By Paul Overbeck

Ozone Process Optimization

New applications and improvements are emerging for ozone technology

It is hard to imagine that 2007 is drawing to a close. The International Ozone Assn. (IOA) has been busy conducting applications and operations workshops during the Water Environment Federation Disinfection Conference, attending the Water Quality Assn. and American Water Works Assn. CA/NV conferences and partnering with the International Center for Water Technology and AINIA for Agri-Food Conferences. The IOA also teamed up with the International Ultraviolet Assn. to hold the first World Congress on Ozone and Ultraviolet Technologies, which featured more than 280 papers on these individual and synergistic combined technologies.

So why the significant interest in ozone and advanced disinfection and oxidation technologies? Hasn't ozone been used for more than 100 years?

Today, ozone is being rediscovered as a result of significant corporate investment in research, development, process improvement and the developing recognition of the benefits ozone delivers to municipal water, wastewater and storm water treatment and many commercial and industrial applications. Of course, governmental regulation will always be a driving force, not to mention the "green" movement.

Ozone process improvements

The generation and use of ozone in aqueous applications has changed significantly in the past 15 years. The resulting cost to generate 1 lb of ozone in large systems has decreased by approximately 40%, opening opportunities in more oxidation and disinfection applications.

The changes were led by the evolution of electrical power supplies that allowed efficient production of ozone from concentrated oxygen feed gas, rather than the previous standard practice of using treated ambient air fed gas. The new electronics allowed systems to operate at corona discharge frequencies at or above 500 Hz with optimized discharge gas gaps and higher power densities. Controlled nitrogen enrichment of oxygen feed gas and improvements in dielectric materials and bow tolerance added performance and efficient production of ozone at 8 to 12% weight, rather than 2% weight for air-fed ozone generators.

These high-output ozone generators allowed the generation of more than twice the amount of ozone at a lower production cost per the same-size ozone generator. The higher gas phase ozone level also offered better mass transfer per Henry's Law.

The first step in harnessing the benefits of higher-concentration ozone was the optimization of ozone-water contacting systems. Improvements in the fine bubble diffuser (FBD) system baffling showed enhanced performance. The lower gas volume from high-concentration generators also drove the evaluation of alternatives to FBD systems, such as venturi inject/nozzle and static mixer systems. These systems allowed pressurized side stream contacting that optimized gas transfer while reducing system size and cost.

At the recent World Congress in Los Angeles, both Ozonia and Mitsubishi introduced enhanced ozone generation technologies that allowed production in the 14 to 16% weight range at energy consumptions typical of existing 10%-weight operating systems.

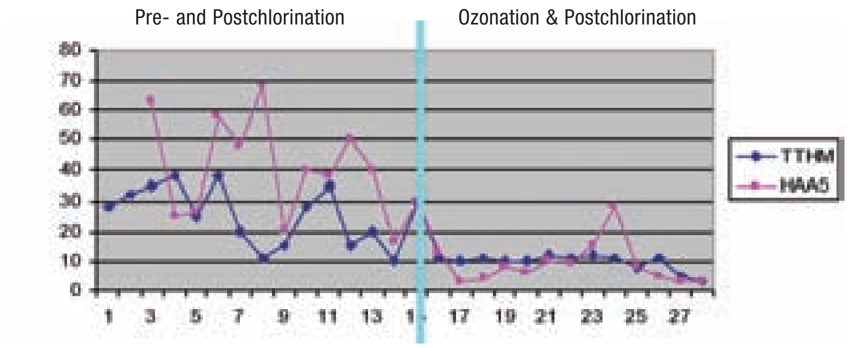
FIGURE 1

Ct Values for Inactivation 99.9% *Giardia* and 99.99% Virus (min • mg/L)

	Free Chlorine pH 6 to 7	Chloramine pH 8 to 9	Chlorine Dioxide pH 6 to 7	Ozone pH 6 to 8
Giardia	122	2,200	26	1.9
Virus	8	1,988	33.4	1.2

U.S. EPA, Office of Drinking Water, Cincinnati, Ohio

FIGURE 2: Byproduct Formation—THM/HAA



Courtesy of Gwinnette County, GA.

This higher-concentration ozone will lead to even lower overall ozone system costs based on reduced oxygen feed gas usage and smaller, more efficient contacting systems.

Ozone process benefits

Enactment of the Long Term 2 Surface Water Treatment Rule and Disinfectant-Disinfection Byproduct Rule (D/DBPR) will require both large and small drinking water utilities to reduce total organic carbon (TOC), *Cryptosporidium* and disinfection byproducts (DBPs) such as trihalomethanes (THMs), trihaloacetic acids (THAAs) and bromate in the treated drinking water distributed to industry and the public. Concerns regarding emerging contaminants, both biological and chemical, will drive interest in alternatives in storm water and wastewater disinfection and reuse.

Ozone has been praised for its microbial inactivation capabilities and benefits versus other oxidizing biocides like chlorine for disinfection of drinking water. This is shown in Figure 1, which reflects U.S. Environmental Protection Agency (EPA)s “Ct” (concentration x time) standards for virus and *Giardia* inactivation.

Most surface water supplies used for drinking water will face seasonal aesthetic and health issues, including taste, odor, color, fluctuations in turbidity and suspended solids particle size and variable microbial challenge and load.

Typical surface water taste and odor issues are due to algae. Common taste and odor algal-generated compounds are 2-Methylisoborneol and geosmin, which, when present in finished water, lead to public complaints. Ozone oxidation has been proven effective in reduction of these compounds, including notable installations at the seven utilities providing 1.6 billion gal per day (bgd) to the Dallas-Fort Worth Metroplex and five treatment plants for the Metropolitan Water District of Southern California, which will soon deliver 2.6 bgd to their 16 million customers.

Utilities using preozonation in combination with biologically active filtration can experience reductions in color and chlorinated DBP formation. Ozone oxidizes organic compounds in raw water. These compounds can be naturally occurring or synthetic compounds from industrial pollution or agricultural runoff. Raw water organic compounds are oxidized directly or indirectly with ozone and/or the formation of hydroxyl radicals in solution. Oxidation reactions break chemical bonds to change the refractive index, reducing apparent color and making many compounds more biodegradable. Biologically active filters then consume more of the dissolved organic compounds before chlorination for distribution.

A typical example of DBP reduction from Gwinnett County, Ga. can be found in Figure 2.

The city of San Diego is currently adding ozone to its drinking water treatment plants to meet EPA Stage 2 D/DBPR.

Preozonation has also delivered microflocculation effects on many surface waters. This improves finished water turbidity at lower coagulant doses. The money saved at lower coagulant usage rates provides a direct payback on the ozone system when costs associated with chemical delivery, storage, handling and filtered solids handling and disposal are considered.

Boundaries fading

Wastewater treatment operations are looking for alternatives to conventional chlorination and dechlorination prior to discharge. Attention to recently identified contaminants, such as endocrine-disrupting chemicals (EDC), pharmaceutical and personal care products (PPCP) and even prions, is increasing globally. Research has shown that EDC and PPCP chemicals can make their way through conventional wastewater treatment and into source water for many drinking water supplies.

More than 20 papers were

presented on treatment of these and other emerging contaminants at the recent Ozone and UV World Congress. Research by Dr. Shane Snyder of Southern Nevada Water Authority, under an AwwaRF Grant, has led Clark County Wastewater in Las Vegas to add ozone to its tertiary treatment process.

According to a new and updated technical market research report, Advanced Technologies for Municipal Water Treatment from BCC Research, the U.S. market for advanced drinking water technologies was estimated at about $1.3 billion in 2006 and expected to grow at a combined average annual growth rate of 10.7% to 2011 to more than $2.1 billion. These technologies include membrane filtration, ozone disinfection, UV irradiation and novel oxidation processes.

These technologies should not be looked at as stand-alone processes. Most applications benefit from the synergistic use of multiple technologies to meet specific treatment goals.

Final thoughts

As more people look for solutions to current and future public health issues, the IOA expects to see continued growth in the use of ozone, either alone or as part of advanced oxidation processes. Ozone—an advanced technology—will see strong future acceptance due to the multiple process benefits delivered in combination with other processes, such as:

- Ozone preoxidation improves filtration performance, extends run time, lowers coagulant addition, reduces taste and odor compounds and makes TOC more bioassimable, which, in conjunction with biologically active filtration, reduces THM and THAA formation.
- Ozone inactivates biological contaminants.
- Ozone, either directly or as part of an advanced oxidation process, breaks down most natural and synthetic organic contaminants. WWD

Paul Overbeck is chairman of the International Ozone Assn. He can be reached at 480/529-3787 or by e-mail at pauloverbeck@io3a.org.

For more information, write in 1103 on this issue's Reader Service Card.

Learn More
For additional articles on this topic, visit:
www.WWDmag.com/lm.cfm/wd120703