Scientists advance research of harmful PFAS chemicals and their impacts

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Chen lab manager Christine Gardiner and technician Lenny Laird collect samples to investigate lake food webs. Credit: Tim Briggs

A bemused fishmonger at a seafood market in Portsmouth, N.H., weighed and packaged a dozen filets of fish and three lobster tails for his

unusually exacting customers, Dartmouth researchers Celia Chen, Guarini, a research professor of biological sciences, and Nathan Giffard on a warm afternoon in May 2022.

The seafood they bought—a sampling of the most commonly eaten fish and shellfish species in New Hampshire—was for a study recently published in *Exposure and Health* intended to gauge people's potential exposure to the family of human-made toxins called PFAS from eating seafood.

Perfluoroalkyl and polyfluoroalkyl substances have been an industry mainstay since their discovery in the 1930s. Nonstick. Waterproof. Stain-resistant. Products advertising these features, be it cookware, food packaging, clothing, or upholstery are likely laced with one or more types of PFAS. The chemicals are also found in firefighting foams that have been used for decades to quell high-heat liquid fuel fires.

Characterized by a backbone made from chains of carbon and fluorine atoms held together by some of the strongest chemical bonds, these widely used, indestructible "forever chemicals" have spread throughout the environment, seeping into soil and water and accumulating in wildlife and eventually, in humans.

"These chemicals stick around in our bodies on the order of years once we've been exposed," says study senior author Megan Romano, associate professor of epidemiology at the Geisel School of Medicine, whose research focuses on understanding the causes and health consequences of environmental exposures, especially for pregnant people and children.

A host of scientific studies have indicated that PFAS exposure is associated with elevated cholesterol levels, kidney and testicular cancer, thyroid and liver disorders, and other adverse health outcomes.

Dartmouth researchers across disciplines study PFAS and its effects on human health, engineer novel solutions to remove the chemicals from the environment, work with policymakers who set screening levels and mandate testing of contaminated sources, and finally, communicate the risks of PFAS and possible measures to mitigate exposure with the public.

"PFAS has been found in nearly all people tested by the CDC, indicating widespread exposure in the U.S." says Chen. The levels are especially high among firefighters, those who work in chemical manufacturing and processing, and people drawing drinking water from sources that are contaminated with PFAS.

On April 10, the U.S. Environmental Protection Agency imposed the first national limits on some of the most widely used PFAS in drinking water. While the new limits are stricter than New Hampshire's own standards, the state has already taken several steps to address concerns about PFAS in drinking water such as requiring all public water utilities to test for PFAS concentrations, providing testing assistance and no-cost filtration options for qualifying households, and offering grants and loans for remediation efforts.

There are rising concerns about PFAS levels in surface water too, according to Romano, making seafood a potent vehicle for carrying the chemicals to consumers. Their survey data revealed that seafood consumption rates for New Hampshire residents are higher than previous estimates based on national or regional information.

"A big part of why we wanted to do this study was to inform the process for setting surface water standards for the state of New Hampshire, which is ongoing," says Romano.

The study published earlier this month found that consumers of diets

high in seafood may be exposed to PFAS concentrations that potentially pose a health risk.

The researchers maintain that in moderation, seafood is a beneficial source of protein and nutrients and eating a varied diet helps reduce exposure to chemicals while accessing important sources of nutrition.

In addition to setting more stringent surface water standards for PFAS based on the findings, efforts must also be taken to effectively communicate the benefits and risks of consumption through robust public health messaging, says Romano, who has previously collaborated with the state of New Hampshire to create PFAS factsheets and other educational materials for clinicians and the public.

In everything, everywhere, all at once

PFAS presents challenges unlike other contaminants that researchers study, says Chen, whose research has focused on metal contaminants like mercury, arsenic, and lead in aquatic food webs both in freshwater and marine ecosystems.

"It seems that PFAS are much more pervasive than any of our legacy contaminants. It's way more in the lives of people; it's in food wrapping, it's in all of our rain gear, it's everywhere," Chen says.

And this poses special challenges for researchers, who must go the extra mile to ensure that equipment is PFAS-free and develop robust experimental checks and balances to keep their analyses accurate. "It's very easy to contaminate samples that we're studying with PFAS because it's in everything. It could be in our pipettes and other lab supplies," she says.

Members of Chen's research group collected water, sediments, plankton,

fish and other vertebrates from six New Hampshire lakes last summer for a project that examines PFAS in lake food webs, alongside continued investigations of PFAS concentrations in marine ecosystems.

Before they begin to analyze their samples, however, they are working to get their chemical analysis procedures verified to ascertain that they aren't introducing any contaminants.

How does PFAS affect our health?

Teasing out health impacts of PFAS is a work in progress, says Romano.

A research project led by Romano examines the associations of PFAS exposure with breastfeeding duration. The study, published in the *International Journal of Hygiene and Environmental Health*, finds that lactating parents who had higher levels of PFAS in plasma collected during pregnancy were more likely to stop relying exclusively on breastmilk to feed their babies prior to six months.

Ongoing projects are investigating influences on blood pressure during pregnancy, birth weight, and infant growth rates as well.

While there is compelling evidence that people exposed to these contaminants are at risk, scientists have barely scratched the surface. More data and studies are needed to gain a deeper and more accurate understanding of health risks and uncover the mechanisms through which PFAS act.

Uncertainty about potential impacts can make health decisions difficult to navigate. "There is emerging evidence that there is a link between people who have higher PFAS blood concentrations and breast cancers," says Christine Gunn, assistant professor of the Dartmouth Institute for Health Policy and Clinical Practice.

Gunn and Romano are working together to develop a risk-based breast cancer screening tool tailored to women from communities in New Hampshire whose environment, particularly drinking water, is known to have high levels of PFAS contamination.

"Should younger women in our community get screened sooner than normal?" is a typical question that health providers are asked, says Gunn. She hopes to create a decision aid that will take into account not just clinical and family health factors but also environmental risk factors to help women make informed decisions about breast-cancer screening.

The experts need help too. "Clinicians often don't feel well prepared to answer patient questions about environmental exposures," says Romano, who is involved in multipronged efforts to promote environmental health literacy. That can include curating good resources, compiling factsheets that physicians can consult, and offering web training on environmental contamination for local community leaders.

Mitigating the damage

Meanwhile, the challenge of ridding groundwater, soil, and surface water of PFAS is an actively evolving area of engineering. "Large-scale remediation efforts remain profoundly costly and time intensive," says Romano.

An environmental epidemiologist who combines skills in basic epidemiology with public health work, Romano sees collaborations across disciplines as vital to solve problems of this scale. "We have to think outside of the box, and we have to come at things from multiple angles and really understand biological mechanisms and engineering solutions."

On the bright side, she says there has been a lot of recent progress on

how to remove PFAS from water and soil at small scales.

For their engineering capstone project in 2023, Dartmouth students took on the challenge of designing a low-cost, open source PFAS filter for small carpet-cleaning businesses. Jen Harfmann, PFAS discharge analyst at the Department of Environmental Services who proposed the project, also advised the team.

The team of four—Ariana Arvelo Marchan, Abbi Fitzpatrick, Thayer, William Gano, and Eliana Ray—worked with a carpet-cleaning business based out of Grantham, N.H. The students collected some of its wastewater, observed how the business was set up, and how much water it would need to treat per day.

Their prototype, created by the team with inputs from project advisor Vicki May, professor of engineering at Thayer, won a $10,000 grand prize Engineering Education Award from the National Council of Examiners for Engineering and Surveying.

Using materials that can be easily sourced from hardware stores, the Dartmouth students constructed a filter that channeled wastewater through a series of tanks filled with activated carbon. "We were able to reduce every single type of PFAS that we tested for, which was about 18 of the major ones that have been deemed more dangerous than others," says Ray, who now works as an environmental consultant.

Romano, who was also an advisor for the project, is of the opinion that cleanup solutions are going to have to be tailored to the specific scenario in a location where contamination has occurred.

"No solution will be one size fits all," she says, "because there are thousands of these chemicals, and the scenarios are different in different places."

More information: Megan E. Romano et al, Plasma per- and polyfluoroalkyl substance mixtures during pregnancy and duration of breastfeeding in the New Hampshire birth cohort study, *International Journal of Hygiene and Environmental Health* (2024). DOI: 10.1016/j.ijheh.2024.114359

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