

# Ozone: Supporting Sustainability

International Ozone Association  
Pan American Group

August 24-27, 2008

Orlando, Florida  
Disney's Coronado Springs Resort



## Abstracts of Oral Presentations & Schedule of Events

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# International Ozone Association - Pan American Group

## Conference Schedule at a Glance IOA Orlando - 2008

### Saturday, August 23<sup>rd</sup>, 2008

**10 AM - 5 PM**

IOA International Committee Meetings, *Yucatan 1*

**NOON - 1:30 PM**

IOA International EOC Luncheon, *Monterrey 2 & 3*

**11 AM - 5 PM**

IOA PAG Task Force Meetings, *Yucatan 2*

### Sunday, August 24<sup>th</sup>, 2008

**7:30 AM - 4:30 PM**

Ozone Basics & Applications Workshop, *Coronado E-G*

**NOON - 1:00 PM**

Ozone Basics Luncheon, *Monterrey 2 & 3*

**9 AM - 1:30 PM**

IOA PAG Board Meeting, *Yucatan 1 & 2*

**1:30 PM - 4:30 PM**

IOA International Board Meeting, *Yucatan 1 & 2*

**7 PM - 9 PM**

WELCOME - 2008 Opening Reception,  
*Monterrey and La Mesa Patio*

### Monday, August 25<sup>th</sup>, 2008

**8:15 AM - 9:30 AM**

General Opening Session, *Coronado L*

**9:30 AM - 10:15 AM**

Coffee Break, *Coronado K in Exhibit Hall*

**10:15 AM - 11:55 AM**

Session 1 - Drinking Water Process I, *Coronado L*  
Session 2 - Equipment - Air & Surface Treatment,  
*Coronado J*

**NOON - 1:15 PM**

Conference Luncheon, *Coronado K*

**1:20 PM - 2:35 PM**

Session 3 - Drinking Water Process II, *Coronado L*  
Session 4 - Air & Surface Treatment - Agri-Food  
Applications, *Coronado J*

Session 5 - Medical Applications, *Coronado M & N*

**2:35 AM - 3:20 AM**

Coffee Break, *Coronado K in Exhibit Hall*

**3:20 PM - 5:25 PM**

Session 3 - Drinking Water Process II, *Coronado L*  
Session 4 - Air & Surface Treatment - Agri-Food  
Applications, *Coronado J*

Session 5 - Medical Applications, *Coronado M & N*

**5:30 PM - 7:00 PM**

Exhibitor Reception, *Coronado K in Exhibit Hall*

### Tuesday, August 26<sup>th</sup>, 2008

**8:15 AM - 9:30 AM**

Session 6 - Wastewater Treatment and  
Industrial Applications, *Coronado J*

Session 7 - Drinking Water Process III, *Coronado L*

Session 8 - Aquatic Animal Life Support,  
*Coronado M & N*

**9:30 AM - 10:15 AM**

Coffee Break, *Coronado K in Exhibit Hall*

**10:15 AM - 11:55 AM**

Session 6 - Wastewater Treatment and  
Industrial Applications, *Coronado J*

Session 7 - Drinking Water Process III, *Coronado L*

Session 8 - Aquatic Animal Life Support,  
*Coronado M & N*

**NOON - 1:15 PM**

Conference Luncheon, *Coronado K*

**1:20 PM - 2:35 PM**

Session 9 - Advanced Oxidation Technologies,  
*Coronado J*

Session 10 - Drinking Water Process IV, *Coronado L*

Session 11 - Workshop, Aquatic Animal Life Support,  
*Coronado M & N*

**2:35 AM - 3:20 AM**

Coffee Break, *Coronado K in Exhibit Hall*

**3:20 PM - 5:00 PM**

Session 9 - Advanced Oxidation Technologies,  
*Coronado J*

Session 10 - Drinking Water Process IV, *Coronado L*

Session 11 - Workshop, Aquatic Animal Life Support,  
*Coronado M & N*

**7:00 PM - 9:30 PM**

IOA Banquet, *Epcot's American Adventure Rotunda  
& Italy Isola (Buses depart at 6:30 PM)*

### Wednesday, August 27<sup>th</sup>, 2008

**8:30 AM - 4 PM**

Technical Tour of Epcot, Typhoon Lagoon  
& the TOHO Water Treatment Plant,  
*Bus departs from the Conference Center Porte  
Cochere & returns to the Resort via  
Orlando International Airport by 3 PM*

#### - REGISTRATION DESK HOURS -

##### SUNDAY

7:30 AM - 8:30 AM  
*(Sunday Workshop Only!)*

NOON - 8 PM

*(Conference Registration)*

##### MONDAY

7:30 AM - 12:15 PM  
1:15 PM - 2 PM

##### TUESDAY

7:30 AM - 9:30 AM



Dear Conference Participant,

I welcome you to Walt Disney World® in Orlando, Florida on behalf of the International Ozone Association – Pan American Group. We are pleased to have you join us for our 2008 Technical Conference which includes an Ozone Basics Workshop, an Aquatic Forum and Workshop and an exclusive behind-the-scenes look at Ozone use in Disney®, thanks to our Primary Sponsor, Disney's Animal Programs®.

From aquariums and water parks to the drinking water and the food we enjoy each and every day, more people are experiencing the safety and benefits ozone delivers. Ozone truly supports sustainability! The strong technical contributions of our authors and speakers will make this clear. Ozone is a valuable treatment tool for a broad range of applications and provides numerous secondary benefits to users.

We especially wish to acknowledge the work of Dr. Keisuke Ikehata and Professor Daniel Smith, who coordinated all of the sessions as well as organized and edited all of the abstracts and papers for this unique technical program. Additionally, we thank Ron Zegers and the Southern Nevada Water Authority for producing this year's CD of conference proceedings and all our exhibitors and sponsors who make this annual event happen.

Finally, we are pleased to acknowledge the efforts of Lonnie Lamb and Dr. Mark Stetter of Disney's Animal Programs for their efforts to bring the magic of Disney to this conference.

Welcome and enjoy!

Jeff Neemann  
IOA PAG Chair

**Organizing Committee**

Jim Jackson	Mazzei Injector Co.
Saad Jasim, Ph.D.	Walkerton Clean Water Centre
Keisuke Ikehata, Ph.D.	University of Alberta
Lonnie Lamb	Disney's Animal Programs
Jeff Neemann	Black and Veatch
Mike Oneby	MWH Americas, Inc.
Paul Overbeck	IOA PAG
Diana Schoenberg	IOA PAG
Prof. Daniel Smith, Ph.D.	University of Alberta

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# International Ozone Association – Pan American Group

Technical Program  
IOA Orlando – 2008

## Monday 25 August 2008

### Monday AM – General Opening Session

Coronado Ballroom L

Start	End	
8:15	9:30	Welcome and Guest Speakers Jeff Neemann; Mark Stetter, DVM; Dr. Silvia Menéndez, M.D.; Shane Snyder, Ph.D.

9:30 – 10:15

Coffee Break in Exhibit Hall

Coronado K

### Monday AM (Two Parallel Sessions)

#### Session 1 – Drinking Water Process I

Coronado L

Session Moderator: Jeff Neemann

Start	End	Title	Authors & Affiliations
10:15	10:40	Trihalomethane Reduction Using Ozonation	<u>Glenn Dunkelberger</u> from Reiss Environmental and <u>M. Ikeler</u> from Orange County Utilities
10:40	11:05	Investigation of the Effects of Ozone on Organics Removal and Trihalomethanes Reduction for a Groundwater Source	<u>Saad Jasim</u> , <u>S. Ndiogue</u> , <u>D. Borikar</u> and <u>L. Liu</u> from the Walkerton Clean Water Centre
11:05	11:30	Ozonation Removal of Drinking Water Tastes and Odors for a High TOC Water	<u>Theping Chen</u> and <u>K. Schnaars</u> from Metcalf & Eddy, an AECOM Company, <u>L. Landry</u> , <u>B. Featherston</u> and <u>D. Fortenberry</u> from the City of Shreveport, <u>J. Bollyky</u> from Bollyky Associates, Inc. and <u>K. Rakness</u> from Process Applications, Inc.
11:30	11:55	Effect of Pre Ozonation on Particles and Organic Matter Removal with Ferric Chloride Coagulation	<u>Ali Torabian</u> and <u>M. Negahban Azar</u> from the University of Tehran Department of Environmental Engineering and <u>A. Rashidi Mehrbadi</u> from Power and Water University of Technology, Department of Water Engineering

#### Session 2 – Equipment - Air and Surface Treatment

Coronado J

Session Moderator: Bob Smith-McCollum

Start	End	Title	Authors & Affiliations
10:15	10:40	New Developments in Electrochemical Ozone Sensors and Ozone Calibrators	<u>Lawrence B. Kilham</u> , from Eco Sensors, Div. of KWJ Engineering, Inc., <u>D. Ebeling</u> from KWJ Engineering Inc. and Wisconsin Lutheran College, <u>J. R. Stetter</u> , <u>V. Patel</u> and <u>M. Findlay</u> from KWJ Engineering, Inc.
10:40	11:05	A Study of Composition of Ozone on the Surface of the Metal Electrode Supplying Pure Oxygen	<u>Akira Murai</u> from The Kansai Electric Power Co, Inc. and <u>C. Yamabe</u> and <u>S. Ihara</u> from Saga University, Department of Electrical and Electronic Engineering
11:05	11:30	Case Studies of Corrosion and Preparation of Ozone Systems	<u>Daryl Roll</u> and <u>M. Dalglish</u> from Astro Pak Corporation
11:30	11:55	Ozone Fog Room Decontamination Study	<u>Nidal A. Samad</u> , <u>A. J. Teran</u> and <u>R. Jacomino</u> from Agrimond L.L.C.

12:00 – 1:15

Luncheon

Coronado K

**Monday PM (Three Parallel Sessions)****Session 3 – Drinking Water Process II**

Session Moderator: Kerwin Rakness

Coronado L

Start	End	Title	Authors & Affiliations
1:20	1:45	Update on Utilizing Ozone to Reduce Hydrogen Sulfide in Groundwater	<b>Stephanie J. Bishop</b> from Malcolm Pirnie Inc. Orlando, <b>J. Bebee</b> from Malcolm Pirnie, Inc. San Diego and <b>B. Bennett</b> from the Toho Water Authority
1:45	2:10	Hydrogen Sulfide Removal Comparison – Ozone versus Chlorine	<b>Mandy Jackman</b> , <b>K. Dixon</b> , <b>E. Myers</b> and <b>R. Copeland</b> from Black & Veatch and <b>C. Owen</b> and <b>A. Rice</b> from Tampa Bay Water
2:10	2:35	Orange County Utilities Ozone System Design for Treatment of Hydrogen Sulfide	<b>Nick Burns</b> , <b>D. Friess</b> , <b>B. Vanlandingham</b> and <b>T. Cummings</b> from Black & Veatch and <b>C. Digerlando</b> from Orange County Utilities
2:35	3:20	<b>Coffee Break in Exhibit Hall</b>	<b>Coronado K</b>
3:20	3:45	Enhancing Ozone Facilities for Primary Disinfection in Henrico County Virginia	<b>Bill Dowbiggin</b> from CDM, <b>R. Navratil</b> and <b>C. England</b> from Henrico County
3:45	4:10	Upgrading an Old Ozone System to Meet New Disinfection Requirements	<b>Christopher R. Schulz</b> from CDM Denver, <b>L. Smith</b> from CDM Philadelphia and <b>R. Farmularo</b> from the New Jersey Water Supply Authority
4:10	4:35	Modeling and Validating the Effective Hydraulic Detention Time for a 10 mgd Ozone Contactor at the Lake Washington Water Treatment Plant, Melbourne, Florida	<b>D. Phares</b> from the City of Melbourne, Water Production and <b>David Rokjer</b> , <b>J. Franko</b> and <b>I. A. Crossley</b> from Hazen & Sawyer P.C.
4:35	5:00	Evaluating Hydraulic Implications of Adding Ozone to Conventional Water Treatment Plants	<b>Ben Kuhnel</b> , <b>M. Mohrle</b> and <b>J. Bebee</b> from Malcolm Pirnie, Inc. and <b>Iraj Asgharzadeh</b> from the City of San Diego
5:00	5:25	Investigating Two Scales of In-Line Multi-Jets Ozone Contactors	<b>M. S. Baawain</b> from Sultan Qaboos University, Department of Civil and Architectural Engineering, <b>M. Gamal El-Din</b> and <b>Daniel W. Smith</b> from the University of Alberta, Department of Civil & Environmental Engineering and <b>A. Mazzei</b> from Mazzei Injector Corporation

**Session 4 – Air and Surface Treatment - Agri-Food Applications**

Coronado J

Session Moderator: Paul Overbeck

Start	End	Title	Authors & Affiliations
1:20	1:45	Update on Ozone Based Low Temperature Oxidation for Control of NOx and Mercury in Flue Gas Emissions	<b>Robert Ferrell</b> from RJF Consultants, LLC
1:45	2:10	Decomposition of VOC's by Ozonation in Gas Phase	<b>Marco Franco</b> and <b>T. Poznyak</b> from Superior School of Chemical Engineering of National Polytechnic Institute, (ESIQIE-IPN), <b>I. Chairez</b> from the Profesional Interdisciplinary Unit of Biotechnology of National Polytechnic Institute (UPIBI-IPN) and <b>A. Poznyak</b> from the Department of Automatic Control, CINVESTAV-IPN. AP
2:10	2:35	Synergistic Use of Ozone and UV Light to Effectively Manage Grease Laden Vapors in Commercial Cooking Operations	<b>Chris Thompson</b> from Franke Foodservice Systems
2:35	3:20	<b>Coffee Break in Exhibit Hall</b>	<b>Coronado K</b>
3:20	3:45	Optimization of CIP Process for Ozone Sanitization Retrofit	<b>James R. Jackson</b> from Mazzei Injector Company, LLC and <b>A. Enriquez</b> from Laboratorios Sanox SA de CV
3:45	4:10	The Utilization of Ozone for Treating Vegetable Processing Lines	<b>Charles D. Sopher</b> from Global Energy Partners, LLC, <b>G.T. Battles</b> and <b>D. Johnson</b> from the Tennessee Valley Authority
			<b>CONTINUED ON NEXT PAGE</b>

4:10	4:35	Ozone Model for Drip Irrigation Systems	<b>J. Chen-Lopez</b> and <b>P. Waller</b> from the University of Arizona Department of Agricultural and Biosystems Engineering and <b>Matthew H. Stong</b> from ARID Group, LLC
4:35	5:00	Tight Control of Ozone Concentration in Spring Water Filling by an Integrated Ozone Contacting System with Advanced Feed Forward Ozone Control	<b>Bob Smith-McCollum</b> and <b>J. Fleck</b> from Pacific Ozone

**Session 5 – Medical Applications**

**Coronado M and N**

Session Moderator: **Dr. Bernard Kirshbaum, M.D.**

Start	End	Title	Authors & Affiliations
1:20	1:45	Ozone Therapy in Cancer Treatment - State of the Art	<b>Silvia Menéndez</b> from the Ozone Research Center, Cuban National Center for Scientific Research, <b>J. Cepero</b> from the Cuban National Oncology and Radiobiology Institute and <b>L. Borrego</b> from V. I. Lenin Provincial Hospital
1:45	2:10	Ozone Therapy for the Treatment of Retinitis Pigmentosa	<b>Robert H. Marmor</b> from the Morehouse School of Medicine
2:10	2:35	Ozone Therapy in Diabetes: A Preclinical and Clinical Study	<b>Silvia Menéndez</b> from the Ozone Research Center, Cuban National Center for Scientific Research, <b>O. S. León</b> , <b>S. M. Al-Dalain</b> , and <b>G. Martínez</b> from the University of Havana Center for Research and Biological Evaluation and <b>H. Alvarez</b> from the Institute of Angiology and Vascular Surgery
2:35	3:20	<b>Coffee Break in Exhibit Hall</b>	<b>Coronado K</b>
3:20	3:45	Oxidative Preconditioning: An Ozone Protective Mechanism of Action	<b>Silvia Menéndez</b> from the Ozone Research Center, Cuban National Center for Scientific Research, <b>O. S. León</b> from the University of Havana Center for Research and Biological Evaluation and <b>Z. Zamora</b> , <b>A. Borrego</b> , <b>R. González</b> , <b>F. Hernández</b> and <b>S. Schulz</b> from the Veterinary Services and Laboratory of Animal Medicine, Philipps-University of Marburg
3:45	4:10	Application of Ozone Therapy in the Treatment of Herniated Disk	<b>Silvia Menéndez</b> and <b>J. L. Calunga</b> from the Ozone Research Center, Cuban National Center for Scientific Research and <b>A. Balbín</b> from the Dr. Fructuoso Rodríguez Orthopedics Hospital
4:10	4:35	Ozonized Sunflower Oil (Oleozon®) A Natural Product Against Fungi, Bacteria and Parasites	<b>Silvia Menéndez</b> from the Ozone Research Center, Cuban National Center for Scientific Research, <b>L. Falcón</b> and <b>A. Palomino</b> from the Dr. Carlos J. Finlay Hospital, <b>M. E. González</b> from the Gastroenterology Nacional Institute, <b>P. Acuña</b> from the Center Havana Pediatric Hospital, <b>J. E. Benítez</b> from the North Pediatric Hospital, <b>M. Díaz</b> from the Juan Manuel Márquez Pediatric Hospital and <b>M. Amoroto</b> and <b>M. Fernández</b> from the Cuban National Center for the Coordination of Clinical Trial

**5:30 – 7:00**

**Exhibitor Reception**

**Coronado K**

## Tuesday 26 August 2008

### Tuesday AM (Three Parallel Sessions)

#### Session 6 – Wastewater Treatment (+ Industrial Applications)

Coronado J

Session Moderator: Prof. Daniel Smith

Start	End	Title	Authors & Affiliations
8:15	8:40	State-of-the-Art Ozonation Practices at Major Municipal Wastewater Treatment Plants in the United States	<u>Joseph A. Drago</u> and <u>C. M. Thompson</u> from Kennedy/Jenks Consultants
8:40	9:05	Ozonation of Secondary Effluent of Sewage Treatment Plant for the Cooling Water of Thermal Power Plant	<u>Kousei Sasaki</u> , <u>N. Yamato</u> , <u>E. Sakuraba</u> and <u>K. Takahashi</u> from Fuji Electric Water Environmental Systems Co., Ltd. and <u>S. Yamana</u> and <u>S. Mitsuma</u> from Tokyo Gas Yokosuka Power Co., Ltd.
9:05	9:30	The Certification and Use of HiPOx™ for Reclaimed Water Disinfection	<u>Keel Robinson</u> from Applied Process Technology, Inc. and <u>A. Salvesson</u> and <u>C. Ishida</u> from Carollo Engineers
9:30	10:15	<b>Coffee Break in Exhibit Hall</b>	<b>Coronado K</b>
10:15	10:40	Product Recovery through Ozone Oxidation of Waste Liquor	<u>James R. Jackson</u> and <u>J. Bennett</u> from Mazzei Injector Company, LLC.
10:40	11:05	Degradation of Naphthenic Acids in Athabasca Oil Sands Tailings Water Using Ozone	<u>Hongjing Fu</u> , <u>K. Ikehata</u> , <u>M. Gamal El-Din</u> and <u>D. W. Smith</u> from the University of Alberta, Department of Civil & Environmental Engineering and <u>M. MacKinnon</u> and <u>W. Zubot</u> from Syncrude Canada, Ltd.
11:05	11:30	Degradation of Triclocarban by Ozone	<u>Jeya K. Ephraim</u> , <u>C. Tizaoui</u> , and <u>N. M. Grima</u> from the University of Bradford School of Engineering, Design and Technology
11:30	11:55	Emergency Water Mobile Response Unit with Ozone Heart: The Life Saving Power of Water	<u>Ernie Wilmlink</u> from "The Key" Water and Air International

#### Session 7 – Drinking Water Process III

Coronado L

Session Moderator: Saad Jasim, Ph.D.

Start	End	Title	Authors & Affiliations
8:15	8:40	Ozone System Expansion and Contactor Dissolution System Upgrades at the Sweeney WTP	<u>Nick Burns</u> , <u>R. Hulsey</u> and <u>B. Townsend</u> from Black & Veatch, and <u>M. Richardson</u> from the City of Wilmington
8:40	9:05	Biofiltration without Chlorinated Backwash	<u>Justin Sutherland</u> from Carollo Engineers, Austin, <u>C. Vokes</u> From the City of Arlington, <u>J. Gallovich</u> from Carollo Engineers, Dallas, and <u>R. Joost</u> from Carollo Engineers, Phoenix
9:05	9:30	Ozone System Data Collection, Analysis and Operations Optimization	<u>Sajal Mitra</u> and <u>R. Johnston</u> from the Metropolitan Water District of Southern California and <u>K. Rakness</u> and <u>G. Hunter</u> from Process Applications, Inc.
9:30	10:15	<b>Coffee Break in Exhibit Hall</b>	<b>Coronado K</b>
10:15	10:40	Initial Operating Experience with a State-of-the Art Ozone System Retrofit to Replace the Original 20 Year Old Ozone System	<u>Craig Thompson</u> and <u>C. Correa</u> from Kennedy/Jenks Consultants, San Francisco, <u>B. Yates</u> from Kennedy/Jenks Consultants, Lakewood, <u>T. Fessenden</u> from the Eagle River Water and Sanitation District and <u>G. Hunter</u> from Process Applications Inc.
10:40	11:05	Optimization of an Ozone Side Stream Injection System	<u>Bill Mundy</u> from the Regional Municipality of Halton and <u>K. Rakness</u> from Process Applications Inc.
11:05	11:30	Pre- and Post-Ozone Dose Study at the North Bay Regional Water Treatment Plant	<u>Mike Oneby</u> from MWH Americas Milwaukee, <u>C. Bromley</u> from MWH Americas Las Vegas, <u>D. Rodgers</u> and <u>L. de Albidress</u> from the City of Fairfield Public Works Dept. and <u>J. Lodge</u> from MWH Americas Sacramento
11:30	11:55	Good Process Control in Ozone Plants Starts with Proper Tuning	<u>Jim Muri</u> from the John J. Carroll Water Treatment Plant

**Session 8 – Aquatic Animal Life Support****Coronado M & N**Session Moderator: [John Overby](#)

Start	End	Title	Authors & Affiliations
8:15	8:30	History of Ozone in Aquarium and Aquatic Environments	<a href="#">Lonnie Lamb</a> from Walt Disney Company - Animal Programs Group
8:30	9:00	Pilot Testing for Inactivation of Non-Indigenous Seawater Organisms by Ozonation and Ultraviolet Sterilization	<a href="#">Joel V. Johnson</a> from TJP, Inc., <a href="#">A. Hotz</a> from Nautilus Environmental and <a href="#">J. Lord</a> from Birch Aquarium at Scripps
9:00	9:30	Operator Interface Implications for Automated Ozone Dosage & Control of Aquatic Life Systems	<a href="#">Lonnie Lamb</a> from Walt Disney Company - Animal Programs Group
9:30	10:15	<b>Coffee Break in Exhibit Hall</b>	<b>Coronado K</b>
10:15	10:40	Management of Ozone Application in Aquarium Life Support Systems	<a href="#">Andrew Aiken</a> from the National Aquarium in Baltimore and Aiken & Associates, Inc.
10:40	11:05	Ozone Use at the Monterey Bay Aquarium: A Natural Seawater Facility	<a href="#">Eric Kingsley</a> , <a href="#">R. Phillips</a> , and <a href="#">S. Mansergh</a> from the Monterey Bay Aquarium
11:05	11:30	Considerations for Ozone Treatment on Recirculating Aquarium Systems with Biological Filtration	<a href="#">Kent J. Semmen</a> from WDW Life Support, Epcot's The Seas with Nemo and Friends
11:30	11:55	Session Q & A	<b>All Speakers</b>

**12:00 – 1:15****Luncheon****Coronado K****Tuesday PM (Three Parallel Sessions)****Session 9 – Advanced Oxidation Technologies****Coronado J**Session Moderator: [Shane Snyder, Ph.D.](#)

Start	End	Title	Authors & Affiliations
1:20	1:45	Evaluation of •OH Quantification Methods for Advanced Oxidation Processes	<a href="#">Fernando L. Rosario-Ortiz</a> , <a href="#">S. A. Snyder</a> , and <a href="#">B. J. Vanderford</a> from the Southern Nevada Water Authority, Applied Research & Development Center
1:45	2:10	Advanced Oxidation - An Effective Process for the Removal of 1,4-Dioxane and TCE in Contaminated Groundwater	<a href="#">A. Ried</a> and <a href="#">J. Krüger</a> from ITT-WEDECO GmbH, <a href="#">Dennis Csalovszki</a> from ITT-Wedeco and <a href="#">N. Singh</a> from ITT ICS
2:10	2:35	Quantification of the Hydroxyl Radical Scavenging Capacity during Advanced Oxidation Treatment	<a href="#">Fernando L. Rosario-Ortiz</a> and <a href="#">S. A. Snyder</a> from the Southern Nevada Water Authority, <a href="#">S. P. Mezyk</a> and <a href="#">D. F. R. Doud</a> from California State University at Long Beach, Department of Chemistry and Biochemistry
2:35	3:20	<b>Coffee Break in Exhibit Hall</b>	<b>Coronado K</b>
3:20	3:45	Decomposition of Clofibric Acid in Water Using Ozonation with UV Irradiation	<a href="#">Masahiro Asano</a> and <a href="#">T. Oyake</a> from Ryukoku University, Faculty of Science and Technology
3:45	4:10	Degradation of Anatoxin-a in Water by the Ultraviolet/Hydrogen Peroxide Process	<a href="#">Atefeh Afzal</a> , <a href="#">K. Ikehata</a> , <a href="#">M. Gamal El-Din</a> and <a href="#">J. R. Bolton</a> from the University of Alberta, Department of Civil & Environmental Engineering and <a href="#">T. Oppenländer</a> from Hochschule Furtwangen University (HFU)
4:10	4:35	Ozone Nanobubble Treatment of Complex Organics	<a href="#">William B. Kerfoot</a> from Kerfoot Technologies, Inc.
4:35	5:00	Treatment of Ground Water with High VOC's Concentration by O <sub>3</sub> and O <sub>3</sub> /H <sub>2</sub> O <sub>2</sub>	<a href="#">William de los Santos</a> and <a href="#">T. Poznyak</a> from the Superior School of Chemical Engineering of National Polytechnic Institute (ESIQIE-IPN) and <a href="#">I. Chairez</a> from the Professional Interdisciplinary Unit of Biotechnology of National Polytechnic Institute (UPIBI-IPN)

**Session 10 – Drinking Water Process IV****Coronado L**Session Moderator: [Neal Spivey](#)

Start	End	Title	Authors & Affiliations
1:20	1:45	Conversion of Air Feed to Oxygen Feed at the North Bay Regional Water Treatment Plant	<a href="#">Mike Oneby</a> from MWH Americas Milwaukee, <a href="#">C. Bromley</a> from MWH Americas Las Vegas, <a href="#">M. Moughamian</a> from MWH Americas Salt Lake City, <a href="#">D. Rodgers</a> and <a href="#">G. Hernandez</a> from the City of Fairfield Public Works Dept. and <a href="#">J. Lodge</a> from MWH Americas Sacramento
1:45	2:10	A Process for Maintenance of Ozone Contactors - A Report on Planning and Lessons Learned	<a href="#">Gil Machado</a> from the John J. Carroll Water Treatment Plant
2:10	2:35	Impact of Climate Change and Drought on Ozonation at Las Vegas, NV	<a href="#">Eric C. Wert</a> , <a href="#">J. Lew</a> , <a href="#">D. Rexing</a> and <a href="#">R. Zegers</a> from the Southern Nevada Water Authority
2:35	3:20	<b>Coffee Break in Exhibit Hall</b>	<b>Coronado K</b>
3:20	3:45	Hybrid Constant Concentration Control Alternative	<a href="#">Kerwin L. Rakness</a> from Process Applications, Inc. and <a href="#">L. Ballantyne</a> , <a href="#">A. Vukosavljevic</a> and <a href="#">T. Lim</a> from the F.J. Horgan Water Treatment Plant
3:45	4:10	600 MGD. . . What about 2 MGD? Small Municipal Water Treatment with Ozone	<a href="#">Andrew Conner</a> from H&T Systems
4:10	4:35	Impact of Free Chlorine and Chloramine Residuals on Ozonation	<a href="#">Eric C. Wert</a> and <a href="#">J. Lew</a> from the Southern Nevada Water Authority
4:35	5:00	Pre Oxidation Effect on Total Organic Carbon (TOC) Removal in Surface Water Treatment in Iran Case Study: Teheran Pars Water Treatment Plant	<a href="#">Ali Torabian</a> , <a href="#">A. Ghadimkhani</a> , and <a href="#">M. Negahban Azar</a> from the University of Tehran, Department of Environmental Engineering, Faculty of Environment and <a href="#">A. Rashidi Mehrabadi</a> from the Power and Water University of Technology Department of Water Engineering

**Session 11 – Workshop - Aquatic Animal Life Support****Coronado M & N**Session Moderator: [John Overby](#)

Start	End	Title	Authors & Affiliations
1:20	2:35	<b>Rotating Workshop Groups:</b> - Automated Controls for Ozone Systems - Ozone Contacting Considerations - Ozone Generator Repair - Ozone Generator Air Prep Optimization - Ozone Safety Considerations	<a href="#">Tom Nicodemo</a> and <a href="#">Kent Semmen</a> from Walt Disney Company – Animal Programs Group, <a href="#">John Overby</a> and <a href="#">Mark Fisher</a> from Ozone Water Systems, Inc. and <a href="#">Barbara Schilling</a> from Degremont Technologies - Ozonia
2:35	3:20	<b>Coffee Break in Exhibit Hall</b>	<b>Coronado K</b>
3:20	4:10	Continue - Rotating Workshop Groups	
4:10	5:00	Round Table - Q & A	<b>Group Leaders</b> and <b>Session 8 Speakers</b>



**Monday AM – Session 1 – Drinking Water Process I (Coronado L)**

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## **Trihalomethane Reduction Using Ozonation**

**Glenn Dunkelberger<sup>1</sup>, P.E. and Mark Ikeler<sup>2</sup>, P.E.**

1. Reiss Engineering, Inc. 12001 Research Parkway, Orlando, FL 32806
2. Orange County Utilities, 9100 Curry Ford Road, Orlando, FL 32825

Ozonation can be used in potable water treatment as an effective means to remove sulfide without generation of treatment residuals. The results of the study also revealed that ozonation of Central Florida groundwater can reduce trihalomethane (THM) concentration by 10 to 15 parts per billion (ppb) with an ozone dosage of 1 ppm over that required for sulfide oxidation.

Orange County Utilities (OCU), Orlando Florida is developing a new 27 MGD potable water supply facility in the County's Southern Water Service Area. That new facility is the Southern Regional Water Supply Facility (SRWSF). The raw water source for the SRWSF is the lower Floridan aquifer. The use of ozone at the proposed SRWSF is being recommended as an effective treatment process for sulfide removal. At the location of the proposed SRWSF previous water quality analysis of the raw water from the test production well revealed total organic carbon (TOC) levels ranging from 1.4 to 2.4 ppm. The disinfection by-product (DBP) formation potential for this water was not previously tested. The DBP formation rate for ozonated raw water needed to be considered so that further evaluation of this treatment process and the distribution system's compliance with Stage 1 and 2 DBP limits could be made. Specifically, the goal of this work was to determine what effect ozonation has on THM and haloacetic acid (HAA) formation.

Pilot scale ozone testing was performed during the week of November 26, 2007. Water was drawn at a rate of 5 MGD from a well at the SRWSF. The well was pumped for approximately 12 hours prior to pilot scale testing. Raw water sulfide ranged from 2 to 3 ppm. Oxidation of sulfide was found at the rate of 2.9 mg ozone applied per mg sulfide, well within the expected ozone dosage range. Without ozone, THM and HAA levels reached as high as 80 ppb and 35 ppb, respectively. Controlling the ozone dose to 1 ppm above the sulfide ozone demand lowered THM concentration by 10 to 15 ppb; a HAA decrease was not seen, but HAA levels were low at no more than 35 ppb. Further increasing the ozone dose to greater than 1 ppm above the sulfide ozone demand, both THM and HAA concentration were seen to rise. However, under all ozone dosage rates THM and HAA concentrations remained below the regulatory limits for THMs and HAAs of 80 and 60 ppb, respectively.

## **Investigation of the Effects of Ozone on Organics Removal and Trihalomethanes Reduction for a Groundwater Source**

**S. Ndiongue, S. Jasim, D. Borikar and L. Liu**

Walkerton Clean Water Centre, Walkerton, Ontario, Canada

This study examined the effects of post sedimentation ozone on organics removal and trihalomethanes (THMs) reduction for a groundwater source. Pilot tests were conducted with a conventional water treatment process on one train, compared to an ozone assisted water treatment process on the second train. The treatment included Polyaluminum Chloride (PACl) enhanced coagulation, with and without pH adjustment either prior to coagulation or ozonation. Post sedimentation ozonation and pH adjustment to 6 prior to ozonation resulted in 46% less THMs (75 µg/L) compared to the train without ozonation (140 µg/L), for a chlorine dosage of 5 mg/L and raw water DOC of 5 mg/L. Without pH adjustment, high levels of THMs were observed for both treatment trains.

When the DOC was reduced to 2.4 mg/L using enhanced coagulation with pH adjustment, the THMs were 74 µg/L for the conventional treatment and 68 µg/L for the train using ozone.

**Monday AM – Session 1 – Drinking Water Process I (Coronado L)**

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## **Ozonation Removal of Drinking Water Tastes and Odors for a High TOC Water**

**Theping Chen<sup>1</sup>, Larry Landry<sup>2</sup>, Barbara Featherston<sup>2</sup>, Darin Fortenberry<sup>2</sup>, Joseph Bollyky<sup>3</sup> and Ken Schnaars<sup>1</sup>**

1. Metcalf & Eddy AECOM
2. City of Shreveport, Louisiana
3. Bollyky Associates, Inc.

The study was conducted to identify the effective ozonation strategy, system design criteria, and operation conditions for removing the tastes and odors from a high TOC water. The odorants of geosmin and MIB were spiked into the actual raw water or settled water samples. The ozonation with and without hydrogen peroxide were studied and compared for their effectiveness. The bench testing results were used to develop preliminary system design criteria and approaches for upgrading the existing ozone generator systems. Additional bench and pilot tests were also recommended. This paper will focus on the past bench studies for taste and odor of the source water for the T.L. Amiss Water Treatment Plant (WTP) and how the results are used to develop the generator design criteria for the future ozone system.

## Effect of Pre Ozonation on Particles and Organic Matter Removal with Ferric Chloride Coagulation

**A. Torabian<sup>1</sup>, M. Negahban Azar<sup>1</sup> and A. R. Mehrabadi<sup>2</sup>**

1. Department of Environmental Engineering, University of Tehran, Tehran, Iran
2. Department of Water Engineering, Power and Water University of Technology, Tehran, Iran

Despite wide usage of pre-oxidation before coagulation, the impact of pre-ozonation on coagulation is still quiet complicated. In this study, bench and pilot scale investigations were conducted to evaluate the effect of pre-ozonation on particles and natural organic matter (NOM) removal through coagulation. Raw water samples were collected from Third Tehran Water Treatment Plant influent. The removal of suspended particles and NOMs at various pre-ozonation and ferric chloride doses was assessed through measurements of turbidity, particle count and size, TOC, and UV absorbance at 254 nm. Overall, it has been found that the effect of pre-ozonation on coagulation is strongly influenced by ozone dose. The results demonstrate that at low ozonation doses of 0.5 to 1.5 mg L<sup>-1</sup>, removal of turbidity, particle count, TOC and UV<sub>254</sub> increased. In doses, less than 1.5 mg L<sup>-1</sup>, ozone can combine fine particles and make them more destabilized, mineralized and easier to remove. Additionally, particle's mean diameter slightly increased which may help the removal of particles in next unit operation processes. At higher pre-ozonation doses (>2.0 mg L<sup>-1</sup>), results show that coagulation aid of ozone is negligible. In that case, NOM changes to smaller molecular fractions and becomes more hydrophilic, decreasing NOM and particle removal. The optimum coagulation aid of pre-ozonation was achieved at ozone dose of 1.5 mg L<sup>-1</sup> or 0.47 mg O<sub>3</sub> / mg DOC.

## **New Developments in Electrochemical Ozone Sensors & Ozone Calibrators**

**D. Ebeling<sup>1,3</sup>, J.R. Stetter<sup>1</sup>, L.B. Kilham<sup>2</sup>, V. Patel<sup>1</sup> and M. Findlay<sup>1</sup>**

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2. Eco Sensors Division of KWJ, Santa Fe, NM, 87505 USA
3. Wisconsin Lutheran College, Milwaukee, WI, 53226 USA

An electrochemical ozone sensor with a new sensing composite material has been developed. The response to flow velocity and concentration has been characterized in order to develop improved ozone sensing instrumentation.

To work in tandem with and as an accessory to ozone sensors, KWJ has developed a proprietary ozone source for precision calibration. This new source can be built into a separate calibrator instrument with variable output or as an on-board component for auto calibration of ozone-sensing instruments.

## **A Study of Composition of Ozone on the Surface of the Metal Electrode Supplying Pure Oxygen**

**Akira Murai<sup>1</sup>, Chobei Yamabe<sup>2</sup> and Satoshi Ihara<sup>2</sup>**

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An electrical discharge did not produce ozone in pure oxygen and the concentration of ozone increased when nitrogen was added. A third body was required when an oxygen molecule and an oxygen atom collided. A decrease in the temperature of the cooling water led to a proportional increase in ozone. After changing the electrode, we observed the difference in the enthalpy changes which were calculated using van't Hoff's formula. The antimony electrode increases the efficiency of the ozone generator to produce ozone. We have come to believe that ozone is composed on the surface of the electrode.

**Monday AM – Session 2 – Equipment & Air and Surface Treatment I (Coronado J)**

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## **Case Studies of Corrosion and Cleanliness Requirements in Ozone Systems**

**Daryl L. Roll, P.E. and Michael Dalglish**

Astro Pak Corporation, 270 E. Baker Street, Suite 100, Costa Mesa, CA 92626

The presentation reviews a series of case studies with examples of damaged piping systems, in addition to difficulties with components, caused by unsatisfactory conditions existing during operations. Corrosion effects and gasket failures result from a lack of system preparation, presence of water in oxygen gas systems, low quality of welding operations and poor gasket selection. The case studies discuss challenges that were experienced during operations that included excessive corrosion of stainless steel surfaces of system distribution piping and gasket materials that reacted with corrosive fluids/gases within the system. Preventive and corrective measures, as well as processes, are presented and discussed for each case.

This paper addresses oxygen/ozone cleaning requirements and cleanliness verification of components and systems during installation. Installation requirements are reviewed in an aim to yield successful, safe system start-up, operations and attainment of basic cleanliness levels. Cleanliness levels required for oxygen-enriched and ozone atmospheres are defined. Basic oxygen cleaning and passivation chemistries are discussed, as well as precision cleaning in accordance with CGA G-4.1.

## **Ozone Fog Room Decontamination Study**

**Nidal A. Samad, Alfredo J. Teran and Rogelina Jacomino**

Agrimond L.L.C.  
8900 Astronaut Boulevard  
Cape Canaveral, Florida 329520

This study was conducted to determine the effectiveness of the ozone fog decontamination system, in controlling and eliminating the resistant form of *Staphylococcus aureus*, *Staph MRSA*. The study was conducted in an “airborne infection isolation ward, model MS-ICW, manufactured by Agrimond L.L.C. Samples were inoculated with 10 µL of a culture with a population of  $10^7$  cfu/mL, and strategically placed in different location and at different height levels inside the ward. Ozonated fog was introduced using an ozone system and a fog generating unit, also by Agrimond L.L.C. Samples were recovered and incubated after two hours of retention time, using the tryptic soy broth (liquid media) and the tryptic soy agar (solid media). The results of this study showed no observed growth after five days of incubation and 48 hours of incubation at 37 °C in liquid growth media and solid growth media, respectively.

## Update on Using Ozone to Reduce Hydrogen Sulfide in Groundwater

**Stephanie Bishop<sup>1</sup>, Jack Bebee<sup>2</sup> and Bobby Bennett<sup>3</sup>**

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The Toho Water Authority (Toho) was experiencing elevated hydrogen sulfide concentrations in some of their ground water wells at their Southwest Water Treatment Plant in Kissimmee, Florida. To help improve the aesthetic quality of the water and meet new regulations that required additional treatment beyond chlorination and conventional aeration for wells with total sulfide levels higher than 0.6 mg/L, Toho evaluated alternatives for removing the hydrogen sulfide including air stripping and ozonation. Based on costs and long term goals for Toho's water system, it was determined that ozone using a side stream ozone injection system was a cost effective option. Before the design was started, a pilot plant study was conducted at the plant using a small side stream application to a portion of the raw water to determine the optimum ozone dosage range required. After the dosage range was verified by the pilot plant study, ozone was chosen to be used in a side stream application to the raw water prior to the chlorination point.

The design of the side stream ozone treatment system to remove hydrogen sulfide from the raw water wells faced some additional challenges. One issue was that in this application the system must come on line shortly after the well pumps and there is no contactor or intermediate storage between the wells and the ground water storage tank. In addition, demand requirements in the system required the wells to start and stop several times during a 24 hour period. Special design considerations will be discussed that allowed the ozone generation system to have numerous start-up and shut-down cycles during a single day. The design also took into account the need to protect the existing ductile iron piping from the wells to the storage tank from exposure to high ozone residuals. The system was initially operated in a manual mode. Since start up, work was completed to the instrumentation and programming to create an automated system that can be monitored and controlled from a remote location.

This ozone system was installed quickly with a reduced footprint due to the side stream application. Modifications after the manufacturer's installation were required to suit the unique characteristics of this facility. Some of these modifications addressed at the Southwest WTP will be discussed.

## **Hydrogen Sulfide Removal Comparison – Ozone versus Chlorine**

**Mandy Jackman<sup>1</sup>, Kevin Dixon<sup>1</sup>, Ervin Myers<sup>1</sup>, Rachel Copeland<sup>1</sup>, Christine Owen<sup>2</sup> and Amanda Rice<sup>2</sup>**

1. Black & Veatch, Tampa Bay, Florida
2. Tampa Bay Water, Florida

The Hillsborough County Lithia Water Treatment Plant (WTP) treats groundwater supplied by two wellfields owned and operated by Tampa Bay Water – the Brandon Urban Dispersed Wellfield and the South Central Hillsborough Regional Wellfield (SCHRWF). The water is treated at the Lithia WTP for hydrogen sulfide removal utilizing cascade aeration, biological oxidation, and chloramination. The water from the SCHRWF typically exhibits hydrogen sulfide concentrations greater than 2 milligrams per liter. The current treatment process is considered to be unreliable from the standpoint of producing a consistent high quality potable supply that is free of hydrogen sulfide and heterotrophic bacteria and low in turbidity. A 90 day pilot test was conducted to document removal of hydrogen sulfide and turbidity and more completely characterize the fouling potential associated with the treatment of the SCHRWF water. The treatment processes pilot tested included oxidation with ozonation, oxidation with ozonation and media filtration, oxidation with chlorine and media filtration, and oxidation with chlorine and membrane filtration. Two different microfiltration (MF) systems were pilot tested to compare their results. The results showed that ozonation was very effective for hydrogen sulfide oxidation and no filtration downstream from ozonation was necessary for turbidity removal. The chlorination with membrane filtration was effective at hydrogen sulfide and turbidity removal but prone to fouling of the membranes.

**Monday PM – Session 3 – Drinking Water Process II (Coronado L)**

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## **Orange County Utilities Ozone System Design for Treatment of Hydrogen Sulfide**

**Nick Burns<sup>1</sup>, David Friess<sup>1</sup>, Tom Cummings<sup>1</sup>, and Brad Vanlandingham<sup>1</sup> and Charles Digerlando<sup>2</sup>**

1. Black & Veatch, 201 South Orange Avenue, Orlando, FL 32801
2. Orange County Utilities, 9100 Curry Ford Rd, Orlando FL 32825

Orange County Utilities supplies water to the Orlando Florida metro area and has selected ozone for the oxidation of hydrogen sulfide at the new 30 mgd Southern Regional Water Supply Facility. The paper will include the reasons ozone was selected over forced draft aeration for the treatment of hydrogen sulfide, the ozone system design, the methods that were evaluated to lower the dissolved oxygen concentration, the reasons a hydraulic retention time of 3 minutes was selected for the ozone contactor, the safety concerns, operating limitations, and the provisions that are included in the design that will provide future flexibility.

## Enhancing Ozone Facilities for Primary Disinfection in Henrico County Virginia

**Bill Dowbiggin<sup>1</sup>, Russ Navratil<sup>2</sup> and Chip England<sup>2</sup>**

1. CDM, 5400 Glenwood Ave., Suite 300, Raleigh, NC 27612
2. Henrico County, VA

The promulgation of the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) on January 5, 2006 along with the promulgation of the Stage 2 Disinfectants and Disinfection Byproducts (DBP) Rule on January 4, 2006 are increasing the use of ozone primary disinfection for efficient inactivation of microorganisms and for lowering DBP concentrations, respectively. The Henrico County VA Water Treatment Facility is making use of ozone primary disinfection to take advantage of both the disinfection and DBP benefits. This paper overviews current ozone disinfection status for *Giardia* inactivation and potential for future use for *Cryptosporidium* inactivation. Enhancements to keep up with the state of the art are overviewed relative to:

- efficient contactor design as verified by tracer testing
- ozone in water residual sample piping and monitoring
- CT calculation
- changes that can lessen oxygen off-gassing

Each of these items is discussed following an overview of the facility.

## **Upgrading an Old Ozone System to Meet New Disinfection Requirements**

**Christopher R. Schulz, P.E.<sup>1</sup>, Larry Smith, P.E.<sup>2</sup>, Richard Famularo<sup>3</sup>**

1. CDM, Denver, CO
2. CDM, Philadelphia, PA
3. New Jersey Water Supply Authority

The New Jersey Water Supply Authority (NJWSA) operates the Manasquan Water Treatment Plant, located in Wall Township, NJ. The plant treats raw water from the Manasquan River and Reservoir and provides drinking water to five communities in the southern portion of Monmouth County, New Jersey. The plant was commissioned in July 1990 with a rated capacity of 4 mgd and includes a preozonation process for preoxidation and primary disinfection. The NJWSA hired CDM in 2007 to evaluate the existing air-fed preozone system and recommend improvements to achieve the following objectives:

- Reduce O&M costs
- Identify and correct system deficiencies
- Extend the system's service life
- Facilitate compliance with current and future water quality regulations

CDM's scope of work for the pre-design phase of the project includes bench-scale testing of the river and reservoir supplies under normal water quality conditions and storm events, evaluation of air-fed vs. oxygen-fed ozone upgrades, inspection of the structural integrity of the ozone contacting basins, improvements to the existing monitoring and control system, and development of a recommended program of improvements for the ozone system. This paper will discuss CDM's design approach for evaluating the disinfection capability of the existing ozone system and recommended improvements for converting from an air-fed to oxygen-fed ozone system.

## Modeling and Validating the Effective Hydraulic Detention Time for a 10 mgd Ozone Contactor at the Lake Washington Surface Water Treatment Plant, Melbourne, Florida

David Phares<sup>1</sup>, David Rokjer<sup>2</sup>, Ian Crossley<sup>2</sup>, Joe Franko<sup>3</sup>

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3. Hazen and Sawyer, PC, 1905 South 25<sup>th</sup> Street, Fort Pierce, FL 34947

Ozonation has been added to the treatment process at the 20 mgd Lake Washington Surface Water Treatment Plant (SWTP), Melbourne, Florida to improve finished water quality, control taste and odor, and provide greater than 0.5-log credit for inactivation of *Cryptosporidium*. The new ozone contactors (two parallel 10 mgd trains) are located between the existing Actiflo<sup>TM</sup> clarifiers and the filters on a relatively congested site.

A Computational Fluid Dynamics (CFD) study indicated that the proposed contactor design was not optimized to provide the targeted *Cryptosporidium* log inactivation. Based on the CFD modeling, the baffle heights were reduced (increasing end gaps at turns) and the baffle ends were chamfered to improve flow patterns within the contactor. Internal access platforms were rotated from parallel to the flow (along outside walls) to perpendicular to the flow (along baffle walls). These small changes increased the effective detention time ( $t_{10}$ ) for disinfection and the corresponding hydraulic efficiency (baffling factor) by 22 percent. In addition, the dosing location for the ozone quenching chemical (hydrogen peroxide) was modified to provide extra ozone detention.

During the start up of the ozone system, fluoride tracer tests were completed to validate the effective detention time (and baffling factor) calculated by CFD. Furthermore, a series of modifications are planned for the ozonated water sampling regime to take greater advantage of  $Ct_{10}$  credits and reduce the required ozone dose, thereby saving energy and operating costs. This paper discusses several calculation methods for *Cryptosporidium* inactivation  $Ct_{10}$  reporting in compliance with the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) and the LT2ESWTR Pre-proposal Draft Regulatory Language for Stakeholder Review (USEPA 2002). The selection of the method will depend upon ease of implementation, modifications required to the ozone-in-water residual sampling system, results of bromate sampling and actual bin classification under the LT2ESWTR.

The paper and presentation describes the CFD studies, improvements made to the contactor design, the tracer validation of the design,  $Ct_{10}$  reporting methods and modifications to the ozone residual sampling system that the City is considering.

## Evaluating Hydraulic Implications of Adding Ozone to Conventional Water Treatment Plants

**Ben Kuhnel<sup>1</sup>, Iraj Asgharzadeh<sup>2</sup>, Markus Mohrle<sup>1</sup> and Jack Bebee<sup>1</sup>**

1. Malcolm Pirnie, Inc., 1525 Faraday Avenue, Suite 290, Carlsbad, CA 92008
2. City of San Diego, 600 B. Street, San Diego, CA

The recently promulgated Long Term 2 Surface Water Treatment Rule (LT2SWTR) and Stage 2 Disinfectant/Disinfection Byproducts (D/DBP) regulations require many water treatment plants to increase their disinfection capabilities, while at the same time decrease chlorinated disinfection byproduct formation. Compliance with these regulations has many municipalities evaluating disinfection alternatives, such as ozone, as an additional treatment step within their conventional treatment processes. This paper evaluates the typical hydraulic impacts of the addition of ozone to conventional treatment plants and discusses typical approaches utilized at facilities to accommodate the additional headloss within the treatment plant.

This paper also presents the results of recent pilot studies evaluating the use of high speed pumps for intermediate pumping between ozonation and filtration. It shows that the impacts of high speed pumps on filterability may be in many instances overstated and lower cost high speed pumping options may be a viable solution for some facilities to boost plant hydraulics to accommodate the addition of ozonation.

## Investigating Two Scales of In-Line Multi-Jets Ozone Contactors

**Mahad S. Baawain<sup>1</sup>, Mohamed Gamal El-Din<sup>2</sup>, Daniel W. Smith<sup>2</sup> and Angelo Mazzei<sup>3</sup>**

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3. Mazzei Injector Corporation, Bakersfield, CA

This study investigates the mixing and ozone mass transfer characteristics of two scales of in-line multi-jets ozone contactors. The hydrodynamic characteristics of the two contactors were studied by using a laser flow map particle image velocimetry coupled with planar laser induced fluorescence (PIV/PLIF). All measurements were conducted under total liquid flow rate of about 10 L/s (for 0.10 m diameter contactor) and 5.5 L/s (for 0.075 m diameter contactor) with gas flow rate ranging from 0.05 to 0.4 L/s (for 0.10 m diameter contactor) and 0.03 to 0.24 L/s (for 0.075 m diameter contactor). Side injectors (opposing and alternating modes) were used to introduce the gas to the contactors. It was found that for the same number of jets (i.e. same gas flow rate) the liquid dispersion ( $D_L$ ) was higher when alternating jets were used. Higher ozone mass transfer rates were observed when using opposing jet compared to the same number of alternating jets.

**Monday PM – Session 4 – Air and Surface Treatment II – Agriculture and Food Applications  
(Coronado J)**

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## **Update on Ozone Based Low Temperature Oxidation for Control of NO<sub>x</sub> and Mercury in Flue Gas Emissions**

**Robert Ferrell**

RJF Consultants, LLC, 196 Hollister Avenue, Rutherford, NJ 07070

This paper will review the current status of Ozone based Low Temperature Oxidation of Nitrogen Oxides and Mercury for removal from flue gases. A review of Low Temperature Oxidation chemistry and historical installations is provided, including the recent startup and operation of several large scale refinery installations. A summary of recent related intellectual property is also provided. Finally, the paper reviews the application of recent improvements in oxygen recycle technology and its economic impact on ozone based Low Temperature Oxidation for control of flue gas pollutants in coal fired power plants.

## Decomposition of VOC's by Ozonation in Gas Phase

**M. Franco<sup>1</sup>, T. Poznyak<sup>1</sup>, I. Chairez<sup>2</sup>, and A. Poznyak<sup>3</sup>**

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3. Department of Automatic Control, CINVESTAV-IPN. AP. 14740, Av. Instituto Politécnico Nacional No. 2508, C.P. 07360, México D.F., México,

In the present study the decomposition of the model mixture of volatile organic compounds (VOC's) (MTBE and benzene) and the real mixture of the VOC's (MTBE and BTEX), which were absorbed on the contaminated ground water, by ozone in the gas phase were realized. The experiments with the model and the real mixtures of VOC's were conducted in two stages. In the *first stage*, these organics were ventilated by oxygen flow to liberate from the liquid phase (aqueous solution) to the gas phase, and in the *second stage*, the stripped VOC's by ozone in the other section of the reactor in the gas phase were decomposed. The ozonation in the tubular reactor with the variable length (from 0.25 to 1.5 m) was realized. The efficiency of ozonation by the input and the output analysis of the pollutants concentration were determined and by the on-line ozone sensor (BMT-963) was monitored. The VOC's concentration variation and products formed in ozonation by liquid chromatography (HPLC) are analyzed. The experimental data were compared with numerical results obtained by classical mathematical models describing the reaction between two or more gases into tubular reactor. The numerical simulation demonstrates good coincidence with the experimental data for the model mixture of VOC's.

**Monday PM – Session 4 – Air and Surface Treatment II – Agriculture and Food Applications  
(Coronado J)**

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## **Manage Grease Laden Vapors in Commercial Cooking Operations**

**Chris Thompson**

Franke Foodservice Systems, 305 Tech Park Drive, LaVergne TN, 37086

Ozone, in combination with Ultraviolet light (UVC), holds considerable promise in managing the grease-laden vapor produced by commercial cooking operations. The application of UV light and Ozone to a commercial cooking exhaust stream reduces the build-up of grease on the interior of the exhaust duct, the exhaust fan, and the areas surrounding the exhaust fan. The benefits of reducing the buildup of grease is lower fire propagation risk in the duct, less frequent duct cleanings, reduced odor emissions to areas surrounding the commercial cooking operation, and improved energy efficient operation of the commercial cooking operation over time. This paper will review the technology of applying UV and Ozone synergistically to a commercial cooking operation and laboratory efficacy studies of this technology. Field case studies of this technology will also be presented.

## **Optimization of CIP Process for Ozone Sanitization Retrofit**

**James R. Jackson<sup>1</sup> and Arturo Enriquez<sup>2</sup>**

1. Mazzei Injector Company, LLC., Bakersfield, CA, USA
2. Laboratorios Sanox SA de CV, Querétaro, Querétaro, MEXICO

The inclusion of ozone sanitization in CIP processes promises multiple benefits to the food processing and beverage industries. Chief among these is the reduction in plant down time during the CIP procedure, a benefit which goes directly to the bottom line as increased plant production.

Over the years, numerous white papers have lauded the inclusion of ozone sanitization in the CIP process. These case histories credit ozone sanitization with a rapid reduction in bio-film and demonstrate a significant return on the investment made in the ozone system; yet today only a handful of plants include ozone a part of their CIP procedure.

The lack of growth in ozone CIP sanitization suggests that integrating ozone into a CIP process requires a level of knowledge and commitment beyond that required for other ozone applications. This paper examines the intricacies of optimizing a beverage CIP system in preparation for retrofit with an ozone sanitization system; illustrating how the benefits of ozone sanitization are highly dependent on the skill at which the ozone system is integrated into the existing CIP process.

**Monday PM – Session 4 – Air and Surface Treatment II – Agriculture and Food Applications  
(Coronado J)**

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## **The Utilization of Ozone for Treating Vegetable Processing Lines**

**Charles D. Sopher<sup>1</sup>, George T. Battles<sup>2</sup> and Daniel Johnson<sup>3</sup>**

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Adoption of ozone technologies as Food Safety treatments in the Agri-Food Industries today is still being approached with great caution. This caution is due to capital costs, a variety of competing technologies available and a lack of understanding of the exact methods of technology application methodologies that will provide worker safety as well as a safe food product. The promising technologies available today are washing, ozone, chlorination, UV light, advanced oxidation and chemical rinses. Each technology has many merits as a stand-alone treatment as well as considerable evidence that combination treatments can increase food safety as well as providing extended shelf life and enhanced product quality. Additionally, there is mounting evidence that technologies utilizing ozone, UV and advanced oxidation will provide considerable energy savings by reducing water use, chilling costs, HVAC costs and labor costs associated with water use.

This paper reviews selected successes in using ozone UV and advanced oxidation to enhance food safety and reduce energy costs in the Agri-Food industry. Included is a preliminary case study of utilizing ozone and chlorination in a FTNON vegetable washing system. Vegetable flotation washing systems such as the FTNON equipment produced by Noord-Oost in the Netherlands have the potential to vigorously wash sand as well as floating particulate from vegetables and fruits. With minor modifications these machines can be adapted to utilize combinations of ozone, UV and chlorination. Preliminary trials indicate plate counts are lowered with the combination treatment. Because of water agitation off-gassing can be a problem.

The utilization of combination treatments in these new flotation washing machines will challenge the ozone and UV industries to develop techniques to inject ozone without off-gassing and locate UV lighting in the system to provide maximum microbe reductions and ensure worker safety. Future data will need to be collected to determine the levels of chlorination required to ensure residual microbial protection without detracting from product taste and quality. When developed, these systems have the potential to enhance food safety, reduce water use and wastewater discharge amounts, reduce electrical demand and increase product shelf life.

## **Ozone Model for Drip Irrigation Systems**

**Jose Chen-Lopez<sup>1</sup>, Matthew H. Stong<sup>2</sup> and Peter Waller<sup>1</sup>**

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Ozone concentration was modeled along a subsurface drip irrigation system. The project generated two models; a model with two-phase flow with ozone in the gas and liquid phases within the tube, and a model with single-phase flow using only aqueous ozone. The equilibrium concentrations of ozone in the gas and liquid phases were calculated with Henry's Law. The models were evaluated with field experiments in which ozone was produced and injected into a drip irrigation system. In order to obtain a control measurement, in some experiments, ozone gas was removed prior to the drip irrigation tube by a degasser. Three water qualities were used in the experiments, potable water with chlorine, open storage tank water with high organic matter concentration, and open storage tank water with low organic matter concentration. Water was collected every 10 m along the irrigation system and aqueous ozone concentration was measured. The best-fit degradation coefficient for potable water was 0.003/s, and for storage tank water (for both high and low organic matter concentrations) was 0.004/s. This ozone model could be used in the field to calculate the required ozone production rate and concentration at the injector in order to maintain an acceptable concentration at end of the irrigation system.

**Monday PM – Session 4 – Air and Surface Treatment II – Agriculture and Food Applications  
(Coronado J)**

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## **Tight Control of Ozone Concentration in Spring Water Filling by an Integrated Ozone Contacting System with Advanced Feed Forward Ozone Control**

**Bob Smith-McCollum and Joe Fleck**

Pacific Ozone, 6160 Egret Court, Benicia, CA 94510

Final bottling of spring water requires tight control of the concentration of ozone to ensure a consistent balance between sanitation and bromate formation. An integrated ozone contact system has been developed for dosing ozone on a spring water filling line utilizing an integrated ozone contacting system with advanced feed forward ozone control. System requirements included delivery of the spring water to the filling line with a dissolved ozone concentration of 0.36-0.40 parts per million (ppm) for a final target concentration of 0.15-0.20 ppm in the bottle over a broad range of bottle sizes. The target variation of ozone concentration was  $\pm 10\%$  of set point. The limitations of traditional PID control were overcome with an advanced, nested loop, feed forward control system. Before the implementation of the control system, the recorded concentration of dissolved ozone over time revealed broad swings to  $\pm 25\%$ . Much tighter control of ozone concentration resulted after implementation of the feed forward control system – well within the original goals for the system.

## Ozone Therapy in Cancer Treatment - State of the Art

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2. National Oncology and Radiobiology Institute, Havana, Cuba.

3. "V. I. Lenin" Provincial Hospital, Holguín, Cuba.

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The development of an effective cancer therapy is a major focus of biomedical research. In this paper we reviewed the state of the art of the different ozone biological effects, in relation with the possibility to use medical ozone as a therapeutical strategy for cancer treatment. Erlich Ascitic Tumor and Sarcoma 37 were implanted in mice and afterward the animals were treated with ozone, by rectal application. These results demonstrated a significant decrease in the number of metastasis. In another preclinical study, ozone was applied intraperitoneally, before Lewis' lung carcinoma inoculation. In this study, a delayed effect in the tumor development kinetics, as well as in the increase rate of tumor volume in the ozone pre-treatment groups in comparison with the control group were observed. With regard to the clinical trial, patients with prostatic cancer were treated with cobalt-60 therapy and ozone (applied rectally), decreasing the presence of side effects and the prostatic specific antigen figures. In spite of its potential usefulness as an adjuvant in chemo-radiotherapy and its antimetastatic effect, further investigations are necessary to be performed.

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**Monday PM – Session 5 – Medical Applications (Coronado M & N)**

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## **Ozone Therapy for the Treatment of Retinitis Pigmentosa**

**Robert H. Marmer, M.D.**

Morehouse School of Medicine, Atlanta, Georgia

Traditionally, patients with Retinitis Pigmentosa have been told that there is no hope and that peripheral field of vision will continue to progressively constrict until all vision is eventually extinguished. RP patients anticipate blindness.

A treatment recently developed in Cuba whereby 200 cc's of blood is collected, ozonated, and is re-infused into the patient on 15 consecutive days was found to increase contrast sensitivity, enhance color perception, augment glare recovery, facilitate function in low light, and in some cases expand the visual field.

If repeated every 4-6 months it is felt that progression of the disease can be slowed or stabilized.

## Ozone Therapy in Diabetes: a Preclinical and Clinical Study

**Silvia Menéndez<sup>1</sup>, Olga Sonia León<sup>2</sup>, Saied M. Al-Dalain<sup>2</sup>, Gregorio Martínez<sup>2</sup> and Héctor Alvarez<sup>3</sup>**

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In Diabetes, an increase of reactive oxygen species (ROS) plays an important role in diabetic complications. In this study, we evaluate ozone efficacy in an animal model using streptozotocin as a diabetic inductor and in a clinical trial with type 2 diabetic patients suffering of ulcers of the feet and lower extremities in comparison with antibiotic therapy. In both studies, ozone treatment improved glycemic control and prevented oxidative stress, not occurring in the antibiotic group. In the animal model, ozone treatment improved pancreas integrity. The length of hospitalization decreased in patients treated with ozone with regard to the antibiotic group, with less number of amputations. Ozone therapy could be a future alternative in the therapy of diabetes and its complications.

## Oxidative Preconditioning: an Ozone Protective Mechanism of Action

**Silvia Menéndez<sup>1</sup>, Olga Sonia León<sup>2</sup>, Zullyt Zamora<sup>1</sup>, Aluet Borrego<sup>1</sup>, Ricardo González<sup>1</sup>, Frank Hernández<sup>1</sup> and Siegfried Schulz<sup>3</sup>**

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A better understanding of the ozone basic reactions is needed in order to dispel the skepticism surrounding ozone therapy. In order to demonstrate the improvement of the antioxidant defense system due to the ozone medical application, four animal models were evaluated: hepatotoxicity induced by carbon tetrachloride; liver ischaemia-reperfusion; cisplatin-induced nephrotoxicity and endotoxic shock using lipopolysaccharide. An improvement of the antioxidant defense system and a preservation of the cell redox state were achieved, maintaining the renal and hepatocellular integrity, avoiding the establishment of a chronic inflammatory response and an oxidative stress. The lipid oxidative processes are avoided or attenuated by ozone oxidative preconditioning. This study contributes to clarify an important pharmacodynamic effect after prolonged ozone therapy treatments.

## Application of Ozone Therapy in the Treatment of Herniated Disk

**Silvia Menéndez<sup>1</sup>, José Luis Calunga<sup>1</sup> and Alberto Balbín<sup>2</sup>**

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Low back pain can affect up to about 80% of the world's population, limiting their daily activities. The aim of this study is to evaluate the efficacy of ozone therapy in patients with herniated disk comparing three ways of ozone administration: intradiscal, peridural and paravertebral combined with ozone applied rectally. All variants of treatment were effective for these patients and no hospitalization was needed. The results demonstrated that ozone therapy in patients with disk herniation produced between 85% to 95% and 60% to 80% of clinical and radiological improvements, respectively. No side effects were observed during the study.

## Ozonized Sunflower Oil (OLEOZON<sup>®</sup>): a Natural Product Against Fungi, Bacteria and Parasites

**Silvia Menéndez<sup>1</sup>, Leopoldina Falcón<sup>2</sup>, Amada Palomino<sup>2</sup>, María Elena González<sup>3</sup>,  
Pilar Acuña<sup>4</sup>, Juana Elisa Benítez<sup>5</sup>, Manuel Díaz<sup>6</sup>, Mayté Amoroto<sup>7</sup> and  
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OLEOZON<sup>®</sup> is obtained by the ozonization of sunflower oil. Taking into account its effective antimycotic, bactericidal and parasiticide properties, three controlled randomized phase III clinical trials for the treatment of tinea pedis, impetigo and giardiasis were performed. The results demonstrated that OLEOZON<sup>®</sup> is equivalent to the medication used as control for each clinical trial, showing its efficacy in the treatment of tinea pedis, impetigo and giardiasis. Also, OLEOZON<sup>®</sup> can be considered as a safety medication for these purposes.

## **State-of-the-Art Ozonation Practices at Major Municipal Wastewater Treatment Plants in the United States**

**Joseph A. Drago and Craig M. Thompson**

Kennedy/Jenks Consultants, 622 Folsom Street, San Francisco, California, 94107

This paper describes known ozone applications at operating major (average dry weather flow greater than 1 million gallon per day) municipal wastewater plants in the United States. The review is based in part on a recent Water Environment Research Foundation (WERF) survey of U.S. municipal wastewater disinfection practices that identified seven major municipal wastewater treatment plants that were using ozone for disinfection and/or oxidation. The paper provides information on the original purposes for ozone selection, ozone feed capacity, feed gas type, ozone injection system, contactor design, and ozone dosing strategy at these plants.

## **Ozonation of Secondary Effluent of Sewage Treatment Plant for the Cooling Water of Thermal Power Plant**

**Kousei Sasaki<sup>1</sup>, Nobuhiro Yamato<sup>1</sup>, Eiji Sakuraba<sup>1</sup>, Kazutaka Takahashi<sup>1</sup>, Seiji Yamana<sup>2</sup> and Shigeo Mitsuma<sup>2</sup>**

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2. Tokyo Gas Yokosuka Power Co., Ltd., 5-2931-70, Uragou-cho, Yokosuka-city, Kanagawa, 237-0062, Japan

We have developed the technology to reuse secondary effluent for the cooling water of a power plant. The reuse flows were as follows: secondary effluent, filtration, ozonation, storage tank and cooling tower. COD value of secondary effluent was 8 to 10 mg/L, and that of make up water after ozonation was 5 to 8 mg/L. However, it showed 30 to 40 mg/L at the cooling tower because of evaporation. Change of water qualities during a day was very little. As for scaling, electric conductivity and hardness were measured, and a scale prevention chemical is added. In these conditions, the power plant was being operated well.

## **The Certification and Use of HiPOx™ for Reclaimed Water Disinfection**

**Keel Robinson<sup>1</sup>, Andrew Salvesson, P.E.<sup>2</sup>, Cari Ishida, Ph.D.<sup>2</sup>**

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2. Carollo Engineers, 2700 Ygnacio Valley Rd., Ste. 300, Walnut Creek, CA 94597, USA

We performed detailed pathogen disinfection testing at both the bench- and pilot-scale for ozone and advanced oxidation (ozone and hydrogen peroxide) using Applied's HiPOx technology to meet the stringent disinfection criteria for "tertiary recycled water" under Title 22 of the California Code of Regulations. The data suggest that the disinfection of seeded virus with HiPOx is rapid with CT values less than 0.20 mg-min/L. Similarly, the log reduction of total and fecal coliform disinfection occurs rapidly, but moderate CT values of 1.0 mg-min/L are needed to bring coliform counts below detection limits. The findings of this study will help establish the proper use of HiPOx for reclaimed water treatment and provide an alternative technology to various regulators and municipalities for water reuse.

**Tuesday AM – Session 6 – Wastewater Treatment and Industrial Applications (Coronado J)**

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## **Product Recovery Through Ozone Oxidation Of Waste Liquor**

**James R. Jackson and Justin Bennett**

Mazzei Injector Company, LLC. Bakersfield, CA, USA

The manufacturing of soda ash from Trona, a crystalline mineral composed of hydrate sodium bicarbonate carbonate, is a multi-step process that results in the production of a waste liquor that contains significant levels of organic contamination.

US Environment Protection Agency (USEPA) regulations do not allow for disposal of this chemically rich liquor without extensive processing; consequently, manufacturers of soda ash must collect the waste liquor and store it in an environmentally acceptable manner.

This paper reviews a chemical plant's pilot success at converting the waste stream from their soda ash processing facility into a marketable product, by reducing the liquor's total organic content (TOC) through ozone oxidation. The positive environmental impact and projected bottom line return on the investment in an ozone system are reviewed in detail.

## **Degradation of Naphthenic Acids in Athabasca Oil Sands Process-Affected Water Using Ozone**

**Hongjing Fu<sup>1</sup>, Keisuke Ikehata<sup>1</sup>, Mohamed Gamal El-Din<sup>1</sup>, Daniel W. Smith<sup>1</sup>,  
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Naphthenic acids (NAs) are natural low molecular weight surfactants released from bitumen during caustic hot water digestion of oil sands ore. As a result, NAs are released into the oil sands process-affected waters (OSPW) at concentrations ranging from 40 to 120 mg/L. NAs are closely related alicyclic carboxylic acids ( $C_nH_{2n-z}O_2$ ), and have been shown to contribute to most of the acute toxicity of OSPW. The treatment of OSPW to reduce or remove NAs is critical for their reclamation and potential discharge options. As a part of an ongoing study, a series of preliminary experiments were undertaken where OSPW samples from an Athabasca oil sands tailings pond was treated with an advanced oxidation approach. Using a simple non-optimized treatment, in which ozone was bubbled through an OSPW sample for different periods of time (1 to 30 min), up to 99% reductions of NAs were achieved. In the same samples, the maximum reductions in dissolved organic carbon and chemical oxygen demand were 32% and 53%, respectively. This indicates that ozonation produced smaller organic by-products. This preliminary data shows that ozone offers a promising treatment for the removal of NAs in OSPW within water management options. Further research will focus on optimizing ozone treatment efficiency, assessing of the dose-relationship, and understanding the mechanisms of NAs degradation pathways and the effects on toxicity of OSPW.

## **Degradation of Triclocarban by Ozone**

**C. Tizaoui, N.M. Grima and J.K. Ephraim**

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UK

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Triclocarban, also known as TCC, (CAS number: 101-20-2) is widely used as an antimicrobial compound due to its sanitizing properties in a wide range of household and personal care products such as detergents, soaps, shampoos, toothpastes, wipes, and cleansing lotions. Research studies have shown that TCC persists in effluents discharged from sewage treatment plants and is difficult to biodegrade. TCC can contaminate surface waters since it persists in discharged waste waters or accumulate in biosolids that may be used as a fertilizer and soil conditioner for crops. Therefore, there is concern about the fate and potential impacts of TCC released in the environment. Few research studies have shown that TCC can be toxic when ingested and can potentially pose human health risk. It is only recently that the adverse impacts of TCC in the environment and humans are studied, though the compound has been in use for several decades. Studies concerned with the removal and degradation of TCC in water are almost inexistent.

This paper presents results of an experimental investigation on the degradation of TCC by ozone at concentrations in the order of 100 mg/L TCC in a mixture of 70%<sub>vol</sub> acetonitrile and 30%<sub>vol</sub> water using a semi-batch gas/liquid reactor. The work revealed that ozone was effective to degrade TCC and the degradation rates increased substantially by increasing the inlet ozone gas concentration. The chemical reaction was found to follow second order reaction kinetics. The effect of pH was studied and it was found that an increase in pH showed significant increase in the reaction rate constants, which suggests that hydroxyl radicals contribute to TCC degradation process. To confirm this, the effect of a radical scavenger (*t*-butanol) at 0.2 M was also studied. It was found that the addition of *t*-butanol decreased the reaction rate by almost 78%, which proves that hydroxyl radicals play an important role in TCC degradation in addition to molecular direct ozone reaction. The average overall reaction rate constants were found in the order of  $4.2 \times 10^4$  and  $9.3 \times 10^3$  L/mol.s for conditions without and with *t*-butanol, respectively. The stoichiometry of the reaction was found to equal 1.

## **Emergency Water Mobile Response Unit with Ozone Heart: The Life Saving Power of Water**

**Ernie Wilmink**

“The Key” Water and Air International, 45585 State Hwy 91, PO Box 93, Lindsay, NE 68644-0093

Every minute 3.5 children die world wide due to inadequate drinking water. Due to this horrific fact, the Emergency Water Mobile Response Unit (EWMRU) was researched, invented, designed, engineered, manufactured and tested to eradicate all harmful contaminants from drinking water. The EWMRU uses span from potable drinking water to wound care and injury treatment. Ozone Oxidation/Disinfection is the heart of the operation, which is one of seven different stages of treatment, including: sand filtration, micro filtration, multi-media filtration, carbon filtration, reverse osmosis, and ultraviolet disinfection. The Emergency Water Mobile Response Unit itself is self-contained in a 21 foot, custom built dual axle trailer that can be towed behind a typical pickup truck or air lifted to any location from which to pull water. One mobile unit produces 21,000 gallons of safe drinking water per day. This unit is equipped with a 15,000 Watt generator and a heating/air conditioning system to allow the unit to function independently in extreme fluctuating temperatures. It is equipped with laboratory facilities to be used to test water and determine which stages of treatment are needed before starting the water purification process. The lab work recognized by our engineers has been validated. Water tests done on the unit in Metro Vancouver, Canada found *E. coli* at 60 MPN/100 mLs and coliform at >2093 MPN/100 mLs in the sample test water. After treating the water with the EWMRU, both were decreased to <1 MPN/100 mLs.

## Ozone System Expansion and Contactor Dissolution System Upgrades at the Sweeney WTP

**Nick Burns<sup>1</sup>, Robert Hulsey<sup>1</sup>, Brian Townsend<sup>1</sup> and Michael Richardson<sup>2</sup>**

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2. City of Wilmington, NC 28402

The Sweeney WTP is undergoing an expansion to 35 mgd, and as part of that expansion, one additional ozone generator will be installed and all of the existing ozone dissolution systems will be replaced with sidestream injection. The paper includes the reasoning used to select one additional 690 ppd generator based on historical operations and water quality; the design criteria for the pre- and intermediate-ozone sidestream equipment; a description of the sidestream retrofit and the modifications made to the transfer cell; and the full-scale testing performed to document the improvements in CT.

## **Biofiltration without Chlorinated Backwash**

**Justin Sutherland, Ph.D., P.E.<sup>1</sup>, Charles Vokes<sup>2</sup>, Jim Gallovich, P.E.<sup>3</sup>  
and Ron Joost, P.E.<sup>4</sup>**

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2. City of Arlington, Water Utilities Department, Arlington, TX 76001
3. Carollo Engineers, 14785 Preston Rd., Suite 950, Dallas, TX 75254
4. Carollo Engineers, 3033 North 44th Street, Suite 101, Phoenix, AZ 85018

The City of Arlington, Texas has consistently produced high quality water with its biological GAC filters. Despite this filter performance, their production has been decreasing over time. A preliminary investigation showed that this decrease is likely due to the presence of excess biological growth on filter media and the fouling of the underdrain porous plates. Based on these findings, a pilot test was developed to evaluate alternative biofilter media configurations. Results showed that the anthracite and GAC test filters were capable of achieving similar removal of turbidity, biodegradation, and manganese as compared to the existing GAC (control) filter.

## **Ozone System Data Collection, Analysis and Operations Optimization**

**Sajal Mitra<sup>1</sup>, Ric Johnston<sup>1</sup>, Kerwin Rakness<sup>2</sup> and Glenn Hunter<sup>2</sup>**

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2. Process Applications, Inc., 2627 Redwing Rd., Suite 340, Fort Collins, Colorado 80526  
Phone: 970-223-5787.

The Metropolitan Water District of Southern California began operating the ozone systems at the Mills and Jensen water treatment plants in 2003 and 2005, respectively. The Mills ozone system is sized to treat 160 million gallons of water per day (MGD) and the Jensen plant 750 MGD. The design ozone dose at both plants is 2 mg/L. Ozone is used for compliance with the Disinfection/Disinfection Byproducts Rule, plus reduction of taste and odor problems.

Important ozone system operations data is retrieved every four hours from SCADA and stored in an Excel database. This data, which is now available for several years, is analyzed and interpreted to make operational changes and perform corrective maintenance activities. This paper discusses the features of the database, some of the important analytical results, actions taken to implement recommended changes and resulting performance improvements.

## **Initial Operating Experience with a State-of-the Art Ozone System Retrofit to Replace the Original 20 Year Old Ozone System**

**Craig Thompson<sup>1</sup>, Cristina Correa<sup>1</sup>, Bill Yates<sup>2</sup>, Todd Fessenden<sup>3</sup> and  
Glenn Hunter<sup>4</sup>**

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2. Kennedy/Jenks Consultants, Lakewood, Colorado
3. Eagle River Water and Sanitation District, Vail, Colorado
4. Process Applications Inc., Ft. Collins, Colorado

The Eagle River Water and Sanitation District (District) and Upper Eagle Regional Water Authority (Authority) serve the Eagle Valley on the western slope of the Rocky Mountains west of Denver, Colorado. The District provides contract operations to the Authority. The District and Authority were at the forefront of ozone use in the United States in the 1980s having installed ozone at the Vail Wastewater Treatment Plant (Vail WWTP) in 1986 and at the Avon Drinking Water Facility (Avon DWF) in 1987.

The Authority must comply with increasingly stringent water quality regulations. District staff believes that ozone oxidation is, and will continue to be, a critical part of their on-going efforts to comply with the new Stage 2 Disinfectants and Disinfection Byproducts Rule. When it became impractical to continue operating and maintaining the original ozone system components at the Avon DWF, the Authority decided to replace the original ozone system with a new state-of-the-art ozone system.

This presentation will provide information on initial operation of the new ozone system at the Avon DWF. The Avon DWF is located at 7,400 feet elevation. This creates an additional challenge due to the lower ambient air pressure being near 11 pounds per square inch (psi) absolute (psia), which is about three-quarters of the pressure available at sea level. The ozone system improvements provide the ability to monitor the dissolved ozone concentration in the two contactors designed in 1995, and also to recycle the ozone-rich off-gas from inside the two pre-ozone contactors into the raw water as it enters each of these two ozone contactors.

## Optimization of an Ozone Side Stream Injection System

**Bill Mundy C.E.T.<sup>1</sup> and Kerwin Rakness<sup>2</sup>**

1. Regional Municipality of Halton, 1151 Bronte Road, Oakville, Ontario, Canada, L6M 3L1
2. Process Applications Inc., 2627 Redwing Drive, Fort Collins, Colorado, USA, 80526

The Oakville Water Purification Plant (BWPP), located in Halton Region, Oakville, Ontario has a capacity of 110ML/d. Source water for the facility is from Lake Ontario which has low to moderate levels of bromide. The OWPP has an ozonation system designed for *Cryptosporidium* inactivation and enough capability for taste and odour removal with the option of advanced oxidation through the use of hydrogen peroxide.

The Oakville Ozone system is a side stream injection system by design. It has three side stream injection systems (2 firm capacity) with variable speed controllers for process optimization.

It was demonstrated through optimized process control that the gas/liquid ratio can be adjusted to maximize ozone transfer and minimize operating costs.

## **Pre- and Post-Ozone Dose Study at the North Bay Regional Water Treatment Plant**

**Mike Oneby<sup>1</sup>, Charlie Bromley<sup>2</sup>, Doug Rodgers<sup>3</sup>, Laura de Albidress<sup>3</sup> and Jeff Lodge<sup>4</sup>**

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2. MWH Americas, 3010 W. Charleston Blvd, Suite 100, Las Vegas, NV 89102
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4. MWH Americas, Inc., 3321 Power Inn Rd, Suite 300, Sacramento, CA 95826-3889

The City of Fairfield conducted a pre- and post-ozone dose study at the North Bay Regional Water Treatment Plant (NBRWTP). The purpose of the study is to verify the current ozone dose practices by monitoring operating conditions and a wide variety of water quality parameters while sequentially varying pre-ozone and post-ozone dosages. The study preceded an upgrade of the existing ozone system that expanded ozone production capacity from 1,000 lb O<sub>3</sub>/d (19 kg/h) to 1,400 – 1,500 lb/d (26 - 28 kg/h). The Cities of Fairfield and Vacaville, California jointly own the NBRWTP, operated by the City of Fairfield (City). Constructed between 1989 and 1990 with a design capacity of 40 mgd (6,300 m<sup>3</sup>/h), the plant has utilized pre- and post-ozone since it began operation in Fall of 1990. The pre-ozonation process is primarily for oxidation of NOM for improved coagulation/flocculation/sedimentation and filtration. The post-ozone process is used for reduction in chlorine demand and incidental disinfection. The ozone dose study, conducted between April 21 and May 23 2008, was timed to coincide with the highest historical raw water TOC and maximum ozone demand. The information gained from the study provided the City with revised ozone dosages designed to optimize finished water quality.

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**Tuesday AM – Session 7 – Drinking Water Process III (Coronado L)**

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## **Good Process Control in Ozone Plants Starts with Proper Tuning**

**Jim Muri**

John J. Carroll Water Treatment Plant, Process Control  
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The Massachusetts Water Resources Authority (MWRA) utilizes ozone as the primary disinfectant at its 405 MGD John J. Carroll Water Treatment Plant (JJCWTP). This facility supplies water to 2.1 million Metropolitan Boston and MetroWest consumers. A description of the process control used at JJCWTP and the improvements gained in process control through proper design and tuning of control loops is described. The primary goals of process engineering staff have been improvements in efficiency and reliability.

A description of the plant and its processes are described. The plant consists of hydraulic control of water through the plant, ozonation using LOX, ozone quench with bisulfite, fluoridation, pH and alkalinity adjustment with soda ash and carbon dioxide, and chloramination prior to distribution.

A brief primer is given on process control, including flow-pacing, feed-forward, feed-back, and PID control loops. Controllability, stability and instability, and robustness are briefly described. Concrete examples of control challenges at the JJCWTP are given and their solutions are described, including ozone gas feed control, ozone gas concentration control, contactor vacuum control, and bisulfite quench control.

## Pilot Testing for Inactivation of Non-Indigenous Seawater Organisms by Ozonation and Ultraviolet Sterilization

**Joel V. Johnson<sup>1</sup>, Angi Hotz<sup>2</sup> and Jeremy Lord<sup>3</sup>**

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2. Nautilus Environmental, 5550 Morehouse Dr., San Diego, CA 92121
3. Birch Aquarium at Scripps, 9500 Gilman Dr., Mail Code 0207, La Jolla, CA 92093

Research was conducted to develop and implement controls to result in a negligible risk of the release of non-indigenous species (NIS) including foreign pathogens (parasites, protozoa, bacteria, and viruses) into the Ocean. To remove viable NIS and prevent discharge of possible invasive species to the Ocean, a pilot study – using a pilot-scale treatment plant – was performed to evaluate the effectiveness of various treatments for inactivating at least 99% of NIS from seawater effluent discharge without chemical additions. For evaluation of NIS, the following five indicator species were selected: brine shrimp nauplii (*Artemia salina*), marine rotifers (*Brachionus plicatilis*), heterotrophic bacteria, marine green algae (*Nannochloropsis* spp.), and mussel larvae (*Mytilus* spp.).

The pilot test skid included mechanical filtration, UV sterilization, and a foam fractionator unit for ozone contacting. The objective of the pilot testing was to determine the combination of treatments, along with their corresponding doses and exposure periods, required for the desired level of inactivation. These data will be used for sizing of ozonation and UV sterilizer equipment required in the full-scale treatment system to deliver similar kill rates. The pilot testing concluded that filtration (or micro screening) will be required, in addition to both ozonation and UV sterilization, to meet the treatment goals.

**Tuesday AM – Session 8 – Aquatic Animal Life Support (Coronado M & N)**

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## **Operator Interface Implications for Automated Ozone Dosage & Control of Aquatic Life Systems**

**Lonnie Lamb**

Walt Disney Company – Animal Programs Group  
2016 N. Avenue of the Stars- EC Trl. W-251  
Lake Buena Vista, FL. 32830

This presentation will discuss various options for control and monitoring of applied Ozone for use in fish & aquaculture habitats. It will also explore data feedback models and how they may be used as an aid to optimizing Ozone dosage and improving the aesthetic quality of fish systems in zoos and Aquariums. The presentation will include case studies from the Walt Disney World Animal Programs Team, Life Support Group.

## **Management of Ozone in Aquarium Life Support Systems**

**Andrew Aiken**<sup>1,2</sup>

1. National Aquarium In Baltimore, 501 E. Pratt Street, Baltimore MD, 21202, USA
2. Aiken & Associates, Inc., 8229 Bayside Drive, Pinehurst MD, 21122, USA

Utilization of ozone in aquatic Life Support Systems differs from other water treatment processes in that aquatic animals reside in the ozonated process water. Residual oxidants can be severely damaging or fatal to animals held in the system. A means to balance oxidation/disinfection goals with low or no residual oxidants is necessary. Factors important in ozone management include oxidation reduction potential, calculation of applied ozone dose, total and residual oxidant measurements, turbidity and monitoring the effects of husbandry practices. With a balanced approach, ozone provides excellent control of microorganisms, dissolved organic molecules and other contaminants that threaten aquatic animal health without creating damaging residual oxidant accumulation.

**Tuesday AM – Session 8 – Aquatic Animal Life Support (Coronado M & N)**

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## **Ozone Use at the Monterey Bay Aquarium: A Natural Seawater Facility**

**Eric Kingsley, Roger Phillips and Sarah Mansergh**

Monterey Bay Aquarium, 886 Cannery Row, Monterey CA, 93940

In 1984, the Monterey Bay Aquarium opened its doors as a flow-thru natural seawater facility exhibiting regional species. Over the years the aquarium has expanded and ozone was introduced to several life support systems. The aquarium now includes over 2.5 million gallons of exhibits displaying both regional and non-native species. Our only major expansion, the Outer Bay Wing, opened in 1995, and includes as its centerpiece the Outer Bay Waters (OBW) Exhibit; a 1.2million gallon semi-closed system that uses ozone as part of its life support system. This talk will present the history of ozone use in the OBW, research conducted on this system to date, tentative plans for future life support system modifications, and ideas for future research.

## **Considerations for Ozone Treatment on Recirculating Aquarium Systems with Biological Filtration**

**Kent J. Semmen**

Walt Disney Company – Animal Programs Group  
2016 N. Avenue of the Stars- EC Trl. W-251  
Lake Buena Vista, FL. 32830

This presentation will discuss the demonstrated and theoretical roles of biofilms in the treatment of recirculating aquarium systems and how these roles might be affected by ozone treatment. It will make suggestions for analytical monitoring and research to improve ozone treatment methodologies for better fish and invertebrate health in these types of systems based on current research by WDW Epcot's The Seas Animal Program Departments.

## Evaluation of $\cdot\text{OH}$ Quantification Methods for Advanced Oxidation Processes

**Shane A. Snyder, Brett J. Vanderford and Fernando L. Rosario-Ortiz**

Southern Nevada Water Authority, 1350 Richard Bunker Avenue, Henderson, Nevada 89015

Advanced oxidation processes (AOPs) are characterized by the formation of hydroxyl radicals ( $\cdot\text{OH}$ ).  $\cdot\text{OH}$  are extremely reactive and effectively remove numerous contaminants of concern, such as EDCs and PPCPs. Even oxidation by  $\cdot\text{OH}$  is an important pathway for the removal of many chemicals, quantification of this specie is extremely difficult, especially in full scale applications. In this presentation, we will review existing methods to quantify  $\cdot\text{OH}$  and introduce possible approaches that could be used by utilities to estimate the overall concentration or exposure of  $\cdot\text{OH}$ . In this manuscript, a new method is presented for the quantification of  $\cdot\text{OH}$  using pCBA.

## Advanced Oxidation An Effective Process for the Removal of 1,4-Dioxane and TCE in Contaminated Groundwater

Achim Ried<sup>1</sup>, Jens Krüger<sup>1</sup>, Dennis Csalovszki<sup>2</sup> and Nirmal Singh<sup>3</sup>

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The treatment of groundwater and other water or wastewater streams contaminated with hard to degrade micro pollutants is one of the most challenging applications for state of the art water treatment systems. Increasing regulatory requirements for the reduction or elimination of these contaminants requires alternate treatment processes. The thresholds given by the authorities for these micro pollutants are often in the range of their detection limits. Especially in California (USA) these regulations have brought conventional treatment processes to reach their limitation.

The combination of different treatment processes like an ozone treatment, and UV-radiation, combined with the dosing of hydrogen peroxide results in a more powerful process, called AOP (Advanced – Oxidation – Process). These processes are able to reduce these micro pollutants efficiently and in many cases results in contaminant levels which are below regulatory requirements.

Pilot trials were carried out on an industrial site contaminated with 1,4-dioxane and chlorinated compounds like tetrachlorethene (PCE) and trichlorethene (TCE) to find out which combination delivers the best results concerning economical aspects. In this case the combination of ozone and hydrogen peroxide delivered the best results.

## Quantification of the Hydroxyl Radical Scavenging Capacity during Advanced Oxidation Treatment

**Fernando L. Rosario-Ortiz<sup>1</sup>, Stephen P. Mezyk<sup>2</sup>, Devin F. R. Doud<sup>2</sup> and Shane A. Snyder<sup>1</sup>**

1. Southern Nevada Water Authority, 1350 Richard Bunker Avenue, Henderson, Nevada 89015
2. Department of Chemistry and Biochemistry, California State University at Long Beach, Long Beach, California 90840

The use of advanced oxidation treatment for the removal of contaminants is hindered by the overall scavenging of the water matrix. Of special interest is the effect of effluent organic matter (EfOM) on the availability of  $\cdot\text{OH}$ . In general, EfOM will react rapidly with  $\cdot\text{OH}$ , resulting in the decrease in the available  $\cdot\text{OH}$  for contaminant removal. In this study, second order reaction rate constants between EfOM and  $\cdot\text{OH}$  ( $k_{\text{EfOM}\cdot\text{OH}}$ ) were measured in bulk samples using pulse radiolysis. The measured rate constants ranged from  $0.27 \times 10^9$  to  $1.21 \times 10^9 \text{ M}_C^{-1} \text{ s}^{-1}$ , with an average value of  $0.86 (\pm 0.35) \times 10^9 \text{ M}_C^{-1} \text{ s}^{-1}$ . These absolute values were 3 to 5 times faster than previously reported values using natural organic matter and wastewater isolates and varied between geographical areas. In order to be able to estimate the value of the reaction rate constant (and therefore be able to estimate the overall  $\cdot\text{OH}$  scavenging of a specific water) an empirical model was developed. The model ( $R^2 > 0.99$ ) related reaction rate constants to bulk EfOM properties, such as polarity, apparent molecular weight, and fluorescence index of the effluent organic matter. These results will improve the ability of researchers to accurately model scavenging capacities during the advanced oxidation process treatment of wastewaters.

## **Decomposition of Clofibric Acid in Water Using Ozonation with UV Irradiation**

**Masahiro Asano and Takuya Oyake**

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A method for oxidative degradation of clofibric acid (CA) in water using a combination of ozonation and UV irradiation (ozone/UV treatment) was investigated. The results showed that CA was degraded by ozone/UV treatment up to 120 min. The optimum concentration for the injected ozone gas was about 60 g/m<sup>3</sup> under a constant level of UV irradiation. Furthermore, LC-MS analysis showed no specific or reproducible peaks due to by-products of CA. It was therefore concluded that CA was completely degraded by ozone/UV treatment.

## Degradation of Anatoxin-a in Water By the Ultraviolet/Hydrogen Peroxide Process

**Atefeh Afzal<sup>1</sup>, Keisuke Ikehata<sup>1</sup>, Thomas Oppenländer<sup>2</sup>  
James R. Bolton<sup>1</sup>, Mohamed Gamal El-Din<sup>1</sup>**

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2. Department of Process Engineering, University of Applied Sciences Furtwangen, Villingen-Schwenningen, Germany

The ultraviolet/hydrogen peroxide (UV/H<sub>2</sub>O<sub>2</sub>) advanced oxidation process was investigated for the elimination of anatoxin-a from aqueous solution in this study. Aqueous solutions of anatoxin-a-fumarate were treated with UV and H<sub>2</sub>O<sub>2</sub>, where fumaric acid served as a reference compound in competition kinetics. Direct photolysis of anatoxin-a using a medium pressure UV lamp was also investigated. The second order rate constant for the reaction between anatoxin-a and hydroxyl radical ranged from  $5.2 \times 10^9 \text{ M}^{-1} \text{ s}^{-1}$  to  $9 \times 10^9 \text{ M}^{-1} \text{ s}^{-1}$ , depending on the initial anatoxin-a concentration. It was found that 0.5 mg/L anatoxin-a could be eliminated below the detection limit (<33 µg/L) using a UV dose of 150 mJ/cm<sup>2</sup> in the presence of 30 mg/L of H<sub>2</sub>O<sub>2</sub>. On the other hand, the direct photolysis results showed that 59% of a 1.5 mg/L anatoxin-a solution could be degraded by a UV dose of 1020 mJ/cm<sup>2</sup>. The addition of H<sub>2</sub>O<sub>2</sub> clearly enhanced the degradation of anatoxin-a in the solution.

## **Ozone Nanobubble Treatment of Complex Organics**

**William B. Kerfoot**

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Nanobubble ozone is a nanotechnology breakthrough for groundwater and soil remediation. A generator has been developed to produce both coated and uncoated nanobubble ozone. The half-life of ozone, with nanobubble gaseous ozone, compared to dissolved ozone, is significantly increased as well as its reactivity. A negatively-charged, micelle-like structure of ozone is formulated to explain the observed behavioral characteristics. The spheroids modify the surface tension with water, allowing a higher density of bubbles at higher concentrations of ozone, compared to air or nitrogen gas bubbles with comparable flow.

At nanosize, the aqueous solution becomes milky, and the liquid/gas mixture becomes almost stable as vertical rise times are less than 1 meter/hour with the smaller fractions. Solutions of both nanobubble ozone and hydroperoxide-coated nanobubble ozone (Nanox<sup>TM</sup>)<sup>1</sup> show exceptional reactivity with petroleum alkanes, polyaromatic hydrocarbons (PAHs), and 1,4-dioxane.

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<sup>1</sup> U.S. Patents 7,156,984; 7,264,747; others pending

## Treatment of Ground Water with High VOC's Concentration by O<sub>3</sub> and O<sub>3</sub>/H<sub>2</sub>O<sub>2</sub>

**W. de los Santos<sup>1</sup>, T. Poznyak<sup>1</sup> and I. Chairez<sup>2</sup>**

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2. Profesional Interdisciplinary Unit of Biotechnology of National Polytechnic Institute (UPIBI-IPN), Av. Acueducto s/n., C.P. 07480, México, D.F, México.

In the present study the comparison of the effectiveness of the VOC's mixture decomposition (MTBE and BTEX) by ozone (the ozone concentration is 33 mg/L, the gas flow is 0.5 L/ min) and the O<sub>3</sub>/H<sub>2</sub>O<sub>2</sub> (the H<sub>2</sub>O<sub>2</sub> concentration is 2.8 x 10<sup>-2</sup> mole/L) combination in water was realized. In the *first stage*, the experiments with the model mixture of VOC's (methyl-ter-buthyl-ether (MTBE) and benzene with the concentration of each compounds in distilled water of 200 ppm, are carried out. In the *second stage*, the real contaminated ground water by the O<sub>3</sub>/H<sub>2</sub>O<sub>2</sub> combination is treated. In the last case, the contaminants concentrations are MTBE 3000 ppm, benzene 200 ppm and toluene and m- p-xylenes traces (< 10 ppm). The decomposition of VOC's by the on-line ozone sensor (BMT-963) is monitored and the products formed in ozonation by HPLC are analyzed. The obtained results confirm the high effectiveness of the O<sub>3</sub>/H<sub>2</sub>O<sub>2</sub> combination for the complete decomposition of MTBE and benzene in the model mixture as well as in the real contaminated ground water with the oxalic and formic acids formation as basic final products. So, the MTBE total decomposition is carried out during 6 min and the complete benzene degradation during 10 min of the treatment by ozone. Meantime, the stripping degree of the same VOC's, which was controlled by activated carbon absorption, remains comparatively low (4% for benzene and 7% for MTBE).

## Conversion of Air Feed to Oxygen Feed at the North Bay Regional Water Treatment Plant

**Mike Oneby<sup>1</sup>, Charlie Bromley<sup>2</sup>, Matt Moughamian<sup>3</sup>, Doug Rodgers<sup>4</sup>, Gil Hernandez<sup>4</sup> and Jeff Lodge<sup>5</sup>**

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2. MWH Americas, 3010 W. Charleston Blvd, Suite 100, Las Vegas, NV 89102
3. MWH Americas, Inc., 10619 S. Jordan Gateway, Suite 100, Salt Lake City, CA 84095
4. City of Fairfield Public Works Dept., 5110 Water Works Ln, Fairfield, CA 94533-8908
5. MWH Americas, Inc., 3321 Power Inn Rd, Suite 300, Sacramento, CA 95826-3889

The North Bay Regional Water Treatment Plant (NBRWTP) is upgrading its ozone system from an air-fed system to an oxygen feed gas system and increasing ozone production capacity. The upgrade includes replacing the feed gas system and converting the ozone generators from air to oxygen feed gas. The Cities of Fairfield and Vacaville (Cities), California jointly own the NBRWTP, operated by the City of Fairfield. Constructed between 1989 and 1990 with a design capacity of 40 mgd (6,300 m<sup>3</sup>/h), the plant has utilized pre- and post-ozone since it began operation in Fall of 1990. The pre-ozonation process is primarily for oxidation of NOM for improved coagulation/flocculation/sedimentation and filtration. The typical pre-ozone dose is between 0.4 and 0.6 mg O<sub>3</sub>/mg TOC; the raw water TOC varies from 3 to 20 mg/L. The post-ozone process is used for reduction in chlorine demand and incidental disinfection; the typical post-ozone dose is between 0.3 and 1.0 mg O<sub>3</sub>/L. The original equipment still in use includes three ABB Model OF-290L generators, each capable of producing 333 lb/d (6.3 kg/h) ozone at 2.5% gas concentration. The current ozone demand is approaching and occasionally exceeds the capacity of the ozone system. Frequently, all three generators are on-line. Additionally, the air feed system requires frequent maintenance due to equipment breakdown, corrosion, and insufficiently dry feed gas. In order to meet the ozone demand with uninterrupted production and firm capacity, the Cities are upgrading the NBRWTP ozone system. The upgrade boosts production of each generator to 470 – 500 lb/d (8.9 – 9.5 kg/h) ozone at 5% gas concentration and solves the major maintenance problems associated with the feed gas supply.

**Tuesday PM – Session 10 – Drinking Water Process IV (Coronado L)**

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## **A Process for Maintenance of Ozone Contactors A Report on Planning and Lessons Learned**

**Gil Machado, Jr.**

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The Massachusetts Water Resources Authority (MWRA) utilizes ozone as the primary disinfectant at its 405 MGD John J. Carroll Water Treatment Plant (JJCWTP). This facility supplies water to 2.1 million Metropolitan Boston and MetroWest consumers. The JJCWTP came online in July of 2005 and supplies its customers with unfiltered water from two surface water sources of very high initial quality. Primary disinfection is achieved with ozonation. The JJCWTP is MWRA's first experience with a large, centralized treatment facility and with ozone. Operations and maintenance staff had many new challenges to deal with in starting up and running this facility.

The paper will describe development of a winter maintenance program and will describe two cycles of phased plant shutdown that occurred in 2006 and 2007. It will focus primarily on maintenance activities in the ozone contactors. The major considerations for undertaking these activities will be covered and will include the following:

- Determining date and duration of the shutdown
- Procuring equipment and supplies as well as staging for easy access
- Staffing and training
- The cleaning process
- Evaluating conditions and maintenance performed
- Refilling and restarting
- Adapting the process

## Impact of Climate Change and Drought on Ozonation at Las Vegas, NV

**Eric C. Wert, Julia Lew, David Rexing and Ronald Zegers**

Southern Nevada Water Authority, P.O. Box 99955, Las Vegas, NV USA.

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During the summer of 2000, the Colorado River began experiencing one of the worst droughts on record. Since then, the elevation of Lake Mead has dropped nearly 105 ft from an elevation of 1215 to 1110 ft. During a pilot study conducted from May-November 2007, the water quality and treatment impacts from epilimnion water were investigated. The results showed the following impacts on ozone treatment. These impacts were largely due to the temperature increase from the existing 12-17°C to 24-28°C in epilimnion water. The required ozone dose may increase up to 0.8 mg/L when treating epilimnion water due to accelerated ozone demand and decay rate. The amount of dose increase depends upon the desired *Cryptosporidium* inactivation level, and whether AwwaRF or EPA guidelines are used to determine the required CT. The Cl<sub>2</sub>-NH<sub>3</sub> pretreatment strategy for bromate control will require higher chemical dosages to assure compliance with the bromate MCL of 10 µg/L. The prechlorine dose could increase from 0.35 mg/L to 1.0 mg/L. The ammonia dose could increase from 0.1 mg/L to 0.5 mg/L. After bromate mitigation, residual ammonia is removed through breakpoint chlorination, where chlorine is added using a 10:1 ratio. Therefore, an ammonia residual of 0.5 mg/L NH<sub>3</sub>-N would exert a chlorine demand of approximately 5.0 mg/L. These results illustrate the impact on ozone treatment due to climate change and declining lake elevation.

## **Hybrid Constant Concentration Control Alternative**

**Kerwin L. Rakness<sup>1</sup>, Liza Ballantyne<sup>2</sup>, Alex Vukosavljevic<sup>2</sup> and Teik Lim<sup>2</sup>**

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2. F.J. Horgan Water Treatment Plant, 201 Copperfield Road, Toronto, ON M1E 5G7

Several drinking water ozone systems implement manual control, but have a desire to implement automatic control if they could. Most of these systems with manual control were constructed several years ago. Recently, several plants have implement constant-concentration automatic control, with an option to select constant flow control. A few plants have implemented constant-range-concentration control. Each of these automatic control strategies has advantages and disadvantages, which will be discussed in the paper.

An alternative automatic control option is also presented, called “Hybrid Constant Concentration Control”. This “hybrid” control strategy combines the advantages of constant-concentration, constant-gas-flow, and constant-range-concentration control and is an applicable control strategy for most drinking water treatment ozone facilities. The strategy is being implemented at the F.J. Horgan Water Treatment Plant in Toronto, Canada. Each control strategy will be described in the paper.

## **600 MGD . . . What About 2 MGD? Small Municipal Water Treatment with Ozone**

**Andrew Conner**

H&T Systems, 11057 Allisonville Rd., #333, Fishers, IN 46038

Much attention is given to large water treatment facilities throughout the world that have successfully applied ozone to their treatment process. Large surface water plants have, after all, been the historical patron to ozone technology. These facilities were the only clients with the pocketbook and manpower to run complex ozone systems.

With changes in ozone generation and transfer technology, the modern ozone system has become more simplified and durable. With more affordable generators on the market, small municipalities are now able to take advantage of the many benefits ozone has to offer.

This presentation will take a look at some of the small municipal plants in the heartland. Many are finding that ozone can be affordable. Their systems are simple yet effective. With large surface water facilities finally gathered behind ozone technology, the new fertile territory is small facilities. Surface water or ground water – ozone technology is gaining momentum.

## Impact of Free Chlorine and Chloramine Residuals on Ozonation

**Eric C. Wert and Julia Lew**

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The Southern Nevada Water Authority is considering prechlorination as a Quagga mussel control strategy. During routine operation, prechlorine will be dosed to achieve a free chlorine residual of 0.3 mg/L or greater. Once a year, the prechlorine dose will be increased to achieve a free chlorine residual of 2.0 mg/L for a 21-day period. The higher exposure to free chlorine is designed to kill any veligers that may have attached during the year. The impact of free chlorine and chloramine residuals were investigated with respect to subsequent ozone disinfection.

During pilot plant testing, dissolved ozone, free chlorine, and chloramine residuals were measured concurrently to monitor their respective decay rate. Results showed that 1-2 mg/L of chloramines did not react very rapidly with ozone. The ozone decay rate was increased slightly in the presence of chloramines. Bromate formation was minimized below the MCL of 10 µg/L at 2.0-log *Cryptosporidium* inactivation. Chloramine did not interfere with the indigo method nor interfere with the accuracy of the online dissolved ozone analyzers. However, free chlorine residuals did interfere with the indigo method for dissolved ozone measurement. As a result, ammonia was added to the sample to form chloramine, and then the indigo test was performed to measure dissolved ozone concentrations. Results showed that free chlorine was destroyed by ozone at a faster rate than chloramines.

## **Pre Oxidation Effect on Total Organic Carbon (TOC) Removal in Surface Water Treatment in Iran Case Study: Tehran Pars Water Treatment Plant**

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In drinking water treatment, pre-disinfection are often applied in order to control microorganisms and taste-and-odor-causing materials, which may influence organics removal by pre-oxidation and adsorption.

Using commercial and natural water humic substances, the positive effect of pre-chlorination and pre-ozonation as an aid to coagulation-flocculation of these compounds were confirmed by removal of Total Organic Carbon removal in Tehran city. These experiments were conducted at bench-scale through a series of jar test using different pH, coagulant dosage and total organic carbon concentration of approx. 4, 8 and 12 mg/L. In addition to TOC removal the existence of an optimum pre-ozonation dose and an optimum pre-chlorination dose were also confirmed. Experiments show that pre-chlorination and pre-ozonation can improve of coagulation and flocculation depended on TOC concentration of influent surface raw water. The results demonstrate differential effect between pre-chlorination and pre-ozonation on removal of TOC. Pre-ozonation showed a positive effect on a system with low influent TOC and very low molecular weight (noncolloidal) humic substances.

Tuesday PM – Session 11 – Aquatic Animal Life Support (Coronado M & N)

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## **Workshop - Aquatic Animal Life Support**

### **Hands-on Work Group Sessions**

**T. Nicodemo<sup>1</sup>, K. Semmen<sup>1</sup>, J. Overby<sup>2</sup>, M. Fischer<sup>2</sup>, B. Schilling<sup>3</sup>**

1. Walt Disney Company – Animal Programs Group  
2016 N. Avenue of the Stars- EC Trl. W-251  
Lake Buena Vista, FL. 32830

2. Ozone Water Systems  
5401 S. 39th Street, Suite 1  
Phoenix, AZ 85040

3. Degremont Technologies, Inc.- Ozonia  
491 Edward H. Ross Drive, Elmwood Park, NJ 07407

#### **Rotating Work Stations**

"Automated Controls for Ozone Systems"

"Ozone Contacting Considerations"

"Ozone Generator Repair"

"Ozone Generator Air Prep Optimization"

"Ozone Safety Considerations"

#### **Roundtable Discussion**





# International Ozone Association - Pan American Group

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

Disney's Animal Programs mission is to:

- Deliver uncompromising excellence in animal care and welfare
- Inspire cast and guests to conservation awareness and action
- Build a united team of leaders who are respected partners within the Disney, AZA and conservation communities
- Champion the wise use of resources to support both financial and conservation goals



#### CDM

[www.cdm.com](http://www.cdm.com)

**LISTEN.** Pay careful attention to each client's unique concerns— technical, financial, regulatory, community, and operational issues— every step of the way.

**THINK.** Understand and balance technical and business needs, environmental and public health protection, and fiscal reality, and put the best minds to work to create the right total solutions.

**DELIVER.** Offer flexible project delivery options and start-to-finish services-plan, design, build, and operate.



#### Degremont Technologies - Ozonia

[www.Degremont-Technologies.com](http://www.Degremont-Technologies.com)

Ozonia is one of the world's largest leading suppliers of UV and Ozone disinfection systems. Ozonia has a long history and extensive experience in both technologies, and supplies Ozone and UV equipment to the municipal and industrial sectors. As disinfection of water and wastewater is a global need, Ozonia has representatives in many countries worldwide, each of which use the same core technologies to provide global customers the proper support services.



### GOLD

#### Black & Veatch

[www.bv.com](http://www.bv.com)



#### Southern Nevada Water Authority

[www.snwa.com](http://www.snwa.com)



### SILVER

#### ITT Water & Wastewater

[www.us.ittwww.com](http://www.us.ittwww.com)



#### Carollo Engineers

[www.carollo.com](http://www.carollo.com)



#### Air Products and Chemicals, Inc.

[www.airproducts.com/ozone](http://www.airproducts.com/ozone)



#### Fuji Electric

[www.fujielectric.com](http://www.fujielectric.com)



#### ClearWater Tech

[www.cwtozone.com](http://www.cwtozone.com)



#### Pacific Ozone Technology, Inc.

[www.pacificozone.com](http://www.pacificozone.com)

#### Jordan, Jones & Goulding

[www.jjg.com](http://www.jjg.com)



#### Mazzei Injector Corporation

[www.mazzei.net/ozone\\_syst.htm](http://www.mazzei.net/ozone_syst.htm)



### BRONZE

#### Tessengerlo Kerley

[www.tkinet.com](http://www.tkinet.com)



#### Mitsubishi Electric Power Products, Inc.

[www.meppi.com](http://www.meppi.com)

