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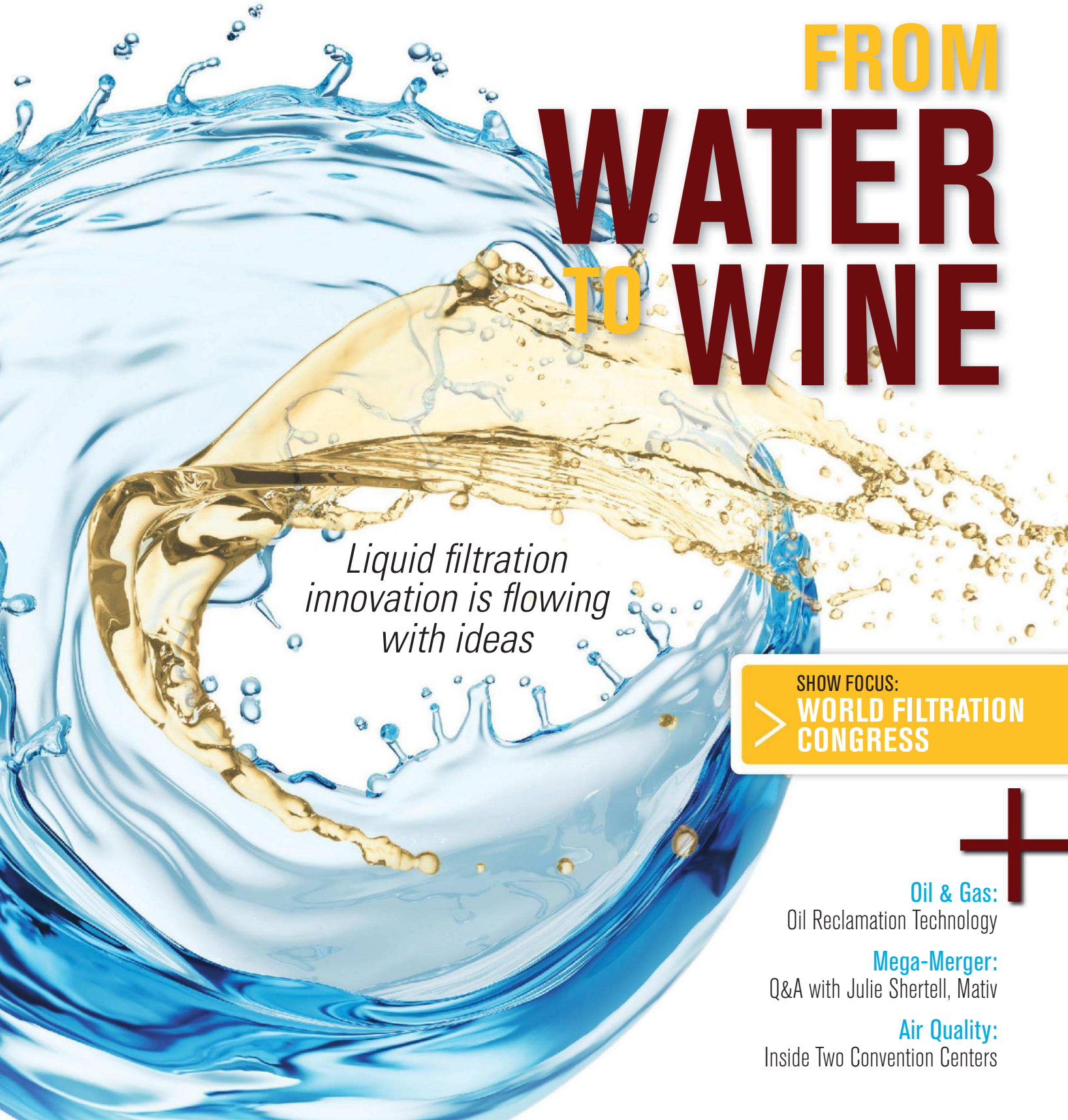
INSIGHTS ISSUES & INNOVATIONS



FROM WATER TO WINE

Liquid filtration innovation is flowing with ideas

SHOW FOCUS:
WORLD FILTRATION CONGRESS

Oil & Gas:
Oil Reclamation Technology

Mega-Merger:
Q&A with Julie Shertell, Mativ

Air Quality:
Inside Two Convention Centers

The upstream & downstream impacts of PFAS Pollution

How one company combats 'forever chemicals' with chemistry

By Amy Phillips

Products that resist heat, fire, oil, stains, grease, and water have revolutionized the marketplace. Think nonstick pans, water-repellant clothing, and smudge-resistant touch screens. What has made such advantageous features possible is a family of synthetic chemicals called per- and polyfluoroalkyl substances (PFAS), which are known as "forever chemicals" because they don't naturally degrade. But PFAS could just as aptly be known as "everywhere chemicals" because they are in so many products now, as well as in the water, soil, and air — and human bodies — virtually everywhere in the world, even Antarctica.

Only about 40 PFAS compounds are currently regulated in the United States even though the Environmental Protection Agency (EPA) says there are more than 9,200 created since their introduction in the 1940s. There is direct evidence that PFAS negatively affect human health, including increased risk for various cancers, hormone disruption, weakened immunity, and reproductive problems. The "forever chemicals" also harm the environment, especially in aquatic ecosystems downstream of discharges from industrial and wastewater treatment plants.

These risks to the environment and human health are leading to reputational, legal, and regulatory liabilities for a host of industries and wastewater treatment plants.

PFAS Pollution – A Pervasive Problem

The Environmental Working Group (EWG) created a map of 41,828 U.S. industrial and municipal sites that are "suspected industrial discharges of PFAS" using data from the EPA, Federal Aviation Administration (FAA), and a survey by the New York Department of Environmental Conservation.

"PFAS exposure can cause serious health impacts at very low levels. It is a public health crisis that these chemicals can and may be dumped into the air and water downstream of textile mills and other industrial sites," said David Andrews, a senior scientist at EWG.

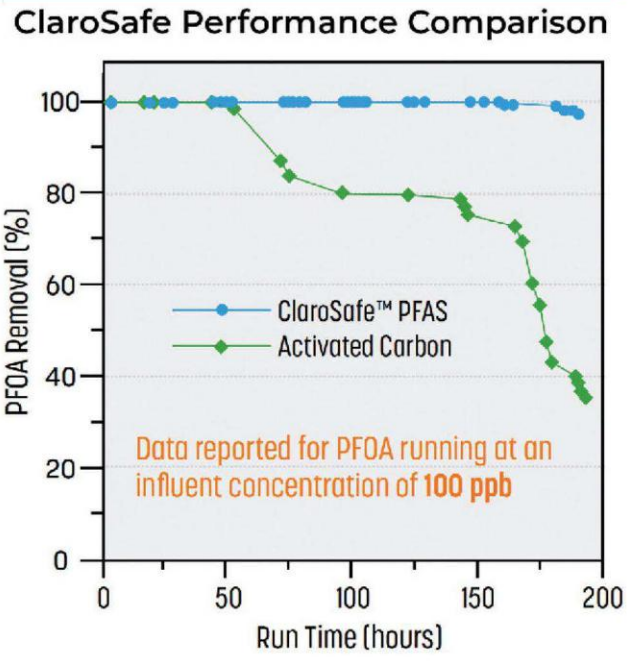
But PFAS pollution isn't just found at industrial sites. It can also be found downstream, including in plants that are designed to safely treat wastewater. The Natural Resources Defense Council (NRDC) said "a significant portion of PFAS in manufacturing waste streams are released into industrial wastewater treatment plants," which cannot adequately capture PFAS, according to its report, "Engaging the Textile Industry as a Key Sector in SAICM: A Review of PFAS as a Chemical Class in the Textile Sector."

In fact, Western Michigan University (WMU) researchers found that wastewater treatment plants can actually worsen PFAS pollution. Matt Reeves, an associate professor of hydrogeology at WMU, said he and colleagues Ross Helmer and Daniel Cassidy, found higher concentrations of PFAS in treated water

ClaroSafe Capture Comparison

Class of PFAS	Compounds	Capture Performance
Short Chain	PFHxS, PFBA, PFBS, PFPeA	> 98% removal at parts per billion (ppb) & parts per trillion (ppt) level
Long Chain	PFNA, PFOA, PFOS, PFHpA, PFHxS, PFHxA,	> 99.5% removal at parts per billion (ppb) & parts per trillion (ppt) level

▲ ClaroSafe™ PFAS has shown the capability to capture high percentages of both long- and short-chain PFAS molecules.



▶ In a head-to-head comparison, ClaroSafe™ PFAS was shown to have greater than seven times the longevity of granular activated carbon.

discharged from such plants than in the influent, due to the increase in aeration and oxygenation.

"They can cause some of these compounds that we can't detect in the influent water. It can transform and change the molecular structure into some of the compounds that we can see," Reeves told Michigan Radio, adding that further study is needed.

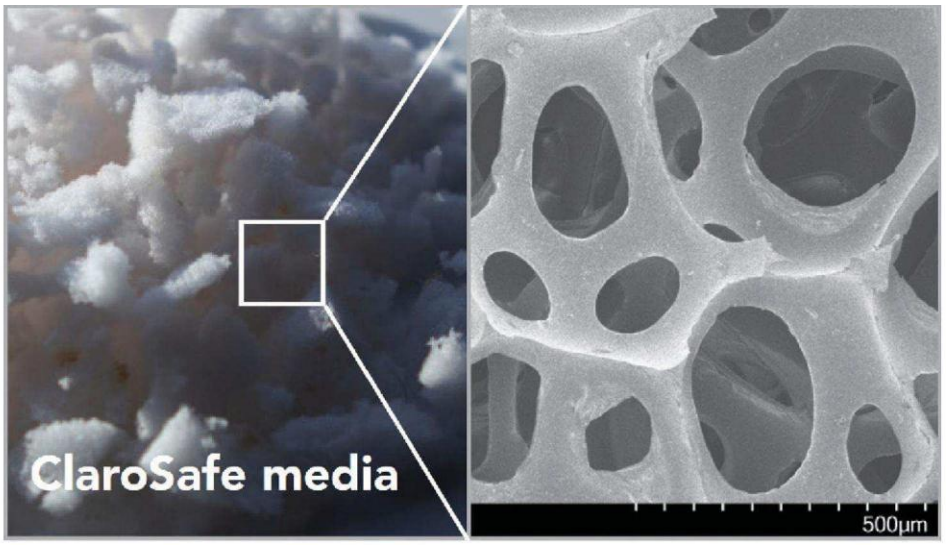
But these plants aren't all to blame. "Wastewater treatment plants make easy targets," Scott Frimin, director of wastewater services for the Portland Water District in Maine told Bloomberg Law. "We smell sometimes. But we are taking the sins of society and cleansing them and discharging clean water. We allow communities to thrive."

Stricter U.S. Regulation is Expected

The EPA is expected to classify perfluorooctanoic (PFOA) and perfluorooctane sulfonate (PFOS), two of the most common PFAS compounds, as hazardous substances under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA), aka Superfund, by 2023, which would create "cradle-to-grave" requirements of the compounds. The EPA also has the authority to regulate PFAS through the Toxic Substances Control Act (TSCA) and the Safe Drinking Water Act (SDWA).

On June 15, the EPA released four new drinking water health advisories for PFAS and announced it is investing $1 billion to reduce PFAS and other contaminants in drinking water. The new health advisories are: 0.004 parts per trillion (ppt) for PFOA, 0.02 ppt for PFOS, 10 ppt for hexafluoropropylene oxide (HFPO) dimer acid and its ammonium salt (together referred to as "GenX chemicals") and 2,000 ppt for perfluorobutane sulfonic acid and its related compound potassium perfluorobutane sulfonate (together referred to as "PFBS"). The agency continues to take action on its PFAS Strategic Roadmap, which seeks to get upstream of the PFAS problem, hold polluters accountable, and ensure science-based decision making, among other goals.

In addition, more than 50 bills to address PFAS have been introduced in the U.S. Congress between 2021 and 2022, according to policy consulting group Global Counsel. As of May, 20 states have issued widely ranging PFAS standards or regulations for drinking water, with California having the smallest allowable concentration of 5.1 ppt for PFOA only and Nevada having the largest with 667,000,000 ppt for PFBS only, according to the JD Supra website. More state and federal regulations are expected.



▲ A microscopic view of the ClaroSafe PFAS media shows the intricacy of the matrix that captures PFAS molecules.

PFAS Litigation is On the Rise

Another risk for companies is lawsuits related to PFAS pollution. More than 6,400 PFAS-related lawsuits have been filed in federal courts between July 2005 and March 2022, according to Bloomberg Law.

And the cost of such lawsuits is consequential. For example, it cost DuPont, Chemours, and Corteva $4 billion for PFAS-related liabilities and it cost 3M $850 million to settle with the state of Minnesota over PFAS contamination of drinking water and natural resources in the Twin Cities metropolitan area.

Michael Blumenthal, an attorney with McGlinchey Stafford PLLC, said to Bloomberg Law that if PFOA and PFOS are classified as hazardous waste, "landfills will have no choice but to go after industries that contributed the chemicals." He added, "There will be so much litigation."

Current PFAS Management Falls Short

The most common practices for PFAS management are reverse osmosis, ion resins, or granulated activated carbon to filter PFAS from wastewater streams.

A major problem with current PFAS filtration is, as the NRDC reports, "that widely used treatment technologies for the removal of PFOA and PFOS from water, such as granulated activated carbon, become progressively less effective for removing shorter chain PFAS as the chain length diminishes." And short-chain PFAS molecules do not seem to be any less toxic than long-chain PFAS. C&EN reported that the U.S. National Toxicology Program found higher doses of short-chain PFAS have the same harmful health effects as their long-chain counterparts.

Filters laden with PFAS are then sent to landfills, which

▶ The Elemental is a novel PFAS-destruction system that reduces complex PFAS molecules down to their constituent elements.

contaminates soils, or incinerated, which contaminates air and soil. One of the most common disposal methods, incineration breaks down long-chain PFAS into small-chain PFAS that are quickly spread by ash and smoke. The U.S. Department of Defense recently banned incineration of PFAS materials and there are many efforts afoot worldwide that seek to do the same.

In addition to the recontamination issue, both landfill and incineration disposal methods for PFAS are becoming too expensive to make sense for many industries, especially since the originator of the waste may still hold significant liability risk in the future.

▲ A Claros scientist de-stills PFAS waste to a highly concentrated solution, making it more cost-effective and efficient to destroy in high quantities.

A paper published in the April issue of American Chemical Society's *ES&T | Water* says most water treatment techniques such as ferric or alum coagulation, granular/micro-/ultra-filtration, aeration, oxidation, and disinfection were ineffective in removing PFAS. It noted that reverse osmosis is one of the most effective techniques for removing long- and short-chain PFAS. But, both the high capital expenses to install the reverse osmosis technology and energy costs to run it are big obstacles to widespread adoption.

Chemistry Solves Problem of "Forever Chemicals"

While quick to point out the risks and liabilities of the EPA designating PFOA and PFOS as hazardous substances, Global Counsel also pointed out that "tailwinds abound for companies monitoring and remediating PFAS chemicals, and chemical manufacturers developing PFAS-free products."

New technologies hold the promise of destroying PFAS, taking the "forever" out of "forever chemicals." Claros Technologies, a chemical engineering company, is a case study in how such technologies can provide an end-of-life solution for PFAS. The company has a sorbent that captures PFOS and PFOA in water, a process that concentrates them, and a defluorination treatment that breaks their powerful chemical bonds.

"We designed a system that protects the planet and profits," said Dr. John Brockgreitens, research and development director for Claros. "Our ClaroSafe™ PFAS system, which effectively destroys PFAS, is highly adoptable, adaptable, and cost-effective for many types of facilities. We have removed barriers to PFAS remediation."

The first step in the ClaroSafe™ PFAS system is capturing all PFAS pollutants — not just those that are currently regulated. That means companies would remain in compliance with expected future regulations. Brockgreitens enumerated the five key ways the ClaroSafe™ PFAS filtration system differs from granulated activated carbon:

- Facilitates flow rates that are five times faster
- Captures short- and long-chain PFAS and other pollutants
- Has a loading capacity that is 30 times higher
- Requires less space since it's 40% smaller
- Has seven times the longevity, requiring fewer filter changes and disposal

The second step concentrates PFAS waste by more than 100,000 times, making it easier to manage and destroy, Brockgreitens said. Lastly, the concentrated PFAS waste is put in the Elemental™, a PFAS-destruction mechanism that permanently breaks the powerful carbon-fluorine bond, he said, leaving behind only safe, naturally occurring elements.

"The ClaroSafe™ PFAS system reduces production slowdowns and bypasses thorny disposal issues," Brockgreitens said. "And the system is customized for each facility so there is no need for costly retrofitting."

Claros announced in May a partnership with Kureha Corp. of Japan to install the ClaroSafe™ system for its Asian markets. Kureha manufactures specialty chemicals and plastics, agrochemicals, and pharmaceuticals.

"As a chemical company, Kureha has responsibility for mitigating the environmental impact of PFAS," said Naomitsu Nishihata, president of Kureha America. "We seek to be socially responsible, accelerate innovation, and expand our business portfolio. And Claros' comprehensive PFAS solution helps us meet each of those goals."

Dr. Abdennour Abbas, Claros founder and CTO said of ClaroSafe™: "Our approach is to concentrate PFAS from millions of gallons of wastewater into a few gallons of PFAS concentrate that can be cost-effectively and permanently destroyed in a traceable fashion. It works on a variety of industry wastewater and even on firefighting foam. Changing the way we treat our chemical waste by adopting a closed-loop system will not only reduce risks for the public and the environment but also eliminate latent and future liabilities for manufacturers and waste disposal companies." IFN

Amy Phillips is a former journalist who now provides freelance editorial, marketing and PR services.