Combating Emerging Contaminants in Drinking Water

An advanced oxidation UV reactor unit. PHOTO COURTESY H2M ARCHITECTS + ENGINEERS

Emerging contaminants like per- and polyfluoroalkyl substances are creating greater challenges for water suppliers, but with advances in technology, treatment solutions that protect public health while remaining mindful of economic impacts can be delivered.

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Water supply providers face an ongoing list of challenges in the effort to continue to deliver safe and reliable drinking water. In addition to ongoing issues such as lead, disinfection byproducts, and algae blooms, new contaminants including per- and polyfluoroalkyl substances (PFAS), 1,4-dioxane, and perchlorate have emerged and quickly become large concerns. These new contaminants have been a particular focus of the Department of Defense, which, among other efforts, has created a PFAS Task Force to coordinate its approach to address the presence of the chemicals on military installations. The public awareness of the need for safe potable drinking water is no longer a topic of discussion solely within the community of water supply practitioners. It is now a topic for discussion in schools, at the dinner table, town meetings, and is frequently the lead story on the evening news.

In addition to health and safety concerns, and heightened attention, water supply providers, both large and small, additionally face the challenges of meeting new regulatory requirements while balancing capital and operational expenses. Challenging them more is an increasing tendency toward decision-making driven by short-term public perception than an evaluation of health data and heeding the council of experienced engineering/scientific professionals.

The current state of regulatory oversight regarding emerging contaminants is a stark example of this phenomena playing out.

OPTIMAL TREATMENT PROCESS

H2M has completed numerous projects related to each of the most prominent emerging contaminants currently in discussion. Similarly, the company has performed over 40 AOP pilot studies and designed unique treatment systems tailored to each well site, though versatile enough to offer economy of scale in design and cost, both capital and operational.

By carefully analyzing pilot data, optimized concentrations of peroxide and UV dosing, combined with the proper selection of process sequence, will provide the owner savings on operating cost and flexibility for future contaminant concerns. In some cases, cost savings of 30 to 40 percent per million gallon of water treated have been recognized.

An illustrative example is the study of a well site treatment system that needed to consider 10 different contaminants at varying levels of concentration. To maintain reliability of the treatment facility, a packed tower was proposed followed by low pressure UV and hydrogen peroxide AOP. Downstream of the new proposed treatments, existing GAC filters at the plant were re-utilized.

The presence of Freon-22 and 1,1,1 TCA required packed tower aeration, and the emergence of 1,4-dioxane necessitated the usage of AOP, as packed tower aeration and GAC have no effect on its removal. The existing GAC was used for the dual purposes of treatment of PFOS/PFOA (packed tower aeration and AOP having no effect on their removal) as well as quenching residual hydrogen peroxide from the AOP effluent stream. While there were significant concentrations of TCE and 1,1 DCE present, they did not drive the treatment process selection. Depending on other contaminant variables, these compounds could be treated by either the packed tower or the AOP system.

REGULATORY OVERSIGHT

Under the 1974 *Safe Drinking Water Act*, the Environmental Protection Agency (EPA) delegates primary public water supply enforcement responsibility to states and Indian tribes as long as they meet certain technical, enforcement, and regulatory operational requirements. States can then set maximum contaminant levels (MCLs) that are more restrictive than EPA regulations or that regulate additional contaminants.

The contaminant regulation process stipulated in the *Safe Drinking Water Act* requires public suppliers to implement periodic monitoring in a series of Unregulated Contaminant Monitoring Rule activities. However, many emerging contaminants have significant exposure routes besides drinking water. As such, assigning a "relative source contribution" can be one of the more challenging aspects of standard setting, particularly for those contaminants where health risks have not been adequately demonstrated. This has proven to be an issue for contaminants such as PFAS, perchlorate, and 1,4-dioxane (as shown in Figure 1).

Complicating this issue, prior to the late 1990s, reliable analytical detection methods were accurate down to several hundred to a thousand µg/L. Yet PFAS analysis has evolved very rapidly since the Unregulated Contaminant Monitoring Rule 3 program of 2013-2015. Today, several PFAS chemicals can be detected at a level of 2-ng/L. These relatively few PFAS chemicals analyzed may just be the beginning, however, as PFAS may number in the thousands.

Confronted with a growing list of emerging contaminants and frequency of contaminant detections due to improved analytical methods with lower detection limits, state agencies and public water suppliers are facing considerable challenges in risk communication and public perception. This has resulted in individual states developing local regulations, many conflicting, based on the current state of knowledge. This unfortunately leads to differing approaches and MCLs for contaminants. Often, the rigor of extensive studies, once routine, which quantify public health effects and risks before MCLs are set, are delayed. The urgency to address the yet un-quantified concern, in many cases, has overtaken the process. The standard for human health risk in terms of drinking water should not simply be based on boundary and state lines.

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The engineering profession is challenged to evaluate a limited number of possible treatment technologies in an environment of evolving science and regulations, as well as growing public concern. An overarching concern in designing a solution is the possibility of unintended consequences. While selecting a technology that focuses on the contaminant of today, it could be ineffective for other contaminants, or perhaps even create a yet undefined emerging contaminant as a byproduct.

BALANCING TREATMENTS

The challenges of treating emerging contaminants are perhaps somewhat less complex on an individual compound basis. Historically, when a single contaminant of concern was detected

Figure 1: Regulatory Status for Three Unregulated Contaminants/Groups

Contaminents	Federal EPA Status	Federal EPA MCL/Guidance	Number of States with regulations in place or adopted	MCL Ranges HIGH	MCL Ranges LOW	State Level Comments
PFAS	3/10/2020: Draft Regulatory Determination, Intent to Regulate PFOS, PFOA.	Current Health Advisory Level, 70 ng/L for combinations of PFOS and PFOA	17	1 ng/L	70 ng/L	Regulations include adopted recommendations, MCL Goals, MCLs, and advisory levels for several individual PFAS chemicals, or a group of several PFAS.
Perchlorate	6/26/2019: Draft proposal for comment.	EPA proposes 56 ppb and requests comments for regulatory MCL and MCLG alternatives ranging from 18-90 µ g/L, as well as proposal withdrawal.	14	1 µg/L	40 µg/L	Regulations include advisory levels, MCLs and MCL Goals, and cleanup levels.
1,4-Dioxane	3/10/2020: Draft Regulatory Determination status discussion; announces no determination as of yet. EPA "has not determined whether there is a meaningful opportunity for public health risk reduction."	Health Reference Level, 0.32 µg/L, Federal Register 3/10/2020	10	0.3 µg/L	70 µg/L	Regulations include advisory levels, guidelines, and remediation values.

Sources: Water Research Foundation, SUNY Center for Clean Water Technology, Federal Register: 6/26/19, 3/10/20

in source water, technically viable treatment alternatives could be compared based on anticipated capital and operational costs. The sequence was simple: source water underwent treatment and the treated water was sent to the distribution system.

With an increasing number of regulated contaminants and lower detection limits driving more stringent MCLs and treatment, water suppliers must contend with cocktails of compounds that may require a combination of treatment technologies such as filtration, aeration, adsorption, ion exchange, and advanced oxidation processes (AOP). Treatment sequence selection is critical for optimal system performance and is specific for each source water based on the nature of the detected contaminants, their concentrations, and existing site conditions.

Depending on specific water quality, engineers must optimize the sequencing to achieve the best result, balancing compliance, operation constraints, and cost. For instance, if AOP and aeration are both required, the sequencing of AOP to aeration or aeration to AOP can vary depending upon several factors. If concentrations of some contaminants are reduced by both aeration and AOP, the former sequence may require additional energy for AOP and the latter sequence may require a taller packed tower.

Multiple treatment processes may be advantageously sequenced. For example, if AOP for 1,4-dioxane removal is completed upstream of granular activated carbon (GAC) adsorption for PFAS removal, GAC can serve to quench residual hydrogen peroxide in the AOP effluent. If the processes were reversed, an alternate hydrogen peroxide quenching process would likely be required.

Varying source waters, space constraints, energy considerations, and overall costs can impact sequencing. By carefully analyzing pilot data, optimized concentrations of peroxide and UV dosing, and the proper selection of process sequence, H2M has recognized cost savings up to 30–40 percent per million gallon of water. Importantly, additional target contaminants may require additional separation processes and yield additional sequence alternatives.

INVESTING IN THE FUTURE

In a 2019 Congressional Oversight hearing, Pentagon officials acknowledged contaminated water at more than 400 military bases, with cost estimates for remediation in the billions of dollars. Communities across the United States face similar concerns, underscored by the 2019 film *Dark Waters*. As technology and contaminant awareness continues to evolve, engineers, water quality scientists, regulators, and equipment manufacturers will likely be faced with additional challenges with new emerging contaminant concerns.

Consistent with the core mission to provide safe and reliable drinking water for future generations of Americans, water supply professionals must continue to face these challenges head-on, mindful of the responsibility to protect public health, ensure public confidence, and remain respectful of the economic implications.

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