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**State of the Ozone
Water Treatment Industry**

**Secondary Versus Supplemental
Disinfection Systems**

**Stretch Your Chlorine
by Adding Borates**

**Trio Bring Water to
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UPCOMING ISSUES

September

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October

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November

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ON THE COVER



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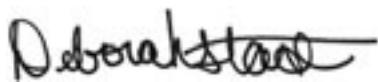
When the pandemic brought a myriad of changes into our lives in 2020, one of those changes was a boom in home improvement. Driven by sheltering in place and a hot real estate market, owners made their homes into places they wanted to stay for the long term. More than three-quarters of all US homeowners said they had done some type of home improvement project during the pandemic, a survey by *Porch.com* revealed. One of the more popular projects was installing a pool. Bolstered by money saved from not traveling, eating out or commuting, captivating outdoor spaces were in high demand. Searches in 2020 for pool and spa professionals were three times what they were in 2019, according to *Houzz*.

Now with the pandemic slowly moving into the rear view, pool maintenance is no less important. We have gathered experts from across the pool and spa industry as well as ozone experts to provide you the best technical information and latest developments. Water treatment professionals will need to navigate spotty supply chains, shortages in chlorine, automatic controller requirements and more. Secondary disinfection systems are critical in certain applications and add another layer of safety using UV light or ozone treatments. Ozone as a method of purification is growing in use in wastewater, advances oxidation and PFAS removal applications.

Anthony Sacco, Managing Director of Spartan Environmental Technologies, goes into detail about the many uses of ozone in varied industries in his article on the state of the ozone water treatment industry. From aquaculture to pools to water reuse, ozone is a primary source treatment. The Pool & Hot Tub Alliance explains their guidelines on maintenance, as well as secondary and supplemental disinfection systems and why they are required. Ozone is a common treatment option for both pools and spas but the regulatory requirements must be met. The same applies to using UV light for treatment. Terry Arko of HASA Pools explains the chlorine shortage that is ongoing and offers a workaround to ensure pools are kept at the highest possible standards. If chlorine is in short supply, borates may be the solution.

Dr. Brooke Meyer delves into the world AOPs and discusses the matter of efficiency. AOPs are gaining a larger audience in the water treatment industry as more emerging contaminants must be addressed, almost on a daily basis. Adrian Aspenson of NSF International gives us more insight into the standard that governs the use of automatic controllers, a highly complex technology. Amanda Crangle asks you to take a look at what you have been doing to improve your business and what more you could do to ensure you are known as the water treatment expert consumers and businesses will be looking to when they need help.

As things begin to open up, the conference/convention schedule is building back up as well. Many events have been postponed multiple times, for months or even a year. Now it appears things are about to get back on track so get your best shoes ready to traverse the convention floor. The lack of in-person contact has taken a toll on everyone, business as well as personal. Now is the time to prepare to get back into the swing of things, meet with current customers and new prospects, gain an educational advantage over your competitors and expand your network in the industry. We hope to see you at more than one upcoming event. Until then, don't forget to let us know how we are doing and what you want to see more of in WC&P International. Send us your original technical material and throw your name in the hat to be featured in our profiles. We can't wait to hear from you.



Deborah Stadler, Publisher



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North America

California drought order issued

Amid intensifying drought and record-breaking temperatures across the Western US, Governor Gavin Newsom added nine counties to the regional drought state of emergency and called on Californians to voluntarily reduce their water use with simple measures to protect water reserves if drought conditions continue and to help maintain critical flows for fish and wildlife wherever possible. The Governor signed an executive order calling on all Californians to voluntarily reduce their water use by 15 percent compared to 2020 levels through simple actions such as reducing landscape irrigation, running dishwashers and washing machines only when full, finding and fixing leaks, installing water-efficient showerheads and taking shorter showers. These voluntary efforts complement specific local conservation mandates already in place in some communities experiencing acute water shortage conditions this summer. State officials estimate an additional 15-percent voluntary reduction by urban water users from 2020 levels could save as much as 850,000 acre-feet of water over the next year for future use or enough to supply more than 1.7 million households for a year. The State Water Resources Control Board and the Department of Water Resources will monitor progress on voluntary conservation, reservoir storage, soil moisture and other metrics in the coming months to determine whether additional drought response actions are needed. For more tips on saving water, visit www.saveourwater.com.

WQRF predictive modeling research update

A study bringing together previous research efforts into a qualitative model that highlights drinking water contaminants most likely to cause violations, impact public health or generate widespread consumer attention in the next five to 10 years has been funded by the Water Quality Research Foundation. Researchers at Corona Environmental Consulting will develop the model in Phase 2 of the *Predictive Modeling of U. Drinking Water Emergencies* study. Researchers Carleigh Samson, PhD, and Chad Seidel, PhD, will use data from WQRF's Phase 1 study, water quality data collected from state regulatory agencies as a part of the WQRF-funded *Contaminant Occurrence Study* and US EPA data, including the *Fourth Unregulated Contaminant Monitoring Rule (UCMR4)*, the *Safe Drinking Water Information System*, chemical data production, use and spill data from US EPA's Chemical Data Reporting program and Toxics Release Inventory. Each dataset will be reviewed to highlight contaminants with known or widely suspected human health impacts, broad occurrence, increasing trends in occurrence or regulatory violations over time, and likelihood to impact a large population. In addition, contaminants that are currently regulated or likely to be regulated in the future will be identified. After the qualitative model is developed, the project team will work with WQRF subject matter experts to review existing and potential future POE and POU treatment options for the highest priority contaminants likely to be needed in the future. Phase one of this study developed a comprehensive database of drinking water crises in the last five years and their associated environmental and socioeconomic factors. Phase two is expected to be completed by July 2022. More detail on this study and others is available at wqrf.org.

PWQA events announced

The Pacific WQA annual Summer BBQ will be held August 12 at Laguna Niguel Regional Park in Laguna Niguel, CA. It will run from 11 a.m. until 1 p.m. PWQA's 64th Annual Trade Show & Convention and will be held October 12-15 at LA Marriott Convention Center in Burbank, CA. All details are available at the website, <https://pwqa.com/>

First National Backflow Prevention Day



The first National Backflow Prevention Day, to be celebrated August 16, will recognize the role of backflow prevention and cross-connection control and those who install, maintain and test backflow preventers. August 16 holds particular significance: on that day in 1933, a backflow incident occurred at two popular hotels near the Chicago World's Fair, resulting in 98 deaths and 2,000 illnesses. The incident led to the establishment of the Foundation for Cross-Connection Control and Hydraulic Research and to safe plumbing regulations for backflow assemblies. All those in the industry are encouraged to mark the day, use the official logo and use the hashtag #BackflowDay on social media. For more information on National Backflow Prevention Day and how to observe it, go to the website at <https://www.nationaldayarchives.com/day/national-backflow-prevention-day/>

E+H field rep named

Endress+Hauser announced an expansion of its partnership with sales representative Field Instruments and Controls in the Pacific Northwest region. Effective July 1, that company became Endress+Hauser's Authorized Service Provider for OR, WA and the ID panhandle. Field Instruments and Controls is based out of Woodland, WA and has been an Endress+Hauser sales representative in the Pacific Northwest for the past 12 years. The company was established in 1987, with the main goal of providing the finest instrumentation and controls technical sales and support to its customers.

Winsupply acquisition announced

Winsupply Inc. announced it has completed the purchase of Simon's Supply Co., Inc. Terms of the purchase of substantially all the assets of the company were not disclosed. Simon's Supply is one of the oldest and most established plumbing and heating distributors in Southeastern Massachusetts and adjacent Rhode Island. The company serves customers from five locations in Fall River, New Bedford, Plymouth and West Yarmouth, Massachusetts, and Pawtucket, Rhode Island.

Europe

Aquatech Amsterdam news

Aquatech Amsterdam will be back live in Amsterdam from November 2-5. Over 90 percent of the floor space has been sold. The focus is to bring back valuable, in-person meetings and conduct business in a way that is safe for everyone. To ensure

no one is left out, the event will blend live and online, combining the best of both worlds. The blended version of Aquatech Amsterdam consists of the following parts: Aquatech Amsterdam journey started in June, with Aquatech TV talk shows and Aquatech BreakOuts; Aquatech Amsterdam live in RAI Amsterdam will include the Online Aquatech TV broadcast from the show floor and attendees can continue the conversation post-show, including a throwback program into 2022 and beyond.

Asia

Aquatech China recap

The 14th edition of Aquatech China 2021 was a winning mix of business, content and networking. As the world navigated the complexities of a global pandemic, Aquatech China retained an unprecedented high level of loyalty from Chinese visitors. Next to a packed show floor, an esteemed speaker line up was present at the 5th Industrial Water Leaders Forum,

providing highly topical content combined with unique Chinese insight. The Industrial Water Leaders Forum (IWLF) brought together representatives from government, research institutes, water resource management companies, service providers as well as end users to share insights on the topic of Water-Carbon Nexus for Sustainable Future. **WCP**



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August Recess— Host a Site Visit!

August is upon us and that means August recess for our elected officials in Washington DC. Contrary to popular belief, our representatives and senators are not off sipping piña colodas on the beach. Most are still hard at work back home in their states and districts rather than in the oppressive mid-summer heat and humidity of our nation's capital. This presents an excellent opportunity for water professionals to meet their senators and representatives and to invite them on site visits. While they are home, elected officials place a high priority on engaging with their constituents – and of course getting in some PR-boosting photo-ops along the way. Taking advantage of this increased availability to showcase the importance of the water sector to our friends in Washington is something you can and should be doing!

This year, August recess is also an opportune time for a site visit because it comes as Congress is in the middle of negotiating many pieces of legislation key to the water sector. At stake are hundreds of billions in funding and historic policy changes in multiple infrastructure packages as well as in the annual federal budget and appropriations process. A meeting with your representatives in-district or a site visit are excellent ways for you to show off the tangible benefits of increased federal funding for water infrastructure at the time when these issues are top of mind. Showcasing the positive impact your products and jobs have on the quality of life of their constituents may influence them to fight for increased funding now but can also prepare them to prioritize water infrastructure moving forward.

Simply scheduling a visit is a great start, but there are additional steps you can take to maximize the effectiveness of the meeting. First, a visit should be designed to demonstrate the full breadth of the water sector's positive community impacts. Highlight the impact your company has on jobs and the economy—including those you make possible by providing your products to your customers. So, if you supplied the new carbon filtration system that your local utility is using to filter PFAS contamination from their water, your company isn't just providing jobs for several employees, you are keeping an entire town safe. Don't forget to explain the real-world impacts of your work.

Don't let this August be the first and last time your representatives ever hear from you—fostering a long-lasting relationship with their staff is essential. After the visit you should send a handwritten thank you note both to the representative but also to the staffers who helped set up the meeting and joined the visit.

With this contact established you can follow up with a message any time your company rolls out a new product or signs a big contract. You can also leverage this contact to invite lawmakers to a subsequent site visit, or to speak at an event you are hosting. Senators and Representatives want to hear from their constituents and communicating with district staff is an effective way to accomplish this.

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I look forward to hearing about your site visits all month long! Post about it on Twitter (<https://twitter.com/maestevens>) and LinkedIn (<https://www.linkedin.com/in/maestevens/>)—politicians love positive press! Don't forget to tag me, I love seeing democracy in action. As always, please do not hesitate to reach out if you have any questions about engaging with lawmakers.

About the author

◆ Mae Stevens is an Executive Vice President at Signal Group and the Chair of Signal Water. She provides strategic environmental and infrastructure policy expertise to a diverse range of corporate, municipal and non-profit clients. Prior to joining Signal Group, Stevens served as Environmental Policy Advisor to Sen. Ben Cardin (D-MD), handling the Senator's responsibilities on the Environment and Public Works Committee, including staffing the Senator during the crafting and passage of the FAST Act and the 2016 and 2018 Water Resources Development Act bills. **WCP**



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Making Excellence Your New Average

The law of averages implies that the result of any given situation will be the average of all outcomes. Can we all agree, however, that average, for the most part, is a moving target? What about in our own lives? Has our 'average' shifted in the last month, year, or decade? Did you start exercising two times a week on average and, over time, you worked your way up to an average of four days a week? What about in our business? Has your average number of online leads improved over the past year? What about in our industry? When it comes to aspects of our lives we can control, what are we doing to improve our average? A quote from Hal Elrod comes to mind, "It's okay to be average, as long as you surround yourself with extraordinary people that you become the average of."

At the 2021 Florida Water Quality Association Convention in Orlando, this year, one thing was certain: all of those in attendance were excited about surrounding themselves with extraordinary people who can move our industry, our businesses and our personal lives forward in a positive direction. The beauty of having a member-driven organization like the national and regional WQAs is that you can benefit from AND be a benefit to the industry by becoming an active member. As a business owner, a data-driven online marketer and someone who constantly evaluates both the value return and dollar return on an investment, getting involved regionally and nationally with these associations provides a healthy return of both. Let's discuss a few ways getting involved can increase your return on investment and improve your online presence.

Competitive advantage

Imagine for a moment you're walking down the aisle at your local grocery store, scanning the shelves for a gluten-free protein bar. Your spouse texted you minutes before saying, "Be sure the protein bars are ACTUALLY gluten-free." You pick up two different boxes. One says, 'Gluten-Free Goodness Delivered in Every Box.' The other has a giant seal on it that says, 'Certified Gluten-Free' by the Beyond Celiac Organization.' You look at the first box again and scour it for the same or similar certification. You see nothing of the sort. Within a split second, your brain has identified the box with the third-party certification as the more trustworthy brand. You weigh the certification on the second box against the product images and price on both options, wondering if it will taste as good as it looks and if it is worth the value it will provide. You put down the first box and place the certified gluten-free box of protein bars in your cart and move to the next item on your list.

This mundane scenario is played out over and over again when consumers shop for products and services. According to Nielsen's *Global Health & Wellness Survey*, 44 percent of people in North America do not trust claims manufacturer's make about their own products. This is one of the many reasons why third-party certifications matter. In the water treatment industry we're all used to seeing NSF, ISO, ANSI and numerous other certifications; however, not as many are certified by nationally recognized industry associations like the Water Quality Association (WQA).

At the Florida WQA Convention, Immediate Past President of the WQA, DJ Shanahan, announced a new certification for OEMs entitled, Certified Treatment Designer. This certification is the seventh certification offered through the WQA. If you're an OEM, this certification can help set you apart from your competitors. If you're a dealer, this certification can add value and differentiate you as well.

Envision a website that showcases multiple WQA certifications, each describing what they mean when you hover over them. How will a homeowner react to these certifications versus a competitor's site who has less or none of these? Based on my experience running hundreds of marketing tests on websites, third-party certifications drive more clicks and leads than sites without them. In the home, how much more confident will your sales professionals be when equipped with an entire pipeline of people and manufacturers holding these elite certifications?

You are the sculptor, the industry is your clay

To say that one person can directly impact the direction of an industry is an understatement. We can look to icons like Henry Ford, Claude Hopkins, Jeff Bezos and Ray Kroc to see that it only takes one person to make a huge shift. We also can see, however, that working together we can make an impact as well. This concept can be seen playing out anywhere WQA members meet. As top-notch water treatment dealers, manufacturers, suppliers and consultants invest their time, they move the industry, their businesses and their personal lives forward in a positive direction, creating a massive ripple effect that improves water and, therefore, the lives of people around the world. As positive awareness in the industry increases, so do our businesses. As consumer perception of the industry improves due to excellent ethics, service and products, so do our businesses. As state and national legislators look to our industry to solve water problems locally, our businesses benefit.

The upward spiral begins with you proactively getting involved and communicating through your ads, website, staff and marketing materials why it's so important to do business with a team who is actively part of the industry associations. It is the difference between average and excellence and making excellence your new average. When you commit to proactively molding your life, your business and your industry, the dollars will naturally flow as your customers and prospects see how different you are from those around you. They'll see your passion and they'll believe in you, your team and your products because you do.

Give your people something to believe in

In the book, *The Power of Habit*, author Charles Duhigg details the story of Paul O'Neill's turnaround of the company, Alcoa. Instead of focusing on producting outputs like units produced, sold and the ROI, he focused on safety. Specifically, his goal was zero workplace accidents. Due to the nature of this business, many employees had been hurt and all too many had lost their lives. He cared so much about the people of the company and their safety that an entire culture was built around analyzing every aspect of the organization to eliminate future injuries and death. The outcome was a belief by the employees that O'Neill truly cared about them and their families and in turn, they worked harder, came up with innovative ideas and drove the company's value through the roof.

What does your team believe in? Industry organizations like national and regional WQAs are a great way to provide education

about why what we do is so important and, even more importantly, it provides relationships with people who will inspire, educate and share wisdom. Getting your team involved on committees is also a great way to help them see the bigger picture while also allowing business owners to delegate responsibilities so they can still be involved without over allocating their time. Millennials and Generation Z both care greatly about being a part of something bigger than themselves. These industry associations are a perfect way to immerse them into the water treatment industry family and help them understand the importance of what they do on a day-to-day basis. Many times I've heard dealers complain about retaining Millennials while they sit alone at a WQA event. Perhaps including more of their team at these events is a positive place to start.

Happy employees mean happier customers and increased profits. People want to do business with people, in particular people who are passionate. If someone calls from your website, fills out a form online, or inquires through a live chat, how is your team sharing the story of your business and the water treatment industry? Are they using their passion to elicit passion from your prospects?

When we, as industry professionals, work together to improve ourselves, our businesses and our industry, we'll continue to see our personal and professional averages increase greatly. A wise man once said, "Rising tides raise all ships" and he was spot on.

About the author

◆ Amanda Crangle and the team at Lamplight Digital Media help residential and commercial water treatment companies profitably grow their dealerships using digital marketing.



They have worked with over 100 water treatment dealerships spanning North America, managed millions of dollars in ad spend and performed over 1,000 scientific website split tests. Crangle intimately knows the water industry, having worked in a dealership as a sales rep and as a general manager. She and her team are passionate about expanding consumer awareness of water quality issues and providing education on final barrier solutions.



David Loveday



David Loveday, of Villa Park, IL, was born June 17, 1956 and passed away on July 3, at the age of 65. He was a long-time strategist for a range of public officials and organizations in Illinois and nationally. Through the years, Loveday applied his talents as an aide in the Reagan White House, a US point-man in Africa helping save lives during the famines of the 1980s and a widely respected advisor to

agencies and campaigns empowering and uplifting people here and throughout the world. A giving husband, father of three and brand new grandfather, Loveday served his local communities as a volunteer fireman and President of the local hockey league, which he played avidly for years.

Loveday's wide-ranging career in public service began when he was brought in as one of the earliest members of the Reagan transition team in 1980. He later administered all US federal disaster aid in Ethiopia and Sudan, traveling extensively in Africa. Loveday was also called on to work closely with senior officials in Mongolia and Iraq, advancing human rights and fair elections. He held senior staff positions on more than 10 statewide and national campaigns, oversaw public relations and media for the second largest US transit system and served as External Affairs Director for the second largest American tollway system. Those who knew Loveday praise him for upholding his deeply held principles. Though he found himself pulled close to political controversies churning in Illinois, he maintained his integrity with no hint of personal accusations.

For the past 15 years, Loveday managed public affairs for the global Water Quality Association. In that position, he developed innovative approaches to help ensure safe and clean water for local communities nationwide facing crises. "Dave was an especially gifted person who used his gifts so well, transforming an extraordinary stream of positive ideas into real world projects," said a local entrepreneur who collaborated with Loveday. "Even more importantly, he generously brought people together to make these plans successful." Other remembrances from those who knew him best: Funny. Intuitive. Smart. Well-liked and respected by everyone. Infectious smile. Inclusive. Welcoming.

Loveday met his future wife Natalie while they both worked at the White House. One of the many thank you letters the family has framed is one from President Reagan saying: "On a happy note, they say you get out of an undertaking what you put into it. Well, Dave, you gave us your dedication and service and we, in turn, gave you Natalie. I would say that definitely is a fair trade!" They were married for more than 35 years and raised three children, Drew, Cate and Emily.

A native of New York, Loveday graduated from the New York Institute of Technology with a BA Degree in communications in 1979. He will be forever remembered with love by his wife and children, his grandson, brother Jeff (Terri), nephew Jamison (Sarah), niece Kelsey and grand-niece Millie. He was predeceased by his parents Ray and Jeanne and sister Laura. Memorial arrangements are being made.

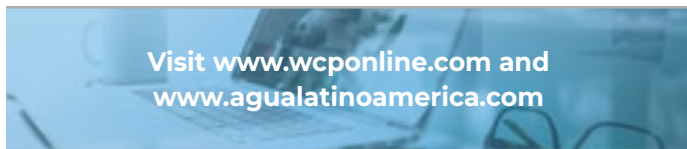
Six honored by IWA

Six outstanding scientists, individuals and organizations were announced as winners of the prestigious IWA Awards during the recent Digital World Water Congress. Renowned academic **Professor Marcos von Sperling** won the IWA Global Water Award, which recognizes an innovative leader who has made a significant contribution to a water-wise world. Professor von Sperling, from the Universidade Federal de Minas Gerais in Brazil, won the award for his work on wastewater and water pollution. His research, which has influenced policy in Latin America and beyond, has inspired many students, researchers and policy-makers. The IWA Women in Water Award, which celebrates the work of women in the field of water, has been won by sanitation advocate **Nafisa Barot**. The award also promotes greater inclusion and female leadership in the sector. Nafisa was recognized for using her role at NGO Utthan in Gujarat, India to influence people and policies around water, gender justice and sustainable development. Malaysian sewerage company **Indah Water Konsortium** won the IWA Professional Development Award for their exceptional record of developing and retaining talent in the sector. Renowned scientist and engineer **Dr. Siddhartha Roy** was recognized for winning the IWA Young Leadership Award, which had been announced earlier this year. The award is granted to an exceptional young water professional for their achievements, leadership and future potential. Moreover, two exceptional individuals were awarded IWA Honorary Life Membership, for their sustained contribution to the water sector and the Association. Those recognized were **Professor Jiri Wanner**, from the University of Chemistry and Technology in Prague, Czech Republic and **Professor Mark van Loosdrecht** from Delft University of Technology, in the Netherlands.

2020 US SJWP winner, runners-up announced

The Water Environment Federation (WEF) announced that **Eshani Jha** has won the 2020 US Stockholm Junior Water Prize for her method to use modified biochar for the removal of toxic contaminants from water. Jha won \$10,000 (USD) and will represent the US at the international competition this month. Students from 43 states, armed forces abroad and Puerto Rico competed in the national finals during a virtual event. The Stockholm Junior Water Prize is the nation's most prestigious youth competition for water-related research and aims to increase students' interest in water issues and careers. The competition is open to projects focused on improving water quality, resource management, protection and drinking water and wastewater treatment. Runner-up **Jessica Yan**, a student at The Mississippi School for Mathematics and Science in Starkville, MS, developed a method to reinforce lignin foams to increase absorption of heavy metals and oil. The foam strength improved by more than twelvefold and adsorption capabilities improved by 10 percent. Yan received a \$1,000 prize.

Runner-up **Julius Yoh**, a student at Manhasset Secondary School in Manhasset, NY, developed a process for the optimization of desalination and ion removal rates in an electrodialysis system. He received a \$1,000 prize. **Junzhi Xie** of Richard Montgomery High School in Rockville, MD, received the Bjorn von Euler Award for Innovation in Water from Xylem, Inc. for developing a method for removing microplastic particles from wastewater using phytoremediation. The majority of recovered particles were absorbed onto the surface roots and fronds of duckweed, with little evidence of accumulation inside the plant. **Shemai'ya Peak**, a student at Stanhope Elmore High School in Milbrook, AL, received the James L. Condon Recognition for Environmental Stewardship for her work, an experiment on how to effectively convey the importance of water conservation and investigate how free-flowing channels of water and man-made/stationary bodies of water differ in pH and light absorption. She also gauged the ability of the water bodies to absorb light at different wavelengths, consequently determining their health status. **WCP**



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Upcoming Events

Highlighted listings denote WC&P attendance or distribution (subject to change)

Please note that, due to COVID-19, many events have been cancelled, postponed or changed to a virtual format. As of press time, if new dates have been given, they are added in their respective months. We will continue to update as the situation warrants.

August 2021

- 1-3** **AWWA/WEF Young Professionals Summit**
Atlanta, GA, USA
<https://www.awwa.org/Events-Education/Utility-Management>
- 3-5** **AMTA/NMWOA Technology Transfer Workshop**
Fargo, ND, USA
<https://www.amtaorg.com/amta-nwmoa-joint-technology-transfer-workshop-august-3-5-2021>
- 3-6** **Utility Management Conference (UMC)**
Atlanta, GA, USA
<https://www.awwa.org/Events-Education/Utility-Management>
- 12** **PWQA 2021 Summer Picnic**
Laguna Niguel, CA, USA www.pwqa.org
- 23-27** **SIWI Virtual World Water Week**
<https://www.worldwaterweek.org/>
- 24-26** **Water Expo 2021 (10th Edition)**
Miami, FL, USA <https://www.thewater-expo.com/>
- 30-31** **Smart Water Utilities USA 2021**
Long Beach, CA, USA
<https://www.usa.smart-water-utilities.com/>

September 2021

- 7-9** **Aquatech Mexico**
Mexico City, Mexico <https://www.aquatechtrade.com/mexico/>
- 12-15** **AWWA Water Infrastructure Conference**
Phoenix, AZ, USA
<https://www.awwa.org/Events-Education/Water-Infrastructure>
- 13-14** **2021 Drowning Prevention Symposium**
San Diego, CA, USA <https://watersafety-conference.com/conferencefees/>
- 14-16** **2021 WQA Mid-Year Leadership Conference**
Lisle, IL, USA <https://wqa.org/events>

14-15 **Elementary Nonwovens Training Courses**
Cary, NC, USA <https://www.india.org/training/elementary-training.php>

21-23 **5th Arab Water Forum**
Abu Dhabi, UAE <https://arabwater-forum.org/>

22-24 **EWQA 2021 Conference & Trade Show**
Wilkes-Barre, PA, USA
<https://ewqa.org/2021-conference-trade-show/>

22-27 **WorldSkills Shanghai 2021**
Shanghai, China <https://worldskills.org/>

26-30 **IAPMO 92nd Annual Education and Business Conference (Virtual)**
<https://www.iapmo.org/ibu/events>

October 2021

4-8 **drinktec 2021 POSTPONED TO 2022**
Munich, Germany
<https://www.drinktec.com/index.html>

6-7 **Watersmart Innovation Conference & Exposition**
Las Vegas, NV, USA <https://www.watersmartinnovations.com/>

11-13 **IDA Water Reuse and Recycling Conference**
Rome, Italy <https://wrr.idadesal.org>

12-15 **PWQA 64th Annual Convention and Trade Show**
Burbank, CA, USA
<https://pwqa.com/event-calendar/#event/2021/10/12/2021-convention-and-trade-show>

13-15 **World Aquatic Health Conference**
Houston, TX, USA
<https://www.phta.org/education-and-events/events/world-aquatic-health-conference/>

14-16 **CGA 2021 Education Conference and Tradeshow**
Stateline, NV, USA
<https://www.groundh2o.org/events>

15 **Global Handwashing Day**
<https://globalhandwashing.org/global-handwashing-day/>

19-21 **Aqua Ukraine**
Kyiv, Ukraine <https://www.iec-expo.com.ua/en/aquaen-2021.html>

20-22 **drink technology India**
Mumbai, India drinktec-worldwide@messe-muenchen.de

20-22 **National Hydropower Association's Clean Currents Tradeshow and Conference**
Atlanta, GA, USA
<https://www.hydro.org/events/>

November 2021

2-4 **food & drink technology (fdt) Africa and IFAT Africa**
Midrand, South Africa <https://fdt-africa.com/>

2-5 **Aquatech Amsterdam 2021**
Amsterdam, The Netherlands
<https://www.aquatechtrade.com/amsterdam/>

3-4 **CIPHEX West**
Vancouver, BC, Canada <https://www.ciphexwest.ca/west2020/public/enter.aspx>

3-5 **WWEMA 113th Annual Meeting**
Miami Beach, FL, USA <https://wwema.org/>

4 **Aquatech Innovation Forum**
Amsterdam, The Netherlands
<https://www.aquatechtrade.com/innovation-forum/>

7-10 **AWWA Water Quality Technology Conference**
Tacoma, WA, USA
<https://www.awwa.org/Events-Education/Water-Quality-Technology>

7-11 **IDA 2021 World Congress (POSTPONED TO 2022)**
Sydney, Australia
<https://idadesal.org/event-schedule/ida-2021-world-congress-2/>

10-11 **Virtual AWWA | SWAN International Smart Water Symposium**
<https://www.awwa.org/Events-Education/Smart-Water>

13-18 **PSP/Deck Expo 2021**
Dallas, TX, USA <https://www.poolspapatio.com/en/home.html>

19 **UN World Toilet Day**
<https://www.un.org/en/observances/toilet-day>

29-Dec 2 **IWA Digital Water Summit**
Bilbao, Spain <https://digitalwatersummit.org/>

December 2021

- 14-16 **Groundwater Week and Summit**
Nashville, TN, USA <https://groundwater-week.com/>

February 2022

- 21-25 **AMTA Membrane Technology Conference (MTC22)**
Las Vegas, NV, USA
<https://www.awwa.org/Events-Education/Events-Calendar>

March 2022

- 11 **World Plumbing Day**
<https://www.worldplumbing.org/world-plumbingday/>
- 22 **World Water Day**
<https://www.worldwaterday.org/>
- 29-31 **FiltXPO® International Filtration/Separation Exhibition & Technical Conference**
Miami Beach, FL, USA
<https://www.filtxpo.com/>

April 2022

- 11-14 **National Water Safety Conference**
Fort Worth, TX, USA <https://watersafety-conference.com/>
- 17-21 **Singapore International Water Week 2022**
www.siww.com.sg/

May 2022

- 10-11 **Emerging Water Technology Symposium**
San Antonio, TX, USA <https://ewts.org/>
- 16-18 **Global Water Summit**
Madrid, Spain
www.watermeetsmoney.com/
- 29-Jun 2 **IDA 2022 World Congress**
Sydney, Australia <https://wc.idadesal.org/>

June 2022

- 12-15 **AWWA Annual Convention & Exposition (ACE22)**
San Antonio, TX, USA
<https://www.awwa.org>

July 2022

- 12-14 **AMTA/SEDA Workshop: PFAS and Emerging Contaminant Rejection by Membranes**
Durham, NC, USA
<https://www.amtaorg.com/event/amta-technology-transfer-workshop-durham-nc-april-27-29-2021> **WCP**



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A large advertisement for the PureWaterMachine Green Machine with Rextex 1:1. The background is a dark blue gradient. At the top, the text "PureWaterMachine" is written in white, with a blue swoosh underneath. To the right of this text is the VERTEX logo, which consists of a white 'V' inside a blue circle. Below the main title, the words "Green Machine with Rextex 1:1" are written in a large, bold, green font. A yellow starburst graphic with the word "NEW" in red is positioned to the left of the main product image. The product image shows a white water filtration unit with a blue Rextex 1:1 membrane cartridge. The unit is shown from a three-quarter perspective. Below the main product image, there is a smaller image of the Rextex 1:1 membrane cartridge, which is blue with white text. To the right of the product image, there is a list of features in white text: "Rextex 1:1 membrane fits standard membrane housings", "Eco-Friendly Greenblock® filtration media", and "4 and 5-stage versions available". At the bottom of the advertisement, there is a white banner with the text "Only 1 gallon of water is wasted for each gallon of fresh water produced". Below this banner, there is a red banner with the text "Full Range of Filtration Products at Affordable Prices". At the very bottom, there is a white banner with the VERTEX logo, the text "VERTEX WATER PRODUCTS", the phone number "(800) 627-2146", and the website "www.VertexWater.com". The background of the advertisement features a scenic view of a mountain range with snow-capped peaks and a body of water in the foreground.

State of the Ozone Water Treatment Industry

Ozone is a widely used agent for water treatment including public drinking water, industrial wastewater, purification of process water, aquariums, bottled water, ground water remediation and aquaculture, among many others. Ozone finds value in these applications because it can provide multiple benefits in water treatment while decomposing back to oxygen after use. The benefits of ozone include:

- Disinfection – ozone is a biocide that can inactivate a wide range of microorganisms including virus and bacteria.
- Oxidant - ozone is capable of directly oxidizing various organic compounds, including those of emerging concern such as pharmaceuticals and personal care products found in our drinking water sources, as well as organic compounds found in industrial wastewater.
- Advanced oxidation – In combination with peroxide or UV light, ozone can be the base of an advanced oxidation process that can oxidize virtually any organic compound including difficult to treatment materials such as 1,4 dioxane.

This article will touch on some of the major existing applications and some emerging applications for ozone.

Public drinking water treatment

Chart 1 shows the distribution of ozone use in US public drinking water. Ozone provides several benefits to drinking water facilities. These include primary disinfection, taste and odor removal, color removal, removal of inorganic materials such as Fe, Mn and H₂S, enhanced filtration via a micro-flocculation effect and removal of certain organic compounds. In a well-engineered process, several of these benefits can be achieved in a single injection of ozone. Being able to accomplish several treatment objectives

at the same time make ozone an excellent choice for certain drinking water plants. This explains the growth of ozone for this application.



Chart 1: Count of plant capacity by state/province

Municipal wastewater reuse

Because of water shortages caused by growth in water demand as well as loss of water supply caused by drought, more cities are thinking about reusing their wastewater for drinking water, either directly or indirectly. Several facilities have already been built using membrane-based technologies. This is a proven approach but comes with several notable drawbacks. First, you need a place to dispose of the waste brine rejected from the RO membranes. In coastal locations, the brine can be rejected to the ocean. In other locations it is not as simple. The second factor

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is cost, because of the high pressure needed in RO membranes, the electrical demand to treat the water is high.

Ozone in combination with biologically active filters (ozone-BAF) can be used to treat municipal wastewater to achieve high degrees of water purity at lower cost than membrane processes and without the need to dispose of a brine waste. Currently, large scale trials are being run by the Hampton Roads Sanitation District, in Eastern Virginia to demonstrate this technology through their SWIFT project. Other water authorities are also running ozone-BAF pilot trials. If successful, ozone-BAF could provide inland wastewater facilities with a technology to reuse their wastewater for drinking water.

Advanced oxidation processes

Another emerging application for ozone is in advanced oxidation. Advanced oxidation refers to processes that produce hydroxyl radicals ($\cdot\text{OH}$). The hydroxyl radical is one of the strongest and fastest acting oxidants that can oxidize virtually any organic compound. They can be produced in a variety of ways, but ozone with peroxide and ozone with UV are two such methods. The advantage of the ozone routes is that little if any by product is left after complete and pH adjustments are not required. An important application of ozone based advanced oxidation is the removal of 1,4 dioxane from ground water contaminated with solvents. Dioxane is not readily air stripped from water, absorbed on activated carbon, or oxidized by most chemicals. Advanced oxidation by ozone and peroxide has been proven to be effective in removing the dioxane from the water via oxidation. Ozone with peroxide has also found use in industrial wastewater applications where other methods were not able to remove difficult to treat organic compounds. The use of advanced oxidation appears to be a growing technology for water treatment and ozone-based processes are a growing part of this application.

Biosolids reduction

Wastewater treatment plants utilizing the activated sludge process typically produce excess sludge that needs to be removed and disposed of from the process. Ozone has been shown in the literature and in commercial application to offer an alternative method for reducing excess sludge. This process involves exposing a portion of the activated sludge to ozone. Some of the bacteria that make up the sludge are lysed via exposure to ozone releasing COD into the wastewater. Even though some of the cells are damaged or killed, the overall process generally does not show an increase in BOD/COD leaving the process.

Depending on the amount of ozone required per unit of sludge removed and the costs associated with the current handling of the excess sludge, ozone can represent an economical alternative with conventional sludge handling processes. Ozone also offers other potential advantages to the activated sludge process including a reduction in bulking/foaming, scum control and improved denitrification. A number of wastewater treatment plants in Europe have adopted this technology and have realized a 30-40-percent reduction in excess sludge with no loss of wastewater treatment performance. A new installation is planned for the US later this year at a chemical manufacturing plant.

PFAS removal

PFAS are group of various fluorochemicals including PFOA, PFOS, among others. They are of emerging concern since they are distributed widely in the environment, do not readily break-down in the environment/human body and can accumulate over time. There is some evidence that they may have adverse impacts on human health. US EPA points to studies of PFOA and PFOS that show: reproductive and developmental, liver and kidney, and immunological effects and tumors in laboratory animals. As a result, the agency is studying regulation of these compounds.

A novel approach to PFAS removal is ozofractionation. Ozofractionation is a form of foam fractionation, a method to remove hydrophobic materials from water. In ozofractionation, ozone is used as an oxidant, as well as the foam-forming gas. Proposed advantages for using ozone as the bubble forming gas include co-contaminant reduction and smaller bubble sizes. Smaller bubbles result in higher surface area to volume ratios and thus more material can be captured for a given volume of gas. Formation of hydroxyl radicals around the bubbles may result in negative charges that better hold the PFAS molecule.

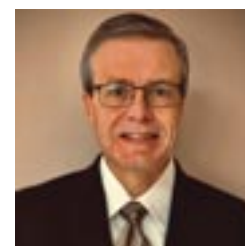


Conclusion

Ozone continues to find new applications in water treatment while expanding its existing applications. The future looks bright for the use of ozone in various parts of the water treatment industry.

About the author

Anthony Sacco is the Managing Director of Spartan Environmental Technologies, a supplier of ozone-based water treatment systems. He is also a VP and member of the Executive Operating Committee of the International Ozone Association – Pan American Group. He has been working the ozone field since 2004.



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Secondary Versus Supplemental Disinfection Systems

Photo courtesy of
Cascade Custom Pools, Austin, TX

Proper sanitation helps keep pools free of microorganisms that can lead to and cause waterborne illnesses. Traditionally, the primary source of sanitation has been a halogen (chlorine or bromine). More recently, it has been determined that halogen-tolerant pathogens, such as *Cryptosporidium*, require the use of an additional means to disinfect pools.

The Pool & Hot Tub Alliance (PHTA) Recreational Water Quality Committee (RWQC) compiled the following information on the differences between and uses for secondary and supplemental disinfection systems. This article focuses on the equipment for secondary or supplemental treatment systems used in commercial pools as defined by ANSI/APSP/ICC-11 *American National Standard for Water Quality in Public Pools and Spas*.

Secondary disinfection systems

Secondary disinfection systems are installed in addition to the required primary disinfection systems and are *required* for increased risk aquatic venues. These systems are designed to achieve a minimum 3-log (99.9-percent) reduction in the number of infective *Cryptosporidium parvum* oocysts and other pathogenic microorganisms per pass through the secondary disinfection system at the maximum flowrate. These systems shall be listed and labeled to *NSF/ANSI Standard 50 Equipment for Swimming Pools, Spas, Hot Tubs and Other Recreational Water Facilities* by an American National Standards Institute (ANSI)-accredited certification organization and shall be installed according to the manufacturer's directions. When listed as an NSF-approved system, it is classified as a sanitizer.

Increased risk aquatic venues have a higher risk of microbial contamination due to their primary users being children under the age of five and/or people more susceptible to infection, such

as therapy patients with open wounds. All new construction or substantial alteration of the following increased risk aquatic venues are required to use a secondary disinfection system.

- Wading pools
- Interactive water play venues
- Other aquatic venues designed primarily for children under the age of five
- Therapy pools

Secondary disinfection systems may be installed on other aquatic venues. At present, secondary disinfection systems are either ozone or UV light systems. These systems require the use of a primary disinfecting halogen, such as chlorine or bromine.

Supplemental treatment systems

Supplemental treatment systems are *not* required in an aquatic venue for health and safety reasons but may be used to improve water quality and/or enhance overall system performance. These systems are designed to enhance water quality but are not required to achieve the minimum 3-log reductions, unlike secondary disinfection systems. Metal ion-based systems are often used as supplemental treatment systems. Ozone or UV light systems, however, can be considered supplemental systems when they are not required at an increased risk venue. Like secondary disinfection systems, supplemental treatment systems also require the use of a primary disinfecting halogen, such as chlorine or bromine.

Ozone secondary disinfection system

An oxidation reaction occurs once ozone has been dissolved in water. Once this reaction takes place, organic contaminants are destroyed and many dissolved metals become insoluble. Ozone is capable of killing all known microorganisms (including *Cryp-*

tospodidium and *Giardia*), destroying organic contaminants that may create chloramines and break down existing chloramines. This oxidation occurs immediately at the ozone gas injection point and continues in the return lines. A small residual (~0.1 ppm) of dissolved ozone may enter the pool, providing further oxidation. An ozone system is considered a pesticidal device under the US EPA *Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)* and has a US EPA establishment number. The use of secondary systems in combination with a primary halogen should be used in accordance with manufacturer's recommendations.

UV light secondary disinfection system

UV light systems use a process known as photolysis to inactivate microorganisms (including *Cryptosporidium* and *Giardia*). The intensity of the lamp and the flowrate through the unit will produce a dosage measured in mJ/cm³. UV light is most effective at a known wavelength of 254 nm.

Ultraviolet light and ozone supplemental treatment systems

Both ozone and UV light systems can also be used as supplemental treatment systems. They enhance both water and indoor air quality. Air quality has become critical in protecting swimmers, pool attendants, spectators or anyone spending time in an indoor pool environment. Both UV light and ozone systems have been proven to be effective in destroying chloramines in swimming pools and, therefore, improve indoor air quality. Both commercial ozone and commercial UV light systems are tested and listed under *NSF/ANSI Standard 50*. The device must meet the requirements of *NSF 50, Disinfection Efficacy* in Section 14.20 and must be used with a US EPA-registered sanitizer to impart residual concentrations in accordance with federal, state or local regulations. Supplemental systems in combination with a primary halogen should be used in accordance with manufacturer's recommendations.

Metal-based systems

While metal-based systems have been recognized as US EPA-registered sanitizer systems when used with a primary halogen, the metal ionizer component has always served as a supplemental treatment system to the halogen. When operating, maintaining or servicing a water feature, it is always important to be aware of the requirements for that particular water feature and what treatment options you have available to ensure users have a safe and healthy aquatic experience.

Conclusion

The health and safety of pool users should always be at the forefront of successful pool and aquatic venue operations. As our understanding of waterborne pathogens improves, our disinfection systems also improve. UV light and ozone treatments provide an additional level of protection for users when used as either secondary or supplemental disinfection systems.

The Pool & Hot Tub Alliance protects and advances the common interests of the industry by providing education, advocacy, standards development, research and market growth to increase our members' professionalism, knowledge and profitability. **WCP**



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Need to Stretch Your Chlorine This Summer? Try Adding Borates

The summer of shortage

Let's face it, this summer has been a hot one. For pool owners, the ability to seek relief via a cool plunge just steps away from the backdoor has been needed, now more than ever. Having the supplies needed to keep the backyard oasis crystal clear and inviting, however, has been a real challenge. Just prior to summer, the newswire was abuzz with stories of chlorine shortages. This initially was singled out to only one form of pool chlorine, tri-chlor tablets. The reason for the shortage was a fire and the complete destruction of the manufacturing facility of a company that supplied 40 percent of the US market. This left a big gap in one of the most popular methods for chlorinating pools. We still, however, had cal-hypo tablets and granular and the old reliable liquid chlorine bleach.

The increased demand on the alternate forms of chlorine, coupled with the enormous increase in new pools as well as high demand is causing a domino effect: both cal-hypo and liquid are now very precious commodities for homeowners and professional pool service providers. As a result, many are seeking to find ways to make chlorine go further in the pool. Many of these alternatives involve the installation of costly secondary devices, such as ozone and UV systems. Some are resorting to the installation of saltwater generators that produce chlorine on site and deliver it into the pool. All of these methods have a benefit; it comes, however, at a high additional price and increased maintenance cost. For those looking for a way to improve the longevity and effectiveness of chlorine in the pool, without the addition of a costly device, the answer may be as simple as adding borates to the water.

What are borates?

Elementally speaking, borates are what are known as isotopes of boron. If you geek out on science or are going to audition for the game show *Jeopardy*, then you already know that boron is number five on the *Periodic Table of Elements*. Not to be confused with *The Fifth Element* (which was a cool sci-fi flick), boron was discovered in 1808 by two French chemists. Boron is wide-spread in small amounts throughout the Earth's crust. It is naturally present in the earth as borate and is found in soil, rocks and water. Due to either underground hot springs or ancient volcanic activity, a lot of it ended up in the California area known as Death Valley. By 1881, the motherlode was located and the Borax Company was born. Since the area was very desolate and over 165 miles from any railway, tons of borate was hauled in wagons, pulled by a team of 20 mules. It was determined that 20 mules could haul a wagon containing 40 tons of borate. Later the mule wagons became the symbol for what is known today as 20 Mule Borax laundry treatment.

What do borates do?

Borates are used in many industries. These are just a few of the beneficial uses:

- Agriculture as a safe pesticide
- As a corrosion inhibitor in cooling systems and auto anti-freeze
- Provides glass and textile strength for cell phone and laptop screens
- Used in eye drops to provide artificial tears
- A fire retardant for clothing
- An anti-fungal and preservative for wood
- Enhances the cleaning ability of detergents
- Considered an essential nutrient for human health

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Benefits of borates in swimming pools

- Softens water
- Reduces scaling
- Improves water clarity
- Reduces corrosion of plaster and surfaces
- Improves oxidative power and longevity of chlorine (makes chlorine last longer)
- Acts as a buffer to prevent excessive pH increase
- Helps provide algae control
- Improves swimmer comfort-eyes and skin

At levels in swimming pools of 50 ppm, borates are a safe and effective additive for the overall chemistry of the pool. Pool owners and pool service techs have F. M. 'Borax' Smith to thank for the discovery and mining operations in Boron, California, which is one of the largest natural mineral deposits in the world. In pools, borates have a toxicity level similar to common table salt. Normal levels of borates in pools not exceeding 50 ppm are low in toxicity. It would take an average person to ingest several gallons (at once) of pool water for any toxicity to occur. The same applies for animals. The likelihood of either a human or animal ingesting that much in a single instance are virtually nil.

How borates work in pool water

The primary role of borate in pool water is to act as a buffer. Any wise pool pro knows that when it comes to managing water, it is all about balance. pH plays a vital role in the proper production of the killing agent of chlorine known as hypochlorous acid (HOCl). Keeping pH in the level of 7.4-7.5 is one of the keys to ensuring good chlorination. A balanced pH also is vital to prevent corrosion, scale formation and metal staining. Total alkalinity and cyanuric acid (CYA) are both buffers that help to keep pH from drifting downward. Borates are efficient at keeping the pH from drifting up.

Borates also act as a good water clarifier, especially in hard water areas. The unique buffering capacity of borates gives them the ability to lock up calcium in much the same way as a metal chelate or sequestering agent would. This action prevents the calcium from combining with carbon and precipitating out as scale. Because the calcium is held in solution, the water has a softer feel and is gentler on the skin. Your pool customers will notice. Borates act as an anode inhibitor in the presence of oxygen. This means they are excellent at preventing corrosion of less noble metals such as copper. Borates in chlorine generator pools can help to prevent the metal staining that can be a result of galvanic corrosion. So ladders, light rings and heat exchangers are less likely to corrode and will last longer.

Because of the unique ability as a buffer and softener, borates increase the performance and longevity of chlorine in the pool. Many pool techs report longer lasting free chlorine residuals with borates. It is this ability, along with the algaestatic characteristics, that make borates a great algae prevention tool. It should be noted that borates are NOT an algaecide and should not be used directly to kill visible algae in a pool. Borates are strictly a preventative along with good pool maintenance.

Types of borates for pools

As pointed out there are several differing forms of borates. This is dependent upon what the borate is blended with. Borates are

more commonly known as Borax, which is sodium borate. There are a few different forms, which are all simply a combination of boron (remember number five on the table of elements), oxygen and sodium. In the pool market, the types of borate products available are:

- Boric acid
- Borax
- Sodium tetraborate pentahydrate

Boric acid. This is a weak acid of boron which when dosed at 50 ppm has very little effect on pH. This has a cost savings in that muriatic acid does not need to be added. It takes 35.06 pounds of boric acid to get a 50 ppm increase in 15,000 gallons.

Borax. This is the same product that is sold as 20 Mule Team Borax in stores. Sodium borate is a powder that is alkaline with a pH of 9.2 and does need the addition of muriatic acid. It takes 54.06 pounds of Borax in 15,000 gallons to get 50 ppm. That is about 11 and a half boxes of Borax from the store. It would take 3.79 gallons of muriatic acid to adjust the pH after treatment.

Sodium tetraborate pentahydrate. This is similar to Borax, however, less is needed as it contains only half the water molecules. It also has a pH of 9.2 so additional muriatic acid is needed after treatment. It takes 42.1 lbs. of sodium tetraborate pentahydrate to provide 50 ppm in 15,000 gallons. It takes 3.29 gallons of muriatic acid to adjust pH after treatment.

More information

There are several options available when it comes to adding borates and much additional information on borates is available. There are several technical bulletins on borates and the dosing of borates on the Pool Chemistry Training Institute web site, <https://pool-chemistrytraininginstitute.com/technical-bulletins/>. Also, the Borax website (<https://www.borax.com>) is interesting in explaining history and uses of borates. As in many situations, sometimes the simplest of solutions is best. This summer continues to be challenging from the standpoint of obtaining the chlorine we need to keep our pools safe and clear. Borates could very well be that simple solution to stretching out the chlorine we need.

About the author

◆ Terry Arko has more than 40 years of experience in the recreational water industry, working in service, repair, retail sales, chemical manufacturing, technical service, commercial sales and product development. He has written over 100 published articles on water chemistry and has been an instructor of technical courses for over 25 years. Arko is a voting member on the board of the Recreational Water Quality Committee (RWQC) and serves as a board member for the California Pool and Spa Association (CPSA). He is also a Certified Pool Operator instructor with the Pool Hot Tub Alliance (PHTA). Arko is currently working as Technical Content and Product Training Manager for HASA Pool, makers of HASA Sani-Clor. He can be reached at terryarko@hasapool.com





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Philanthropic Trio Bring Water to Americans in Need

Introduction

Hometown H2O is a domestic water program dedicated to bringing clean, sustainable water to people and communities in need across the United States. The program, launched in early 2020, is a united effort between retired NFL player Chris Long and his Waterboys initiative and Xylem Inc., to address domestic water scarcity issues, which currently leave more than two million Americans without access to clean water. Hometown H2O works alongside the Water Well Trust, a national nonprofit that helps qualify low-income families. This article reports on the most recent projects.



A new water lifeline for rural Texas family

For David and Beverly Daily, their 83-acre property in Jacksonville, TX, had everything they and their extended family could want. Everything but access to clean running water. The Jacksonville

water and sewer lines don't reach the rural property where the Dailys live, along with their three children and their families. Other homes in the area use water wells, but installing one was cost-prohibitive for the family, according to Beverly Daily. Instead, they relied on rain barrels to collect water for everyday use and traveled to a filling station for potable drinking water.

While researching various options online, the Dailys' daughter, Kimberly Holt, found the Water Well Trust, a non-profit partner of Xylem, and Hometown H2O. "They were only doing it in other parts of the country, but I thought, you know I am just going to ask and the worst thing they can do is say no, right?" she said. About a week after Holt submitted the application, the Water Well Trust reached out to provide assistance. The new well, which provides the Dailys, their children and their families with potable water directly to their homes, is the third Hometown H2O well donation project completed in 2020.

"The reality is that many American families – especially in rural areas – are forced to source their water from rain barrels or other unsanitary means for everyday use, and that should not be happening," said Chris Long, two-time Super Bowl champion as well as Founder and trustee of the Chris Long Foundation. "Water access for many Americans is a growing issue. Through Hometown H2O, we are working to ensure everyone has access to safe, clean water at home. A key part of that is working with one of the world's leading water tech companies so that we can deliver sustainable projects and impact everyday quality of life for families as quickly as possible."

Donations and price reductions from local businesses also make the projects possible. For the Daily project, Xylem donated Goulds Water Technology brand equipment while local distributor

partner Wholesale Pump & Supply of Tyler donated casing, sand and concrete. Well installation services by Jackson Distributors of Cushing were provided at a discount. "It's an honor to be able to help fulfill the promise for a better life for these families," said Rick Laborde, President, Wholesale Pump & Supply. "We could not be more thrilled to support the Water Well Trust, Xylem Watermark and Hometown H2O missions in order to provide the Dailys access to water."

Following prep work at the site for well installation, the new 720-foot well was outfitted with a Goulds Water Technology 35-, 7.5-HP submersible pump and motor. Additionally, the volunteer team installed a 116-gallon tank, 10 HP variable frequency drive (VFD) and a VFD output filter. Wholesale Pump & Supply assisted with the electrical installation of the pump house and pump equipment.

Xylem's corporate social responsibility program Watermark provided volunteers who conduct various improvement projects on the property beyond the well donation. Using social distancing precautions amid coronavirus concerns, local Xylem employees joined forces with Wholesale Pump & Supply and Jackson Distributors employees to help build the pump house for the new water well, ensuring its longevity for the family's access to water. "COVID-19 has made already challenging circumstances even more difficult, and we recognize how imperative our resources are to helping those in need during this unprecedented time," said Susan

O'Grady, Director, Americas Building Services & Agriculture, Xylem. "Not having access to running water and/or potable water is an unimaginable reality that has since become unbearable for these families. For Xylem and its partners, we feel it's the right thing to do to use our collective expertise, solutions, services and donations to bring a potentially life-saving resource to such deserving people."

Following the installation of the water well and other improvements to the property, Beverly Daily expressed the family's appreciation. "If you've ever done without water for even a few hours, it's inconvenient, but if you do without it on a regular basis for a period of months or even years, it's a whole new aspect," she said. "We're very grateful for it."

Missouri veteran now has water

A local family of four in Eureka, MO, recently gained access to clean water with a donated water well system, equipment, well drilling and pump installation. The Illert family (30-year old veteran Justin, wife Sarah, five-year-old Lilah and one-year-old Austin) previously lived without clean, running water in their home and relied on bottled water and rainwater for cooking and cleaning. The family now has reliable access to clean, potable water for the first time. "It feels like we won the lottery," said Sarah. "It means the world. It really is life changing for us. We are so grateful to have clean water to cook with, do our laundry, clean the dishes, and take clean showers and baths."

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The donation marked the fourth project between Xylem Inc., Water Well Trust and Hometown H2O. This project was also supported by beverage company Talking Rain, which donated water to project staff and made a financial contribution to the family. “Nobody should have to live without access to clean water – especially the brave and honorable men and women that have served our nation,” said Chris Long. “Clean water access for many Americans is an increasingly serious problem. Since Hometown H2O launched in 2020, we have raised awareness for water equality that affects policy at the state and federal levels. We will continue to prioritize this mission in our future projects. The organizations we work with, including Xylem and Water Well Trust, bring industry expertise to the table and passionately do what it takes to make these projects successful. Thank you to our supporting partners for helping us to change lives and ensure that clean, running water is a basic human need that no American lacks.”

Xylem donated Goulds Water Technology brand equipment while local distributor partner Water Works of Springfield, MO, coordinated the discounted installation through pump installer Schroeffer Well Drilling, Inc. of Franklin County, MO. A team of volunteers – from Water Works and Xylem employees – also donated time to clean up the property’s yard.

“The unacceptable reality is that many Americans do not have access to potable, running water,” said Susan O’Grady, Director of Marketing, Building Services and Agriculture, Xylem. “For Xylem and its partners, we are honored to be able to use our expertise and passion for the cause to bring this vital service to people who deserve to have clean water.”

For more information about the Hometown H2O project, visit or contact Megan McDowell at mmcdowell@braniganinc.com or (920) 493-0532. Listen to “In the Field with Goulds Water Technology,” a series dedicated to the residential water and irrigation industries on Solving Water: A Xylem podcast, anywhere podcasts are available. [WCP](#)

An advertisement for Water Well Trust. On the right, a young girl with brown hair and blue eyes is smiling and holding a clear glass of water to her lips. The background is a solid blue color. On the left, white text reads: "WE LITERALLY HAD RUNNING WATER WITHIN 30 DAYS OF OUR INITIAL PHONE CALL. THIS OPPORTUNITY WE WERE BLESSED WITH IS NOTHING SHY OF A MIRACLE." - FLIPPIN, AR. Below this is a horizontal line, followed by the text: "We're helping drill new wells for rural homeowners without access to a public water supply. Visit waterwelltrust.org for info." At the bottom left is the Water Well Trust logo, which consists of a stylized water drop icon and the words "waterwell trust".



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Behind the scenes of healthy drinking water are engineers, chemists and researchers that build the plants and systems on which the water treatment industry relies so heavily today. ProChemTech International, Inc. is on the front lines of these activities and does it all.

The company was founded in 1987 by Timothy Keister as a privately owned, Pennsylvania-based company, dedicated to innovating the industry. With his 'odd ball' degree in ceramic science, Keister gained his knowledge of the industry at a Fortune 500 manufacturing firm, as a corporate water/wastewater manager, where he stayed for 13 years. "I ended up with 38 plants under my jurisdiction," Keister said, "Basically anything with water or wastewater belonged to me. I never expected it. However, it was a good education." After the company was purchased, he started ProChemTech. Keister was very particular about the people he started the business with, some of his first employees being chemists from the manufacturing company R&D Center.

Years down the road, ProChemTech, a Delaware C Corporation, continues to operate out of Brockway, PA, in addition to its most recent addition, a chemical plant in Apache Junction, AZ. The company provides both commercial and industrial services in nine states centered around the two manufacturing/service center sites. Of ProChemTech's 11 patented technologies, it primarily offers chemical products to treat boiler, cooling and industrial wastewaters with onsite service. Its Engineered Systems Division designs and builds industrial wastewater and cooling tower systems, inclined plate clarifiers, electrolytic bromine generators and BlueTrak sensors, as well as assemble water softeners, multimedia filters and various membrane-based devices.

ProChemTech is a multigenerational business with Keister being the Chief Chemist and President and his wife, Kathy, the CEO. In the next seven years, the plan is for their children to completely take over the company. His son Joseph, the Erie District Manager, has been with the company for almost eight years now doing both sales and service. His daughter Jessica, the 'silent owner,' is in charge of marketing. Both Joseph and Jessica are excited to become the face of a second-generation company.

Scouting for new members has proven to be difficult though, considering the close company network with its loyal employees. "In our business, our salesmen have to know technology as well as being a good people-person. Some salesmen we've had in the past have been chemists," Keister said. Because the company is selling highly technical content, not just anyone is suitable for the job. "It's a lot more complex than your typical water treatment guy who's a softener salesman," he continued. When the President is a Certified Water Technologist, the VP is an environmental engineer and licensed wastewater treatment plant operator and several of the employees are registered professional engineers, one must come in knowing a thing or two about the chemical products and high technical content.

Having treatment plants both in the Southwest and on the East Coast has given Keister a unique perspective. "The water that

"Many management companies are not interested in performance. All they want is the cheapest program they can get away with. They don't care about water conservation or anything," he said about companies in the Southwest. The company has been doing government business in Arizona for 20 years, only to find that, as Keister put it, "the government, states, cities, schools, universities and our technologies could save them literally millions of gallons of water per year, but none of them are very interested in it."



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you see here (on the East Coast) is very, very high quality compared to what you see in Arizona or California. There are very few HVAC counts. The Southwest water is harsh, it's high in chloride... totally different water," he said. The different experiences have been nothing short of educational for the crew. "When we first opened the Arizona office, we just didn't have much experience in HVAC, but we have found out that it's a radically different business," Keister said.

Now being knowledgeable about these serious issues, Keister has used ProChemTech as a platform to promote awareness to the systemic barriers preventing proper conservation of Arizona water. "Many management companies are not interested in performance. All they want is the cheapest program they can get away with. They don't care about water conservation or anything," he said about companies in the Southwest. The company has been doing government business in Arizona for 20 years, only to find that, as Keister put it, "the government, states, cities, schools, universities and our technologies could save them literally millions of gallons of water per year, but none of them are very interested in it." As he continues to watch famous landmarks (such as Lake Mead,) lose more feet of level every year, he cannot help but to shudder at the companies who will do nothing about it.

Keister has been long pushing awareness for his products that will help solve issues in the absence of correct use of certain treatment products, poor service and inadequate chemical control



systems, all of which lead to excessive water use. "There's all sorts of non-chemical devices floating around... none of them work," he noted. With the proven chemistry behind ProChemTech's Aqua Save and Aqua Ionic products, the company is contributing to the advancement of the industry and providing healthier water with less waste. "Aqua Ionic permits cycles of concentration to be increased nine-fold, reducing cooler tower water use (which accounts for 30-85 percent percent of water used in many facilities) by up to 35 percent," Keister said.

Other company endeavors include raising overall sales by 10 percent per year in addition to developing new sales districts. The business is also currently working on another patented system with new cooling water chemistry that lowers water surface tension to improve heat transfer in HVAC and process applications. \$600,000 was recently invested to expand the Brockway chemical manufacturing plant.

ProChemTech's mission and goals all surround the idea of improving the industry for both the environment and the customers, and to therefore be the most respected company for it. Due to an increasing lack of fresh water in many areas, especially in the Southwest, interest in cooling tower water use reduction and wastewater treatment with means to recycle and reuse water will also increase. Keister believes it is their duty to be the best in the industry, so that other companies might view them as the standard to follow.

About the author

◆ Emma H. Peterson, author of WC&P International's corporate and dealer profile series, is a student at the University of Arizona, majoring in journalism, with a minor in natural resources. Throughout her college experience, she has developed a following for her photography and photojournalism endeavors. After graduation, Peterson intends to broadly expand her creative/feature writing and photography prospects, as well as pursue her personal interests in skiing and rock climbing. **WCP**



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NSF/ANSI/CAN-50 Requirements for Automatic Controllers

Almost nothing is accomplished in the recreation water industry without the assistance of electromechanical devices, systems and components. It's simply the nature of the task of circulating, cleaning and treating this water that leads to these mechanisms needed to deliver safe, sanitary and consistent water quality to the swimmers that enjoy the benefits.

A comprehensive standard

NSF/ANSI/CAN 50 is a standard organized by sections according to product types. It includes requirements for filters, valves, skimmers, chemical feeders and more. One section stands out as covering (arguably) the most technically complex products within the realm of recreation water. Section 19 addresses automatic controllers, which are described in this section according to Figure 1. Taking into account the scope of *NSF/ANSI 50* with regard to automatic controllers, one might wonder what specific evaluations for automatic controllers are included and what additional standards or evaluations could apply. Let's explore. *NSF/ANSI/CAN 50* Section 19 evaluates the following:

1. Chemical resistance of any part that is in contact with treated water
2. Monitor display functions including status of set points, parameter levels and units of measurement.
3. Life test consists of testing three units with minimum cumulative cycle of 295,000. There is a minimum of cycles for each controller and at least one controller must meet 110,000 cycles.
4. Output performance including evaluation of:
 - a. Set point tolerances
 - b. Failure sensing designed to alert the end user of parameters outside of the specified range of delivery
 - c. Operational protection specifically for chemical feeder and injection functions
5. The standard also requires evaluation of the installation and user manual of the product to ensure the manual expresses
 - a. The correct settings per testing conducted
 - b. Any cautionary statements applicable
 - c. Replacement parts
 - d. Correct installation procedures
 - e. Expressed electrical ratings and requirements for service.
6. Lastly the data plate is required to be evaluated so that at a glance the end user can visibly reference a label on the controller, to include the following relevant information:

- a. Equipment name
- b. Manufacturer's name and contact information (address, phone number, website, or prime supplier)
- c. Model number
- d. Electrical requirements; volts, amps and Hertz
- e. Maximum external load rated in volts and amps
- f. Serial number and date of manufacture
- g. Caution statements (prominently displayed)
- h. Replacement sensor model numbers

Other aspects of automatic controllers – electrical safety

As comprehensive as the standard is, there are some aspects of automatic controllers that are not covered. These aspects include electrical component recognition, electrical product certification, or EMC testing. It doesn't provide documentation to support a CE declaration for electrical safety, it doesn't guarantee the product will pass an installation inspection and it doesn't represent every aspect of safety needed for the end use.

When considering electrical safety of automatic controllers, there are certain standards that could be applicable. These include:

1. *UL 61010-1 Electrical equipment for measurement and control*
2. *EN/IEC 61010-1 and Low Voltage Directive (LVD)*
3. *UL 979 Water Treatment Appliances*
4. *UL 1563 Electric Spa and Associated Equipment*
5. *CSA 218.1 and CSA 218.2 Spas, Pools, and Hot Tubs*
6. Directive 2014/30/EU relating to electromagnetic compatibility. *EN 61326-1 - Electrical equipment for measurement, and control - EMC requirements - Part 1: General Requirements*
7. *FCC CFR 47 Part 15, subpart B - unintentional radiator (FCC SDoC)*
8. *ICES-003 - Information Technology Equipment (ITE) - Limits and Methods of measurement*

Elements of conformity assessment

The first step to electrical safety conformance is for a construction review to be performed. This process includes a technical assessment of the components and how those components may or may not be electrically recognized or certified and if they are properly sized and used in an application appropriate to the complete system. Findings identified during the construction review must be addressed and corrected prior to testing.

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Upon completion of testing, whether that testing is to the requirements of *NSF/ANSI/CAN 50* or electrical safety, reputable testing laboratories will issue test reports and/or certificates of conformance. If non-conformances are identified, accredited certification bodies will require an investigation into each non-conformance and a corrective action to address each of them.

Certification – the ultimate demonstration of conformance

Manufacturers seeking third-party certification of automatic controllers, whether for electrical safety or according to *NSF/ANSI/CAN 50*, are required to have an audit of the manufacturing facility. Depending on the scope of the certification, these audits are required either annually or quarterly.

There is tremendous value in third-party certification as a demonstration of conformance. A test report without certification is simply that - a test report. The additional oversight provided via an audit ensures a consistent configuration is being manufactured and distributed – the same one that was tested and certified. It's the added credibility regulators, consumers and installers depend on to be sure a product consistently conforms to the need.

Evidence of certification is provided by marking on the product. These marks are specific to the certification body and they convey the scope of certification. For automatic controllers, certification marks will make it clear whether the certification is covering the requirements of *NSF/ANSI/CAN 50*, or electrical safety, or both. Additionally, all accredited third-party certifications are verifiable via online listings per the certification body's website.

Assuring safety and performance

The complexity of a product such as an automatic controller and the potential sensitivity of its end uses with recreation water, dictate a regulatory, human health and safety response proportional to the risk. Certification bridges the gap for the client wanting to get their product to market and general need for market acceptance. Certification creates confidence for manufacturers, regulators and end users alike.

Figure 1. NSF/ANSI/CAN 50 Scope of Automatic Controllers Automated controllers are used to monitor water conditions such as pH, ORP, free chlorine or other parameters specified by the manufacturer and to control equipment such as chemical feeders and pumps. Equipment covered by this section includes the controller and the chemical probes, and flow cells. Water contact components and materials of automated controllers shall be evaluated to the health effects criteria of Section 4. Mechanical chemical feeders are covered in Section 11, and flow-through chemical feeders are covered in Section 12.

NOTE: Verbatim text from *NSF/ANSI/CAN 50*.

About the author

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Advanced Oxidation Processes— With so many options, how can we gauge efficiency?



Advanced oxidation processes (AOPs) featuring highly reactive oxidizing species, e.g., hydroxyl radicals, can degrade an array of recalcitrant organic pollutants that are not well removed using conventional water and wastewater treatment processes, e.g., personal care products, pharmaceuticals and pesticides. The advanced oxidation aspects of such systems go beyond traditional oxidation/disinfection methods, typically using additional inputs of chemicals (such as H₂O₂ or catalysts) and/or energy (such as UV or electrolysis) to accelerate reactions.

Full-scale AOPs are most commonly installed in water reuse facilities, as well as some drinking water operations.¹ As shown in Figure 1, UV/H₂O₂ is one of the most widely used AOPs at large-scale potable reuse facilities (likewise, varying combinations of UV, H₂O₂ and/or O₃ are most widely adopted for full-scale municipal or industrial water treatment²). For 24/7/365 treatment focused on organic pollutants and disinfection, total UV/H₂O₂ life cycle costs are approximately \$1.00 - \$5.00/1,000 gallons treated.³ For more selective operation, e.g., disinfection plus seasonal taste and odor control, total life cycle costs drop to approximately \$0.30 - \$2.50/1,000 gallons treated.³

AOPs can also be operated as smaller, decentralized systems, e.g., POE or POU treatment systems, as well as portable greywater reuse operations⁵. Whereas centralized systems will likely continue to rely on well-established AOPs, electricity-based AOPs may have strong potential for decentralized use as they avoid chemical sourcing and transport.⁶ Operating costs for highly advanced POU treatment systems may be on the order of \$100/\$1,000 gallons treated (although POU offer lower initial capital costs compared to centralized facilities).⁷

Beyond UV/H₂O₂, an array of other AOPs have shown potential in bench, pilot and full-scale configurations (see Box 1 for examples of AOPs; note that O₂ alone is considered a conventional oxidant, but it also generates hydroxyl radicals as it decomposes, leading some to classify it as an AOP or AOP-like process). Many AOPs have demonstrated effective treatment, but these processes are not equally able to remove all compounds, nor are they equally efficient with respect to energy and/or chemical inputs.⁸ Despite many years of lab-scale AOP development and testing, pilot- and full-scale operations remain rather sparse. Yet, studies at these scales are needed to overcome the difficulties in comparative

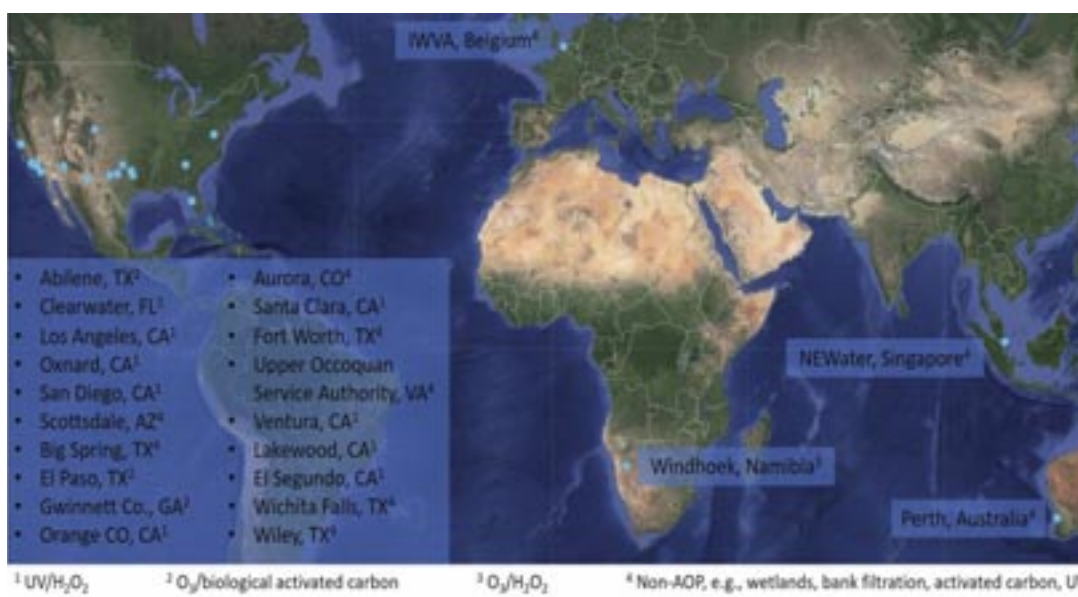


Figure 1. Examples of potable water reuse, including varying combinations of filtration (e.g., B/GAC, microfiltration, ultrafiltration, RO) and AOPs. Each systems' major mode of advanced treatment is indicated by superscripts. The map and information were derived from the digital repository Water360.⁴

Box 1. Examples of AOPs. Full-scale installations have been established for those listed in bold.¹ Note that some processes combine multiple mechanisms and could be categorized under several different headings. See Miklos et al. (2018)¹ for a brief description and review of the advantages and disadvantages of many of these alternatives.

- Ozone-based**
 - O₃
 - O₃/H₂O₂ (peroxone)
 - O₃/UV
 - O₃/Cl₂
- UV-based**
 - UV/H₂O₂
 - UV/Cl₂
 - UV/peroxydisulfate
- Catalyzed**
 - UV/catalyst (e.g., UV/TiO₂)
 - Fenton
 - Photo-Fenton
- Electrochemical**
 - **Electrooxidation**
 - Electro-peroxone (E-peroxone)
 - Electro-Fenton
- Physical AOPs**
 - Electron beam
 - Microwave
 - Plasma
 - Ultrasound

evaluations due to physical and chemical differences in AOPs⁹ and to establish more direct means of comparing AOP efficiencies.¹⁰ This begs the question: how can we gauge AOP efficiency?

The mechanism of oxidant generation and pathways of contaminant degradation vary dramatically amongst different AOPs. Reaction efficiency can be quantified using reaction rate kinetics, which are modeled as zero, first or second order depending on the target compound and oxidant pairing. Understanding the kinetics of the reaction, at least the order thereof, is key to understanding advanced treatment processes.¹¹ Extensive databases of oxidant reaction rates with organic micropollutants are available.⁶ Organic degradation using AOPs can often be phenomenologically modeled using pseudo first-order kinetics. Table 1 shows several examples of first order rate constants for degradation of carbamazepine (a pharmaceutical), methyl orange (a common dye) and nitrobenzene (an industrial chemical) using a range of AOPs.

Notably, kinetic rate constants characterize reaction efficiency, but do not encompass other aspects of AOP efficiency, for example the costs to operate a system. To help address this issue, Bolton *et al.* (2001)¹² developed the figure of merit Electrical Energy per Order (EEO; Equation 1). This metric is defined as the electrical energy normalized to reactor volume required to decrease a target contaminant's concentration by one order of magnitude. Electrical energy consumption often accounts for a major fraction of AOP operating costs and EEO values <1 kWh/m³/order are often considered most viable for full-scale operation.^{1,13}

$$EEO = \frac{Pt1000}{V \log \left(\frac{C_0}{C} \right)}$$

where: EEO is electrical energy per order (kWh/m³/order), P is system power (kW), V is volume of water treated (L) in time t (hr), C₀ is the initial contaminant concentration (EEO is valid for low initial concentrations, typically <100 mg/L) and C is the final concentration.

Table 1. AOP comparison assessed using kinetic rate constants and electrical energy per order (EEO) values. Data are from the direct process comparison performed by Ambrogi *et al.* (2019)¹⁰

(with EEO values estimated from graphs). Higher process efficiency is indicated by higher rate constants and lower EEO values (green in the color scale).

Differences in interpretations of AOP efficiency using rate constants versus EEO are evident, as illustrated by the color scale in Table 1. For instance, while the O₃-based AOPs were characterized by rapid kinetics, energy inputs to generate O₃ led to higher EEO values, particularly in the case of methyl orange and nitrobenzene.¹⁰

Miklos *et al.* (2018)¹ conducted a carefully curated review of AOP EEOs, as summarized in Figure 2. Despite high variability, the EEOs suggest that ozone- and UV-based AOPs are the most readily applicable for full-scale implementation given that their median energy efficiencies are within the realistic realm of EEO <1 kWh/m³/order. Within this group of technologies, there was no statistical difference among energy efficiencies, with observed variations likely stemming from experimental conditions. In direct comparison tests, however, ozone-based AOPs were reportedly more energy efficient for production of hydroxyl radicals⁹ and degradation of organic micropollutants¹⁴ compared to UV/H₂O₂ (EEOs for which are generally about 4 – 20 times higher than for O₃/H₂O₂⁶). Additional considerations for ozone-based AOPs include the potential to generate DBPs such as bromate^{1,14} and the reduced disinfection potential of O₃/H₂O₂ compared to UV/H₂O₂.⁶

Technologies with median EEOs > 1 kWh/m³/order (Figure 2) are less likely to be used in typical large-scale installations in the near-term as current configurations are likely too energy intensive. These technologies, however, warrant further investigation targeting energy savings. In particular, AOPs with median EEO values between 1 and 100 kWh/m³/order may still provide attractive solutions for specific challenges.¹

One approach to improve energy efficiency is using renewable energy sources to power AOPs.¹⁵ For example, the World Health Organization did not recommend ozone for POU treatment because of the need for a reliable source of electricity for ozone

AOP	Metric and Contaminant					
	First order rate constant (min ⁻¹)			Approximate EEO (kWh/m ³ /order)		
	Carbamazepine	Methyl Orange	Nitrobenzene	Carbamazepine	Methyl Orange	Nitrobenzene
O ₃	>8	2.2±0.4	0.107±0.008	1.5	11	105
O ₃ /UV	0.309±0.008	0.325±0.004	0.134±0.003	60	60	110
O ₃ /OCl	>8	3.0±0.6	0.051±0.002	1.5	7	400
UV/H ₂ O ₂	0.151±0.003	0.0412±0.001	0.0857±0.01	5	20	0.8
TiO ₂ photocatalysis	0.015±0.001	0.020±0.001	0.027±0.001	60	40	30
UV/OCl	0.423±0.05	1.38±0.06	0.0252±0.003	1.5	0.5	30
Fenton	0.103±0.007	0.09±0.01	0.038±0.005	2.5	3	9
Photo-Fenton	0.046±0.008	0.10±0.02	0.039±0.003	13	4	12

Color scale: Lowest efficiency Highest efficiency

Table 1

generation, the complexity of the system for appropriate operation and dosing and its relatively high cost.¹⁶ However, alternate sources of energy may alleviate some of these challenges. For example, solar-driven AOPs can reduce energy use and enable AOP deployment in low income or off-the grid applications, i.e., rural or developing areas, transient systems (e.g., emergency response, military operations), etc.^{17,18}

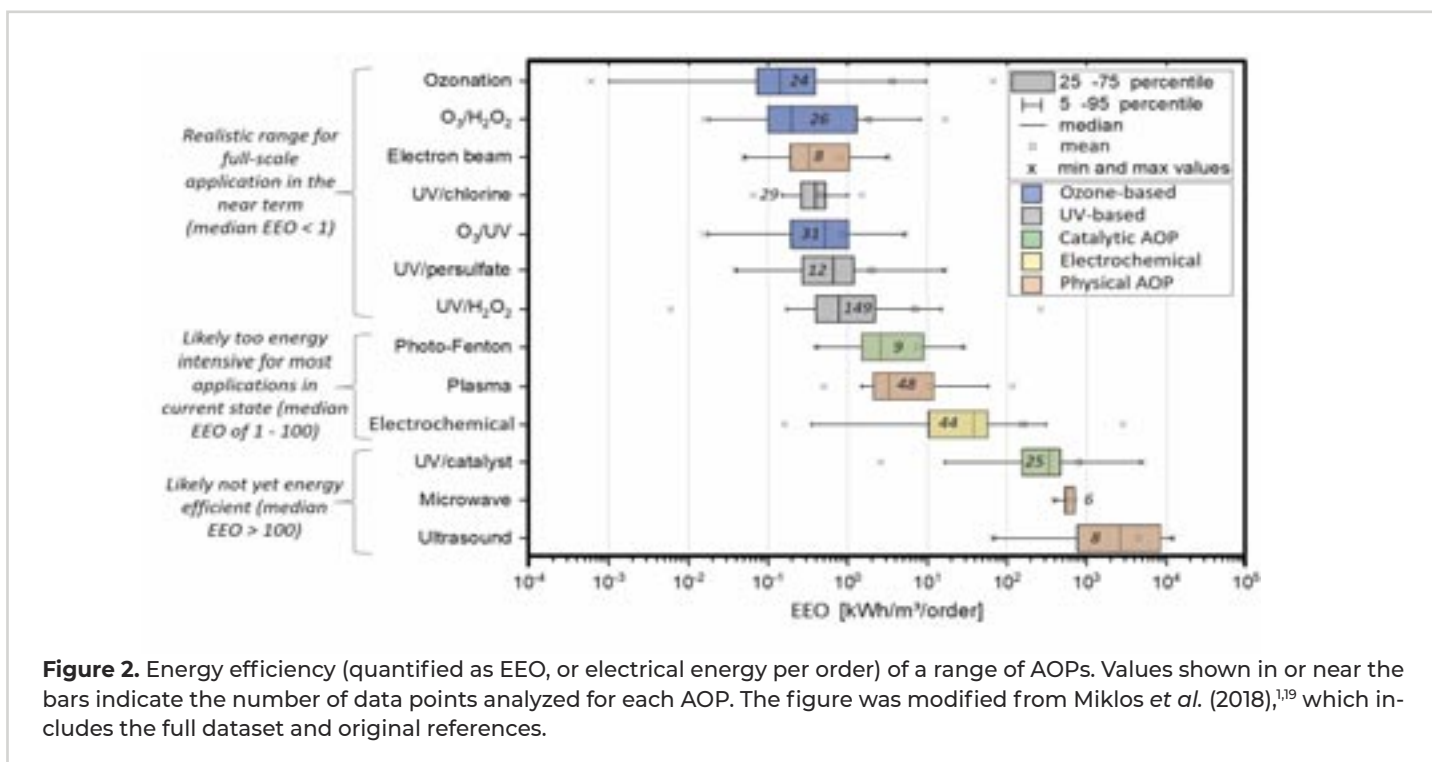


Figure 2. Energy efficiency (quantified as EEO, or electrical energy per order) of a range of AOPs. Values shown in or near the bars indicate the number of data points analyzed for each AOP. The figure was modified from Miklos et al. (2018),¹⁹ which includes the full dataset and original references.

The high variability in EEOs reported in the literature to date, particularly for non-optimized, lab-scale tests, illustrates strong dependence on system configuration, process capacity, energy-independent parameters such as chemical doses and water matrix.¹⁰ Thus, the EEO metric is most relevant for AOPs that have been optimized in terms of oxidant demand, reactor geometry and other process-specific parameters.¹ In most cases, full-scale EEO data will be lower than bench- or pilot-scale EEO results.¹³ Another caveat is that while EEO accounts for energy costs, it does not account for chemical costs, which are essential to consider for any real-world application.¹⁰ Some researchers have accounted for such costs by incorporating estimated costs of H₂O₂ production in EEO assessments⁹, but this has not been done universally. An additional real-world consideration is the impact of water quality; EEO comparisons across experiments performed in different water matrices is not recommended.¹ Accordingly, direct experimental AOP comparisons using equivalent conditions (e.g., water matrix) are most desirable as they provide the data needed to scale-up and evaluate AOP economics and sustainability against conventional technologies.¹ Although EEO cannot fully characterize AOP performance, it is a powerful metric that enables a simple comparison of the magnitude of energy efficiency across widely variable AOP technologies.

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