared using the aerosol-assisted synthesis process. Prepared photocatalysts materials are well ordered porous structures and with the crystallized frameworks. The specific surface areas measured using N_2 adsorption at 77K by BET analysis were 143, 120, 115, and 116 m^2/g for TiO_2-m, 0.1%, 0.5% and 1.0% Fe-TiO_2-m, respectively. The specific surface areas decrease with increasing the iron grafting among porous structure. Photocatalytic degradation of common analgesic and antipyretic drug, paracetamol, was investigated to determine the degradation condition in water. The preparation of photocatalytic degradation of paracetamol in water was studied using TiO_2-m and Fe-TiO_2-m as the catalyst with 420 nm light source. No degradation of paracetamol was found in the absence of photocatalysts, although significant reduction in paracetamol concentration was obseverd using Fe-TiO_2-m during the 420 nm light irradiation. A much faster degradation and effective mineralization of paracetamol took place using 0.5% Fe-TiO_2-m. Experimental results showed that the rate constants were 0.008, 0.0011, 0.026 and 0.012 min^{-1} for TiO_2-m, 0.1%, 0.5%

and 1.0% Fe-TiO_2-m, respectively.

5. TiO_2-based enhanced photocatalytic degradation and disinfection of water under solar light irradiation
Miguel Pelaez, Polycarpos Falaras, Erick R. Bandala, Patrick Dunlop, John Byrne, Armah A. de la Cruz, Dionysios D. Dionysiou
In this study, we employed a novel nanotechnological procedure to synthesize visible light activated nitrogen and fluorine-doped TiO_2 nanoparticles and films with enhanced structural and photocatalytic properties including visible and solar light response, high surface area and small crystallite size. The photocatalytic activity of these doped TiO_2 nanomaterials was evaluated for the degradation of microcystins (MCs), cylindrospermopsin and the inactivation of Escherichia coli (E.coli) under solar light irradiation.

6. Coupling photocatalysis with non-thermal plasma for removal of odorous pollutants
Alina Maciuca, Catherine Batiot-Dupeyrat, Jean-Michel Tatibouët
By combining non-thermal plasma and photocatalysis a synergy effect has been observed in low concentrated gaseous isovaleraldehyde oxidation in air. The study of the behavior in isovaleraldehyde oxidation by the separate processes has shown that this synergy effect could be due to the activation by UV on TiO_2 of the ozone produced by the non-thermal plasma. According to the results, plasma-photocatalysis system significantly increases the efficiency of isovaleraldehyde removal and tends to favor the complete mineralization of isovaleraldehyde. It means that plasma-photocatalysis system could be a relevant method for the removal of low concentrated volatile organic compounds from air.

Session 2. Ozone reactor design

1. Optimizing Ozone Transfer Through Pipeline, Multi-Jet Gas Mixing
James R Jackson, Michael Oneby P.E., Celia M. Mazzei, Michael G. Priest P.E.
Ozone injection using venturi-type gas injectors was introduced to the US ozone market in the early 1980s as an alternative to fine bubble diffusion and other ozone gas dissolution techniques. A dissolution system using venturi-type gas injectors achieved higher ozone transfer efficiency and required lower maintenance than conventional fine bubble diffusion. Initially, venturi gas injectors required an excessive amount of energy to transfer ozone to solution: up to 25 MJ per kg/hr (3.20 kW·h/lb) of ozone gas transferred. The high power consumption was due to the significant gas volume required to deliver an ozone dose at concentrations of 1 wt% using air as the feed gas. Consequently, ozone gas injection was excluded from US municipal ozone plant designs. By 2000, ozone designs had changed from producing 1 – 2 wt% ozone with air as the feed gas to 10 wt% ozone using high-purity oxygen, reducing the gas volume per kilogram of ozone generated by nearly an order of magnitude. Simultaneously, the science of gas injection turned toward the use of secondary gas mixing devices, which shifted the emphasis away from ozone transfer at the venturi and allowed for a significant increase in the injector's gas/liquid ratio (G/L). The increase in the G/L ratio significantly increased the amount of ozone transferred by the gas injection system. The development of a specific secondary mixing device, the Pipeline Flash Reactor™, a multi-jet pipeline gas mixing device, together with the ability to produce high concentration ozone gas has reduced gas injection energy requirements to less than 4 MJ per kg/hr (0.50 kW·h/lb) of ozone gas transferred, making gas injection a viable alternative to fine bubble diffusion. A case study presents the capital cost, power consumption, ozone transfer efficiency and footprint for a specific municipal application that utilizes a venturi-type injector with the Pipeline Flash Reactor™ for ozone contacting. The municipal wastewater application utilized an applied ozone dosage of 8 mg/L and required substantial basin floor area for the fine bubble diffusion grids. The total basin floor area was reduced from 265 $m^2$to 168 m^2 by replacing fine bubble diffusion with a system consisting of venturi type injectors with the Pipeline Flash Reactor™. At the design condition of 31.2 kg/h ozone production, the energy requirement of the contacting system is 3.7 MJ per kg/hr (0.46 kW·h/lb) of ozone applied.

2. Static Mixers for Ozonation of Water
Rein Munter
The aim of this study was to compare the pressure drop (□p) generated by a static mixer with 3-8 sieves in two-phase concurrent downflow (water as a continuous phase), and the mass transfer efficiency (kLa, a) with the performance of other static mixers (Lightnin, Sulzer, Kenics, Karman etc.). The relationships for □p, kLa and interfacial area (a) calculation depending on liquid and gas phase velocities and geometry of the sieves in this static mixer are presented. kLa was found strictly proportional to the power consumption (P/V) and it's values quite close to those obtained in the Sulzer & Kenics mixers with 8-element mesh. Comparing to other static mixers with mixing elements of different configuration, the static mixers with sieves (mesh) have lower pressure drop. Enhancement factors for oxygen absorption in the sodium sulphite solution and for ozone absorption in Lake Ülemiste water were in the static mixer with 3-8 sieves calculated and the plausible values of the interfacial area (a) were estimated.

3. Basics and Engineering of a Bubble Column
Pierre-André Liechti
The Bubble Column BC is the most applied diffusion system for the treatment of water and wastewater with Ozone.
It is possible to observe the behaviour of a BC and the macroscopic movements of bubbles within the BC or a swarm of bubbles, and of a swarm of bubbles, but what really happens dynamically at the interface gas – liquid cannot be observed with the human eye. A BC can be generated by several means, such as porous diffusers, hydro-injectors, static mixers and radial diffusion. However all these BCs have very different hydraulic and hydrodynamic patterns, with the result that the overall reaction kinetics, which include chemical reactions, and the fate of the oxidation by-products are fundamentally affected by these patterns. Depending upon the type of application of ozone, secondary reactions of the by-products resulting from the first reaction with ozone may be wanted or not. Mitigation of secondary reactions will lead to a reduction of ozone consumption which can be important and therefore beneficial economically, in particular for applications in wastewater. In potable water applications the selection the adequate BC may also help to mitigate bromate formation. To be mentioned also is the fact that in wastewater applications, the ozone dosage is generally much larger than for potable water, with kinetics of the chemical reactions ozone – organic matter, dissolved, colloidal and suspended, quite fast. The selection of the correct BC is therefore of the essence. A BC is made of a single swarm or several swarms of bubbles. Therefore it is of basic advantage to have first a good knowledge about the hydrodynamics of a single bubble, the impact of its wake on the surrounding bubbles and on ozone

diffusion from underneath its gas-liquid interface towards the bulk of the liquid. In a swarm of bubbles turbulent interactions between bubbles due to their wake are evidence. The intensity of these interactions depends upon the density of bubbles and their behaviour while rising towards the top of the BC. BCs, depending upon the way they are generated can be classified as homogeneous or inhomogeneous, with multiple bubble swarms or not (laminar or turbulent as defined by some researchers). From a point of view of ozone task, these differences in behaviour have a profound impact on efficiency. This paper proposes a qualitative and quantitative approach to the BC, starting first with the individual bubble and ending up with the several types of BCs. Physical, behaviour and design parameters such as bubble wake, mixing power, Reynolds stress, Reynolds and Sherwood numbers, eddy diffusion, bubble surface turbulence, micro-, mini- and macro-turbulence, stability of bubbles, coalescence of bubbles, influence of surface active substances, gas hold-up, head loss, etc. are addressed. Numbers quantifying this problem stemming from basic research off literature and personal experience are presented, applied to a couple of examples.

4. Considering Options to Refurbish and Replace an Aging Ozonation System
Jeff Neemann, Bryan Townsend, Mario Francucci, Kathy Moriarty, Weston Haskell, Rick Pershken, Kevin Pottle
The Bangor Water District (BWD) has evaluated the treatment requirements for compliance with the US EPA's Long Term 2 Surface Water Treatment Rule (LT2SWTR). The LT2ESWTR will supplement existing regulations by mandating additional Cryptosporidium inactivation requirements for higher-risk systems. BWD is an unfiltered water system that currently uses ozonation and chloramination. After an evaluation and selection process, BWD is in the process of adding UV disinfection to meet the LT2ESWTR treatment requirements. Ozone is the main treatment process at the BWD's Butler Ozone facility. This facility treats surface water from Floods Pond, BWD's only water supply source. The Butler ozone facility and the existing ozone system have been in service since 1995, and have allowed BWD to meet existing federal and state drinking water regulations. Ozone is anticipated to be a part of BWD's treatment processes for the foreseeable future; therefore, BWD needs a reliable, cost effective ozone system for the next 20 year planning horizon. Because of the age of the ozone equipment, it is becoming more difficult to obtain parts for the existing system and diffuser replacement has become an annual maintenance item. The ozonation system equipment and maintenance activities were reviewed including hours spent, availability of replacement parts, and overall reliability. Based on information from BWD staff, service records, and discussions with equipment suppliers, cost projections were developed to keep the major equipment of the ozonation system running for the next 20 years. Ozonation system options were developed for each of the major systems.

5. Reengineering for improving the operation of wastewater treatment plants by using ozone
Robert Hausler, Pierre-André Liechti
In order to address the problems incurred by the presence in treated wastewater of micro-organisms and pollutants which disrupt the endocrine systems ozonation becomes an interesting choice. It is a fact that multiple test results show that ozonation allows for meeting the Environmental Discharge Goals EDGs set to treated wastewater with respect to thermo-tolerant coliforms and enterococci, with simultaneous abatement of pharmaceuticals and chronic toxicity. In order to optimize the use of ozone, application strategies must be developed and implemented with consideration of all the stages of the WWTP.

6. Design of oxygen and ozone systems for a large scale advanced tertiary treatment plant
John Mieog, Jon Bates, Andrew Nelson, Nick Burns
Melbourne Water's Eastern Treatment Plant will be upgraded by 2012 through the implementation of advanced tertiary treatment. The proposed process train comprises pre-ozone, biological media filtration, post-ozone, UV and chlorine and will treat secondary effluent to a very high quality to reduce impacts on the receiving marine environment and create a high quality recycled water resource. At average and peak flows of around 380 and 700 MLD treated water production respectively, the Eastern Treatment Plant advanced tertiary treatment plant will be amongst the largest and most sophisticated of its kind in the world. The peak oxygen and ozone demands for the project are 125 MTPD and 9 000 kg/d (375 kg/hr) respectively. Extensive investigations and analysis were undertaken to determine the specific oxygen and ozone demand requirements to meet the treatment objectives for the project, and subsequently optimise the design response, treatment system availability, and project whole of life costs. This paper presents the broad range of cost and non-cost considerations which were applied to design and decision making processes to achieve optimised and best for project outcomes.

Session 4. UV reactor design and validation – Part 1

1. New York City UV system validation by Lagrangian actinometry using dyed microspheres
Chengyue Shen, O. Karl Scheible, Ernest R. Blatchley III, Eric Cox, Matthew Valade
Validation testing was conducted in 2009 for the New York City Department of Environmental Protection (NYC DEP) prototype ultraviolet (UV) unit (Trojan Technologies) that is designed for installation at the Catskill/Delaware UV Disinfection Facility in Eastview NY, the largest such facility in the world. These tests demonstrated protocols to directly measure the dose-distribution of UV reactors by Lagrangian actinometry (LA) using dyed-microspheres (DMS). The ultimate goal of this project was to demonstrate and use these validation results in the context of the USEPA Ultraviolet Disinfection Guidance Manual (UVDGM, November 2006). The ability to directly measure the dose-distribution in a UV unit resolves a significant issue in the UV industry, effectively defining the key characteristic in UV reactor design. Integrating the dose-distribution with the dose-response kinetics of a pathogen allows one to determine the inactivation performance that can be accomplished by the UV unit, eliminating the uncertainties associated with using microbiological surrogates, and the need to re-validate when new pathogens are identified. Simultaneous validations using biodosimetric (with MS2 and T1 phage) and actinometric (dyed microspheres) protocols was directed to establishing the log-inactivation reduction-equivalent-dose (RED) delivery performance within the stated operating range of the UV unit. Testing comprised more than 60 operating conditions, as define by flow, UVT, power and the number of lamps in operation.

2. Comparison of CFD, biodosimetry and Lagrangian actinometry to assess UV reactor performance
Bas A. Wols, Roberta C.H.M. Hofman-Caris, Danny J.H. Harmsen, Erwin F. Beerendonk, Johannis C van Dijk, Po-Shun Chan, Ernest R. Blatchley III
Computational fluid dynamics (CFD) is becoming increasingly popular for assessing UV reactor performance. However, due to

uncertainties in flow fields, lamp output and microbial response to UV, the CFD model needs to be validated by measurements. The combination of several experimental techniques with CFD modelling allows for a thorough understanding of the dominant processes occurring in UV reactors. Therefore, CFD modelling, Lagrangian actinometry (Blatchley et al., 2008) and biodosimetry experiments were performed for a bench-scale UV reactor containing four cross-flow LP lamps. These series of measurements provide useful data for model validation. In addition, it provides an overview of three techniques (biodosimetry, LA and CFD) that are used to determine UV reactor performance. A good agreement was found between biodosimetry and CFD modelling. Lower inactivation levels were found for the Lagrangian actinometry method, which was explained by fluorescence decay of the microspheres.

3. Is the REF of UV-Plants for Drinking Water Disinfection Proportional to Lamp Power and Flow Rate?
Alexander Cabaj, Regina Sommer, Georg Hirschmann, Thomas Haider
If the biodosimetrically determined REF (Reduction Equivalent Fluence) of UV-disinfection plants for drinking water shall be calculated for other flows or lamp powers than used during biodosimetry it is often sufficient to know if a certain change is on the safe side or not. For instance in the Austrian Standards ÖNORM M5873-1 and -2 it is allowed to calculate flows to a value where the REF is 400 J/m² if the biodosimetrically determined REF was up to 600 J/m².

4. Demonstrating 4-log Adenovirus Inactivation in a Medium Pressure UV Reactor
Karl G. Linden, Karl Scheible, Chengyue Shen, Charles Gerba, Akrum Tamimi, Phyllis Posy
UV disinfection is a well-accepted technology for inactivation of bacterial and protozoan pathogens in water and wastewater. Until recently, UV was also considered a viable technology for disinfection of viruses. In fact, UV disinfection at doses typically used in water treatment is very effective (>4 log inactivation) against almost all known pathogenic viruses tested, with the one exception of adenoviruses. According to 2006 US EPA regulations (LT2ESWTR), the inactivation of adenoviruses to a level of 4-log requires a UV dose of 186 mJ/cm^2 based on an 80% credible interval of the data from previous inactivation studies. It appears that adenovirus will likely be the limiting organism in determining reactor design and UV dose for systems that need 3 to 4 log virus credit. In addition, adenovirus is currently listed on the US EPA Candidate Contaminant List (CCL3). However, all data in the recent regulations are based on research performed using only one type of UV technology - low pressure (LP) UV sources emitting at 253.7 nm in the germicidal UV range. Recent bench scale studies by Linden and colleagues, however, suggest that polychromatic UV sources such as medium pressure (MP) and pulsed UV, which emit at wavelengths throughout the 200 to 300 nm range, are 2 to 4 times more effective than low pressure sources for inactivation of adenoviruses.

5. UV System Checkpoint Bioassays: Proof of Scale-Up, Challenges from the Field, and Comparison Methodology
Brian Petri, Ji An, Victor Moreland
The NWRI/AwwaRF "Ultraviolet Disinfection Guidelines for Drinking Water and Water Reuse" (the Guidelines), require that UV systems be sized based on bioassays, which are done on reactors up to some practical size and capacity. To treat higher flows, scale-up must be considered. Once installed, a UV system is evaluated in a Checkpoint (commissioning) Bioassay, which can often be done only at a lower level of accuracy than a product validation at a test center. This paper will outline the challenges in obtaining high accuracy results in checkpoint bioassays, and techniques to maximize the accuracy. Methods for comparing test results from checkpoint bioassays to product validation bioassays will be discussed. Limitations on the usefulness of Checkpoint Bioassays will be discussed, together with a summation of experience that supports alternative methods for having confidence in UV systems.

6. Yikes! What the UVDGM Does Not Address on UV Disinfection
Harold Wright, Mark Heath, Jeff Bandy
The USEPA UV Disinfection Guidance Manual (UVDGM) provides guidance for the design, validation and operation of UV systems in the United States for disinfection under the Long Term 2 Enhanced Surface water Treatment Rule. The UVDGM was prepared over six years with drafts released in 2001 and 2003 and a final version released in 2006. The preparation of the UVDGM was challenged by the limited experience in the US with full scale UV system implementation and validation. During the drafting of the UVDGM and over the course of a decade of full-scale experience, there has been considerable evolution in the understanding of UV disinfection. This paper describes nine issues not fully addressed by the UVDGM that impact UV dose delivery and monitoring by installed systems. Solutions to each issue are proposed.

Session 5. Ozone in Medecine – Part 1

1. Ozone as a medical drug. Toxicity versus therapeutic benefit. Guidelines and treatment strategies
Renate Viebahn-Hänsler
Medical ozone is included among the hormetic substances and its effects can be assigned to those defined by hormesis (3): In living organisms, single or repetitive administration of otherwise potentially dangerous or toxic substances in small doses increases their homoeodynamics (homoeodynymic space), i.e. their self-regulatory capacity. Or, alternatively: Moderate oxidative stress stimulates the protective mechanisms of cells and organs and is biologically useful.

2. Ozone Oxidative Postconditioning protects against the injury associated to Alcohol Withdrawal Syndrome
Olga S. León Fernández, Maria T. Díaz-Soto, Angela Fraga, Jaqueline Dranguet, Mayté Casanova, Renate Viebhan, Silvia Menéndez
Alcoholism is a serious health problem. In western industrialized countries, approximately two-thirds of the entire population above the age of 18 years consumes alcohol. Alcohol is the third leading cause of healthy years lost to death and disability in developed nations. The role of chonic oxidative stress on liver and Central Nervous System injury in alcoholism has been well-grounded. On the ohter hand, Ethanol Withdrawal (EW) Syndrome has not specific therapeutical treatment and its symptoms are so laborious that patients frecuently abandon the medical treatments. Since Ozone Oxidative Pre/Postconditioning mechanism promotes the reestablish of cellular redox balance the aim of this work has been to study the effects of OzoneOxPostconditioning (OzoneOxPost) on EW syndrome in order to clarify pathological mechanisms and improve laborious symptoms during EW through ozone therapy.

3. Effects of Medical Ozone as an Anti Cancer Agent in Hepatocellular Carcinoma in Rats (A Histopathological Study)
M.N. Mawsouf, M.A. Fadel
This study was performed on 64 albino rats. It were divided into four groups: (1) Control group included 10 rats which didn't

receive any drugs or ozone sessions (2) Ozonized control group included 10 rats that received ozone in oxygen by rectal insufflations 0.7mg/kg, five sessions per week for three weeks (3) DBA group included 22 rats that were kept for 9 months fed with bread in milk and 2500 ppm of sodium nitrate and 1250 ppm dibutyl amine (DBA) (carcinogenic agent) dissolved in drinking water (4) Ozonized DBA-group was same like DBA group but after the nine months they received ozone in oxygen by rectal insufflations 0.7 mg/kg, five sessions per week for three weeks. Rat liver tissue was biopsied for histopathology before and after the study. In the DBA-group, the histopathological examination showed hepatocytes with foamy cytoplasm and vesicular nuclei, congested central vein surrounded by micro-vesicular and macro-vesicular lipidosis and, slight hemorrhage in the blood sinusoid, peripheral lobular necrosis and hemorrhagic areas. Also lymphocytic cell infiltration, degenerative areas, sever hemorrhage of blood capillaries, vacuolar degeneration of hepatocytes, foci of necrotic hepatocytes as well as portal infiltration with lymphocytes and lymphocytic cells infiltration in the portal triad associated with ballooning of the hepatocytes. In the Ozonized DBA-group, Ozone treatment improved towards normal the liver structure. There was good healing effect showing apparent normal hepatocytes strands.

4. The role of O_3/O_2-Pneumoperitoneum in a cardiac allograft survival study in rats

Aline Henriquez Santana, Siegfried Schulz, Harald Tillmanns, Thomas Stadlbauer

Heart transplantation has evolved into the treatment of choice for people with end stage heart failure. Survival among cardiac transplant recipients has improved as a result of improvements in treatments that suppress the immune system and prevent infection. Heart transplant recipients are still dependent on a life long immune suppression by pharmacological drugs. Those potent immunosuppressive drugs (e.g. Cyclosporin A) are responsible for a great number of side effects and result in increased rates of cancer, opportunistic infections and some also in organ toxicity. Furthermore, those drugs do not prevent the development of graft vasculopathy (GVP) which remains the major cause for morbidity and mortality in the long term outcome after heart transplantation. For this reason, research is nowadays focused on finding new strategies to prevent graft loss and avoid side effects.

5. Cardioprotective Effects of Ozone Oxidative Preconditioning in an in Vivo Model of Ischemia/Reperfusion Injury

Azza M. Agha , Amina S. Attia, Mohamed N. Mawsouf, Hesham A. Salem, Lamiaa A. Ahmed

The present study was designed to investigate the cardioprotective effects of oxidative preconditioning in ischemia/reperfusion (I/R) injury. Rats were randomly assigned into 5 groups. Groups 1 and 2 were normal and I/R groups, respectively. Other 2 groups received 2 different doses of ozone therapies by rectal insufflations. The last group received vehicle (oxygen). Rats were subjected to myocardial I/R (40min/10min). Heart rates and ventricular arrhythmias were recorded during I/R progress. At the end of reperfusion, plasma creatine kinase-MB (CK-MB) activity and total nitrate/nitrite (NOx) were determined. In addition, lactate, adenine nucleotides, thiobarbituric acid reactive substances (TBARS), reduced glutathione (GSH) and myeloperoxidase (MPO) activity were estimated in the heart left ventricle. Histological examination was also performed to visualize the protective cellular effects. Both doses of ozone therapy were equally protective in reducing CK-MB release. However, the higher dose was more effective in reducing oxidative stress, lactate accumulation, elevated MPO activity and plasma NOx as well as preserving myocardial adenine nucleotides. Histological examination revealed also better improvement by higher dose of ozone therapy compared to I/R group. It could be concluded that the higher dose of ozone therapy provided more effective cardioprotection against the biochemical and histological changes associated with I/R injury.

6. Comparative analysis of the effect of small dozes of ozone and doxorubicin on the therapeutic pathomorphism of an experimental tumor

C.N.Kontorshchikova, A.V.Alyasova, B.E.Shakhov, I.G. Terentiev, S.N. Tzybusov, S.N.Kuznetzov, S.S.Sazanov

The aim of present research was to estimate the effect of ozonated physiological solution (OPS) low concentrations on therapeutic pathomorphism of a tumor experimentally. Experimental neoplasia was modelled by transplantation of the breast cancer strain to laboratory rats. OPS was prepared by bubbling of 0.9 % NaCl with ozone-oxygen mixture. On finishing the experiment the histological study of tumor tissues was performed. The biochemical investigation included analysis of induced biochemiluminescence parameters and level of lipid peroxidation products measured in the tumor tissue homogenates. Atomic emission spectrometer with inductively coupled plasma was used for the measuring of tumor tissue microelements spectrum. The increase of coefficient (Schiff bases/dien conjugates+trien conjugates) which reflects the directivity of lipid peroxidation process towards predominance of products destroyed the cell membrane and thereby facilitated destruction of tumor cells and tumor decay was statistically significant for this group compared with others. While combinative using of doxorubicin and OPS content of Fe, Cu, Zn were invariable and remained at high level which could be been the basis for additional activation of the free radical processes. Thus, the combined action of doxorubicin and OPS makes the most pronounced damaging effect on a tumor tissue. The application of OPS has promoted the antitumor activity of doxorubicin which on the basis of activation of free radical reactions proved by reliably most pronounced inhibition of the tumor cells mitotic activity, statistically significant decrease of viable elements number and, therefore, achieving of more advanced appearances of therapeutic pathomorphism.

7. Ozone and the periodontal health and diseases

Judit Martinez Abreu, Mark T. Weiser, Eduardo Llanes Llanes, Silvia Menéndez Cepero

The periodontal diseases is one of the illnesses that affect the human being in any part of the world, in its pathogenia and evolution participate several factors of risk, some of difficult control. Free radicals or species reactivate of the oxygen are present and they play a very important role in the worsening of this entity. It is necessary to know the mechanisms of generation in the ways of the free radicals and their consequence at cellular and molecular level for their action on the lipids, proteins and nucleic acids, as well as on the system of defense that it prepares the organism for their protection. To be able to measure the oxidativ estres or the level of damage present in patient with periodontal affections to establish a predictiv diagnostic and to act precociously to avoid the advance of the diseases, it would be a step to implement in an immediate future. Ozonetherapy is an effective and innocuous alternative that evidences its potential of stimulant of the inmunological system to counteract the effect of the species reactivate of the oxygen and as antimicrobial agent too. With this study we expose some reflections based on studies carried out in Cuba and in other parts of the world with good results.

Session 1. Advanced Oxidation Processes – Part 2

1. Impact of Combined Coagulation-UV/H_2O_2 Treatment on Biological Stability of Water

Mahdi Bazri, Madjid Mohseni

Ultraviolet (UV) based advanced oxidation processes (e.g., UV/ H_2O_2have been emerging as viable alternative technologies for treating surface drinking water. The efficacy of the UV processes, however, is hindered by the presence of natural organic matter (NOM). Commercial application of advanced oxidation processes (AOPs) in drinking water treatment could lead to partial oxidation of natural and complex organic molecules, potentially producing Assimilable Organic Carbon (AOC). Earlier studies have found AOC as the potential cause of bacterial regrowth and other water health concerns thereof within the distribution system. This work investigated coagulation as pretreatment alternative to UV/H_2O_2 process in order to enhance treatment efficacy and the final finished water quality. A rapid method was utilized to assess biological stability of the treated water at various stages through measurement of AOC. Alum coagulation was effective in removing a substantial portion of large to medium weight organic molecules. This in turn led to a considerable decrease in the AOC of the finished water. Even though, the remaining organics showed to promote some level of bacterial regrowth after undergoing UV/H_2O_2 treatment. Combined Alum coagulation followed by UV based AOPs showed to be an effective strategy for reducing formation of AOC as a result of NOM oxidation.

2. Control of TCE Using UV Combined with Hydrogen Peroxide or Chlorine

Ding Wang, Tim Walton, Leigh MacDermott, Ron Hofmann

A full-scale study at the Middleton Water Supply System in Waterloo (Ontario, Canada) was carried out to compare the treatment effectiveness of UV alone, UV combined with free chlorine (UV+chlorine) and UV combined with H_2O_2 (UV+ H_2O_2) to destroy trichloroethylene (TCE) in a ground water source (pH = 7.55) for drinking water. The water was treated with a medium pressure UV reactor, either alone, or with 9 mg/L free chlorine or 8 mg/L H_2O_2 added upstream. The results indicated that at approximately the same UV dose, UV alone could destroy 70% of the TCE but the efficiency was better (about 90% of TCE destroyed) with UV+ H_2O_2 and UV+chlorine. Moreover, UV+chlorine was found to be less expensive than UV+ H_2O_2 for approximately the same amount of TCE removal, with predicted costs of 12, 13 and 18 cents per cubic meter of treated water by UV alone, UV+chlorine and UV+ H_2O_2, respectively. In addition, a theoretical model based on assumed mechanisms for TCE destruction under the three treatment scenarios was built to predict the degradation kinetics of TCE. The concentrations of trihalomethanes, haloacetic acids, and chlorite formed during UV+chlorine treatment were minimal. Chlorate formation approached 1 mg/L, but following blending with other wells prior to water entering a reservoir the chlorate was reduced to 0.3 mg/L, which is well below the Health Canada standard of 1.0 mg/L. Nevertheless, chlorate formation, as well as the formation of other chlorination DBPs, should be further explored.

3. Application of UV/H_2O_2 as post-treatment of WWTP secondary effluents for water reuse

Bruno S. Souza, Renato F. Dantas, Angel Cruz, Santiago Esplugas, Carme Sans, Márcia Dezotti

Water reuse can be considered as an attractive strategy which can significantly contribute to water conservation in areas suffering from water scarcity or overconsumption. This approach allows the use of reclaimed water to specific purposes, which depending on the application requires different level of treatment. Despite the importance of water reuse, only few countries are carrying it out. Among them, USA, some south European countries and countries in the more humid north-western climate have arrived to a certain degree of water reuse. A number of these countries have also developed guidelines that give quality criteria and advice on how effluents should be treated for some purposes such as irrigation, groundwater recharge and recreational reuse. Examples of these guidelines are the “Guidelines for water reuse” and the Spanish “Real Decreto 1620/2007”. Among the diverse types of effluents with potential to be reused, those from municipal waste water treatment plants (WWTP) are an attractive and common source of water, that lately have been used for a large type of application such as in soils on cultivated and marginal areas, various facilities and within urban building complexes. Nevertheless, the presence of micropollutants in these and other effluents is a topic of great concern. Most of these contaminants, including pharmaceuticals and pesticides, may have potential to cause effect on natural ecosystems as well as bioaccumulate. In this context, the treatment of secondary effluents (SE) appears as an alternative to minimize the discharge of these contaminants in receiving waters as well as to improve the overall SE quality for a possible reuse.

4. A method for quantifying the assimilable organic carbon in water treated with UV/H2O2 and biological activated carbon filtration

Mihaela I. Stefan, Siva R. Sarathy

The UV/ H_2O_2 advanced oxidation process has proven as a viable means to remove micropollutants of various chemical structures and origins from contaminated waters. Currently, there are several full scale UV systems installed around the globe which remove or reduce substantially environmental contaminants from drinking water sources. The impact of UV/ H_2O_2 process on biological stability of treated water is highly dependent on water quality parameters, including the dissolved organic matter level and speciation. Studies reported in the scientific literature indicate that assimilable organic carbon (AOC) is primarily responsible for biological instability of water treated with an oxidative process; AOC is effectively removed during biological activated carbon filtration [1-5]. In this work we advanced a novel method for AOC determination developed by Hammes & Egli [6] for use with UV/ H_2O_2 treated water. The key advancement to the Hammes & Egli [6] AOC quantification method consists in development of an H_2O_2 quenching agent that does not interfere with the AOC determination. We applied this new method for quantifying AOC before and after UV/ H_2O_2 treatment and compared our in-house AOC data to those reported by commercial labs employing the van der Kooij method for AOC determination [7] adopted as AWWA Standard Method 9217 [8]. Additionally, BAC filtration was investigated as a complimentary downstream process to UV/ H_2O_2 for the elimination of residual H_2O_2 and reduction of potentially-formed AOC.

5. International project on new concepts of UV/ H_2O_2 oxidation

C.H.M. Hofman-Caris, D.J.H. Harmsen, E.F. Beerendonk, M. Heringa, A.H. Knol, K. Lekkerkerker-Theunissen, J. Geboers, M. Meyer, D. Metz

Improved purification processes are required as sources for drinking contain increasing concentrations of (new) contaminants.

Advanced oxidation processes, like UV combined with H_2O_2 oxidation, seem to break through as important barriers against organic micropollutants in full scale water treatment. During the past four years, a large international project was carried out to study various aspects of the UV/ H_2O_2 process. This study was carried out by KWR Watercycle Research Institute, Greater Cincinnati Water Works (GCWW), Dunea (formerly known as Dune Water Company South Holland) and Philips Lighting. Pilot plants were designed and built, in which the conversion of triazines, hormones and priority compounds, as well as the disinfection capacity of the system was studied. For this study different UV-lamps were compared, with and without the addition of H_2O_2: "conventional" Medium (MP) and Low (LP) pressure mercury lamps, a Low Pressure High Output (LP-HO) lamp and a new "dielectric barrier discharge" (DBD) lamp. The latter two lamps were developed by Philips Lighting. It was found that these types of lamps can be successfully applied for disinfection purposes, and to convert a significant amount of priority compounds to a high degree (>80%), independently of the type of water used. CFD modeling was used to determine the degree of optimization of the various pilot plants. The performance of the various pilot plants was compared using Electrical Energy per Order (EEO) data (0.1 -1.8 kWh/m3 depending on reactor design and water quality). Furthermore, the possible formation of genotoxic byproducts was studied at the different locations. By implementing a filtration process over GAC after the UV-reactor, the excess of H_2O_2 can be removed. Besides, this GAC also appeared to be effective in removing any formed byproducts.

6. Removal of Antibiotics from Urban Sludge: A Comparison of Ozonation and Fenton Processes
L.Elif Acar, Nalan Bilgin Öncü, Isıl Akmehmet Balcıoglu
Ozone and Fenton processes were investigated as potential technologies to treat waste activated sludge for the removal of a tetracycline group antibiotic which was selected due to its representativeness for pharmaceuticals having high sludge binding capacities. Effect of process parameters such as pH and oxidant dose on the process efficiency were investigated by monitoring antibiotic abatement as compared to sludge solubilisation. Potential of sludge minimization by the studied processes was also investigated by analysis of their effect on the conventional sludge parameters such as nutrients and metals release. Both antibiotic removal rate and the rates of release of nutrients and metals during the investigated processes were found to be closely dependent on sludge solubilisation. It is expected that both ozone and Fenton processes can be utilized for the degradation of pharmaceuticals that tend to accumulate in sludge as well as sludge minimization management.

Session 3. Industrial applications – Part 1

1. Economic, environmental and microbiological benefits of ozone laundering systems
Rip G. Rice, Marc DeBrum, Jacqueline Hook, Dick Cardis, Cameron Tapp
Three primary benefits (advantages) of properly designed and operated ozone laundering systems have been proven in successful commercial installations – microbiological kills/inactivation of all microorganisms found in linens to be laundered; economic cost savings and significant environmental benefits. Each of these benefits of ozone laundering is described and quantified in new the Ozone Laundry Handbook [1] and are discussed in this paper.

2. UV irradiation for the manufacturing of viral vaccines: state-of-the-art and perspectives in modern vaccine processing
Ines Mayerhofer, Heinz Anderle, Otfried Kistner, M. Keith Howard, Thomas R. Kreil, P. Noel Barrett
A century ago the general concept to use ultraviolet radiation for the production of non-pathogenic vaccine antigens was established. The parallel progress in virology and technology lead to the successful propagation of viruses and to the availability of reliable UV lamps, resp., so that production-scale irradiation equipment enabled the manufacturing of viral vaccines some 50 years ago. Meanwhile, biotechnology has advanced to the large-scale production of virus suspensions from cell-culture fermenters, and UV equipment and process design can be tailor-engineered to the respective target viruses. In combination with the well-established formaldehyde inactivation step and a cell-culture safety test, orthogonally dual-inactivated viral vaccines can be obtained with a very high margin of safety and high efficacy. The recently licensed pandemic and seasonal influenza vaccines ("Celvapan" and "Preflucel", resp.) are among the first practical examples of a large-scale UV irradiation procedure incorporated into the manufacturing of state-of-the-art vaccines.

3. Effects of dissolved ozone in internal and external fish body systems
Cathy Shuk-wun Fong, Grace Ka-yan Man, Wo-wing Cheng, Gilbert Yuk-sing Chan
About 40% of the global harveseted aquatic yields were consumed by people in China in recent years. This huge consumption urged quick development in aquaculture in China and better aquaculture management is in need to maintain the quality of aquaculture produce. With reference to fish stress and health after ozone application, the changes in the fish internal and external body systems were investigated. Fish samples were subjected to ozone treatment with resultant oxidation reduction potential (ORP) of 600, 700 and 800 mV for 15 min and blood samples were collected. The physiological changes in aspartate transaminase (AST), alanine aminotransferase (ALT) and epidermal mucus secretion were determined. The AST level increased with increasing concentration of ozone, while the number of cell the higher dose (800 mV) was less in that in the lower doses (600, 700 mV). The level of ALT was stable in the 3 ozone treatments. The results indicated ozonation resulted in 600 mV or above in ORP causes damages in liver function. Fish mucus plays an important role as the first defence system and it contains lectins, lyzosomes and antimicrobial peptides (AMP) with antibacterial activity. The colour of the fish mucus is a factor to determine the quality of fish food. In order to test for the effects of ozonation, epidermal mucus protein content and its total bacterial count were determined. Ozone is a strong oxidizing agent and it might alter the fish mucus secretion and kill the mucus dwelling bacteria. If the mucus secretion change to a large extent, this would not be beneficial to the fish industry.

4. Application of O_3 and UV for disinfection of seawater in Ballast water treatment
Joon-Wun Kang, Yeojoon Yoon, Yumi Jung
The biological efficiency and formation of oxidants and by-products after ozone and UV ballast water treatment were investigated. In microorganism disinfection test, the results clearly show that the E. coli could be inactivated by ozone and UV treatment which are shown more than 99.99% inactivation efficacy in the seawater. However, in case of the ozonation, the B. subtilis spore was inactivated only 1.3log (95%) with 7 mg/L of applied ozone dose and more inactivation were not observed with additional ozone dose. In addition, there were no residual oxidants in the UV treated seawater except for H_2O_2 (18~48 μg/L) and harmful by-products were formed in this study. In sum, the UV irradiation process is cleaner and more effective technology that can safely treat ballast water without affecting marine aquatic environment than ozone process does.

5. Effect of Low Pressure Ultraviolet Irradiation on Barnacle Growth under Open Sea Conditions
XIE, Rongjing
Barnacle growth on solid surfaces, such as ship hulls, tidal gates and equipment submerged in seawater, augments poor aesthetics, deteriorates their performance and increases their operation and maintenance cost. Premature failure of the facilities is the prevailing outcome. Most of the currently available measures to manage the problem of barnacle growth are not environmentally friendly and have no long term effect. They are also expensive to implement and require frequent maintenance and services. The effectiveness of UV irradiation in preventing the invasion of barnacle colonies under a tropical marine environment was investigated. Two metal plates were prepared and submerged in water: one as the control and the other for UV treatment. The UV system consisted of one metal surface onto which barnacles can attach, grow and form colonies, six 120-w low pressure lamps parallel to the metal plate surface and a UV light reflecting surface. The metal plate surface subject to barnacle fouling was examined at least once every month for the growth of the barnacles. Within 7 weeks, the entire control plate was colonized by the barnacles. Barnacles grew to approximately 0.5 cm in diameter. Barnacles, however, did not invade the UV irradiated metal plate. There were no barnacles on the UV irradiated surface after 11 weeks. The result of the study was conclusive that UV irradiation completely prevented barnacles from attaching, colonizing and growing on the metal plate surface.

Session 4. UV reactor design and validation – Part 2

1. Impact of advanced validation techniques and dose-monitoring strategies on UV reactor operating efficiency
Bryan Townsend, Bob Hulsey, Jeff Neemann, Xi Zhao
UV systems validated today with the most recent and advanced techniques are far more efficient than similar systems validated just a few years ago. To increase the accuracy of dose-monitoring strategies and maximize the operating efficiency of UV reactors, advanced validation techniques are currently being employed using surrogate organisms that better match the dose-response characteristics of the target pathogens. UV facilities utilizing reactors that were validated using older techniques as well as systems that were originally designed to achieve elevated dose requirements may be able to increase the their operating efficiency through the application of modern dose-control algorithms.

2. On-Site Testing Extends Validated Range for Year-Round Operation of a Medium Pressure UV Disinfection System
Mark Heath, Harold Wright, Jeff Bandy, Irfan Gehlen, Mark Forsyth
In December 2009, Carollo Engineers was contracted by Kerr Wood Leidal Associates Ltd. (Burnaby, B.C.) to conduct on-site validation of a Trojan 4L12 UV disinfection system for the City of Armstrong, B.C. The purpose of on-site validation was to extend the validated range of the original validation, conducted at the Portland UV Validation Facility in Portland, OR in January, 2006, from a UV transmittance (UVT) of 70 percent to approximately 50 percent. This extension was needed to allow for UV system operation at Armstrong during their spring freshet, when the UVT at the WTP can drop to 55 percent or below, requiring system shutdown and reliance on groundwater, a system that would require further development for long-term demand projections. On-site validation of the UV reactor at Armstrong was conducted from April 19 to 21, 2010. Results demonstrated that UV system performance closely matched that defined during the original validation. Extension of the original validated range to an operating UVT of 50 allows the City of Armstrong to operate on a continuous basis during all anticipated water quality conditions and prevents the need for shutdown and reliance on groundwater during the annual 6 to 8 week period of low UVT. As such, the City no longer needs to pursue development of further groundwater resources to meet demand during periods of low UVT.

3. Development, Challenges and Validation of a High Efficiency UV Unit for Title 22 Reuse
Keith Bircher, Bill Sotirakos, Andy Salveson
Parallel flow in-channel systems with higher power amalgam UV lamps require greater spacing between lamps for higher flows and to not exceed pressure drop limitations. This paper describes the development of a special mixing system that results in a system with fewer lamps and higher efficiency than competitive systems. Pilot testing for compliance with the California Title 2 regulations for water reuse is described along with a case study presented comparing the cost with alternate systems.

4. Drinking Water UV Operation Without On-Line UVT Monitoring: The Default UVT and Sensor Setpoint Approaches to Validation
Jeff Bandy, Harold Wright, David Gaithuma, Oliver Lawal, Steve Larner
UV reactors used in drinking water applications use an on-line dose monitoring algorithm to define disinfection performance. The USEPA UV Disinfection Guidance Manual describes two types of UV dose algorithms: the first is the calculated dose approach, which predicts the log inactivation or reduction equivalent dose (RED) as a function of flowrate through the reactor, the UV transmittance (UVT) of the water at 254 nm, the UV intensity measured by UV sensors, and lamp, row, or bank on/off status. The second is the UV intensity setpoint approach, in which case the reactor is in compliance with a required RED when the UV intensity measured by the UV sensors is greater than a required value defined as a function of flowrate through the reactor. A key benefit of the UV intensity setpoint approach is that no online UVT monitor is required, which is ideal for small or remote UV systems. The UV intensity setpoint approach is validated by measuring the log inactivation and RED of a test microbe at various flowrates with the UVT and lamp power setting adjusted to provide specific UV sensor readings at the setpoint. Typically, the reactor is validated under two conditions of UVT and ballast power: maximum power and reduced UVT, and maximum UVT and reduced power. Depending on UV sensor position, the RED values measured at these two conditions may or may not be the same. The RED assigned to the reactor is the lower of these values. UV vendors will often validate their reactors knowing neither the relationships between RED and UV sensor response nor the impact of UV sensor position on those REDs, which can lead to expensive iterative validation as the vendor works to identify the UV sensor readings required to achieve the required RED (e.g. 40 mJ/cm^2) and to optimize the UV sensor position to minimize the differences between the REDs measured with the two test conditions. This approach also provides no information about REDs at UV sensor readings above and below the setpoint value or the relationship between RED and flowrate. In order to resolve these issues, Hanovia Ltd. of Berkshire, United Kingdom developed a new approach for validating their ProLine series of in-vessel UV reactors using the UV intensity setpoint approach. The approach provides a UV dose algorithm that calculates RED as a function of flowrate

and UV sensor reading but does not require an online UVT monitor.

5. Sensor-Based Control - THE Way for Safe, Energy-Efficient UV System Operation
Mike Newberry, Paul Ropic
Ultraviolet disinfection systems for wastewater have been widely implemented and accepted over the last two decades. They are proven to provide reliable reduction of pathogens in the effluent if sized and operated correctly. In recent years discussions in the UV industry were often dealing with the subject of the most appropriate sizing model. For water reuse applications the NWRI/AwwaRF 2003 Guidelines for Drinking Water and Water Reuse describe a design method utilizing biological verification (bioassay). Calculated ultraviolet sizing models, such as point source summation, have been largely used for secondary discharge installations. Top priority for the successful operation of a UV system is to stay in compliance under all design conditions. Therefore sizing is usually based on conservative estimations for peak flow conditions, water quality, and design UV dose. As a result underperformance is seen very rarely. However, in the light of recent discussions about reliability and sustainability, the challenge is to operate the UV equipment with the highest level of energy-efficiency. The goal is the smallest carbon footprint possible without putting the safety of the disinfection process at risk. In order to accomplish safe disinfection at minimum cost, sophisticated disinfection units are calculating the operational UV dose based on real time sensor readings. This sensor-based control methodology allows observing worse or better fouling conditions during operation, reducing the number of lamps and / or the UV lamp output with better water quality or less fouling than expected, and saving energy without compromising safety.

6. Reflections cause measureable error when calculating UV dose in a collimated beam apparatus
Shawn Verhoeven, Harold Wright, Conrad Odegaard, Jessica Shaw, Keith Bircher
The UV dose-response of microbes is measured using a collimated beam apparatus, where a suspension of microbes is exposed to a known UV dose. The UV dose is calculated using a standardized approach, which is provided in the the US Environmental Protection Agency's Ultraviolet Disinfection Guidance Manual for the Finial Long Term 2 Enhanced Surface Water Treatment Rules (UVDGM). This standardized approach does not account for UV light that is reflected off the side walls of the reaction vessel into the microbial suspension, resulting in an underestimation of the UV dose. Here it is shown that this error is a measurable factor impacting the calculated UV dose response of microbes.

Session 5. Ozone in Medicine – Part 2

1. Effect of ozone on TGFβ1, VEGF, FAS and TIMP2 in chronic hepatitis C patients (An immune histochemistry study)
Sadek A, Abd El Hady A M, Hammam O, Abdel Hady A A, Mansy S, Elbasha H, Alawam H.
AIM: To evaluate the effect of ozone on different parameter involved in fibrosis in chronic hepatitis C patients treated by ozone/oxygen gas mixture. METHODS: Thirty three patients with chronic hepatitis C, non-responders (n = 11), with contraindications (n = 5) or lack of compliance (n = 17) to interferon plus ribavirin therapy in different stages of liver fibrosis were enrolled. Clinical evaluation, Liver and kidney function tests, abdominal ultrasound, and liver biopsies were performed at baseline and after 12 weeks of ozone/oxygen gas mixture administration, using both the major auto-hemotherapy and rectal insufflations. Quantitative PCR was done before and 12 weeks after ozone administration. Histological activity index (HAI) with inflammation grade and fibrosis stage was assessed under blind conditions by two pathologists by means of Ishak's score. Immune-histochemistry for TGFβ1, VEGF, FAS and TIMP2 was done for all cases before and after treatment.

2. Effect of Rectal Ozone Gas on Viral Kinetics liver functions and Liver Histopathology, in Hepatitis C Patients: A Phase II Clinical Study
Sadek A, Kamal E, Abd El Hady A M, Aashour M, Hammam O, Shalaby S, Abd El Hady A A
The aim of this work is to study the effect and safety of ozone/oxygen gas mixture given rectally on chronic hepatitis C patients in different stages of liver fibrosis. METHODS: thirty patients with chronic hepatitis C, non-responders (n = 12), with contraindications (n = 7) or lack of compliance (n = 11) to interferon plus ribavirin therapy in different stages of liver fibrosis were enrolled. Clinical evaluation, Liver and kidney function tests, abdominal ultrasound, and liver biopsies were performed at baseline and after 12 weeks of ozone/oxygen gas mixture administration, using only the route of rectal insufflation. Quantitative PCR was done before and 12 weeks after ozone administration. Histological activity index (HAI) with inflammation grade and fibrosis stage was assessed under blind conditions by two pathologists and independent pathologist by means of Ishak's score. At the end of therapy, significant improvement in hepatic fibrosis and inflammatory activity based on Ishak scoring system was detected, while liver enzymes showed only improvement of (AST.).

3. Application of Ozone Therapy in the Vestibulocochlear Syndrome
Silvia Menéndez, Alejandro del Cerro, Tania Alvarez
Vestibulocochlear syndrome is the name given to a group of affections characterized by hearing and equilibrium disturbances. Vertigo is the main symptom, though hearing loss, tinnitus, pain and humid sensation can also be presented. The aim of this study was to evaluate the efficacy of ozone therapy in the treatment of patients with peripheral vestibulocochlear syndrome. Sample was of 50 patients, with diagnose of mild peripheric vertigo-MPV (34), labyrinthitis (4), MPV + acoustic trauma (2), Menière´s disease (7), MPV + otosclerosis (3). Ozone (at a concentration of 20 mg/L and a volume of 5 mL) was injected into the points located in the paravertebral muscle, corresponding to the cervical region C2-C3, at 2 cm calculated bilaterally to the spinal process (twice per week, for 20 sessions). The evaluation criteria was based in the evolution of nystagmus, tinnitus, hearing loss (audiometric test) and vertigo (by means of the Romberg, Babinsky Star and Osterhamser tests) at the beginning, after fifth and tenth sessions and at the end of the treatment. Also, oxidative stress parameters were measured at the beginning and at the end of the treatment. Females (56 %) and the range between 46 and 55 (42 %) years old were predominant. Vertigo was the main symptom. The results demonstrated that patient improvements, according to vertigo, hearing loss, tinnitus and nystagmus, were of 90, 80, 65 and 100 %, respectively, after 20th ozone sessions. Respect to vertigo, in 90 % of patients disappeared. These patients, at the beginning of the treatment, were under condition of systemic oxidative stress. However, at the end of the study a redox balance was achieved. Ozone therapy, in patients with peripheral vestibulocochlear syndrome, is effective, ease to perform, no structural damage is produced and can be used in outpatients with a minimum recovery time. No side effects were observed during the study.

4. CT-guided Oxygen-Ozone Nucleolysis for the Treatment of Degenerative Spinal Disease – the Role of Age, Gender, Disc Pathology and Multi-Segmental Changes
B. Oder, S.A. Thurnher
OBJECTIVE: Oxygen-ozone nucleolysis (ONL) is a new, minimally invasive procedure for the treatment of discogenic low back pain with or without radicular symptoms. The aim of the present study was to determine associations between the morphology of the basic disease, patient-specific factors and the outcome of the treatment. METHODS: 612 patients not responding to conservative therapy were divided into five groups (disc bulging, disc herniation, postoperative patients, osteochondrosis, others) and subjected to nucleolysis with ozone and to periradicular infiltration with steroids and local anaesthesia. The success of treatment was assessed by means of a visual analogue pain scale (VAS) and the Oswestry Disability Index (ODI).

5. Results of combined intradiscal and periganglionic injection of medical ozone and periganglionic administration of steroids and anesthetic for the treatment of lumbar disk herniation: effects on disk size and lumbar radiculopathy in 283 patients
Thomas Lehnert, Nagy Naguib, Thomas J. Vogl
PURPOSE: To evaluate the therapeutic benefit and morphologic changes in herniated lumbar disk after CT-guided intradiscal and periganglionic ozone-oxygen injection combined with a periganglionic administration of steroids and anesthetic. MATERIAL AND METHODS: 283 patients with lumbar radiculopathy received an intradiscal (3 mL) and periganglionic (7 mL) injection of an ozone-oxygen mixture (ratio 3:97), followed by a periganglionic injection of corticosteroid (1 mL of Celestan®Depot, ESSEX PHARMA, Munich, Germany) and anesthetic (2 mL of Carbostesin® 0.25%, AstraZeneca, Wedel, Germany) in the same session. Under CT guidance, intradiscal and periganglionic injection was administered by means of an extraspinal lateral approach, using a 22-gauge 17.8-cm spinal needle (Becton Dickinson & Co, Franklin Lakes, NJ, USA). 6 months after treatment, clinical outcome was assessed by applying the modified MacNab method. The effects on disk matrix and disk volume were evaluated by MRI.

6. Correlation of plasma interleukin-1 levels with disease activity in rheumatoid arthritis with and without ozone
Ziad Fahmy
The balance between the numerous pathological and related downmodulatory diseases mechanisms in RA are mediated mainly by cytokines. Cytokines are soluble proteins and peptides without enzymatic activity and function in small quantities as mediators of information between cells. The cytokine network consists of molecules such as interleukines (IL)(IL-13), growth factors and interferons. Cytokines bind to the correspondent receptor of target cells. After internalization of the cytokine-receptor complex various signals are triggered, which most often lead to the induction of new proteins. The down modulation of the cytokine action can be effected by soluble receptor molecules which often consist of an enzymatically cleaved extracellular part of a receptor molecule. This process is referred to as receptor shedding. In RA a lot of different cytokines work in concert. Some of them are well known today but the fine tuning of their action and disease modulation still remains unclear. The cytokine network with its characteristics makes a lot of sense if we look at the main communication systems of our body. TNF and IL-1 are major players in the pro-inflammatory process of RA of which some conceptual aspects will be discussed now.

7. Application of ozone therapy in patients with knee osteoarthritis
José Luis Calunga, Silvia Menéndez, Rodolfo León, Soulien Chang, Dailen Guanche, Alberto Balbín, José Zayas, Pedro García
Osteoarthritis is a common degenerative joint disease. It causes pain, swelling and loss of motion in the joints. Mechanic stress, biochemical factors and reactive oxygen species are involved in the degradation of cartilage. Taking into account the ozone (O_3) effects in cellular redox balance and upon biomarkers of inflammation, the aim of this study was to evaluate the action of ozone therapy in oxidative stress parameters in synovial fluid of patients suffering of knee osteoarthritis and their clinical evolution. O_3 was administered rectally (20 sessions) at scaling doses and by intra-articular (15 sessions) applications. Forty two patients were involved in this study. Half of the patients (21) and a sample of 10 healthy volunteers (control group) were extracted synovial fluid, at the beginning and at the end of the treatment, for the measurement of parameters associated to oxidative stress, as: reduced glutathione (GSH), superoxide dismutase (SOD), catalase (CAT), CAT/SOD ratio, malondialdehyde, advanced oxidation protein products (AOPP), total hydroperoxides (ROOH) and peroxidation potential. Also, evaluation of the joint capacity, pain and ultrasound imaging were performed in all patients, at the beginning and at the end of the treatment. At the beginning, patients presented a remarkable oxidative stress in synovial fluid. At the end of the O_3 treatment, AOPP and ROOH levels decreased significantly and for ROOH, similar values to those of the control group were obtained. SOD, CAT/SOD and GSH presented significant differences at the end of the treatment, with values more similar to those of the control group. The evaluation of the joint capacity, the imaging studies and the pain showed positive results. Combined ozone therapy produced an intra-articular redox balance and a significant reduction of pain. All these O_3 effects contributed to increase the quality of life of these patients.

8. Role of intra-articular Ozone gas injection in the management of internal derangement of the temporomandibular joint
Emad T Daif
OBJECTIVES: The current study was carried out to compare the intra-articular Ozone gas injection with drug therapy as conservative treatment modalities for internal derangement of the temporomandibular joint (TMJ). STUDY DESIGN: Sixty patients (49 females & 11 males) having bilateral internal derangement of the TMJs, disc displacement with reduction, were included in this study. They were divided randomly into two equal groups. The first group was treated by a direct injection of Ozone gas into the superior joint space. Each joint received 2 ml of Ozone – Oxygen mixture (Ozone gas concentration was10 µ/ ml). The injections were repeated two times per week for three weeks. The second group received non steroidal anti-inflammatory drugs & muscles relaxants. The clinical signs & symptoms before and after the treatment were assessed according to Helkimo's clinical dysfunction index.

Session 1. Advanced Oxidation Processes – Part 3

1. Efficiency and mechanism of catalytic ozonation on metal oxide catalysts
Roberto Rosal, Soledad Gonzalo, Javier Santiago, Antonio Rodríguez, José Antonio Perdigón-Melón, Eloy García-Calvo

2. Influence of catalyst synthesis method of Ni/TiO2 on the 2,4-dichlorophenoxyacetic acid decomposition by ozone in water
J.L. Rodríguez S, T. Poznyak, M.A. Valenzuela, F. Pola H

3. A Comparison between catalytic ozonation and activated carbon adsorption of aqueous dyes solutions in a semi batch reactor
S. Faleh, M. Guiza, A. Ouederni

4. Ozonation of sulfamethoxazole promoted by MWCNT
Alexandra Gonçalves, José Órfão, Manuel Pereira

5. Catalytic ozonation of organic pollutants using nanocarbon materials grown on a macro structured support
João Restivo, José J.M. Órfão, Manuel F.R. Pereira, Sabino Armenise, Enrique Garcia-Bordeje

6. Petrochemical Effluent Treatment By Zeolites Combined To Ozone
Marie-Hélène Manero, Jean-Stéphane Pic, Stéphan Brosillon, Julie Mendret, Anne Galarneau, Nicolas Lesage

7. The method of eliminating bromate in catalytic ozonation in treating drinking water
Ping Dong, Xiangdong Kong

8. Heterogeneous catalytic ozonation of diethyl phthalate
Chedly Tizaoui, H M Mohammed, L Mansouri, N Hilal, L Bousselmi

9. The Application of Catalytic Ozonation by Combining with Goethite and UV on the Oxidation and Recirculation of Swimming Pool Water
Jerry J. Wu, Gang-Juan Lee

Session 3. Industrial applications – Part 2

1. Natural zeolite reactivity towards ozone: the role of compensation cations
Héctor Valdés, Serguei Alejandro, Claudio. A. Zaror

2. Synergistic Effect of Hydrogen Peroxide and Ozone in a Gaseous Environment
Simon Robitaille, Marie-Christine Gagné, Sylvie Dufresne

3. Quantification of the microbiological efficacy of the JLA Ltd ozone diffusion laundering system
Kyle Allison, Jacqueline Hook, Dick Cardis, Rip G. Rice

4. Removal of phosphorus from iron mineral using ozone
F. R. Carrillo-Pedroza, M. J. Soria-Aguilar, R. Perales Cárdenas

5. Metallic nanoparticles obtained from cyanidation solutions treated with ozone
Ma. de Jesús Soria-Aguilar, F. Raúl Carrillo-Pedroza, L.A. García-Cerda, Marco Sanchez-Castillo, Damáris M. Puente-Siller, Delia M. Valdéz Zavala

6. Ozone disintegration on waste sludge: enhanced biogas production and energy balance in wastewater treatment plant
Albert Canut, Begoña Ruiz, Mireia Fiter, Carlos Ferrer, Andrés Pascual

7. Purification of grease trap by ozonation and sonication
Michal Piotr Kwiatkowski, Satoshi Ihara, Chobei Yamabe, Saburoh Satoh, Masanori Nieda

8. Advances in UV irradiation technology for biopharmaceuticals to enhance process robustness
Heinz Anderle, Ines Mayerhofer, H. Peter Matthiessen, Manfred Reiter, Wolfgang Mundt

9. Effects of temperature on the synergistic disinfection of biofilms in the combination use of ozone water followed by hydrogen peroxide water
Mariko Tachikawa, Kenzo Yamanaka

10. Innovative O_3/O_2 reactive flotation for paper deinking
Nathalie Marlin, Filipe Almeida, Davide Beneventi, Marc Aurousseau

Session 4. UV reactor design and validation – Part 3

1. Application of UV Disinfection to achieve Enterococci - Removal at a Trickling Filter Plant
Gary Hunter, Amy Kliewer, Bob Hulsey, Charlie Klinger, Manuel Carrera
The City of Leavenworth, KS operates a Wastewater treatment plant with an average day capacity of 16.54 mld (4.38 mgd) with a peak flow rate of 104.98 mld (27.50 mgd). The plant currently uses trickling filters to remove organics (BOD) and suspended solids. The trickling filters are lightly loaded and achieve partial nitrification. In 2010 the State of Kansas (KDHE) issued a discharge permit that required disinfection be incorporated into the plant and that a plan be developed to provide nutrient removal. Early grab sample testing of the transmittance indicated values around 65 percent. This is extremely high for trickling filter effluent that typically ranges from 35 to 45 percent. To confirm the transmittance data, measurements were collected using an on-line HACH UVAS transmittance sensor. This data indicated values more in line with typical values observed from trickling filter plants. One of the key items with using the sensor was that it need to be cleaned on a weekly basis to ensure that correct measurement were collected. Design transmittance values were developed that resulted in a T-10 of 38 percent. Collimated beam testing was conducted during the month of October 2010. Results of the testing indicated that a fluence rate of 600 J/m^2 would be needed to achieve compliance with either the e Coli permit compliance or future Enterococci limits. In 1986, USEPA recommended the establishment of water quality standards using Enterococci. Using the low transmittance and high dose requirements resulted in an extremely large and costly UV system. In order to reduce the costs, additional testing was conducted to examine both filtration and chemical addition to determine if either of these alternatives could result in a reduction in the cost and size of the UV system. The results of these preliminary tests indicated that a higher UVT could be used for design which allowed a smaller UV system to be installed in preparation of future nutrient and increased water quality.

2. Technology limitations of UV-validations
Paul Buijs, Willem Bakermans, Andrew Clark

3. Updating the Approaches in the NWRI/AwwaRF UV Guidelines: The Impacts of Water Quality and Recirculation Mode Testing on UV Validation
Brian Petri, Chengyue Shen, O. Karl Scheible, Stephen Tang

4. Constrained regularization for Lagrangian actinometry
Eric Cox, Ernest R. Blatchley III

5. Defining UV Dose Monitoring Equations
Harold Wright, Jeff Bandy, Mark Heath, Keith Bircher

6. Another Intense UV Dose of Fluence – Musing on Photons and the Vector Properties of Light
Harold Wright

Session 5. Ozone in Medicine – Part 3

1. Ozone as oxidative detoxication factor in early period of burn disease
Peretyagin S.P., Struchkov A.A., Kostina O.V., Martusevich A.K., Lusan A.S., Kontorschikova K.N., Atyasov I.N., Pogodin I.E.
Using of systemic ozone therapy connecting with antioxidants in early period of burn disease for detoxication and metabolic disorders correction is investigated. Method of ozone dose individualization in intravenous ozone therapy and pharmacological treatment as oxidation stress correction is shown. This method based on biochemiluminescence detection of patient blood antioxidant system reaction in ozonization in vitro. It is important, that first stage of method is pro- and antioxidant potential estimation. It was shown, that this algorithm use determines fully correction of oxygen homeostasis disorders and endotoxicosis. It optimizes results of complex treatment of burned patients.

2. Antimicrobial effectiveness of ozonated vegetable oils controlled by their total unsaturation
Arizbeth Pérez, Jesús Rodríguez, Tatyana Poznyak, Isaac Chairez, Susana Mendoza
The ozone application as a disinfection agent has become a popular object of scientific research due to its oxidative nature; it has been widely proved and compared against other disinfectant agents on a broad group of microorganisms. Particularly, ozonated oils have found application in wounds disinfection improving the process of healing, being an effective therapeutic alternative in the field of ozone therapy. In this sense, their preparation as well as their dosage is an object of scientific research. The aim of this study was to characterize three vegetable oils such as olive, avocado and grape seed by the total unsaturation of oil (TUO) and compare their antimicrobial effect related with their ozonation degree (varying the reaction time an ozone doses) and the TUO. The results obtained shows that the TUO for the three vegetable oils was practically the same (9.6×10^{-3}, 10.0×10^{-3} and 9.1×10^{-3} mole d.b./mL), however, the ozonation kinetics and the ozone doses were different and they varied up 351.79 to 671.30 mg O_3/ g oil. The bacteria Pseudomona aeruginosa and Escherichia coli were used to evaluate the antimicrobial effectiveness of all oils by Scanning Electron Microscopy (SEM) and image analysis. It was observed that the bacteria death was faster with the grape seed oil, at 6 hours of exposition with an oil ozonation time of 240 min.

3. Importance of the Toxicological Tests in the Application and Safety of Ozone Therapy
Silvia Menéndez, Zullyt Zamora, Frank Hernández

4. In vivo antimicrobial activity of ozonized theobroma oil vaginal suppositories against *candida albicans*
Rosa I. Meneau, Maritza F. Díaz, Irán Fernández, Yaíma Sánchez, Dayana Gil, Bárbara M. Manet, Gastón García

5. Antioxidant effects of an ozonized oil formulation on damaged-inflammatory rat skin
Yaíma Sánchez, Maritza F. Díaz, Frank Hernández, Dayana Gil, Gastón García

6. Ozone Therapy Immunomodulatory Effect in Children with Selective Immunoglobulin A Deficiency
Jacqueline Díaz Luis, Silvia Menéndez Cepero, Consuelo Macías Abrahan

7. Effect of Ozone Gas With and Without Anti-Oxidants on Viral Kinetics and Liver Histopathology, in Hepatitis C Patients: A Phase II Clinical Study
Sadek A, Abd El Hady A M, Hammam O, Elbasha H, Abd El Hady A A

8. Is Ozone antifibrotic? An electron microscopic study on chronic Hepatitis C patients
Sadek A, Mansy S, Abd El Hady A M, Hammam O, Abdel Hady A A, Elbasha H.

9. Effect of ozone/oxygen gas mixture on bilharzial hepatic fibrosis induced in infected mice
Sadek A, Alawam H, Kasem M, Abd El Hady A M, Hammam O, Mahmoud S, Abd El Hady A A, Diab T

Tuesday, May 24

Session 1. Advanced Oxidation Processes – Part 4

1. OH-Radical Yield in the Peroxone Process ($H_2O_2 + O_3$)
Alexandra Jarocki, Myint Sein, Justus von Sonntag, Alfred Golloch, Torsten C. Schmidt, Clemens von Sonntag
The peroxone process is one of the Advanced Oxidation Processes (AOPs) generating OH radicals (•OH). It is generally assumed that the •OH yield is unity with respect to O_3 consumption. The present study deals with experimental data that suggest that the •OH yield must be about 0.5. Therefore competition reactions of •OH with p-chlorobenzoic acid (p-CBA), p-nitrobenzoic acid (p-NBA) and atrazine as competitors in trace concentration toward tertiary butanol (t-BuOH) in excess were conducted. For comparison, the experiments were carried out with •OH generated by peroxone process and γ-radiolysis. Fitting the peroxone process data, the degradation of the trace compounds indicates that the •OH yield is only about 0.5 (p-CBA: 0.51;

p-NBA: 0.45; atrazine: 0.59). Additional information for an •OH yield of 50 % of the assumed yield give the results obtained from the reaction of •OH with t-BuOH.

2. Combined O_3/ H_2O_2 and UV for multiple barrier OMP treatment and bromate formation control – One year pilot plant research

K. Lekkerkerker-Teunissen, J. Scheideler, A.H. Knol, A. Ried, J.Q.J.C. Verberk, J.C. van Dijk

Dunea duin en water, the water company for The Hague and surroundings, has the objective of producing drinking water of impeccable quality, particularly with respect to organic micropollutants (OMPs). OMPs are only a minor part of the total natural organic matter (NOM) in raw water, posing a challenge in targeting removal of a very small, specific part of the NOM, without removing all of the NOM. In addition, OMPs encompass a broad field of physicochemical properties, which make their removal by a single treatment step difficult. By combining different AOP technologies, efficient degradation occurs with limited formation of by-products. In addition, combined processes are expected to provide a synergistic hybrid for removal of OMPs, according to the Dutch multiple barrier approach. Dunea produces drinking water from the Meuse River, which contains a variety of organic micropollutants as a result from upstream activity. Dunea is performing research to extend the current multiple barrier treatment (e.g. pre-treatment, artificial recharge and recovery (ARR), post-treatment) with advanced oxidation processes (AOP), situated at the pre-treatment location in Bergambacht, before ARR. The degradation of organic micropollutants as a result of advanced oxidation using different combinations of hydrogen peroxide, ozone, low pressure (LP) mercury vapour ultraviolet lamps has been assessed by means of pilot-scale (5 m^3/h) experiments. The influent was river water pre-treated by dual media rapid sand filtration. The peroxide doses were varied as 0, 5 and 10 ppm, the ozone doses were varied as 1, 2 and 3 g ozone /m^3. The UV doses were varied between 300 and 650 mJ/cm^2. The installed power for the LP reactor was 0.26 kWh/m^3. Atrazine, Bromacil, Ibuprofen and NDMA were spiked (10-20 µg/L) and used as model compounds. Bromacil was completely (>99%) removed by Ozone/Peroxide. Atrazine and Ibuprofen were good (50-65% and 80-92% respectively) removed by Ozone/Peroxide and NDMA was not (0-12%) removed by this technique, whereas NDMA showed good (85%) removal by UV/Peroxide. Atrazine, Bromacil and Ibuprofen were degraded by UV/Peroxide by 55, 50 and 62 %, respectively. All four compounds showed highest degradation during combined AOP treatment. With this combined AOP, lower ozone dose and lower UV dose result in comparable degradation compared to single AOP treatment. The electrical energy for 80 % reduction, EE80, was calculated for LP-UV and for the combination of ozone and LP-UV. For an 80% degradation of Atrazine, LP-UV consumed 0.44 kWh/m^3 and ozone + LP-UV consumed 0.30 kWh/m^3. Other advantages of the combined AOP are limited by product formation, especially bromate, and a future barrier against OMPs encompassing a broad spectrum of properties.

3. Degradation of atrazine by sulfate radical anions. Reaction rate constants and mechanistic aspects

Holger Lutze, Stephanie Bircher, Clemens von Sonntag, Torsten C. Schmidt

The present work deals with the reaction of atrazine with sulphate radical anions ($SO_4^{\bullet-}$). As reported for hydroxyl radicals, atrazine is dealkylated after reaction with $SO_4^{\bullet-}$. The reaction rate constants for the reaction of $SO_4^{\bullet-}$ with atrazine and its degradation products desethylatrazine (DEA), desispropylatrazine (DIA) and desethyl-desisopropylatrazine (DEDIA) have been determined. With increasing degree of dealkylation the reaction rates decreased from 2.6×10^9 M^{-1} s^{-1} (atrazine) to 4.5×10^7 M^{-1} s^{-1} (DEDIA). The alkyl chains are probably released as acetaldehyde and acetone, since their formation has been observed during atrazine degradation. Additional experiments in argon saturated solution indicate that oxygen influences the sulphate radical based oxidation.

4. Efficient Degradation and Decomposing Mechanism of Perfluoro Compounds in Water Using Discharge Plasmas

Koichi Yasuoka, Ryuichi Hayashi, Nozomi Takeuchi

Two types of plasma reactors have successfully demonstrated the efficient decomposition of perfluorocarbons; such as perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS), which are environmentally harmful and persistent substances. DC plasmas were generated within small oxygen bubbles in PFOA/PFOS solution and their decomposing capabilities were examined. The defluorinate rate and energy efficiency for PFOA/PFOS were evaluated by measuring the concentration of fluoride and sulfate ions. After 180 min operation, 99% of fluorine atoms were detached from PFOA and almost all of PFOA molecules were decomposed. PFOS decomposition was more difficult than PFOA decomposition and the treating time for complete decomposition of PFOS was 480 min, at which time almost 70% of fluorine atoms were detached. Dielectric barrier plasmas generated over the solution surface showed the almost same decomposing rate and energy efficiency as DC plasma. Higher decomposing energy efficiency was obtained with argon gas than oxygen. These plasma reactors showed a much higher decomposition energy efficiency compared with energy efficiencies reported in other studies.

5. Degradation of pesticides and taste and odour compounds using a flow-through Vacuum-UV reactor

Gustavo E. Imoberdorf, Madjid Mohseni

Vacuum-UV (VUV) radiation can photolyze water molecules to form hydroxyl radicals (HO·), hydrogen radicals (H·), and free electrons (e-). These species, especially HO·, are very reactive, so they can partially oxidize and even mineralize organic compounds. The Vacuum-UV (VUV) photoinduced degradation of different micro-pollutants (2,4-D, atrazine, and geosmin) in raw surface water was studied using a flow-through photoreactor with and without recycle. Relatively short retention times (in the order of 10-20 sec) were required the obtain conversions in the range of 55-80%. Under the same conditions, reductions of the dissolved organic carbon (DOC) were in the order of 15-25%. Structural and chemical changes in natural organic matter (NOM) were observed, indicating that VUV irradiation not only removes micro-pollutants, but also partially degrades NOM. To better understand the process, the reactor was operated under different operation conditions: with and without recycle, with and without baffles, and with air or N2 sparged in the reactor. Experimental results show that increasing the turbulence reduced diffusive resistances and increased the efficacy of the process. Complementary experiments were also conducted to compare VUV, H_2O_2/UV, and H_2O_2/VUV processes. For all the experimental conditions investigated, H_2O_2/VUV showed the highest degradation rate, followed by VUV, and finally the H_2O_2/UV process. Overall, the results demonstrated that VUV processes constitute a very promising alternative for micro-pollutants removal.

Session 6. Ozone for Agrifood

1. Ozone Clean in Place in Food Industries - Industrial validation of an Ozone Clean in Place system in a dairy industry
A. Canut, I.Llorca, V.Martínez, A. Pascual
Cleaning and disinfection (C&D) of equipment are key operations in the agro-food industry. Nevertheless they produce a significant environmental impact in terms of waste water and water consumption. Ozonecip (LIFE 05 ENV/E/000251) is a Demonstration Project funded by LIFE-ENVIRONMENT that was run from 1/12/05 to 1/12/08. Its objective is the reduction of the environmental impact of cleaning operations through the integration of ozone as an alternative sanitising agent instead of traditional chemicals in CIP systems. The results obtained demonstrate the environmental benefits of the ozone CIP compared to the use of traditional chemicals in CIP. Also, non-environmental factors that can affect the feasibility of the technique have been considered. Efforts focused in tank cleaning operations in winery, brewery and dairy sectors, as they are intensive users of CIP technologies. Cleaning In Place (CIP) is considered as BAT in the European reference documents, according to the project results, ozone cip is more advanced than the BATs described.

2. Ozone Clean in Place in Food Industries - Industrial validation of an Ozone Clean in Place system in a dairy industry
A. Canut, I.Llorca, V.Martínez, A. Pascual
Hygienic standards are a main concern in dairies. Some of the most important cleaning tasks are those related to the washing of closed equipment where Cleaning In Place (CIP) systems are of common use. CIP are characterized by automatic cleaning programs based on a succession of several solutions of water, cleaning chemicals and disinfectants that are discharged together with large amounts of water to rinse out residual chemicals. So health and environmental concerns are supporting the need for alternative sanitation technologies. This project deals with the first industrial application of an ozone based CIP system and its validation in technical and economic terms at industrial level to boost its wide implementation in dairy industry. The partnership is composed of ainia technological centre as coordinator of the project, a dairy industry as technology end user, a company expert on ozone engineering and a company expert on CIP systems. The technical tasks scheduled include an on site environmental and hygienic diagnosis, design and retrofitting of the existing CIP system into ozone based CIP and monitoring and validation of the ozone based CIP system at industrial scale.

3. Some ozone applications in seafood
Walter J. Blogoslawski, Mary E. Stewart
The use of ozonized seawater to reduce and eliminate bacterial pathogens in mariculture facilities and to extend shelf life of marine food products is demonstrated. Consequent benefits of this treatment are also discussed. Laboratory and pilot experiments were conducted using ozone gas to reduce disease-producing Vibrio bacteria at a shrimp (Penaeus vannameii) hatchery in Ecuador, South America. Pacific Ocean seawater was treated in a 1,540 Liter capacity fiberglass contact tower (5-7 minute retention) with an ozone oxidant residual of 0.07 mg/Liter. Prior to ozone treatment, Vibrio determined by TCBS plating was too numerous to count, causing shrimp to die of disease (30 tanks of 13,000 Liters each). After treatment, Vibrio counts and shrimp disease were eliminated, ozonized seawater decreased the time required for normal molting of shrimp and the total growth cycle was reduced by three days versus control water. After one year of ozone use, survival rates of larval shrimp were robust, routine antibiotic addition was reduced, and one additional growth cycle was realized. Ozonized ice (fresh water) was prepared in the Milford Laboratory CT, USA; Gloucester Food Tech Lab, MA, USA; and a field station (brine water) for sockeye salmon (Ohcorhynchus nerka) In Homer, AK, USA. In these studies, squid (Loligo pealei) and commercially captured salmon demonstrated a reduction in spoilage and extension of shelf life of three to five days time using ozonized ice. Bacteria associated with commercial ice-producing machines were reduced by four logs using ozone treatment. In addition, no flavor aberration was noted using ozonized ice.

4. Ozone applications in the postharvest of papaya (Carica papaya l): an alternative to Amistar fungicide
Mayra Bataller, José E. González, Eliet Veliz, Lidia A. Fernández, Dariem Nápoles, Caridad Álvarez, Silvia Menendez
The paper objective was to evaluate ozone applications in the postharvest of papaya (Carica papaya L) as an alternative to Amistar fungicide taking into account the effect on the control of fungal pathogens growth, the shelf life, the seed germination percentage and soluble solids content. Ozone doses (300 to 1000 mg m-3) were applied in vitro to seven species of fungi, among the most common, which cause rot of papaya. The mycelial growth was evaluated. The species evaluated showed morphological and color changes, as well as difference regarding the resistance to ozone. Papaya cv Mardol-red from INIVIT were harvested with a superficial coloration about 25% different to green and selected with similar size, weight and appearance. Ozone concentration of 500 mg m-3 was employed in the gaseous ozone treatment. The ozonated water treatment was carried out with 1 mg L^{-1}. The control group was treated with a solution of Amistar fungicide with 0.1 ml L^{-1}. The papayas were storage during 10 day at no-controlled temperature and relative humidity. The results indicated that the fruits must be harvested with a 25% color change from green to yellow. The washing with ozonated water was the most favorable disinfection alternative. The ozone use showed a delay in fruit ripening. The effect on seed germination percentage and soluble solids content was not significant. A methodology for the ozone use in the postharvest of papaya cv Maradol-red was proposed, which can be applied to other cultivars.

5. Plague Elimination and Ozone Effects on Types Stored Corn
Jose G. LLanes O, Miguel Angulo
Here its introduced a study about the impact of ozone on some types of stored corn (physical conditions), its analyzed the effects that different contact times had with the elimination of plague, fungi, total aflatoxins, oily free acids, index of peroxides and acidity, proximal quality and mineral of the grain. The research was done under a completely experimental randomized design. The work was done in laboratory and pilot level submitting corn to 4 treatments, one works as a witness and the rest of them received a fixed concentration of ozone for 2, 4 and 8 hours. The ozonation was carried out in PVC columns simulating industrial silos. It's demonstrated that the level of mortality of the plague depends on the contact time and concentration; nevertheless the characteristics of the grain have a special importance. The nutritional properties of the grain did not suffer any significant changes and the total aflatoxins were reduced under the action of ozone.

6. Effects of ozone and UV treatment on biomass, chlorophyll and antioxidant production in wheatgrass
Emmanuelle Mansier, Gilbert Yuk-sing Chan, Sarah Kam-lan Yeung
The effects of ozonated water, UV and combination of both on biomass production, antioxidant, chlorophyll, vitamin C, and total phenolic levels of wheatgrass were investigated. The wheatgrass samples were exposed to 50 mL 0.84 mg/L ozonated water twice a day (ozone treatment), 2.9 kJ/m^2 UV-C 1 hour per day (UV treatment) and combination of both for 10 days. The antioxidant level of the grass was measured using the ferric reducing/antioxidant power (FRAP) assay. No significant difference in vitamin C or total phenolic contents were detected whereas the antioxidant level significantly increased by 17% in UV treated samples and 13% in UV and Ozone treated samples. UV induced physical damages to the grass, as shown by a significant decreasing in the chlorophyll content for the UV- and Ozone and UV-treated samples (74 and 29% respectively) whereas ozone treatment showed promising results in increasing the chlorophyll content (by 34%) and biomass production (by 15%). The study shows positive results for enhancing antioxidant capacity of wheatgrass by the use of Ozone and/or UV treatment.

Session 9. Full scale applications – Part 1

1. 12-Month UV Fouling Study on Unfiltered Source Water
Chad Talbot, Mark Heath, Harold Wright, David Peters
To comply with the Long Term 2 Enhanced Surface Water Treatment Rule, the Portland Water Bureau has begun the design of a 212 mgd UV disinfection facility to achieve the 2-log Cryptosporidium inactivation requirement for unfiltered surface waters. To assist in the pre-selection of the UV equipment, a pilot fouling study was undertaken to investigate the fouling tendencies of the unfiltered source with different UV disinfection equipment. The study was conducted over a 12-month period with three different UV reactors, a Calgon Carbon medium-pressure reactor, an ITT-Wedeco low-pressure high-output (LPHO) reactor, and a Trojan Technologies medium-pressure reactor. The UV reactors were operated in parallel, with raw unfiltered source water for approximately 10 months, then with pre-chlorinated unfiltered source water for approximately 6-weeks. The results of the fouling study showed that when using raw water, the un-wiped medium-pressure UV lamp sleeves demonstrated a significant amount of fouling during the months of August, September, and October when the raw water source contained an elevated level of minerals, notably iron. During the remainder of the year, when the raw water mineral levels were low, the un-wiped medium-pressure lamp sleeves demonstrated little or no fouling. The un-wiped LPHO UV reactor quartz sleeves demonstrated no significant fouling during any month of the year. When the raw water was pre-chlorinated, both the medium-pressure and the LPHO UV lamp sleeves showed rapid fouling tendencies. The Portland Water Bureau was able to use the results of this study to aid in the pre-selection process of the UV equipment.

2. UV Disinfection in Germany: Results of a Field Study in Drinking Water Treatment Plants
Jutta Eggers, Burkhard Wricke
Over the last few years, UV irradiation for the disinfection of drinking water has steadily gained in importance in the field of public water supply. According to a DVGW (German Technical and Scientific Association for Gas and Water) survey published in 2008, approx. 50 % of the 954 interviewed water suppliers with own water production disinfected the drinking water they deliver. In 271 cases, i.e. approx. 57 % of the suppliers using disinfection, UV systems were employed [1]. The availability of UV reactors which are tested and certified by the DVGW, thus ensuring safe disinfection of drinking water when properly used and operated, was an important precondition for the broad use of UV disinfection. The general requirements for UV systems were established as early as 1994 in the “DVGW Merkblatt W 293” [2]. In 1997, they were defined in Testing Standard W 294 [3], and in 2006, the revised version of the worksheet W 294 „UV-Geräte zur Desinfektion in der Wasserversorgung“ (UV devices for disinfection of the water supply) was published. In addition to requirements for the test of UV systems and sensors, it also defines requirements for their operation [4]. To gather the experience gained during implementation of the worksheet, more than 60 UV systems were examined on site within a research project funded by the DVGW [5]. This article presents the major results of this project.

3. Design and Operation of UV Equipment for Large Scale Municipal Wastewater Disinfection: City of Moscow
Sergey Kostychenko, Sergey Volkov, Andrey Tkachev, Olga Petrova, Pavel Parilov
More than 50% of the water flowing through the Moscow River is coming from two very large Wastewater Treatment Plants (WWTPs) in the city of Moscow, Kuryanovskiye and Lyuberetskiye. Disinfection of such extremely large amounts of wastewater by means of chlorine would lead to ecological problems, an important reason why the wastewater, flowing into this river, was not disinfected until UV disinfection was accepted as an excellent alternative. Designs and technical solutions of the revolutionary new UV systems for Lyuberetskiye and Kuryanovskiye WWTPs were based on long term pilot tests [1, 2]. A completely new design approach was applied to develop a UV system for these plants, which consisted of vertically arranged UV modules equipped with LIT’s equipped with unique low pressure high-output (LPHO) amalgam lamps DB-600. These efficient, powerful and compact UV systems were tailor made to fit the existing plant lay-outs of the Lyuberetskiye and Kuryanovskiye WWTPs.

4. City of Winnipeg Water Treatment Program. Deacon UV Disinfection Facility – Lessons Learned from a Large Scale Installation
S.R. (Ray) Bilevicius, A.Weremy, D. Taylor
Prior to 2010, the City of Winnipeg operated an unfiltered water supply system. As part of its long term water treatment program implementation, UV disinfection was accelerated and put into service in 2005; well in advance of the new water treatment plant. This paper will discuss the rationale for selection of UV and accelerating its implementation, the procurement and selection process, design and construction challenges, commissioning and on-site validation, and finally conversion to a filtered water source in 2010. The Winnipeg installation includes 6 @ 48” diameter reactors, each equipped with 9 @ 20 kW medium pressure lamps. The UV equipment was retrofit into an existing pumping station presenting significant challenges. The installed capacity is presently in excess of 750 ML/d under the filtered water condition. Numerous system issues occurred through the course of the project; from lamp breaks to capacitor fires to component failure. While all challenges were ultimately overcome, this paper will share many lessons learned since the UV system was put into service.

5. An improved control of the microbiological health risk of drinking water quality for Parisian consumers – the new implementation of UV disinfection on the surface water drinking water treatment plants of Eau de Paris
B. Welté, M. Joyeux, V. Pilmis, S. Baig
French regulations concerning the limits and quality references for raw water and water intended for human consumption (ruling of January 11, 2007) specify that the quality limit for bromates was set at 25 µg /L until December 25, 2008 and thereafter 10 µg/L. Since 2000, Eau de Paris has been studying the concentrations of bromates formed at its treatment plants and has carried out various studies to allow for reduction of the concentrations formed (Bouland et al. 2004). This article describes the thinking carried out by Eau de Paris that led to the installation of UV reactors at two of its surface water treatment facilities. Half of the water supply for the City of Paris comes from two plants located upstream from Paris, one on the Seine in Orly, the other one on the Marne in Joinville.

6. Biodosimetry of a Full-Scale Wastewater UV Disinfection System Using Multiple Surrogate Microorganisms
Bruno Ferran, Wei Yang
With the objective to anticipate on the possible implementation of an RED bias for wastewater UV disinfection Ozonia North America (ONA) undertook a bioassay validation study of a low-pressure very high-output (LPVHO) ultraviolet (UV) reactor using T1 phage as surrogate microorganism. This bioassay is an addition to MS-2 phage bioassay work conducted in 2006 with the same LPVHO UV reactor. Validation of the LPVHO UV reactor with T1 phage was designed to conform mainly the 2003 UV Disinfection Guidelines for Drinking Water and Water Reuse [1], hereafter referred to as the UV Disinfection Guidelines. The analysis of the combined MS-2 and T1 phage bioassay data was conducted in accordance with the principles set forward in the US EPA UVDGM [2]. Curves of Validated RED versus flow rate and lamp effective output (EO) were obtained for wastewater effluents at 55% and 65% UVT. These curves can be applied towards disinfection of common wastewater indicator pathogens with UV sensitivities comprised between 4.9 and 19.7 $mJ/cm^2/logI$.

Session 5. Ozone in Medicine – Part 4

1. Workshop on medical ozone therapy: How to successfully integrate ozone therapy into other clinical treatments
Michael Schreiber

2. Ozone therapy for viral hepatitis
Heinz Konrad
The author introduced ozone therapy (OT) into Brazil in the year 1975 and can therefore be considered the pioneer of ozone therapy in this country. This paper describes the clinical observations made by the author, in his private medical office in Sao Paulo, Brazil, during the last 36 years. It must be emphasized that the author has neither the setup, nor the desire or purpose of executing laboratory research work, biochemical analyses, microbial research, etc. in his office, thus justifying the pure clincal and observational nature of this paper. Also, it must be mentioned that in Brazil, despite enormous efforts by several medical professionals during the last few years, ozone therapy is still not totally legal and amply permitted, remaining in somewhat of a legal gray zone until these days, as opposed to so many other countries, especially western Europe, where this method has been fully accepted and recognized for many years. In this paper, the author presents what, in his opinion and based on his clinical observations, can be expected from ozone therapy and how it should be given, for the treatment of acute or chronic viral hepatitis.

3. Role of ozone therapy as an adjuvant in management of the childhood asthma
M.N.Mawsouf, A.Gomaa
Childhood asthma is a multi-factorial disease that has been associated with familial, infection, environmental, socioeconomic and psychological causes. Chronic inflammation and airway remodeling are two key steps in asthma patho-physiology. The present work was done to evaluate the role of ozone therapy on moderate persistent and severe persistent childhood asthma; the study included 40 asthmatic children divided into 4 groups. Group I: included 15 children having moderate persistent asthma. Group II: included 15 children having severe persistent asthma. Both groups (1&2) were treated with bronchodilators and ozone as an adjuvant therapy by rectal insufflations in a dose of 80µg/Kg BW of medical ozone in a concentration of 20µg O_3/ml O_2 , 3 sessions /week for 5 weeks. Group III: included 5 children having moderate persistent asthma. Group IV: included 5 children having severe persistent asthma. Both groups (III & IV) were treated with bronchodilators only. Asthmatic children were subjected to history taking, general examination, local chest examination, and chest radiography, determination of absolute eosinophilic count, total serum IgE and pulmonary function tests (peak flow "PF"). All investigations were done to all studied groups before and after treatment. Following treatment there was a statistical significance decrease in serum IgE ($P \leq 0.0271$) and decrease of eosin count ($P \leq 0.006$) and increase of PF ($P \leq 0.002$) in Group I in comparison to Group III. Also there was statistical significance decrease in both IgE ($P \leq 0.019$) and eosin count ($P \leq 0.011$) in Group II in comparison to Group IV, while there was no statistical significant difference regarding PF. In addition there was statistical significant decrease in IgE level ($P \leq 0.004$) and eosin count ($P \leq 0.018$) and increase of PF ($P \leq 0 .001$) in both groups I & II combined following treatment. This study raises the role of systemic ozone therapy in atopic asthma mainly due to its immune-modulatory properties.

4. Ozone therapy as a valuable component in the treatment of chronic inflammatory diseases of the female internal genital organs
Chandra-D'Mello Rajani, Grechkanev Gennady, Peretyagina Natalia, Grechkaneva Olga
There were examined 120 patients with non-specific bacterial colpitis and bacterial vaginosis, which received ozone therapy in the form of vaginal circulatory insufflations of an ozone-oxygen mixture; 120 patients with chronic adnexitis, underwent ozone therapy and bacteriophage therapy, 140 women with infertility of tubal peritoneal genesis were done laparoscopic reconstruction of fallopian tubal patency in combination with rectal insufflations of ozone therapy. All patients underwent bacterioscopic and bacteriological investigations, investigation of vaginal local immunity factors, rate of endogenic intoxication, intensity of lipid peroxidation processes & antioxidant activity. The results of the conducted investigations allow us to draw a conclusion that ozone therapy is not only a reliable method of sanitization of female genital organs among the patients with non-specific colpitis and bacterial vaginosis, but also serves to restore the body's own defense abilities by stimulating the normalization of vaginal

mucosal local immunity. Combination of ozone and bacteriophage therapy in a complex of anti-inflammatory treatment was found to produce both, a systemic effect (detoxification, immunal correction, normalization of lipid peroxidation and of antioxidant defense system) and local effect (normalization of vaginal microflora and immunity indices). The use of rectal insufflation with medical ozone in a complex pre-operative management of patients for reconstruction of tubal sterility as well as during the aftercare can improve the immediate and follow up results.

5. Special applications in practice: wound cleaning, disinfection, bagging, ozonized water/topical injections
M. Schreiber, S. Tiron

Session 1. Advanced Oxidation Processes – Part 5

1. Photodegradation of glyphosate acid and its commercial formulations in water by the UV/ H_2O_2 process
Silvana Neder, Antonio Negro, Alberto Cassano, Cristina Zalazar

2. Kinetics studies of n-butylparaben degradation in H_2O_2/UV system
Dorota Błędzka, Jacek S. Miller, Stanisław Ledakowicz

3. Advanced Oxidation Process (UV/H_2O_2) applied to study the inactivation of *pseudomonas aeruginosa*
Maria Franciosi, Rodolfo Brandi, Alberto Cassano, José Di Conza, Marisol Labas

4. Triazine herbicides removal by UV/H_2O_2 in water and secondary effluent
Samanta Pereira, Renato F. Dantas, Santiago Esplugas, Carme Sans, Márcia Dezotti

5. Prediction of advanced oxidation performance in pilot UV/H_2O_2 reactor systems with MP- and LP-UV lamps
C.H.M. Hofman-Caris, D.J.H. Harmsen, E.F. Beerendonk, A.H. Knol, D. Metz, B.A. Wols

6. Destruction of cyanotoxins by UV/H_2O_2 Advanced Oxidation Process
Xuexiang He, Armah A. de la Cruz, Dionysios D. Dionysiou

7. H_2O_2/UV oxidation of Arsenic and Terbuthylazine in drinking water
Sabrina Sorlini, Mihaela Stefan, Francesca Gialdini

8. Photochemical oxidation of arsenic (III) using hydrogen peroxide and UVC radiation
Maia Lescano, Cristina Zalazar, Alberto Cassano, Rodolfo Brandi

9. Elimination and mineralization of sulfonated organic compounds by ionizing radiation: Effect of hydrogen peroxide (H_2O_2) and persulfate ions ($S_2O_8^{2-}$)
Turki S. Alkhuraiji, Nathalie Karpel vel Leitner

10. Enhanced Degradation of Polychlorinated Biphenyls in Soil by Hydrogen Peroxide, Persulfate and Ozone
Marika Viisimaa, Jelena Veressinina, Anna Goi

Session 7. IOA review of industry and technical news

1. Ozone-How much is that really?
Joseph Drago, Glenn Hunter, Robert Jarnis, Susan Neal, Mike Oneby, Kerwin Rakness, Neal Spivey
Ozone has proven effective in improving water treatment plant performance and meeting ever increasing regulatory requirements. Despite ozone's effectiveness in addressing a wide range of treatment issues including Disinfection, By-Product formation, enhanced filter performance and Taste and Odor removal, there remains a perception within the general water works industry that Ozone is too expensive for consideration at all but for the most difficult raw waters. This paper presents the results of an evaluation undertaken by the Municipal Task Force of the Pan American Group that challenges that miss-conception by assessing the real capital and O&M costs of ozonation within the North American water treatment practice.

2. Worldwide Ozone Capacity for Treatment of Drinking Water and Wastewater: A Review
Barry L. Loeb, Craig M. Thompson, Joseph Drago, Hirofumi Takahara, Sylvie Baig
One question often raised when ozone professionals gather is "How much ozone capacity is installed?". Although the use of ozone for industrial purposes is growing, the largest use for ozone resides in the use of treatment of municipal drinking and wastewater. It is very difficult to summarize ozone capacity for industrial applications as much data are kept confidential. A number of reports have been published over the years on installed ozone capacity. Ozone capacity estimation is a moving target as plants are built and others removed from service for a number of reasons. This paper summarizes, using data available, ozone capacity for drinking water and wastewater. Focus is on the US, Canada, Europe and Japan. IOA members and member companies are encouraged to submit additional data to enable this summary to be as accurate and relevant as possible.

3. Accuracy of High Concentration Ozone Photometry
Ralph Christopher
An introduction to ozone photometry is provided. The principle and the inner workings of an ozone analyzer are explained, together with the different units available to express measurement results. Sources of error in an ozone analyzer are identified and quantified on a component basis. Some practical advice is given for operating an ozone analyzer in an industrial environment, including drying of wet sample gas. A manufacturer of ozone analyzers has to provide a self made Primary Standard. An error budget is shown for such a standard. Three Primary Standards were made and compared among each other and also to a 20 year old standard used in production.

4. Ozone: Science & Engineering - Thirty Three Years and Growing
Barry L. Loeb
The first issue of Ozone: Science & Engineering was published in early 1979 with Dr. L. J. Bollyky as the Editor-in-Chief. This was a milestone for the International Ozone Association enabling professional recognition of the advances in ozone technology.

Since this first issue, 33 volumes of Ozone: Science & Engineering have been published containing 168 individual issues, 1128 technical articles and nearly 16,000 pages. Dr. Rip Rice became Editor-in-Chief in 1985 and continued this position until 1998. Under the leadership of these gentlemen, OS&E expanded from about 70 pages per issue four times per year to 100 pages, then to six issues per year, at about 100 pages. In 2001 the dimensions of the journal were increased to accommodate even more manuscripts. Early articles in Ozone: Science & Engineering focused heavily on aquaculture applications, municipal wastewater treatment and industrial applications. In 1980 the application of ozone to trihalomethane control was developed and a shift to papers on drinking water treatment occurred. Early papers also introduced the use of ozone for pulp bleaching, odor control, bottled water treatment, swimming pool treatment, cooling tower treatment, the use of UV, advanced oxidation, and ozone measurement. As the journal and ozone science matured, papers began to cover more in-depth studies on disinfection removal of specific pollutants and to focus on current environmental problems such as inactivation of Cryptosporidium. Current issues are covering new applications for ozone such as agri-food applications and emerging contaminants (endocrine disruptors). In 1989, the Harvey M. Rosen Memorial Award was established to recognize the "best paper" published in Ozone: Science & Engineering during the two-year period between World Congresses. The selection of award is determined by the Editorial Board of Ozone: Science & Engineering. To date, eleven papers have received this prestigious award. This paper reviews the first 33 years of Ozone: Science & Engineering and offers a glimpse into the future of the journal. Emphasis is placed on the contributions to the Journal from France.

5. Ozone in Food Processing – A Forthcoming Book
Colm O'Donnell, B.K. Tiwari, P.J. Cullen, Rip G. Rice

6. The Ozone Laundry Handbook. A Comprehensive Guide for the Proper Application of Ozone in the Commercial Laundry Industry
Rip G. Rice, Marc DeBrum, Dick Cardis, Cameron Tapp

Session 9. Full scale applications – Part 2

1. San Francisco Begins Operation of a 315-MGD UV Disinfection Facility
Michael L. Price, Bijan Ahmadzadeh, Jamal Awad

2. Implementation of UV reactors for cryptosporidium inactivation at two major plants of Paris suburban
Gérard Chagneau, Alain Neveu, Stewart Tattersall, Jean-Claude Laffitte

3. UV Water Disinfection Systems for Canberra's Water Security Programme
Iain F. Johnson

4. UV-chlorine synergy in Ukraine: case studies
Sergey Malyshko, Alla Muskeyeva, Alexander Shavrov, Sergii Ovcharenko, Leonid Vorobiov, Paul Buijs

5. Energy optimization of the Seymour-Capilano UV disinfection facility
Bryan Townsend, Mark Ferguson, Sharon Peters, Timothy Phelan, Alistair Wardlaw

6. Twenty Years and Nearly One Billion Dollars Later, UV and Ozone are an Integral Part of Metro Vancouver's Water Treatment System
Inder Singh, Mark Ferguson

Session 5. Ozone in Medicine – Part 5

1. Systemic application: extracorporal blood treatment, rectal insufflation
Michael Schreiber/Heinz Konrad

2. Treatment with ozone in diabetic patients with periodontal abscess
Judit Martinez Abreu, Mark T. Weiser, Eduardo Llanes Llanes, Silvia Menéndez Cepero

3. Ozonated saline influence on lipid and protein metabolism in patients with metabolic syndrome
J.R.Efremenko., C.N. Kontorshchikova, E.F. Koroleva

4. The usage of ozonized physiologic saline in gynecologic patients after surgery
O.S. Yanchenko, E.U. Kontorschikova, C.N. Kontorshchikova, T.V. Kotelnikova, T.C. Kachalina, V.V. Novikov

5. State of Auditory Analyzer in Modern Human and Its Correction Using Medical Ozone
Barkhotkina Tetiana

6. Ozone using in treatment of rosacea
Bitkina O.A., Kontorchirova K.N., Kopytova T.V.

7. Ozone therapy in diseases associated with atherosclerosis
Oleg V. Maslennikov, Irina A. Gribkova, Claudia N. Kontorschikova, Elena U. Kontorschikova

8. Ozone Therapy in the oncology (experimental research)
Tatiana Scherbatyuk, Mahir Abdul, Victor Selemir

9. Retinitis Pigmentosa patients treated with ozone therapy during 20 years. Cuban experiences
Mirta Copello, Silvia Menéndez

Session 1. Advanced Oxidation Processes – Part 6

1. Benchmark / Comparison of Energy consumption of established and emerging Advanced Oxidation Technologies
F.-J. Spiess, A. Hauser, C. Garcia, C. Sichel

2. Antimicrobial Removal from Environmentally Relevant Matrices by Advanced Oxidation Processes
Nalan Bilgin Öncü, Isil Akmehmet Balcioglu

3. 2,4 - Dichlorophenoxyacetic acid degradation in Aqueous Media: Ozonation and Ozonation combined with Ultraviolet Radiation
María Eugenia Lovato, Carlos A. Martín, Alberto E. Cassano

4. Use of Advanced Oxidative Processes for degradation of organic refractory pollutants
Kátia F. Streit, José L.N. Xavier, Marco A.S. Rodrigues, Andréa M. Bernardes, Jane Zoppas Ferreira

5. The degradation of endocrine disruptors estrone (E1), 17β-estradiol (E2) and 17α-ethinylestradiol (EE2) with UV-based systems and ozone
Chedly Tizaoui, Khaled Mezughi, Hadj Benkreira

6. Application of ozone involving advanced oxidation processes to remove some pharmaceutical compounds from urban wastewaters
Fernando J. Beltrán, Almudena Aguinaco, Juan F. García-Araya

7. Oxidation effect on the Helminth's eggs *Toxocara canis* with ozone and ozone-peroxide
Clementina Rita Ramírez-Cortina, Juan Diego Cruz-Bautista, Benjamin Nogueda-Torres, Maria Soledad Alonso-Gutiérrez, Gabriela Ibáñez-Cervantes

8. Effect of high concentration of chloride ion on ozonation and O_3/ H_2O_2 process
Hiroshi Tsuno, Fumitake Nishimura, Eri Hasegawa, Kensuke Okuda, Yuki Nishida

9. Application of advanced ozone oxidation to the treatment of refractory petrochemical dry-spun acrylic fiber wastewater
Zhiyong Tian, Yonghui Song, Qi Qiao

10. Design and performance of a mobile pilot plant for the evaluation of Advanced Oxidation Processes (AOP) in waste water treatment
Daniel M. Meier, Walter Uttinger, Sylvie Baig, Marijan Romancuk, Sven Bressmer, Fabio Krogh, Bernhard Paolini

11. Formation of toxic by-products in advanced oxidation processes of organic pollutants in aqueous environments
Roberto Rosala, Javier Santiago, Soledad Gonzalo, Ana Agüera, María del Mar Gómez, Amadeo R. Fernández-Alba, Antonio Rodríguez, Eloy García-Calvo

12. Phenol Degradation by H_2O_2, O_3, UV, H_2O_2-O_3 and H_2O_2-O_3-UV Systems
Clementina Rita Ramírez Cortina, Isaías Hernández Pérez, Raúl Suárez Parra, Ricardo Luna Paz, Maria Soledad Alonso Gutiérrez. Carlos Eduardo Ortiz Lozoya

13. Removal of hazardous substances present in treated municipal effluents by Advanced Oxidation Processes based on ozone
Judith Sarasa, Isabel García, Rosa Mosteo, Maria P. Ormad, José Luis Ovelleiro

14. Removal of 1,4-dioxane from water with ozonation
Rominder Suri, Tony Singh, Sagar Vattikonda, Marianne Curran

15. Application of advanced oxidation technologies for propoxycarbazone-sodium degradation
Aleksandr Dulov, Niina Dulova, Yelena Veressinina, Marina Trapido

Session 8. Applications in Wastewaters – Part 1

1. Ozonation versus adsorption for organic matter removal and micropollutants control in urban wastewater
Bruno Domenjoud, Sylvie Baig, Santiago Esplugas
Controlling the micropollutants dissemination in the environment has become a new issue in connection with organic pollution; good status of surface water and groundwater bodies must be preserved or recovered. Among the different existing emission sources, conventional municipal wastewater treatment plants (WWTP) were pointed out as a major one since they do not successfully eliminate micropollutants. Upgrading the existing WWTP with the implementation of advanced technologies as tertiary treatment appears to be indispensable. Ozone and adsorption onto activated carbon were tested on different municipal secondary effluents for evaluation of their capability to remove organic pollution and reduce simultaneously concentrations of regulated pollutants. Both technologies showed to be suitable to remove the major part of the organic micropollutants investigated. However, micropollutants compete with the bulk of organic matter for both oxidation and adsorption. In the case of adsorption application, the substances with molecular weight below 1,000 Da, which represent 80 to 90 % are absorbed simultaneously with the micropollutants using activated carbon. Life time of activated carbon will be strongly limited by the organic matter adsorption. In the case of ozone application at doses below 30 mg/L, micropollutants oxidation mainly occurs during degradation of aromatic, low biodegradable and high molecular weight compounds which constitute 20 to 50 % of the COD. This organic fraction was converted into more biodegradable, less aromatic and smaller substances. Ammonia and suspended solids (SS) were shown to be oxidized also from the first minutes of ozone application. Nevertheless, removal of micropollutants was not limited by the presence of ammonia and SS in the wastewater. Depending on the chemical make-up of water pollution, the best technological solution can either be ozone oxidation or activated carbon adsorption. Cost comparison and Life Cycle Assessment study will draw the final selection of the best solution.

2. Elimination of micropollutants and pathogens and formation of byproducts during wastewater ozonation: effect of wastewater matrix
Yunho Lee, Urs von Gunten, Daniel Gerrity, Shane Snyder
Ozonation has been demonstrated to be a promising technology to improve the quality of municipal wastewater effluents by eliminating various micropollutants and pathogens. Nevertheless, more research efforts are required with regard to the influence of varying wastewater matrices (e.g. organic matter and bromide) on treatment efficiency (i.e. balance between maximizing

elimination and minimizing toxic byproducts formation). In this study which was funded by WaterReuse Research Foundation (WRRF-08-05) and Swiss Federal Offices for the Environment (07.0142.PJ/G372-1794), seven municipal secondary wastewater effluents were treated by ozone alone and ozone with hydrogen peroxide in a series of bench-scale experiments. The treated wastewater effluents were examined for a variety of parameters such as micropollutant elimination, ozone and OH radical kinetics, disinfection efficiency, transformation of organic C and N, and formation of assimilable organic carbon (AOC) or biodegradable organic carbon (BDOC) and bromate. Some of the main findings with regard to micropollutant elimination were: 1) elimination levels of micropollutants in the tested wastewater effluents were comparable at the same ozone dose (normalized by organic concentration, i.e. O_3/DOC-mass ratio) even though their water quality parameters varied significantly, 2) elimination levels of micropollutants were strongly correlated with their ozone and OH radical rate constants, 3) ozone-reactive micropollutants (i.e. $k(O_3) > 10^5\ M^{-1}\ s^{-1}$) were efficiently eliminated, e.g. more than 90% at O_3/DOC of 0.25, 4) even for ozone-refractory micropollutants (i.e. $k(O_3) < 10\ M^{-1}\ s^{-1}$), the elimination was still considerable as long as their reaction rate constants with OH radical are high (i.e. $k(\bullet OH) \geq 5\times10^9\ M^{-1}\ s^{-1}$), e.g. more than 90% at O_3/DOC of 1.5. With regard to the bromate formation, the bromate yield (i.e. Δ[Br O_3-]/[Br-]ini-molar ratio) was <5% at O_3/DOC of $\leq$0.5, but increased up to 5 – 15% at O_3/DOC of 1.0 and 10 – 40% at O_3DOC of 1.5. Therefore, for the wastewater containing more than 50 μg/L of bromide, the bromate formation can be higher than 10 μg/L (drinking water standard) at O_3/DOC of $\geq$1.0.

3. Treatment of secondary municipal effluent with ozone and ultrafiltration
María Teresa Orta L. de Velasquez, Juan Fernando Muñoz Paredes, Ignacio Monje-Ramírez
An advanced wastewater treatment process consisting of ozonation and ultrafiltration was studied in laboratory-scale to produce an effluent suitable for aquifer recharge. The main focus of this work was to determine the effect of ozone on the ultrafiltration membrane and its fouling behavior. Ozonation and ultrafiltration experiments were made in semi-batch tests using the secondary effluent from the Cerro de la Estrella wastewater treatment plant, located in Mexico City. In order to assess the ozone action, the dissolved organic matter (DOM) was fractionated according to its polarity in: hydrophobic, transphilic and hydrophilic fractions, using XAD-8 and XAD-4 resins. The secondary effluent's DOM fractions before the ozonation-ultrafiltration were: 46% hydrophobic, 32% hydrophilic polar and 22% transphilic. Ozone oxidation increased the hydrophilic fraction to 42%, and this value did not change after ultrafiltration. Following 8 hours of continuous operation without any back-flushing, the membrane flux and operation time was reduced by only 40% compared to 81.5% reduction without ozone. In addition, whenever ozone was used the flux was enhanced. For all cases, with and without ozone, the ultrafiltration membrane exhibited the formation of a filter cake. Results show that the ozone time is the variable with the most influence over the removal efficiencies.

4. Influence of wastewater quality on disinfection efficiency and reliability of operation of UV disinfection and ozonation
Valentina Lazarova, Bruno Ferran, Philippe Savoye
The results of pilot plant and full-scale operation confirm the importance of wastewater quality for the design and operation of UV disinfection and ozonation. It was demonstrated that for these two disinfection alternatives, tertiary filtration is the critical prerequisite to consistently achieve strict disinfection limits. UV disinfection is strongly affected by hydraulic flow and UV transmittance. Wastewater ozonation requires short contact times and improved mass transfer.

5. UV disinfection of Waste water effluent: Goals and requirements
Regina Sommer, Alexander Cabaj, Georg Hirschmann, Thomas Haider, Alexander Kirschner
Disinfection of drinking, bathing and waste water serves as most efficient tool to protect human health from infectious diseases. Approved methods are chlorination, ozonation and UV irradiation. Especially for the disinfection of waste water effluent the application of UV irradiation offers eminent advantages. Contrary to chlorination and ozonation no chemicals are required, thus results in an environmentally and ecologically compatible disinfection water treatment process. To guarantee a successful disinfection suitable operation conditions have to be defined and kept during the practical operation. The measurement of the disinfection capacity of UV systems is carried out by means of biodosimetry. This technique uses standardised, UV-254 nm calibrated microorganisms (biodosimeter) under variation of the operating conditions (flow, lamp power, UV-transmittance of the water). From the log reduction of the biodosimeter obtained the UV fluence can be derived (Reduction Equivalent Fluence, J/m²).

Session 9. Full scale applications – Part 3

1. UV: not just for Cryptosporidium anymore
Paul Swaim, Anthony Myers, Todd Elliott, Lisa Voytko, Bruce Jacobs, James Malley, Jr.
In North America, most UV disinfection installations at drinking water treatment plants have been intended to address Cryptosporidium, which has been the focus of new surface water treatment requirements. There have been several UV projects implemented to address other treatment objectives as well. Several of these applications are summarized in this paper.

2. Filtration and UV-irradiation for ships' ballast water management – water quality challenges and UV-dose requirements
Helge Liltved, August Tobiessen, Stephanie Delacroix, Harald Heiaas, Ingun Tryland
Filtration and ultraviolet irradiation is a possible combination for treatment of ships' ballast water. Such systems will be further developed to meet the challenges of ballast water management according to international regulations. UV systems should be designed for inactivation of robust algal species not removed by the filtration step. This study presents UV-dose requirement for one such algae (Tetraselmis suecica). Other algae species may show even higher UV-resistance. Larger organisms like Artemia franciscana exhibit very high UV-tolerance and have to be removed or destroyed by filtration or treatment units imposing high hydraulic shear forces. Reduced ballast water quality (high content of suspended solid and dissolved organic matter) will reduced the UV-transmission and the performance of the UV-system, and have to be taken into account when designing full scale systems. Ballast water treatment systems should include filtration, or a unit to destroy particles and zooplankton capable of harbouring bacteria before UV disinfection.

3. Balancing Risk versus Benefit in the Selection of Equipment for Portland's Bull Run UV Disinfection Facility
Bryan Townsend, Chad Talbot, Harold Wright, David Peters, Timothy Phelan
In order to comply with the Long Term 2 Enhanced Surface Water Treatment Rule, the Portland Water Bureau has begun the

design of a 212 mgd UV disinfection facility to achieve the 2-log Cryptosporidium inactivation requirement for unfiltered surface waters. Since the Bull Run facility does not have a clear well prior to entry in the distribution system, a major focal point of the evaluation was the issue of lamp breakage and potential mercury release. The validation status of the three reactors proposed by UV manufacturers varied from partial validation with preliminary performance equations to a completely non-validated UV system incorporating brand new lamp and ballast technologies. Special attention was required in order to assess the level of risk associated with the validation status and level of experience with the reactor components as well as potential action needed to address system sizing should validated models fall short of the predicted performance. These issues coupled with the concerns associated with potential mercury release and its impact on the design of the UV system resulted in a unique selection experience. Careful assessment of the benefits of each design and the associated risks was paramount in order to identify the best suited equipment for the Bull Run UV disinfection facility, that was not only attractive from a financial perspective but would also safely and reliably provide the required disinfection to protect the public health.

4. Scale up of UV AOP reactors from bench tests using CFD modeling
Keith Bircher, Mai Vuong, Brad Crawford, Mark Heath, Jeff Bandy
A method for scale up of UV/AOP reactors that uses bench scale testing to determine the UV Dose required per log destruction of a particular contaminant (DL) that can be used in CFD Modeling of a full scale reactor. Results from full scale testing of this method are presented.

5. An Australian perspective of ozone and biological filtration for drinking water treatment
Yaode Yan, Paul Thompson, Peter Dennis
The efficacy of ozone and biological activated carbon (BAC) process in reducing trihalomethane (THM) precursors was studied in our recent pilot plant investigations at a number of locations on the east coast of Australia. This paper discusses results from two of these studies that involved very different raw waters. The first raw water represented one of the most challenging raw water sources in Australia, with total organic carbon (TOC) concentrations of 15 – 35 mg/L, while the second raw water had 5 – 10 mg/L TOC, which is more typical of raw waters along the east coast of Australia. In each case the pilot plant process was operated in the intermediate ozonation mode, with the feed water to the pilot plant drawn from the settled water of the full-scale treatment process. In both cases the intermediate Ozone/BAC process was shown to be capable of achieving significant removal of THM precursors and hence reductions in THM formation potential. However, the removal efficiency was found to be highly dependent on the empty bed contact time of the filter, with longer times yielding significantly better removal. While Ozone/BAC treatment may be capable of meeting the current Australian Drinking Water Guidelines limit of 250 µg/L for total THMs even for a water that is highly laden with natural organic matter, it may struggle under tighter THM limits. Our work highlights the importance of undertaking pre-design testing to ascertain the effectiveness of Ozone/BAC in reducing THM precursors for a specific water. This paper also discusses the feasibility of operating an ozonation process on an intermittent basis, e.g., in response to water quality events such as blue-green algal blooms, as well as the filtration performance of the "intermediate" BAC filters.

6. Los Angeles Aqueduct Filtration Plant UV Disinfection Plant: Preparing for the Future
Christine Cotton, Steve Ott, Kurt Wells, Pankaj Parekh, Ben Kuhnel, Patrick Carlson, James Collins
The Los Angeles Department of Water and Power (LADWP) is committed to providing excellent water quality and reliability to its customers. To this end, LADWP owns and operates the Los Angeles Aqueduct Filtration Plant (LAAFP) that has been operating since 1986. The LAAFP is permitted to treat 600 million gallons per day (MGD) with ozonation, rapid mix/flocculation, filtration, and chlorination. LADWP is currently designing a UV Disinfection Plant at the LAAFP that will be built as part of a two pronged approach to comply with the United States Environmental Protection Agency (USEPA) Stage 1 and Stage 2 Disinfectants/Disinfection Byproduct Rules (DBPR). The UV Disinfection Plant will provide a multi-barrier disinfection approach and additional operational flexibility to adjust chlorine and ozone doses to meet the Stage 2 DBPR requirements. The distribution system disinfectant will also be converted to chloramine disinfection and is the second key change to reduce DBP levels. The LAAFP UV Disinfection Plant provides many unique design challenges that are summarized in this paper: selection of conservative design criteria that will meet both the current and future treatment goals; unique plant hydraulics and flow distribution pathways; and an expedited schedule necessary to meet regulatory compliance deadlines.

Session 10. Process development and optimization – Part 1

1. Ozone Residual Meter Calibration Protocol and Results
Kerwin L. Rakness, Glenn F. Hunter
Many drinking water treatment plants with ozone achieve regulatory compliance for disinfection, which is measured by "Ct" value (i.e., ozone residual times contact time). Ozone residuals are collected at three or more locations within an ozone contactor. Most plants operate two or more ozone contactors. Due to multiple sampling, plants use continuous on-line measurement of ozone residual for monitoring and control. Some plants are located in States that allow on-line measurement for compliance reporting. On-line meters are "calibrated" using grab sample analysis with the "Standard Method" Indigo Trisulfonate (ITS) ozone residual test that was developed in 1980 by Hoigné and Bader. Plant staff performs the calibration test using site-specific procedures that have been accepted by State regulatory agencies, as applicable. Until recently, a National regulatory "calibration" protocol was unavailable for ozone. In April 2010, the United States Environmental Protection Agency (USEPA) published the LT2ESWTR Final Guidance Manual that describes an ozone residual meter calibration protocol. The authors have worked with several North American ozone facilities in developing their approach for on-line residual analyzer calibration. The approach generally follows recently published USEPA guidance. The procedure involves collecting grab samples while at the same time record meter readings. Three to five grab-sample meter-reading tests are completed every 15- to 30-sec. Analyzers are installed without signal dampening to ensure that analyzer readings characterize grab-sample results. The grab-sample average is compared to the meter average. Calibration adjustment is indicated when the meter average is beyond acceptable limits of the grab-sample average results. This paper discusses the calibration protocol for ozone that is contained in recently published USEPA guidance manuals and presents operating results from several utilities. In addition, USEPA guidance for on-line chlorine residual analyzers is described for comparative purposes.

2. Evaluating Impacts of Inlet Piping Configuration on UV Dose Delivery

Christopher R. Schulz, Mike Hyland, Mark Allen, David Werth, Inder Singh

The Ultraviolet Disinfection Guidance Manual (UVDGM) provides technical information and guidance on design and operation of UV systems for receiving disinfection credit under the Long-Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR). An important topic in the UVDGM relates to inlet and outlet piping configurations installed in the full-scale UV facility and how they relate to the piping configuration used during validation testing and associated impacts on UV dose delivery. Several design approaches are cited in the UVDGM to ensure that "the inlet and outlet piping to the UV reactor in the UV facility results in a UV dose delivery that is equal to or greater than the UV dose delivered when the reactor was validated." The purpose of this paper is to present an alternative method for meeting the UVDGM dose delivery objective, while allowing for flexibility in the design of UV piping systems to meet project-specific design constraints. The proposed method involves use of physical or computational fluid dynamics (CFD) modeling to evaluate and optimize inlet hydraulics to the UV reactor until acceptable velocity profiles are achieved, and then verification of actual performance by taking measurements of inlet velocity profiles during validation and start-up of the full-scale UV facility. Conservative "acceptance" criteria for comparing these results are proposed to ensure improved UV dose delivery at full-scale. This method was applied to the design of a new UV disinfection facility for the Coquitlam Water Treatment Facility—an unfiltered gravity-fed water system owned and operated by Metro Vancouver in British Columbia, Canada.

3. Application of Real-time RT-PCR for Measuring High UV Dose

Takeyoshi Naruse, Naoyuki Kamiko

Relatively higher UV dose than disinfection is necessary to decompose persistent toxic substances by AOP (Advanced Oxidation Process). But the measurement method for high UV dose in flow reactors is not established. In this study, measurement of high UV dose using real-time RT-PCR was investigated. Several hundreds or thousands mJ/cm^2 irradiation will cause lower plate count of biodosimeter than detection limit. But PCR method must enable partly damaged nucleic acid to be detected if amplified range has no damage. Therefore it was examined whether high UV dose unable to be measured by plate count method could be measured by real-time RT-PCR. Two kinds of lamp for UV sources (Low-pressure mercury lamp (LP) and Medium-pressure mercury lamp (MP)) and RNA bacteriophage MS2 for biodosimeter were used in this study. UV irradiation was conducted using cthe batch reactor. RT-PCR results can be interpreted to remaining rate of template RNA [Log remaining rate=log10(Ct/C0), C0: initial phage template RNA concentration (copies/mL), Ct: phage template RNA concentration after each irradiation (copies/mL)]. UV dose required for 1 log reduction of phage RNA was about 1640 mJ/cm^2 for LP and about 540mJ/cm^2 for MP. From experimental results, log remaining rate of phage RNA was proportional to irradiated UV dose but the slopes of log remaining curve were dependent on the kind of lamps. Therefore, higher UV dose than measurable range by plate count method could be measured by real-time RT-PCR.

4. Disinfection Treatment Performance Defines Ozone Automation

Kerwin L. Rakness

Drinking water ozone systems are often designed to meet disinfection treatment objectives. Other objectives include oxidation of manganese, hydrogen sulfide, taste-and-odor-causing compounds, and more. Utilities that operate disinfection-focused ozone systems achieve secondary benefits from naturally occurring oxidation reactions. The emphasis for this paper is automatic control of ozone contactor gas flow and ozone generator power to achieve continuous compliance with disinfection regulations (USEPA LT2ESWTR Guidance, April 2010). Ozone disinfection credit is monitored by ozone exposure, or "Ct" value, where "C" is residual ozone concentration (mg/L) and "t" is effective (t10) contact time (min). The United States Environmental Protection Agency (USEPA) published the Long-Term-2 Enhanced Surface Water Treatment Rule (LT2ESWTR) final guidance manual in April 2010. This document describes allowable Ct calculation methods. The "Extended T10" method is discussed in this paper. This method accurately measures "Ct10" value and has a rapid response feature that enhances automatic control. Disinfection regulations in North America are based on achieving log-inactivation values for Giardia, virus, and sometimes Cryptosporidium. Ozone systems are controlled to achieve log inactivation values greater than required, which is measured or quantified by the term "Performance ratio" (PR). The term PR is defined for each pathogen as log-inactivation achieved divided-by log-inactivation required. Compliance occurs at PR>1. Due to the dynamic nature of ozone system operation, a margin of safety such as PR=2 or PR=3 might become the operating target in order to achieve continuous compliance. Ozone contactor gas flow and ozone generator power are adjusted to achieve ozone production, ozone dose, and ozone residual that meets PR targets. Ozone dose is the link between PR management (i.e., keeping PR within a selected range) and contactor gas flow and ozone generator power control. If PR is too low, the ozone dose set-point must be increased. When ozone dose set-point is increased, contactor gas flow and generator power must be increased. An automatic control strategy is described herein that ensures that sufficient ozone dose is applied to achieve continuous disinfection compliance during both steady-state and non-steady-state operation. Non-steady-state operation is defined as times of change, such as adjustment of plant water flow rate, switching of ozone generators, malfunction of an ozone concentration meter, malfunction of an ozone residual analyzer, and other disturbances.

5. A New Tool for Optimizing Pretreatment for UV Disinfection of Wastewater

Katherine Y. Bell, Juan Sanez, Martha J.M. Wells

Excitation-emission matrix fluorescence spectroscopy (EEM), or 3D fluorescence, is a relatively new technique to characterize the organic matter present in waters from diverse sources. Organic matter present in a sample can be excited, and at particular wavelengths, only part of the organic matter emits light (fluorescence). When filtered wastewater samples are excited at certain wavelengths [200−600 nanometers (nm)], and the intensity of fluorescence emitted is collected in a certain range (200−650 nm), a 3D map with an excitation, emission and fluorescence-intensity matrix results. This representation makes it possible to localize fluorescence centers related to particular groups of fluorophores, which can be used to "fingerprint" a given sample containing a diverse composition of organic matter. This technique is readily applicable to wastewater samples, making it particularly useful for providing information about sources of wastewater to facilities that have issues with treated wastewater quality as it relates to ultraviolet (UV) disinfection. In the U.S., many municipalities have significant industrial users that contribute organic matter to the influent of a wastewater treatment plant. While in most cases the organic matter is degradable through the biological treatment process, there are industries that can discharge refractory organic matter that can interfere with UV disinfection processes. Managing pretreatment programs to address these interferences can be challenging. The EEM

technique is a tool that can be used to "fingerprint" contributors of refractory organic matter; once identified, an appropriate pretreatment program can be instituted to optimize the overall operations of the wastewater disinfection process. This paper provides a case study example where this technique has been applied. It also presents the continuing work being conducted to improve the potential application of this method as a tool for aiding in wastewater treatment plant process performance.

6. Assessment of the ozonation process under continuous flow in sewage wastewater reclamation
Antonio Rodríguez, Ivan Muñoz, Jose A. Perdigón, Roberto Rosal, Jose. B. Carbajo, Alice Petre, Maria. J. Martínez, Amadeo R. Fernández-Alba, Eloy García-Calvo
Wastewater samples from two STP, spiked with 11 pharmaceuticals and 1 herbicide, were ozonated in continuous flow. The experiments were carried out in one and two bubble column (1.20 L work volume) arrangements. The range of power (0.46 - 6.90 W), gas flow (0.39 NL/min), gas ozone concentration (1.11 - 8.7 mg/L) and water flow (0.15 - 0.30 L/min) determined the operational conditions to optimize parameters as ozone generation energy per cubic meter of water (0.26 $kW{\cdot}h/m^3$), ozone transfer efficiency (90 %), ozone transfer flow (1.33 - 2.23 mg/min), ozone doses transferred (7.23 - 8.86 mg/L) and depletion of pollutants (98 %) in two bubble columns arranged in a series. Direct and indirect environmental impacts were assessed according to Life Cycle Assessment (LCA). LCA helped identify the treatments that lead to the highest effectiveness in potential toxicity reduction, as well as in toxicity reduction per kg GHG emissions. From these results, a compromise option could be chosen, such as applying 0.07 $kW{\cdot}h/m^3$. However the choice of the most desirable treatment alternative will depend on the goal of the treatment: either to maximise toxicity removal and organic matter mineralization, or achieving a given reduction target with the lowest energy use.

Session 1. Advanced Oxidation Processes – Part 7

1. Assessment of the ozonation and Fenton process as a pretreatment of a subsequent biological treatment based on respirometric measurements
Pieter Van Aken, Jan Luyten, Jan Degrève, Sven Liers

2. Heterogeneous photo-Fenton processes for disinfection of treated urban wastewater
Jorge Rodríguez-Chueca, Rosa Mosteo, Mª Peña Ormad, Natividad Miguel, José Luis Ovelleiro

3. Remediation of petroleum contaminated soil by photo-Fenton process applying germicidal light
Otidene Rossiter Sá da Rocha, Marta Maria Menezes B. Duarte, Renato F. Dantas, Marcia Maria Lima Duarte, Valdinete Lins da Silva

4. Oxidative Degradation of Amantadine by the Fenton Processes
Ping Zeng, Yonghui Song, Johanna Dresely, Liang Duan, Shuhu Xiao, Yincheng Ma, Chenhao, Wang, Erhard Hoffmann

5. Influence of the aqueous matrix in photocatalytic process: degradation of pesticides
Natividad Miguel, María P. Ormad, Rosa Mosteo, Judith Sarasa, José L. Ovelleiro

6. Removal of endocrine disrupting compounds from secondary treated wastewater by heterogeneous photocatalysis
Zacharias Frontistis, Vassileia M.Daskalaki, Nikolaos P. Xekoukoulotakis, Despo Fatta-Kassinos, Dionissios Mantzavinos

7. Photocatalytic oxidation of phenol under UV irradiation on a combined TiO_2-AC Tissue
Elham F. Mohamed, Caroline Andriantsiferana, Henri Delmas

Session 8. Applications in Wastewaters – Part 2

1. Oxidation processes for reuse of treated wastewater
Juan Fernando Garcia-Araya, Azahara Espejo, Fernando Beltrán, Pedro Álvarez

2. Comparative Evaluation of Ozonation and UV Disinfection in Municipal Wastewater Treatment Plants for Reuse Applications
Serkan Evcimen, Bugra Alpak, Aslihan Kerc

3. Characterization of the ozonation process in the municipal wastewater treatment for reuse
Eliet Véliz Lorenzo, José G. Llanes Ocaña, Lidia Asela Fernández García, Mayra Bataller Venta

4. Effect of Alginic acid, Peptone, NOM and Alkalinity on the O_3 Process: Degradation of Cyclophosphamide
Yaal Lester, Dror Avisar, Hadas Mamane

5. Required ozone doses for controlling pharmaceutical in Swedish WWTP effluents
Maria G. Antoniou, Per Falas, Gerly Moradas, Jerker Fick, Mats Tysklind, Anna Ledin, Jes La Cour Jansen, Henrik Rasmus Andersen

6. Degradation of emerging pharmaceuticals in water/wastewater matrix with advanced oxidation processes: a comparative study
Irina Epold, Polina Barajeva, Yelena Veressinina, Marina Trapido

7. Identification of ecotoxicity caused by O_3 and ClO_2 treatment of wastewater
Maritha Hörsing, Sara Furuhagen, Anna Ledin, Magnus Breitholtz, Henrik R. Anderssen

8. Monitoring and Oxidative Removal of EDCs in Istanbul Wastewater Treatment Plants
Zehra Semra Can, Aslihan Kerc, Serkan Evcimen, Melike Firlak

9. Characterization and treatment of leachates from municipal solid waste landfill
Lidia Asela Fernández, Ma. del Carmen Espinosa, Eliet Véliz, Matilde López, Mayra Bataller, Yalexmi Ramos

10. O_3/UV treatment of a wastewater consisting of an organic compound (phenol, xylene or t-butanol) and sodium acetate
Wim Van de Moortel, Jan Degrève, Jan Luyten

11. Influence of Activated Carbon on Ozonation of Phenolic Wastewater
Oliver Järvik, Vardo Saarik, Irina Osadchuk, Andres Viiroja, Inna Kamenev

Session 9. Full scale applications – Part 4

1. A Collaborative Design of a 600 MGD Drinking Water UV Facility
Ben Kuhnel, Christine Cotton, Kurt Wells

2. Removal of Trichloroethylene (TCE) and Tetrachloroethylene (PCE) in a full scale ozone/H_2O_2/GAC plant in Switzerland
D. Urfer, P. Houlmann, N. Landoz, J. Gigandet, M. Meyer, G. Voirol

3. Optimization of the Ozone Dosage at the Drinking Water Treatment Plant of Kluizen
Jan Cromphout, Walter Neirynck, Stijn Mortier, Jos Boonen, Liesbeth Verdickt

4. Livestock Wastewater Treatment by Biological Sequencing Digestion/Dissolved Ozone Floatation/Biological Filtration
Moonki Park, Joon-Wun Kang

5. Converting a Large Water Treatment Plant to Enhanced Coagulation and Biological Filtration
Mark Simon, Michael Mikeska, Peter Stencel, Jennifer Cottingham, Jeff Neemann, George Budd, Randy Romack

Session 10. Process development and optimization – Part 2

1. Ozone Monitoring Applications with semiconducting gas sensors
Nicolas Moser

2. The use of polymerase chain reaction - denaturing gradient gel electrophoresis to detect the survival of foodborne microorganisms after UV treatment
Alexa A. Isaks, Pieter A. Gouws

3. Evaluation of the Keitz Equation for Quantifying the Total UV Output of Medium Pressure Mercury Lamps
Farnaz Daynouri, Jim Robinson

4. Effect of preozonation on ultrafiltration of meat industrial waste water
Angéla Szép, Szabolcs Kertész, Gábor Szabó, Cecilia Hodúr, Zsuzsanna László

5. Ozonated Constructed wetland for Tibetan hog sewage treatment
Joanne Chung Yan Ho, Zhi Chong Lee, Gilbert Yuk Sing Chan

6. Hybrid degradation of alkyl-phenol ethoxylate by ozonation and biodegradation
Tetsuji Okuda, Daisuke Okajima, Masashi Hirosaki, Tomoyuki Takeda, Kenji Oda, Satoshi Nakai, Wataru Nishijima, Mitsumasa Okada

7. Biological denitrification of drinking water in a sand filter followed by ozonation
Sabrina Sorlini, Francesca Gialdini

8. Suspended Ultraviolet Irradiation for Algae Eradication in Reservoir Water
R.J. Xie, M. Gomez

9. Disinfection of water and wastewater by solar, UV-A and UV-C irradiation: application of real-time PCR method
Efthalia Chatzisymeon, Maria S. Gonzalo, Roberto Rosal, Nikos Xekoukoulotakis, Dionissios Mantzavinos, Danae Venieri

Wednesday, May 25

Session 11. Reaction study and modelling – Part 1

1. Research to reassess the low dose risks of bromate in drinking water
Joseph Cotruvo, Richard Bull, Brian Cummings, Don Delker, Jeffrey Fisher, Zhongxian Guo, Choon Nam Ong, Shane Snyder, Oscar Quinones
We are working to construct a revised low dose risk assessment that considers the metabolism and the mechanisms that are being elucidated by this work. Human exposure at the WHO Guideline value (10 µg/L) is less than 0.0003 mg/kg/day, an exposure factor from the bioassay cancer dose in the range of 3000X to 20,000X. We have demonstrated rapid reductive metabolism occurring in the rat liver (first pass) and blood both from ingestion and intravenous injection, and in rat liver and kidney homogenates. It appears that there are at least 2 stages in the degradation process: 1st and very rapidly the chemical reactions between bromate and thiols and sulfide at doses below about 60 µM; 2nd and slower reactions probably with enzymes, which gives a long tail. We are developing a pharmacokinetic model for bromate to provide a revised risk assessment. Our findings have also provided insights into bromate's Mode of Action (MOA) that could also affect the risk assessment. Separate form the metabolism work, our MOA work may develop an argument against use of male rat kidney tumors as a suitable model for low-dose extrapolation. If the male kidney data were removed, that alone would result in a reduced risk calculation because the current risk assessments depended on the summed activity in all three organs (i.e., kidney, testes, and thyroid).

2. Ultraviolet Genomic Modeling: Current Research and Applications
Wladyslaw J. Kowalski
Ultraviolet genomic modeling is a method for evaluating the ultraviolet sensitivity of microorganisms by reading and interpreting the complete microbial genome. Base counting software is used to identify short sequences of amino acids that have a high photodimerization potential. The specific sequences that can result in photodimers include thymine-thymine (TT), thymine-

cytosine (TC or CT), cytosine-cytosine (CC), and purine-pyrimidine dimers that form under certain conditions. A mathematical algorithm is used to compute the relative UV sensitivity for each microbe. Correlation of the genomic model with known ultraviolet susceptibilities of over 160 microbes has resulted in a general model that can be used to predict the UV sensitivities of bacteria, RNA viruses and DNA viruses with predictive accuracies over 80% for bacteria and over 90% for viruses. Since current UV bioassays are estimated to have an error range of +/-30%, the genomic model may form a benchmark by which the accuracy of bioassay testing may be gauged. An extensive list of predicted UV sensitivities is presented for microbes that do not currently have published UV susceptibilities, including many nosocomial and zoonotic pathogens and bioweapon agents. Other applications of the model are discussed including the use of the genomic model to assess the survival of microbes in an airstream or water stream via PCR technology. Extension of the ultraviolet genomic model to UVA and UVB applications is feasible and the possibility of applying the model to human skin cancer research is discussed. Further extension of the genomic model to ionizing radiation and potential applications are discussed.

3. Antibiotic Activity of Pre-Ozonated Ciprofloxacin and Sulfamethoxazole
Temesgen Garoma, Melissa Allen
Antibiotics have been frequently detected in the environment, including surface water, groundwater, treated drinking water, wastewater treatment plant effluent, and other environmental media. However, there is still a lack of understanding and knowledge about the adverse effects these substances have on the environment. In addition, the effects of reaction-intermediates generated due to the incomplete mineralization of antibiotics have been largely ignored. Ciprofloxacin (CIP) and Sulfamethoxazole (SMX) are two antibiotics commonly detected in the environment with concentrations in the range of 0.7 to 124.5 in hospital effluents and 0.2 to 2 µg/L in secondary wastewater effluents. In this study, the antibiotic activities of pre-oxidized CIP and SMX using E. coli as a test microorganism were investigated. CIP and SMX solutions buffered at pH of 7.4 with PO_4^{3-} were oxidized at varying degrees using ozonation. E. coli cultures were exposed to the pre-oxidized CIP and SMX solutions for 24 hours (short-term exposure). The experiments were conducted at a temperature of 37°C. Antibiotic resistance was determined at growth/exposure times of 3, 5, 7, 9 and 24 hours as the Minimum Inhibition Concentration (MIC), by a micro-dilution test with six replicates per sample. Preliminary results at residual CIP concentration of 0.001 □g/L show no significant changes in MIC values within the 24 hours of exposure time. However, there appears to be a trend towards higher MIC values as the exposure time increases, indicating that chronic (long-term) exposure studies under environmental conditions are necessary for a complete and sufficient risk assessment for environmentally relevant concentrations of antibiotics and their reaction-intermediates. Currently, we are conducting the chronic exposure studies and the results will be presented at the conference.

4. Kinetic and hypothetical mechanism of the OH• radical reaction with cisplatin
Yalexmi Ramos, Carlos Hernández, Lidia Asela Fernández, Mayra Bataller, Eliet Veliz, Silvia Menendez

5. A simplified analytical method for ozone born radicals monitoring
Jean-Stéphane Pic, Laura Fuller, Marie-Hélène Manéro, Hubert Debellefontaine

6. Impact of Ultraviolet Irradiation on Growth of Chlorellapyrenoidis
Meiting Guo, Hongying Hu, Jian Chen, Xiaobin Liu

7. Degradation of biocide o-phenylphenol in water solutions by ozone
Magdalena Olak, Jacek S. Miller, Stanisław Ledakowicz

8. The molecular products of ozone decomposition in water solutions
C.N. Kontorchshikova, A.A.Sibirkin, L.M. Obukhova, O.Yu. Chernova

9. Methanol Decomposition by the Combination of Ozone/Activated Carbon
Iliana Fuentes Camargo, Tatiana Poznyak

10. Ozonation of atrazine
Rafaela Cristina Landeiro da Silva, Roberto José de Carvalho

11. Ozonation of imidacloprid in aqueous solutions: Reaction monitoring and identification of degradation products
Marc Bourgin, Frédéric Violleau, Laurent Debrauwer, Joël Albet

Session 8. Applications in Wastewaters – Part 3

1. Performance of ozone for EDC removal from sewage effluent
John Churchley, Brian Drage, Emilie Cope, Yvonne Narroway, Achim Ried, Tony Swierk, Ken Alexander, Rakesh Kanda
The presence of endocrine disrupting compounds (EDCs) in treated sewage effluents has been well known for many years. These EDCs have led to symptoms of 'intersex' in wild fish populations especially downstream of sewage treatment works (STWs). In order to promote better understanding of the occurrence and removal of EDCs and in particular of the steroid estrogens, the UK Environment Agency set up a National Demonstration Programme (NDP). This NDP was coordinated through UK Water Industry Research (UKWIR) and required collaborative work to be undertaken using standard methodology and newly developed analytical methods by all 10 Water Companies in England and Wales. Severn Trent Water Ltd. were required as part of their contribution to the NDP to build and operate 3 large pilot plants at the Hallam Fields STW, Ilkeston. These comprised a chlorine dioxide treatment plant, granular activated carbon (GAC) and ozone treatment. All were fed with the effluent from the conventional STW (nitrifying activated sludge plus sand filters) at flow rates of 200-1000 m^3d^{-1}, and were operated for almost 3 years. All the advanced treatment plants caused substantial reductions in the concentrations of steroid estrogens such that the treated effluents would be harmless to the reproductive health of fish at either no or very low dilution in river water. For ozone and chlorine dioxide a dose of 1 mg l^{-1} was effective and for GAC an empty bed contact time (EBCT) of 20 min was used. Although ozonation of bromide-containing waters can lead to potentially harmful levels of bromate, in this case the low ozone dose ensured that the bromate levels were very low. An economic appraisal of the 3 advanced treatments showed that ozone at an applied dose of 1 mg l^{-1} had the lowest operating cost. This work suggests that ozone may be an economically viable option where advanced treatment of sewage effluent for EDC removal is required.

2. Oxidation of Mixed Active Pharmaceutical Ingredients in Biologically Treated Wastewater
Gerly Moradas, Jerker Fick, Anna Ledin, Jes la Cour Jansen, Henrik Rasmus Andersen
Biologically treated wastewater containing a mixture of 53 active pharmaceutical ingredients (APIs) was treated with 0-20 mg/l chlorine dioxide (ClO2) solution. Wastewater effluents were taken from two wastewater treatment plants in Sweden, one with (low COD) and one without (high COD) extended nitrogen removal. The removal of the APIs varied from no significant removal at the highest dose of ClO2 (20 mg/l) to 90% removal at a dose of 0.5 mg/l of the oxidant. From the low COD effluent, only 4 APIs were removed by more than 90% at the lowest oxidant dose of 0.5 mg/l whereas most of the APIs were removed at 5 mg/l ClO2 dose. Removal of the same APIs from the high COD effluent was observed when the ClO2 dose was increased to 1.25 mg/l and an increase in API removal only after treatment with 8 mg/l ClO2. This illustrates that treatment of wastewater effluents with chlorine dioxide has potential to remove pharmaceuticals traces from wastewater treatment plant effluents.

3. Comparison of the Advanced Oxidation Processes for antibiotic wastewater treatment (UV, UV/ H_2O_2 and O_3)
Andrzej K. Bi, Sylwia Sobera-Madej
Among pharmaceuticals that were designed to stimulate a physiological response in humans, animals, bacteria or other organisms, antibiotics belong to important compounds. They have extensively been used in human and veterinary medicine as well as in aquaculture to prevent or to treat microbial infections and in livestock production to promote the growth of animals. Since biocidal substances are designed with the aim of causing a biological effect, they may affect water and soil dwelling organisms when reaching the environment. After administration antibiotics or their metabolites are extracted into wastewater and reach the sewage treatment plant (STP) [1]. Also they can appear in wastes coming from technological wastewaters containing antibiotics in addition to other pollutants hazardous to the environment. If they are not eliminated during the purification process they pass the sewage system and may end up in the environment, mainly in the water compartment. The effectiveness of UV-based processes (UV and UV/ H_2O_2) for the treatment of pharmaceuticals wastewater was investigated and compared with the effects of simple ozonation.

4. Chemical and toxicological evaluation of by-products during oxidative tratment of waste water treatment plant effluents
Jochen Tuerk, Jessica Richard, Claudia vom Eyser, Andrea Boergers, Kai Bester, Elke Dopp
A large number of organic micro pollutants like pharmaceuticals and personal care products have been found in various waste water treatment plant effluents and surface waters. The removal of these persistent substances could be achieved by advanced oxidation processes. Beside the complete elimination of the parent compound the formation of transformation products is likely. The toxicity of these by-products could be relevant and must be considerd during process optimisation. Therefore this study was designed to characterise the unchanged substance and its oxidation by-products by means of toxicity. Transformation products formed in pure water from ciprofloxacin and sulfamethoxazole as well as in WWTP effluents were investigated. After ozonation and UV-oxidation various compounds could be detected using a Q Trap hybrid mass spectrometer. Exemplary a scheme of thirteen by-products for ciprofloxacin is shown. The toxicological evaluation showed no cytotoxic, genotoxic or mutagenic effects during and after the treatment of the two antibiotics. Additional experiments were performed with effluents of two different waste water treatment plants. 16 pharmaceuticals were detected in relevant concentrations. The ozonation of these effluents led to elimination rates between 77 and 99 %. No toxic effects could be detected even after an enrichment of the samples by a factor of 100. Comparing non treated and ozone or UV/ H_2O_2 treated samples no difference in their toxic properties were observed. This indicates that although transformation products were detected, the oxidation only resulted in non-toxic waters. Ozonation is a useful tool for the removal of persistent micropollutants from waste water treatment plant effluents. The developed test strategy for chemical and toxicological analysis will be used for evaluation of the formation of relevant by-products at three full scale applications.

5. Removal of 1,4-dioxane from landfill leachate by O_3 and O_3/ H_2O_2 process
Fumitake Nishimura, Hiroshi Tsuno, Eri Hasegawa, Kensuke Okuda
1,4-dioxane which has carcinogenicity is detected frequently at high concentration in landfill leachates. It is reported that some advanced treatment such as ozonation or advanced oxidation process is necessary to remove 1,4-dioxane. On the other hand, there is possibility to contain high concentration of chloride ion and several kinds of organic compounds in the leachates. When ozonation is applied in the presence of chloride ion, hypochlorite acid which is disinfectant and chlorate ion which is harmful for humans can be formed. In this study, treatment technology of landfill leachate by O_3 and O_3/ H_2O_2 process avoiding hypochlorite acid and chlorate ion formation was investigated. 1,4-dioxane was difficult to decompose by ozonation only, whereas the reaction rate increased about 10 times by O_3/ H_2O_2 process in which the removal ratio of 1,4-dioxane to consumed ozone was in the arrange between 0.50 and 0.75(mol-Dioxane/mol- O_3). It was also shown that the removal efficiency was decreased in the condition of neural pH and existence of highly reactive organic compounds with O_3 or HO radical such as formic acid. Hypochlorite acid and chlorate ion were not generated in the experimental conditions, whereas bromate ion was formed. It was also suggested that O_3/ H_2O_2 process can reduce bromate ion formation and it can accomplish effective removal of 1,4-dioxane with suppressing generation of by-products.

6. Monitoring of EfOM fractions along ozonation of conventional and MBR secondary effluents by LC-OCD
Oscar González, Ana Justo, Jordi Bacardit, Enrique Ferrero, Jorge Juan Malfeito, Carme Sans
Ozonation, which is recognized as reclamation treatment, was studied for treating secondary effluents from an activated sludge reactor and a membrane bioreactor, obtained from two different urban Wastewater Treatment Plants (WWTPs). Liquid Chromatography - Organic Carbon Detector (LC-OCD) technique was used to characterize the Dissolved Organic Matter (DOM) present initially as well as throughout the oxidation process in the effluents. The evaluation of the typical operational and characterization parameters was also carried out. The results obtained indicated a great performance for the elimination of high molar mass fractions (biopolymers and humics) during the first steps of the oxidation. The same efficiency was observed at the end of the process since final removals achieved for these fractions were above 90% for both the conventional activated sludge and the Membrane Biological Reactor (MBR) effluents. On the other hand, ozonation led to more biodegradable effluents due to the accumulation of each time simpler, more oxygenated and less unsaturated compounds such as Low Molar Mass (LMM) acids, especially obtained when ozonating MBR effluents (final concentration was almost 13 times the initial one). No variations in analyzed ions were observed except for the oxidation of NH4+ during the ozonation of the conventional effluent. Unlike what one would expect, the turbidity and pH increased during the ozonation process. A marked aromaticity decrease during the first

minutes of reaction was observed.

Session 9. Full scale applications – Part 5

1. Reconstruction of the largest WTP plant in the Czech Republic – ozone treatment system
Radka Hušková, Jiri Benes, Philip Page, Florian Axt
This paper is outlining the reconstruction of ozonization unit at the WTP Želivka (Czech Republic) and describes the way of ozone water mixing, experiences gained in design, start up and operation of a state of the art ozonization system. The Zelivka water treatment plant is the nation's largest site, completed in 1972, providing drinking water mainly for Prague. The site is currently serving approx. 73 % of Prague´s demand for potable water. Also, some regions of Central Bohemia are being supplied with water from the site. The site is currently operated by PVK, belonging to a VEOLIA Water group.

2. Full-scale Test of a Static Mixer Ozone Dissolution System
Michael A. Oneby, Michael Price, Michael G. Priest
Tests of an ozone dissolution system at an operating full-scale ozone facility provided relevant information on system performance, in particular gas/liquid mass transfer efficiency of ozone produced for potable water treatment. The ozone dissolution system consists of two ozone gas static mixer assemblies, each consisting of a rod-shaped stainless steel diffuser with a nominal 20 µm pore size upstream of five stationary mixing elements installed in a 350 mm (14-in) pipe spool. The ozone gas static mixers were installed in 2010, part of an ozone system with a nominal production capacity of 3.8 kg/h (200 lb/d). The ozone system is one process within a potable water treatment plant in the western US, using pre-ozonation for taste and odor (T&O) control and to replace chlorine as the preoxidant, reducing chlorinated disinfection byproducts. The potable water treatment plant has a production capacity of 1,300 m^3/h (8.3 mgd). Performance tests conducted on three separate site visits during the normal startup and commissioning of the ozone system at the water treatment plant. The test conditions varied over the full range of expected operating conditions, including ozone production range of 0.4 – 3.8 kg/h (20 to 200 lb/d) and ozone concentration range of 4 – 11%. All but a couple of test conditions fell within the specified design parameters of the static mixers. The transfer efficiency from test runs during the first two site visits varied from 74 – 94%. The third set of test runs were conducted after replacing the original 25 mm diameter diffuser with a 50 mm diameter diffuser. The transfer efficiency from third set of test runs, which closely mirrored test conditions of the first two sets, varied from 90 – 97%. Water temperatures dropped significantly in the interim between the second and third testing periods, from 17°C to 6°C, affecting gas solubility. The relative impact of solubility and was not investigated. Estimated power consumption of the ozone gas static mixer varies between 2.8 and 24 MJ/kg (0.35 – 3.0 kW·h/lb) ozone produced, depending on plant flow rate and applied ozone dose.

3. Retrofit of Intermediate Ozonation for Taste and Odour and Cyanotoxin Removal
Craig Jakubowski, Paul Thompson, Mike Brooks
The 40 ML/d Armidale Water Treatment Plant in the New England area of New South Wales, Australia, treats surface water from Malpas Dam to provide drinking water to a community of approximately 25,000 people. Since its commissioning, Malpas Dam has had a history of cyanobacterial (blue-green algae) events with generally at least one bloom occurring per year. Liver damage in the community in the 1980s was linked to high levels of Microcystis aeruginosa in the dam. Powdered activated carbon was employed for mitigation of taste and odours and as a barrier to cyanotoxins, however the system was considered unreliable, expensive and posed operational health and safety issues. An extensive process including technology reviews, bench and pilot testing identified intermediate ozonation and biological filtration as the preferred process barriers for taste and odours and cyanotoxins from the Malpas Dam supply. The intermediate ozonation system including air-preparation, ozone generation and ozone contacting was successfully integrated into the conventional process train, on a site with significant space restrictions. A design development process was undertaken prior to tendering which enabled key system features and operating regimes to be selected which removed water quality risk from the contractor, and gave the principal greater certainty in the technical and operational outcomes and project cost. The upgraded plant has achieved the intended water quality objectives and also provided a number of supplementary water quality and operational benefits. This paper describes the studies undertaken leading to the selection of intermediate ozonation and biological filtration as the preferred taste and odour and cyanotoxin barrier for Armidale Water Treatment Plant, along with a description of the final design, and presents performance data and lessons learnt regarding integration and operation.

4. Ozone implementation for drinking water in the Great Lakes basin
Saad Jasim, Michael Oneby, Gord Devine, Bill Mundy
The Great Lakes that is shared by Canada and the United States is the source of drinking water to approximately 40 million people in the two countries. Canada and the United States created the International Joint Commission (IJC) because they recognized that each country is affected by the other's actions in lake and river systems along the border. The two countries cooperate to manage these waters wisely and to protect them for the benefit of today's citizens and future generations. These lakes and rivers are used for many purposes. Communities and industries may get fresh water from them, allow waste water to drain into them, or use hydroelectric power generated by the flow of rivers. The implementation of ozone in both countries started to grow to deal with different challenges in that region. In Ontario, Canada, the application of ozone was used for disinfection in Windsor, taste and odour control and for improvement of treatment processes; while it was implemented for taste and odour control in Burlington, Oakville, and Mississauga, while the City of Toronto is upgrading and expanding the operation of one of its plants to include ozone. In the United States, the City of Milwaukee implemented ozone in its both plants after a major outbreak of Cryptosporidium in 1993. This paper will include a review and discussion for the application and success of ozone in these cities to address different water quality challenges. The successful application in these cities promoted the use of ozone in many other cities in the Great Lakes basin.

5. Successful Ozone System Operation at San Diego's Largest Water Plants with State-of-the-Art Controls
William O'Neil, Ben Kuhnel, Chris Schulz, Kerwin Rakness, Iraj Asgharzadeh
The city of San Diego (California, USA) began the process of upgrading its largest water treatment plants (WTPs), Miramar and Alvarado, in the mid 1980s. This included studies and pilot scale testing to evaluate water quality, existing conventional treatment process performance, new and pending regulatory requirements, and proposed upgrades. In 2000, the City

committed to retrofitting both WTPs with ozone while completing expansions of those plants. The Miramar WTP was expanded from 140 to 215 mgd with both pre- and settled water ozonation for pre-oxidation and primary disinfection, respectively. The Alvarado WTP was expanded from 120 mgd to 200 mgd with settled water ozonation for primary disinfection. This paper focuses on startup activities to bring equipment and control programming online at both plants, while the existing plants remained operational. The paper also presents ozone control strategies, including constant-concentration as implemented by the Ozone System Supplier (OSS), as well as a new hybrid constant concentration control. The latter was developed by Process Applications, Inc. (PAI) and refined via several coordination workshops between the designer, OSS and third-party integrator. Training activities included the use and refinement of ozone control simulators that also served as the basis for developing SCADA level controls and HMI screen configurations. The simulator allowed operators to evaluate process impacts based upon normal operator setpoint inputs and "what-if" scenarios, based upon abnormal operating conditions. A core team consisting of select city operators, CDM and PAI was created to develop standard operating procedures. The paper provides updates on the initial year of operation at both plants.

6. Effects of ozone on the removal and formation of Tastes and Odors in drinking waters: case studies
A. Bruchet
The examples discussed in this paper illustrate the many benefits of ozone for the elimination or prevention of various types of odors. By destroying phenolic compounds and iodides, ozone prevents the development of halophenols and iodinated THMs that impart medicinal odors. This type of odors is involved in a significant proportion of taste and odor episodes. The rapid and total transformation of iodides into the non reactive and non toxic iodates also presents the advantage of avoiding the formation of undesirable iodo acids. In order to avoid transient medicinal odors caused by halophenols such as 2,6-dibromophenol, operators must make sure that all the water flow gets correctly ozonated. By eliminating at least 50% of geosmin and MIB, ozonation is a necessary process within a multi-barrier approach to eliminate the most common types of natural odors encountered worldwide: earthy and musty. In countries that are allowed to use advanced oxidation for the treatment of surface waters, much better removal efficiencies can be achieved. Ozone is also quite efficient for the removal of various other odors often detected in raw waters such as septic, plastic, hydrocarbons, muddy and fishy odors. Concerning odors, the only minor drawback of ozone lies in the generation of aldehydes that impart orange-fruity odors. These odors are however quite easy to remove with post-GAC filtration.

Session 10. Process development and optimization – Part 3

1. Ozone disinfection: main parameters for process design in wastewater treatment and reuse
Valentina Lazarova, Marie-Laure Janex, Philippe Savoye
Wastewater disinfection by ozone was investigated at pilot and full scale on different wastewater effluents. It was demonstrated that water quality, and in particular suspended solids and organic content strongly influence the required ozone dose for a given level of disinfection. Nevertheless, the increase in contact time and residual ozone concentration did not improved the log removal of investigated microorganisms. Very low hydraulic retention times (2-4 min) are sufficient for efficient inactivation of indicator bacteria and viruses. As a consequence, the "Ct" approach commonly applied in drinking water treatment should not be used for wastewater ozonation. provided a sufficient ozone dose was transferred to the effluent. Therefore, the transferred ozone dose appears to be the critical parameter for the design of wastewater disinfection. Design parameters of ozonation have been proposed for various types of regulations and for effluents of different qualities.

2. Biodegradation of pre-ozonated chlorophenols using acclimated microorganisms
P. Guerra, T. Poznyak, A. García, I. Chairez, I. García-Peña
Chlorophenols are highly toxic compounds, which are present in many industrial effluents, so, it is necessary to develop methods to eliminate them. Biological treatments are cheap and environmentally friendly, but they require long time to eliminate pollutants and are limited by its toxicity and initial concentration. On the other hand, chemical treatments are able to decompose rapidly a wide range of toxic compounds, but they are more expensive than biological ones. Hence, an attractive alternative consists in combining chemical processes (like ozonation) with biological methods. The aim of this work was to evaluate the efficiency of biodegradation of the pre-ozonated and non-ozonated synthetic residual water with the chlorophenols concentration of 120 mg L^{-1} (CPhs) (4–chlorophenol (4-CPh) and 2,4–dichlorophenol (2,4– DCPh)). The complete experimental scheme involves: partial ozonation and a subsequent aerobic bioremediation using a mixed microbial consortium previously acclimated to respective carbon source. Results obtained show the significant reduction of the biodegradation time of pre-ozonated CPhs (10 days contrary 24hr). Best results were achieved with long ozonation times (30 min), since the CPhs and by-products of ozonation decomposition were observed and the major organic acids were accumulated. The organic acids are the carbon source preferred by microbial population.

3. Ozone-enhanced biological treatment of landfill leachates
Claudio Di Iaconi, Antonio Lopez, Achim Ried
Municipal landfill leachates are considered one of the types of wastewater with the greatest environmental impact because of high concentrations of ammonium, salts and organic matter. Usually, recalcitrant pollutants and ammonia removals represent the steps of greatest concern. An innovative process based on ozone enhanced biological degradation, carried out in an aerobic granular biomass system (SBBGR – Sequencing Batch Biofilter Granular Reactor), was tested at lab-scale for treating a typical medium-age landfill leachate. The results have shown that ozonation greatly improves the biological treatment effectiveness allowing the current limits for discharging into the sewer system to be met by using a specific ozone dose of 600 mg O_3/Linfluent; an operating cost of about 4 € per m^3 of leachate was obtained. A strong synergy between ozone and biological degradation was noticed with a O_3consumed/CODremoved ratio of about 0.6.

4. Textile wastewater treatment by ozone integration in a Sequencing Batch Biofilter Granular Reactor
Adriana Maria Lotito, Claudio Di Iaconi, Umberto Fratino, Annalisa Mancini
Effluents from textile industries are usually characterized by the presence of high quantities of different pollutants, which are often intentionally designed to resist degradation (for example dyes). Therefore, traditional methods based on the combination of biological and simple physico-chemical treatments are not able to remove these refractory compounds. Ozone integration in a

Sequencing Batch Biofilter Granular Reactor (SBBGR) could be considered as an optimal treatment. In fact, on the one hand, the setup of the biological reactor allows improving treatment stability and efficiency of this step. On the other hand, ozonation can be easily integrated, resulting in a synergic chemical and biological oxidation. This paper compares the results obtained in the treatment of a textile wastewater by SBBGR alone and after ozone integration with a low ozone dose (i.e., 40 mg/l). For the latter one, successful removal of all the monitored pollutants was achieved, with effluent concentrations amply below the limits for discharge in superficial water bodies. A strong synergic ozone-biological oxidation was noticed, with an ozone consumption of about one third of the chemical oxygen demand removed.

5. Revealing the Secrets Inside UV Oxidation Reactors: Mapping the Reactor Performance
Fariborz Taghipour, Siamak Elyasi
A new laser-based visualization technique was established to monitor concentration profiles inside UV advanced oxidation reactors. This method is based on a modified planar laser-induced fluorescence (PLIF) techniques, using a model organic contaminant. The technique provided significant information on the local and overall performance of UV photo-initiated oxidation reactors. An integrated model of reactor performance was developed to simulate the performance in the UV reactor by solving the governing equations of mass, momentum, radiant energy, and species conservation. The experimental information was applied to a comprehensive evaluation of the reactor performance model.

6. Measurement of the Fluence rate distribution in a UV reactor using a micro fluorescent detector: Influence of different reactor walls
Mengkai Li, Zhimin Qiang, Tinggang Li, James R. Bolton
The influence of ultraviolet (UV) reflection from inner walls is important for the accuracy of model predictions of fluence rate (FR) distributions and the enhancement of reactor efficiency. In this study, the FR distribution in a UV reactor with various reactor walls was determined in-situ by using a micro fluorescent silica detector. The test was performed in water with seven different UV transmittances from 65% to 99% and with reactor walls composed of aluminium foil (AF), stainless steel (SS), and black cloth (BC). The spectral reflection coefficient of each inner wall material was scanned by means of a spectrometer. The influence of highly reflective walls on reactor efficiency was evaluated using the measurement data. This work demonstrates that reflection of UV from inner walls can have a strong influence on the UV performance.

Session 11. Reaction study and modelling – Part 2

1. Efficiency and Mechanism on Decomposition of Diethyl Phthalate by Ozonation
Gang Wen, Jun Ma

2. Effect of wavelength on UV-degradation of N-Nitrosodimethylamine (NDMA)
Hiroshi Sakai, Koji Kosaka, Satoshi Takizawa

3. Calculation of UV-flux emitting by a Medium Pressure Mercury lamp
Alex Voronov

4. Mathematical Modelling of Aqueous Ozonation Processes
Alexey Ignatev, Alexey Pryakhin, Valery Lunin

5. ESVERA: A novel finite-volume-based UV lamp emission model
J. Esteban Duran, Fariborz Taghipour, Madjid Mohseni

6. Use of "large volumes" in Collimated Beam for study of byproduct formation in UV and UV/H_2O_2 processes
C.H.M. Hofman-Caris, D.J.H. Harmsen, B.A. Wols, E.F. Beerendonk, L.L.M. Keltjens, M. Heringa

7. Different ozone damages in *Escherichia coli* and *Salmonella enterica var. thyphimurium* applying low ozone concentrations in aqueous media
Irán Fernández, Mayra Bataller, Carlos Hernández, Elaine Sánchez, Yamelis Morales

8. Effect of pH on phenol ozonation and its toxicity in *Lactuca sativa* seeds
Clementina Rita Ramírez-Cortina, María Guadalupe Pérez-Ramirez, María Soledad Alonso-Gutiérrez

9. Physicochemical characterization of ozonated sunflower oil obtained by different procedures
Maritza F. Díaz, Yaima Sánchez, Magali Gómez, Márcia C. da C. Veloso, Pedro A. da P. Pereira, Antonio S. Mangrich, Jailson B. de Andrade

Session 12. Applications in Natural waters – Part 1

1. State of the Art - Removal and Production of Tastes and Odors by Drinking Water Ozonation
I. H. (Mel) Suffet, K. Weisenthal, G. Crozes, T. Chen, K. Z. Atasi, A. Bruchet
The formation and removal of taste and odor compounds caused by ozonation is explored. Specifically evaluated is the removal of earthy and musty odorants that effect many water supplies. A statistical design for optimized parameters of ozonation is presented. The formation of odors caused by ozonation is explored. The formation of phenolic odors, medicinal and by-products odors such as sweet or buttery/soapy/rancid are discussed and modeled. Water quality of drinking water source are unique and the parameters of the ozonation process must be evaluated in terms of a triad i.e., providing disinfection, minimizing hazardous by-products and removal and formation of tastes and odors.

2. Controlling the efficiency of ozone disinfection for the production of drinking water from surface water: can aerobic spore forming bacteria be a tool?
Eric Chauveheid, Julie Vancoppenolle, Claude Houbrechts
Aerobic spore forming bacteria (ASFB or hereafter named Bacillus spores) have been used as surrogate microorganisms to characterize the efficiency of the ozone disinfection stage at a conventional drinking water treatment plant. A weak seasonality of ozone disinfection efficiency was observed along the year for indigenous Bacillus spores, leading often to similar ozone

disinfection efficiencies in both summer and winter times, in disagreement with laboratory studies reported with reference strains of Bacillus subtilis spores. Therefore, we performed our own laboratory ozone disinfection study with local indigenous Bacillus subtilis spores. The kinetic experiments were accurately modelled by the integrated Chick-Watson model (with decaying ozone concentration) once the lag phase was over. While the temperature influence was similar to previous studies (described with the Arrhenius law), our indigenous Bacillus spores appeared less sensitive to ozone inactivation than reference strains of Bacillus subtilis spores studied previously. Results from our laboratory study were compared to observations made at the industrial ozonation stage, for similar ozone exposure. The seasonality of bromate concentration could not be used to assess the disinfection efficiency or exposure. Integrated ozone exposures estimated at the industrial ozonation stage showed that ozone inactivation of indigenous Bacillus spores was in good agreement with laboratory experiments at low temperature, but strong discrepancies appeared at higher temperature. Therefore, so far published laboratory experiments with ozone inactivation of resistant microorganisms might not be fully transposed to industrial ozone applications.

3. Kinetics and Mechanisms of N-nitrosodimethylamine formation upon ozonation of N,N-dimethylsulfamide-containing waters: Bromide catalysis
Urs von Gunten, Elisabeth Salhi, Carsten K. Schmidt, William A. Arnold
N-nitrosodimethylamine (NDMA) formation from dimethylsulfamide during ozonation is a bromide-catalysed reaction. The kinetics are controlled by the oxidation of bromide to hypobromous acid (HOBr) which reacts with DMS to form Br-DMS. Once this species is formed, NDMA formation proceeds quickly by ozone attack, loss of bromide and extrusion of SO2 with an overall yield of 54%. As a side reaction nitrate is formed with a yield of 39% based on the primary amine group of DMS.

4. Disinfection of seawater- application of UV and ozone
Ywann Penru, Andrea Raquel Guastalli, Santiago Esplugas, Sylvie Baig
Ozone and ultraviolet technologies are proposed as potential disinfecting agent for seawater. Ozone doses were applied in the range 0.38 to 4.89 mg $O_3.L^{-1}$. They permit to observe a complete disinfection as well as UV doses superior to 320 $J.L^{-1}$. Impacts of both processes on organic matter were also studied. UV absorbances were reduced in both cases but in higher proportion using ozone (up to 50% removal). Total organic carbon and biochemical oxygen demand (BOD) were slightly reduced by UV radiation while ozonation achieves up to 10 % mineralization of TOC. Ozone reaction proceeds with BOD increase. Seawater ozonation in addition leads to residual oxidant formation, mainly hypobromous acid at concentration increasing with ozone dose. Those secondary oxidants show an inhibition effect on autochthonous microorganisms so that their formation upon ozonation can represent an advantage for long-term disinfection to prevent microorganism activity. This study contributes to show the potential use of ozone and ultraviolet technologies for seawater disinfection and also to better understand their impact on organic matter.

5. Minimization of chlorinous odor and bromate ion formation by ozonation and Advanced Oxidation Process (O_3/H_2O_2 process) with an ozone bubble contactor
Songkeart Phattarapattamawong, Satoshi Ishihara, Shinya Echigo, Sadahiko Itoh

6. Oxidation of taste and odor compounds and bromate formation during ozonation and the advanced oxidation process O_3/H_2O_2
Holger Lutze, Andreas Peter, Hans-Peter Kaiser, Urs von Gunten

7. Characterization of by-products issued from ozonation of Acetochlor
Yasmine Souissi, Sophie Bourcier, Michel Sablier, Véronique Boireau, Valérie Ingrand, Pascal Roche, Stéphane Bouchonnet

8. Ozonation of benzotriazoles
Holger Lutze, Andreas Peter, Urs von Gunten, Walter Giger, Hans-Peter Kaiser, Clemens von Sonntag, Torsten C. Schmidt

Session 13. UV source technologies

1. Comparison of different long life coating technologies in low pressure mercury lamps
A. Voronov, B. Jung, V. Adam
Amalgam lamps have significantly higher power density and UVC-output in comparison to the standard mercury lamps, including so called High Output Mercury lamps. However, this leads to reduced lifetime of the lamp due to the fast formation of a mercury oxide layer on the inner surface of the quartz tube. This layer absorbs the UVC radiation and results in the lamp UVC output degradation. In order to prevent the mercury oxide formation some different protective coating technologies of the quartz surface have been developed by many amalgam lamp manufactures. In this paper an analysis of the coating technologies is presented. Also, a comparison of lamps in terms of lifetime was conducted with different coatings. It is shown that only a completely closed protective layer is able to provide a stable UVC-output up to 20,000 hrs. Coatings based on nano-particles can only properly stabilize the UVC-output up to 10,000 hrs.

2. Some observations concerning the efficiency testing of low pressure and low pressure high output UV lamps
Michael J. Santelli, James R. Bolton, William Lubarsky
The IUVA Protocol for the efficiency testing of UV lamps requires some modifications to account for reflection and for imperfect radiometer detector angular response. In this research, it has been demonstrated that if reflection of UV from walls and other surfaces is not accounted for, the detector reading can be as much as 8% too high. A procedure is recommended whereby a slotted mask is placed in front of the lamp at a distance at least 25% of the lamp length.In a second set of experiments, by using a small hole moved across a slotted mask, the angular response of the detector was determined. In the case analyzed in this example, the radiometer detector response fell off at a rate greater than the expected cos2 □ dependence. From the data, it was possible to determine a correction factor (4.2%) that would correct the detector to that with a perfect angular response.

3. Microwave UV comes to Texas?
Meera Victor, Andrew Salveson, Dolan McKnight, Ken Wesson
The North Texas Municipal Water District (NTMWD) is looking to install ultraviolet light (UV) disinfection at the Floyd Branch Regional Wastewater Treatment Plant (Floyd Branch). Treatment plant staff is intrigued by the performance and ingenuity of the latest microwave UV reactor manufactured by Severn Trent Water Purification (Severn Trent), the MicroDynamicsTM UV

System. Before including the MicroDynamicsTM UV System as one of several qualified bidders for their project, and because the technology is relatively new in the marketplace, the NTMWD required that Severn Trent provide and test a pilot at no cost to the NTMWD. As a result, Severn Trent contracted Carollo Engineers, P.C. to oversee pilot testing at Floyd Branch. NTMWD agreed to assist with daily monitoring, including field inspections and laboratory work (UV transmittance and E. coli monitoring). There is an important secondary goal to this pilot testing. Previously, the consulting firm Hytecon conducted a detailed bioassay of the MicroDynamicsTM UV System at the Downingtown Wastewater Treatment Plant. This detailed bioassay examined the disinfection of T1 coliphage, a surrogate for coliform. Carollo has analyzed the data from the Downingtown testing and compared those results to the results at Floyd Branch. The goal of the comparison is to determine the accuracy and appropriateness for designing a MicroDynamicsTM UV System based upon the more expansive and detailed Downingtown testing. The important underlying question is whether detailed pilot scale testing at one site can be repeated at other locations. The testing included concentrated short term testing of performance as well as longer term monitoring over a period in excess of 2 months. Testing also included an analysis of performance of the automatic physical wiping system to maintain sleeve transmittance.

4. Inactivation of pathogenic and heat resistant microorganisms in milk by a non thermal UV treatment system
Rudean van Wyk, Pieter A. Gouws
UV processing is a disinfection method used for various foods and beverages and related products but this process is least studied. Its capability to inactivate microorganisms is greatly due to the exposure of UV-C with the germicidal range between 250 and 260 nm. This ionizing radiation causes dimers to form between the pyrimidine bonds in the DNA molecule resulting in the replication and transcription process being blocked, leading to cell death of bacteria, fungi, moulds and viruses. In this study, the efficiency of UV-C radiation technology as a novel process in the inactivation of food-borne pathogens in milk was determined. Milk was inoculated with cultures of Salmonella spp., Bacillus spp., B. sporothermodurans, B. subtilis and E.coli K12 and were treated with UV at dosages between 0 and 13400 $J.l^{-1}$ at a flow rate of 4000 $l.h^{-1}$. Samples were drawn after each UV dosage and microbiologically tested. Bacillus is considered as some of the most heat resistant organisms that can potentially contaminate milk. In the inoculation trials, the initial total viable count in the milk was 106 $cfu.ml^{-1}$. The UV system was able to achieve a mean 3-4 log10 reduction for the Bacillus and up to a mean 5 log10 reduction for E.coli K12 and Salmonella spp. The UV-C radiation system was able to achieve microbial reduction in milk similar to that achieved with pasteurization. These results suggest that UV-C treatment at 254nm decreased microbial levels to an acceptable level. This UV technology could be used as an alternative or adjunct to conventional pasteurization technology in conjunction with good manufacturing and agricultural practices.

5. Considerations in the design and competitive bidding of electrical feed systems for UV units
Arne Fareth, Jae Kim, Jami Walsh, Eduardo Amaba, Robert Jarnis, Edward Barbo

6. Influence of quartz sleeve type on medium pressure UV system performance
Christian Bokermann, Ronnie Bemus, Harold Wright

7. Method for measuring the UVC-output of low pressure germicidal lamps
Sobur Denis, Sergey Kostuchenko, Dmitry Sokolov, Leonid Drozdov, Michiel van der Meer, Hans Maes, Fred van Lierop

Session 3. Industrial applications – Part 3

1. Nitrogen oxides ozonation as a method for NO_X emission
Stanisław Ledakowicz, Kinga Skalska, Jacek S. Miller, Marcin Wilk
Attempts to develop new technologies of reduction of NOx emission are still carried out all around the world. However, most of them as literature survey [1] suggests is focused on NOx emission control from power plants and mobile vehicles. Fewer investigations are conducted on the NOx emission abatement from chemical industry. One of the relatively new approaches is the application of ozone injection into exhaust gas stream followed by absorption process. Ozone is used to transform NOx to higher nitrogen oxides which are better soluble in water and therefore the higher yield of nitric acid is expected. The main objective of this paper is to present results of our studies in which the effectiveness of the ozonation process, as well as the dependence of the conversion rate and the selectivities of NO ozonation into NO_2, N_2O_5 and HN O_3 on the residence time of reagents in the reactor space were studied. Results of laboratory investigations were confirmed during ozonation experiments with real exhaust gases from nitric acid pilot plant in Fertilizers Research Institute in Pulawy, Poland.

2. Powerful impulse UV irradiation for purification of airflows containing bacterial spores
V.I. Sigaev, S.G. Shashkovsky, V.P. Arkhipov, I.A. Zhelaev, S.N. Uspenskaya, A.N. Varfolomeev, E.V. Zvyagina
Dynamics of the processes of Bacillus subtilis spores inactivation by UV irradiation from impulse xenon lamps of continuous spectrum in UV dynamic units was studied. Various operating conditions were used. UV irradiation volume doses in the range 406-813 J/m^3 were established to provide 3-4-order decrease of Bacillus subtilis spores concentration compared to the initial level.

3. Smog in Hong Kong: Statistical analysis on historical database
Jane Wei-Zhen Lu, Xiekang Wang
Population and road traffic densities in Hong Kong are among the highest in the world. As a result of increasing road traffic, vehicle emissions have become the main source of air pollution besides industrial pollution. Air pollution seriously threatens public health, economy, and social wellbeing of Hong Kong residents. Recently, the smog problem and the reduced visibility have been a pressing topic of air pollution in Hong Kong. Two types of smog, i.e., photochemical smog, and combination smog of smoke and fog, often occur in Hong Kong territory. Many districts in Hong Kong are failing to meet statutory health standards for air quality, and the associated costs to individuals, businesses and society are estimated to be in the billions of dollars each year. This study, based on historical database analysis, aims to give comprehensive reviews of smog and its impact factors including the pollutant levels, the urban conditions, and the control strategies to reduce and control major air pollutant levels in Hong Kong.

4. Ozone - From Pen and Paper to Bubbles in Water
Ben Kuhnel, Jeremy Metts, Robert Hoffman, Ed Fordan, Iraj Asgharzadeh
The City of San Diego has recently completed construction and startup of the 200 million gallon per day (mgd) Alvarado Water Treatment Plant (WTP). The inclusion of ozone in the plant was part of a process that took many years, from the initial conceptualization of using ozone to the actual day that ozone was bubbled into the water to provide primary disinfection and taste and odor benefits. Prior to making the choice to use ozone, the plant's water quality was analyzed to determine if ozone was the right choice. This included evaluating the disinfection and treatment goals of the facility and comparing them to the benefits of ozone technology.

Session 12. Applications in Natural waters – Part 2

1. Can UV Protect the Public from Adenovirus in Drinking Water?
Karl G. Linden, Karl Scheible, Phyllis Posy
Adenovirus is known to be resistant to UV disinfection when low pressure (LP) UV lamps emitting monochromatic UV light at 254 nm are used. However, recent research has proven that medium pressure (MP) lamp UV systems are much more effective for inactivation of this virus at an equivalent LP UV dose. The fact that the EPA required UV dose for all viruses is based on the dose-response of adenovirus under LP UV viruses puts an undue burden on systems aiming for virus inactivation with UV light. The dose requirements for virus inactivation for UV systems that use MP UV lamps should be reconsidered in light of these recent findings.

2. Sustainability Analysis for the Implementation of an Ultraviolet Disinfection System in a Low-Income Community
Mario A. Zapata, James R. Bolton, Mohamed Gamal El-Din
Water is a fundamental element for the conservation and maintenance of life on Earth; however, polluted water can be the cause of several diseases, including diarrheal diseases that claim the lives of 2.2 million children under 5 every year. Ultraviolet (UV) light is increasingly being proven as a reliable alternative for disinfection of drinking water in several developed countries, but its feasibility in low-income areas has to be further assessed. The rural community of Cerro Grande in Santa Cruz, Bolivia, has experienced outbreaks of gastrointestinal diseases as a result of the absence of a safe drinking water source. Therefore, a fabricated prototype, as well as a commercially-available UV-based disinfection unit, was installed in the community. The prototype included materials readily available in Bolivia and was equipped with accessories to make its operation and maintenance simple and inexpensive. The prototype was verified against the requirements given by the U.S. Environmental Protection Agency guidelines, and its UV dose delivery was modeled using a joint computational fluid dynamics/fluence rate distribution model. Both units were powered using photovoltaic cells because of a lack of a reliable electricity source. Field observations demonstrated that it is financially feasible to implement UV systems in low-income communities, since the monthly cost is within reach of the residents (around US$ 2 per month per household), with served population sizes ranging from 20 to 48 households. However, a challenge to achieve a mass implementation of these systems in low-income communities is the capital cost, so UV-based disinfection systems should be considered more suitable to be implemented as centralized systems in the communities than in individual households.

3. Photocatalytic Reduction of Nitrate in Water Using Commercial Titanium Dioxides
Paul Westerhoff, Kyle W. Doudrick
A series of titanium dioxide commercial nanomaterials including Evonik P25, Evonik P90, and Hombikat UV-100 were characterized and tested for nitrate reduction capability in an ultraviolet light photoreactor. These commercial materials, rather than custom synthesized titanium dioxide catalysts, are becoming more widely used for pollution abatement. Coupled with formic acid as a hole scavenger, these titanium dioxide catalysts were found to selectively reduce nitrate to non-aqueous nitrogen by-products in nanopure water. In all matrices, P90 outperformed the other catalysts with removals as high as 77% at the maximum irradiance level used (6.46x1022 photons/L). Similar to P25, P90 is a mixed-phase photocatalyst consisting of anatase and rutile. P90's increased activity over P25 is attributed to a smaller crystal size (12 vs. 16 nm) and consequently, a larger surface area (104 m^2/g vs. 51 m^2/g). Although Hombikat has a very small anatase crystal size (6 nm) and a large surface area (403 m^2/g), it reduced little to no nitrate. The greater efficiencies of P25 and P90 were attributed primarily to the mixed-phase nature of the catalysts allowing improved charge separation, and secondly to their crystal size and surface area. Silver was loaded onto P90 and Hombikat to highlight the importance of charge separation. With the use of silver as a co-catalyst the nitrate reduction efficiency for P90 was improved three-fold and Hombikat went from showing no activity to being able to reduce nitrate effectively.

4. Advanced Treatment for Impaired Water Supplies: When AOPs are the Best Option
James Collins, Christine Cotton

Session 12. Applications in Natural waters – Part 3

1. Influence of applied extraction method and genotoxicity test on detection of genotoxic by-products after UV-oxidation treatment of water
Minne B. Heringa, Erwin F. Beerendonk, Roberta H.M. Hofman, Leo.L.M. Keltjens
Previously, we have reported on the detection of increased genotoxic activity in water after UV-oxidation treatment, as measured after water extraction with Oasis HLB solid phase extraction (SPE) columns and analysis with the Ames II mutagenicity test (Heringa et al., IUVA 2009, WQTC 2009, Water Research, in press). No genotoxic activity was measured in the same samples in the Comet assay, which is a complementary genotoxicity test to the Ames II test, detecting different DNA damage and thus different genotoxic compounds. In contrast, Penders et al. (IUVA 2009) found no genotoxic activity in UV-oxidated water from one of the same sources after water extraction with XAD and analysis with the classic Ames test. They did find an increased genotoxic response in the gill cells of fish exposed to this treated water, analyzed with the Comet assay. Metz et al. (WQTC 2009) also reported an increase in genotoxic response after UV-treatment with an oxidation-level dose, in the Comet assay with a Chinese hamster ovary (CHO) cell line. This was also one of the same sources as in the Heringa et al.

study, but Metz et al. extracted the water with XAD. These reports indicate that the choice of extraction method and of the genotoxicity test may have a crucial impact on the outcome of the analysis. We therefore aimed to investigate the influence of the applied extraction method and genotoxicity test on the detection of genotoxic by-products of UV-oxidation of water

2. Byproduct formation and advanced genotoxicity testing to characterize the potential harmful side effects of chemical oxidation and disinfection
Bram J. Martijn, Joop C. Kruithof
Since Rook showed the production of trihalomethanes by drinking water chlorination, byproduct formation by chemical disinfection/oxidation has been investigated thoroughly. Originally the focus was on the identification of individual organic byproducts. For chlorine THM's, HAA's and many other halogenated compounds were found. For ozonation, UV and advanced oxidation, biodegradable organic byproducts such as carboxylic acids were identified. Formation of inorganic compounds proved to be an important issue for these processes as well. By ozonation and ozone based advanced oxidation processes bromate was formed in bromide rich water. After UV and UV/ H_2O_2 treatment, nitrite was found in nitrate rich water when medium pressure UV lamps were applied. In addition to the determination of individual byproducts the side effects of disinfection/ oxidation were characterized by genotoxicity testing. After chlorination a high response was found in the classic Ames test. After ozone, UV and advanced oxidation no significant increase was found for both the classic Ames test and the Comet assay. State of the art in vitro genotoxicity assays (classic Ames, Comet) are not sensitive enough to give a response when exposed to drinking water directly and require concentration of the water sample. Major drawback of concentrating water samples is the potential loss by inadequate adsorption of (hydrophilic) compounds. More advanced and sensitive genotoxicity testing is needed. Modified mutagenicity tests such as in vitro Ames-II and Comet assay and in vivo SCE and Comet assay have been developed and applied on UV/ H_2O_2 treated water. In orientating research efforts contradicting effects were found. Additional data are needed to characterize the side effect of UV and UV/ H_2O_2 treatment. Worldwide use of UV/ H_2O_2 treatment has increased strongly. It is generally accepted that the water matrix plays an important part in the economics. Also the water matrix has a strong impact on the byproduct formation by chlorination and ozone based processes. The impact of the water matrix on byproduct formation by UV and UV/ H_2O_2 treatment is not clear yet. In addition to classic Amestest and Comet assay data, more information with recently modified toxicity tests should be gathered.

3. UV Disinfection of Stormwater Overflows and Low UVT Wastewaters
Jennifer Muller, Wayne Lem
Ultraviolet (UV) light is used for disinfecting many types of waters including low quality waters like primary treated wastewater and combined sewer overflows (CSO). Combined sewer systems are sewers that are designed to collect rainwater runoff and domestic wastewater in the same pipe. Most of the time, combined sewer systems transport all of their wastewater to a sewage treatment plant, where it is treated and then discharged to a water body. During periods of heavy rainfall or snowmelt, however, the wastewater volume in a combined sewer system can exceed the capacity of the municipal wastewater treatment plant. For this reason, combined sewer systems are designed to overflow occasionally and discharge excess wastewater directly to nearby streams, rivers, or other water bodies. These overflows, called combined sewer overflows (CSOs), contain not only stormwater but also raw sanitary wastewater. CSOs may be thought of as a type of urban wet weather discharge. As untreated (or partially treated) effluent flows directly into the river or water bodies, the receiving body can be microbiologically disturbed for months before the river and marine ecosystem recovers. For this reason, treatment of CSOs is becoming a regulatory requirement in many regions in order to protect receiving water bodies and the ecology within those areas.

4. Establishment of a model system for control and prevention of biofouling by UV radiation in water flow systems
Hadas Mamane, Liron Friedman, Eli Margalit, Tali Harif, Eliora Z. Ron

5. Genotoxicity of drinking water treated with different disinfectants and effects of disinfection conditions detected by umu test
Liu Wenjun, Liu Qing, Zhang Liping, Nie Xuebiao, Sun Wenjun, Cui Lifeng

6. A study of by-product formation and toxicity due to LP UV disinfection of ballast water
Liu Wenjun, Sun Wenjun, Liu Che

Session 14. UV for Aquatics

1. Effects of UV_{254} Irradiation on Residual Chlorine and DBPs in Chlorination of Model Organic-N Precursors in Swimming Pools
ShihChi Weng, Ernest R. Blatchley III
Ultraviolet (UV) irradiation is commonly applied as a secondary disinfectant in chlorinated pools. UV-based systems have been reported to yield improvements in swimming pool water and air chemistry, but to date these observations have been largely anecdotal. The objective of this investigation was to define the effects of UV irradiation on chlorination of important organic-N precursors in swimming pools. Creatinine, L-arginine, L-histidine, glycine, and urea, which comprise the majority of organic-N in human sweat and urine, were selected as precursors for use in conducting batch experiments to examine the time-course behavior of several DBPs and residual chlorine in the presence and absence of UV254 radiation. UV254 irradiation promoted formation or decay of several chlorinated N-DBPs and also increased the rate of free chlorine consumption. UV exposure resulted in loss of inorganic chloramines (e.g., NCl3) from solution. CH_3NCl_2 formation from creatinine was promoted by UV exposure, when free chlorine was present in solution; however, when free chlorine was depleted, CH_3NCl_2 decay was observed. $CHCNCl_2$ formation (from L-histidine and L-arginine) was also promoted by UV254 irradiation, as long as free chlorine was present in solution. Likewise, UV exposure was observed to amplify CNCl formation from chlorination of L-histidine, L-arginine, and glycine, up to the point of free chlorine depletion. The results indicate that UV_{254} irradiation promotes several reactions that are involved in the formation and/or destruction of chlorinated N-DBPs in pool settings. DBP enhancement was consistent with a mechanism whereby a rate-limiting step in DBP formation was promoted by UV exposure. Promotion of these reactions resulted in increases of free chlorine consumption rates.

2. Nitrogen trichloride levels in air in chlorinated indoor swimming pools treated by medium-pressure UV radiation
Delphine Cassan, Béatrice Mercier, Françoise Castex, André Rambaud

The air of swimming pools induce irritations of users because the presence of chlorine by-products. Among them the nitrogen trichloride (NCl_3) must be maintained less than 0.5 mg m-3. Recently in June 2010, French National Agency for Food Safety, the Environment and Labour recommend to reduce this level to 0.3 mg m-3. The aim of our study was to determine the NCl3 levels in air in chlorinated indoor public pools (competition and recreational pools) treated with medium-pressure UV lamps (MP UV) installed on the water circuit during a four weeks-period. The first week, which served as control, MP UV were turned off, and kept on 24 h per day during the next three weeks. The third week, water renewal volume was reduced by 58% and the last week the chlorine demand was also reduced. There were neither air renewal neither dehumidifier. Daily, three samples of air at 10 cm (NCl_3(10)) and at 160 cm (NCl_3(160)) of the floor surface over each pool were collected and NCl_3 were measured. Our results showed that MP UV radiation decrease significantly ($P < 0.01$) by 14 to 32% the NCl_3(10) levels of the competition pool. The mean levels of NCl_3 are classed as follow: recreational pool (10 cm) > 160 cm > competition pool (10 cm). The air renewal did not influence the NCl_3 air levels because it was out of order. Our results show that, in this swimming pool, children are more exposed to NCl_3 than lifeguards and swimmers. Chlorinated compounds like NCl3 are potentiel risks for chlidren's health (Bernard et al, 2003). Moreover, children are more exposed to chlorinated compounds than lifeguards due to the particular conditions of bathe (hotter water, not very deep basin supporting a stronger chloramine concentration), their physiological characteristics (lung maturation, oral breathing, more permeable skin) or behavioral (larger water ingestion). In this study, swimmers are less exposed to NCl_3 than lifeguards or children, however repeated exposure to chlorinated compounds increase the incidence of the allergic diseases, subclinical sensitization to aeroallergens, disorders of the cellular immune system, and bronchial hyperresponsiveness in competitive swimmers (Zwick et al., 1990). This study presents the first data on nitrogen trichloride levels of chlorinated indoor public pool (competition and recreational pool) treated by medium-pressure UV lamps installed on the water circuit. This treatment is the unique factor of the decrease in NCl_3 levels. The decrease of the NCl_3 is a determining factor to reduce the irritations particularly for the swimmers.

3. Validation of UV reactors for recreational waters
O. Karl Scheible, Chengyue Shen, Ernest R. Blatchley III
Validation of the performance of UV reactors has become standard practice for drinking water and wastewater reuse applications. This has been driven by regulatory requirements in the United States and Europe, with specific protocols developed for such validations. The Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) requires that reactors are validated at full scale in order to be assigned credit for Cryptosporidium, Giardia and virus inactivation. The rule is supported by the Ultraviolet Disinfection Guidance Manual (UVDGM), which provides guidance on the conduct and interpretation of validation testing for commercial reactors. In the reuse arena, the primary validation protocol has been found in the NWRI/AwwaRF UV Design Guidelines for Reuse and Drinking Waters. UV has been widely applied in swimming pool applications, often for removing chloramines via photooxidation. However, Cryptosporidium outbreaks at recreational facilities such as spray parks have resulted in some jurisdictions requiring the use of UV, and that such systems be validated for RED and log-inactivation performance. A key example is the New York State Department of Health regulation that all spray park water systems have UV installed and operating. Further, these systems have to use reactors that have been validated per UVDGM protocols. A minimum MS2 RED of 40 mJ/cm^2 is required at all times. The performance validation follows a minimum intensity setpoint approach, expanded to allow development of a sensor-flow relationship that meets the minimum dose requirement.

4. UV Technology in Aquatics Applications
Ismail Gobulukoglu, Ken Haagsma

Session 15. Ozone generation

1. Revolutionary Pinnacle Ozone System Design – Compact, Efficient, Reliable, Intelligent
Charles E. Bud Leffler, Bud Francis, Chuck Smith, David Carpenter
Ozone generation technology now has the opportunity to become the number one disinfection treatment method in the world. When talking to engineers and owners of large ozone treatment systems, they believe that current large scale ozone generation technology is expensive to own, operate, requires a lot of maintenance and is very complex to integrate into the application process. Most, if not all, large ozone systems contain glass tubes and fragile components that are sensitive to breakage, power surges and require extensive maintenance. Even large ceramic ozone generation components are subject to problems with vibration and system changes. At Pinnacle Ozone, we realized that the next generation technologies needed to take a substantial leap forward to overcome many of the limitations of current corona discharge, glass tube driven designs. Specifically, we found CD generation technologies not easily scalable to meet the frequent fluctuations of modern day water and waste water processes. Pinnacle's founding members designed a new process adaptable ozone generation system that brings ozone technology into the digital era through intelligent process monitoring of real-time process and hardware conditions. We looked at all ozone generation processes from oxygen generation, ozone supply dynamics, to injection processes. We thoroughly investigated how the system could better interface into other AOP processes.

2. High Efficient Ozone Production with Excimer Lamps
Rainer Kling, PhD.; Mark Paravia, PhD., Markus Roth, PhD.
With efficient pulsed Excimer lamp VUV radiation an ozone generation yield of 82g/kWh could be reached at a 400l/h dry air flow. This result is scalable. For user-friendly Ozone generation instant on – off and no NOx generation are beneficial. With pulsed Excimer lamp operation ozone production rate is more than twice as high as conventional table-top ozone generators with dried ambient air use.

3. Inhomogeneous Feed Gas Processing for Cost Effective Ozone Generation
Fabio Krogh, Daniel Meier, Bernhard Paolini, Alfred Freilich, Jose Lopez
Upcoming European legislations will set higher constraints to the allowed residual concentrations for known and emerging pollutants present in treated water. For emerging pollutants, which show smaller reduction rates in concentration by direct oxidation processes, higher oxidant doses during water treatment are expected, or radical oxidation processes needed. Consequently, an increase in demand for ozonation plants working with higher ozone concentration and lower operational costs

is expected. In this paper the different cost factors affecting capital and operational costs of an ozonation plant are reviewed. Subsequently the ad-hoc ozone synthesis technology called Intelligent Gap System (IGS-Technology) developed by Degrémont Technologies LDT is shown and its improvements in terms of specific power consumption reduction and increase of maximal ozone concentration are highlighted. IGS-Technology achieves an increase in ozone synthesis efficiency of 10% compared to standard Degrémont Technologies' AT LG Technology and increases the maximal stable ozone concentration to 14wt.% for large-scale generators. Through a case study of five different ozonation plants equipped with IGS-Technology the savings on operational costs are shown, by comparing performances on site with inferred performances of same plant but equipped with AT LG Technology. Results show that the specific energy consumption (Es) per kilogram ozone produced is reduced of about 10% and operational costs savings are ranging between 1.8% and 14.7% depending in which market regions were calculated.

4. Microwave Powered Ozone Generator – Concept and Initial Test results
Jaromir Bilek, Richard Little, Russel Sion
This paper discusses a new proprietary concept in Ozone generation and presents results of initial testing of the concept.
UV lamps are one of the means to generate ozone although the efficiency of this process is debatable. Simple microwave generators can be used to excite multiple electrode-less UV lamps and, in the specific and patent pending method described in this paper, the way this is done optimises 185nm UV ozone generation effect whilst reducing the unwanted Ozone breakdown by UVC at 254 nm, thus maximising ozone output. Efficiency is improved and the use of simple mass market components reduces the cost of generation very considerably for small generators of up to 2 kW. The theory behind the device will be explained, the detail of construction and energisation will be presented as will the test results of a working prototype system.

5. Ozone Cost Implications from Oxygen Supply – Advantages of VSA Technology
David Schneider, Soeren Schmitz

Plenary Session. Awards and Closing

Awards Ceremony

IOA Awards
Morton J. Klein Medal of Excellence
W. Masschelein Prize for Research of the European-African-Asian-Australasian Group
Harvey M. Rosen Memorial Award for the best paper published in Ozone Science & Engineering

IUVA Awards
Lifetime Achievement in UV Science and Engineering
UV Engineering Project of the Year (2009-2010)
Green Innovation in UV Science and Engineering
Best UV Paper of the Year (2009-2010)
Classic UV Paper (any year)

Congress Awards for the Best Student Paper/Poster Award

Synthesis and Conclusions

Announcements

ANTICIPATE THE NEXT WORLD CONGRESS WHEN? 2013 WHERE?