Fall 2023

UMaine PFAS+ Initiative — Transformative Solutions for PFAS Pollution

Vice President for Research and Dean of the Graduate School

Office of Research Development

UMaine PFAS+ Initiative

PFAS+ Initiative

University of Maine PFAS+ Initiative

The University of Maine PFAS+ is a multi-disciplinary initiative that focuses on the emerging PFAS pollution crisis and its cascading environmental and societal impacts. The plus sign indicates the breadth of the impacts that PFAS has on society, other emerging environmental pollutants, as well as the transformative and novel approach that UMaine realizes.

Vision

To mitigate the PFAS crisis and its consequences safely and sustainably in Maine and beyond.

Mission

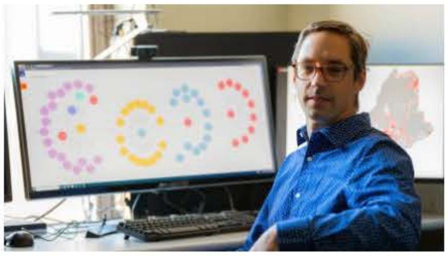
To address through research and development the multifaceted challenges posed by PFAS pollution.

Purpose

Strategic planning of PFAS mitigation efforts, coordination of high quality PFAS analysis and conducting cutting edge research that is driven by

federal and state agencies, University of Maine researchers and impacted stakeholders. The long-term goals of the initiative are to unravel PFAS pollution pathways, and develop safe and sustainable mitigation approaches involving new materials, devices, technologies, processes for food, water and environmental safety. The initiative also aspires to create transparent PFAS communication framework to minimize public health hazards.

UMaine News



UMaine leading development of new state-of-the-art tool for tracking PFAS nationwide

PFAS

'The Maine Question' podcast returns with new video format

FORESTRY AND THE ENVIRONMENT

L.L.Bean supporting UMaine's work on eradicating 'forever chemicals'

OUTREACH

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The University of Maine PFAS+ is a multi-disciplinary initiative that focuses on the PFAS pollution crisis and its cascading environmental and societal impacts. The plus sign indicates the breadth of the impacts that PFAS has on society, other environmental pollutants, as well as the transformative and novel approach that UMaine realizes.

From the EPA: What is PFAS?

Per- and polyfluoroalkyl substances (PFAS) are a group of manufactured chemicals used in industry and consumer products since the 1940s because of their useful properties. There are thousands of different PFAS, some of which have been more widely used and studied than others.

Perfluorooctanoic Acid (PFOA) and Perfluorooctane Sulfonate (PFOS), for example, are two of the most widely used and studied chemicals in the PFAS group. PFOA and PFOS have been replaced in the United States with other PFAS in recent years.

One common characteristic of concern of PFAS is that many break down very slowly and can build up in people, animals, and the environment over time.

Visit the U.S. Evironmental Protection Agency website for more information, and for details regarding EPA Actions to Adress PFAS.

Current scientific research suggests that exposure to high levels of certain PFAS may lead to adverse health outcomes. However, research is still ongoing to determine how different levels of exposure to different PFAS can lead to a variety of health effects.

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UMaine PFAS+ Initiative

PFAS Research Projects at UMaine

- **PFAS competitive uptake in food crops.** A greenhouse-based research trial will assess where in the plant PFAS (short and long chain) accumulate in tomatoes and lettuce. Intercropping distance will vary to determine whether companion planting can minimize PFAS accumulation in edible portions of crops. Project PI(s): Alex Scearce (MS student) working with Rachel Schattman (SFA). *Funded by Maine Agricultural and Forest Experiment Station.*
- **Per- and Polyfluoroalkyl Substances Release from Spent Granular Activated Carbons in Solid Waste Management Facilities.** We investigate the release of PFAS from spent activated carbon surfaces under landfill-relevant conditions. Project PI(s): Onur Apul. *Funded by Environmental Research and Education Foundation.*
- **Thermal Regeneration of PFAS-laden Granular Activated Carbon presents an Opportunity to Break the Forever PFAS Cycle.** Spent activated carbons have been showing superior performance to thermalize PFAS. We will systematically investigate if we can destroy PFAS during GAC regeneration. Project PI(s): Onur Apul. *Funded by National Science Foundation.*

- **Developing and Deploying a Risk framework for PFAS management in rural America: Connecting predictive models of PFAS contamination with risk perceptions to guide management decisions.** PFAS risk framework development for rural America by connecting PFAS contamination models and risk perception. Project PI(s): David Hart, Caroline Noblet, Onur Apul, Dianne Kopec, Jean MacRae. *Funded by the United States Geological Survey.*
- **Integrated assessment of alternative management strategies for PFAS-contaminated wastewater residuals.** Evaluation of PFAS management options. Project PI(s): Dianne Kopec (60%), Onur Apul (25%), Caroline Noblet (10%), Jean MacRae (5%). *Funded by the United States Geological Survey.*
- **Development of a rapid and less expensive method for analysis of PFAS using NMR.** Development of an NMR method that would be fast and likely less expensive than current methods used for PFAS analysis. Project PI(s): Barbara Cole, Sara Biel.
- **Contamination in food waste (past project).** Looked at contaminants (heavy metals, EOX, PFAS, pathogens, antibiotic resistance genes in food waste (different regulatory environments). 60% of samples tested for PFAS had PFBA at up to 1 ng/g. Almost all had antibiotic resistance genes, some at high levels. Also surveyed waste managers on perceived risk associated with food waste. Project PI(s): Jean MacRae. *Funded by Environmental Research and Education Foundation.*
- **Screening the capacity of adsorbents to bind perfluorooctanesulfonic acid (PFOS) across simulated ruminal, abomasal, and intestinal conditions.** Our goal is to screen the effectiveness of several PFAS-adsorbents developed for non-livestock applications using in vitro techniques so we can gather robust results for future field studies. Project PI(s): JJ Romero (90%) and G. Pereira (10%). *Funded by Maine Food and Agriculture Center.*
- **The effect of cutting height and rake type on PFAS levels of grass hay produced from contaminated sites across key production stages.** We hypothesize that management decision involving cutting height and raking influence PFAS levels in hay bales used for animal feeding. Project PI(s): JJ Romero (90%) and G. Pereira (10%). *Funded by Maine Agricultural and Forest Experiment Station.*
- **PFAS Uptake by Pasture Species: Linking Greenhouse and Field Measures.** Assess how well PFAS uptake results from greenhouse pot studies reflect those from field studies to determine the potential for addressing some of Maine's research needs with greenhouse studies. Project results will also contribute to developing transfer rates for four pasture species in Maine and methods for conducting further greenhouse studies. Project PI(s): Ellen Mallory. *Funded by Maine Agricultural and Forest Experiment Station.*

UMaine PFAS+ Initiative

PFAS Resources

UMaine Extension: PFAS Contamination Response

University of Maine Cooperative Extension and other statewide partners are providing communities with important information and responses regarding PFAS.

Visit resources from the UMaine Cooperative Extension website, or contact extension.PFASQuestions@maine.edu.

Senator George J. Mitchell Center for Sustainability Solutions PFAS Research Initiative

The Mitchell Center PFAS Initiative's mission is to understand the extent and characteristics of PFAS pollution in Maine, develop safe and sustainable ways to reduce PFAS exposure and communicate the rapidly developing knowledge base with the concerned public.

Vist the Mitchell Center PFAS Initiative website.

Maine Department of Environmental Protection

The Maine Department of Environmental Protection works to clean up spills and manage short and long-term site remediation with industry, government and citizens.

Visit Maine DEP website for information on spills and site cleanup.

You can also contact the Department directly by e-mailing pfas.dep@maine.gov.

Maine DEP PFAS Spills and Site Cleanup Website

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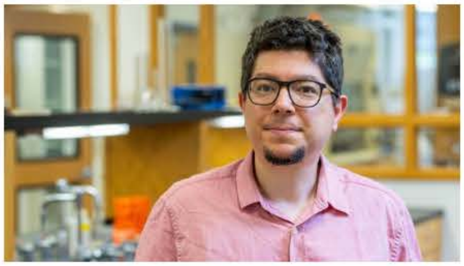

NSF funds Apul's research into novel approach for eliminating PFAS

Mitchell Center researchers examine options for managing PFAS

S7E4: How can we eliminate PFAS?

PFAS in the News

Noblet discusses PFAS conference with Farms.com

Media report on UMaine-led development of PFAS tracking tool

UMaine leading development of new state-of-the-art tool for tracking PFAS nationwide

Civil Eats notes UMaine research on PFAS in farms

Mitchell Center to host talk on PFAS in fish tissue Oct. 2

More

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Published: October 18, 2023

NSF funds Apul's research into novel approach for eliminating PFAS

August 29, 2022

Investigating a possible method for eliminating the toxic per- and polyfluoroalkyl substances, or PFAS, is the objective of a new National Science Foundation-funded study led by Onur Apul from the University of Maine.

NSF awarded $250,000 for Apul, an assistant professor of environmental engineering, to research how to remove PFAS, also known as "forever chemicals", from spent granular activated carbons (GACs).

Many municipalities across the U.S. use GACs, porous substances typically made with coal, charcoal, wood or coconut shells, to adsorb PFAS from their drinking water, since destroying the chemicals is a significant challenge, Apul says. Once the GACs can no longer intake PFAS, they are thrown out or incinerated. Apul says PFAS can then leach from the discarded GACs in landfills into ground or surface water. Burning GACs will release PFAS into the atmosphere.

Rather than discarding them, PFAS-laden GACs can be reused through thermal regeneration, which early research indicates may cause the PFAS in them to decompose, Apul says. For their NSF-funded study, he and David Hanigan, an associate professor with the University of Nevada Reno Department of Civil and Environmental Engineering, and two Ph.D. students will try to determine what properties of GACs, particularly charcoal, and PFAS cause the toxic chemicals to decompose, and which conditions of regeneration can enhance the process without inhibiting GAC recovery.

Their findings could help identify ideal GAC regeneration conditions for eliminating PFAS, and could support efforts to destroy the toxic chemicals in other waste, including biosolids, landfill leachate and consumer products, through incineration and other heat-based treatments, Apul says.

"200 million people in the U.S. are exposed to PFAS via drinking water," he says. "We can resolve this overwhelming PFAS crisis rapidly, safely and sustainably if we explore the use of available this overwhelming PFAS crisis rapidly, safely and sustainably if we explore the use of available technologies and processes."

Apul also will conduct another study to better understand how much PFAS can leach from used GACs in landfills.

Environmental Research and Education foundation awarded $150,000 for the project, which Apul will execute with Arjun Venkatesan, associate director for drinking water initiatives for New York State Center for Clean Water Technology at Stony Brook University, and Navid Saleh, an associate professor with the Department of Civil, Architectural and Environmental Engineering at the University of Texas at Austin.

The team will identify which properties of GACs and PFAS influence the leaching process and which types of PFAS are more prone to seeping from GACs. Their research could help landfill operators, lawmakers and other stakeholders devise practices and regulations to prevent PFAS from leaching from discarded GACs and other waste and entering nearby lakes, rivers and streams.

"Landfills are our last line of defense to stop PFAS leaching back into the natural environment," Apul says.

Apul is one of many faculty members at UMaine, the state's R1 top-tier research university, studying PFAS and ways to mitigate them and providing technical assistance to Maine farmers and other stakeholders.

Maine's congressional delegation, led by Sen. Susan Collins, recently secured funding to bolster PFAS research at UMaine in draft fiscal year 23 Senate appropriations bills. If passed by Congress and signed by President Biden, the university would receive $5 million to establish a PFAS analytical laboratory and $3 million for research at that facility that will help inform short-term management decisions for farms experiencing contamination from the toxic chemicals.

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Courtesy of the U.S. Geological Survey, Department of the Interior/USGS

Mitchell Center researchers examine options for managing PFAS

June 2, 2021

Researchers from the Senator George J. Mitchell Center for Sustainability Solutions at the University of Maine will help identify sources of and management strategies for per- and polyfluoroalkyl substances (PFAS).

In response to concerns raised by many different stakeholders, the interdisciplinary team of Mitchell Center scientists is gathering and documenting knowledge of where PFAS are in Maine and how they move through soil, water, wildlife and food. Researchers also are developing an understanding of how PFAS, also known as "forever chemicals," end up in wastewater residuals — organic materials and solids that are removed during wastewater treatment — and how they are currently managed. They will then analyze and report on options for managing residuals while reducing the risks associated with PFAS and protecting Maine's waters and lands.

The project team also is meeting with public health advocates, representatives from the wastewater treatment industry and agriculture sector, and experts from state government to increase their understanding of concerns from the various stakeholders. The team is applying for federal funding to expand this work.

Dianne Kopec, Mitchell Center faculty fellow and adjunct professor in the UMaine Department of Wildlife, Fisheries and Conservation Biology, is leading the group. Other participants include Jean MacRae, an associate professor of environmental engineering; Caroline Noblet, associate professor in the School of Economics; Onur Apul, assistant professor and environmental engineer in the Department of Civil and Environmental Engineering; and John Peckenham, a research associate with the Mitchell Center.

Researchers will look at the environmental, economic and social costs and benefits of currently available management options for wastewater residuals — including burying in landfills available management options for wastewater residuals — including burying in landfills, incineration and application to agricultural fields — as well as other potential approaches. They also will conduct research to identify potential concerns of Maine residents regarding various management strategies. This information can help determine the social acceptability of different options and how to best communicate with citizens about issues involving PFAs.

"We listen to the questions that stakeholders want answered," Noblet says. "Listening to what people have to say, and to their concerns, feeds into the work from the beginning and through the whole process," from forming questions to identifying and evaluating potential solutions.

The Maine Department of Environmental Protection (DEP) contacted Mitchell Center and UMaine leadership in spring 2020 asking for help in examining the complex environmental, economic, social and technical issues that need to be considered in addressing PFAS contamination.

Gov. Janet Mills created a PFAS Task Force in 2019 to study the extent of PFA contamination and its threats to public health and the environment. In a report issued in January 2020, the task force made recommendations that "reflect a commitment to determine where PFAS contaminants exist in Maine and put in place strategic responses to protect people from exposure."

PFAS have been incorporated in a wide variety of consumer products, including waterproof and breathable rainwear, nonstick pans and takeout food containers, since at least the 1960s to repel water and oil. For decades, PFAS have also been used in firefighting foams to help suppress fires. While the benefits of PFAS are abundant and clear, the risks are only now becoming widely known.

Production of perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS), two PFAS chemicals that have been used in nonstick cookware and a host of other products, was essentially phased out in the U.S. as of 2015. However, many PFAS chemicals are still being produced in the U.S. and around the world, and continue to be used in a wide range of consumer products. There is growing concern about the health effects of these chemicals for people, wildlife and the environment. They have been linked to harmful health effects in humans, including immune system disorders, thyroid hormone disruption and cancer. They also don't break down readily and can biomagnify — or increase in concentration as they move through food webs. PFAS used decades ago are still circulating in the environment, in animals and plants, waterways and even in peoples' bodies, which is why they're often called "forever chemicals."

Maine officials first became aware of PFAS in groundwater near military bases, where firefighting foams had been used for training and fire suppression. In late 2016, more widespread PFAS contamination was found in groundwater, soils, field vegetation and milk from a Maine dairy farm — as well as in the farmers' blood. Since then, DEP and the Department of Agriculture, Conservation and Forestry (DACF) have begun testing across the state and found elevated levels of PFAS in groundwater, farm soils, milk and freshwater fish near contaminated sites.

The search for the cause of this contamination led to several potential sources, including wastewater residuals. Removing residuals during wastewater treatment has significantly improved water quality in rivers and other surface waters since the 1970s. Although these residuals contain valuable nutrients such as nitrogen and phosphorus, they can also contain harmful substances. Depending on the location, wastewater treatment plants may receive inputs from industrial sources as well as households and municipalities.

Since at least the early 1980s, some wastewater residuals have been spread on agricultural fields to provide a low-cost nutrient source for farmers. This use is regulated under federal and state laws to protect soil and water quality. Residuals are treated to reduce the risks from pathogens and metals, which must be below regulatory standards to be used on agricultural fields. If they meet these standards, they are often referred to as biosolids. Until recently, PFAS were not monitored in wastewater residuals or biosolids. They are still not regulated at the federal level, but Maine has set screening levels for some PFAS chemicals.

As the evidence accumulated that biosolids were the likely source of PFAS contamination in agricultural soil and nearby groundwater, DEP increased its focus on how to manage the products of wastewater treatment. In 2019, they required that all licensees that land apply or process wastewater residuals test for PFAS and meet certain screening level concentrations. These licensees are also required to test for PFAS on an on-going basis. DEP has also been testing for PFAS licensees are also required to test for PFAS on an ongoing basis. DEP has also been testing for PFAS contamination in farm soils in fields where biosolids had been applied and nearby water wells. DACF has been testing for PFAS in milk from Maine dairy farms.

The Mitchell Center's approach to addressing PFAS contamination and management in the state benefits from its broad range of expertise, which allows it to look at societal challenges from many different angles. The researchers for this project have expertise in environmental engineering, economics, risk perception, wastewater management, toxic contaminants in aquatic ecosystems and decision-making.

Kopec is a wildlife ecologist whose work focuses on contaminants in fish, wildlife and ecological systems. Her experience includes leading an interdisciplinary team researching mercury in Maine's Penobscot River.

MacRae is an environmental microbiologist with expertise in wastewater treatment, solid waste management and chemical cycling in biological systems. She has worked with the Mitchell Center's Materials Management team since its inception and recently completed a study of potential contaminants, including PFAS, in food waste recycling.

Noblet is a behavioral environmental economist whose research focuses on how people use information, make decisions and perceive risks, especially in relation to natural resources management and the environment. She is working on the cost-benefit analysis of management options, as well as gauging people's knowledge and views on the problem, its associated risks and ways to manage it.

Apul has done research on incineration of PFAS-laden wastes, and will work with MacRae on assessing the technical feasibility of the management options being considered. His lab at UMaine will also investigate the potential for PFAS-contaminated liquids to move through soils and the clay liners that are often used to lessen the migration of pollutants from landfills to groundwater.

Peckenham has worked for decades on wastewater and water pollution in Maine and has direct experience with contamination of groundwater from biosolids. He is the former director of the U.S. Geological Survey's Maine Water Resources Research Institute (WRRI), which is headquartered at the Mitchell Center.

Mitchell Center Director David Hart says he knows the importance of supporting partnerships in which interdisciplinary teams of researchers collaborate with diverse stakeholders to help address pressing sustainability challenges in Maine.

"We recognize that there are many different views on the challenges posed by PFAS contamination, as well as on the potential solutions," he says. "There's no easy fix to problems like this. But we're committed to working with a wide range of stakeholders to understand the options for addressing PFAS problems, including the trade-offs and uncertainties of those options."

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The Maine Question

S7E4: How can we eliminate PFAS?

October 13, 2022 | Episodes

In recent years, communities across Maine and the U.S. have discovered the presence of toxic chemicals called per- and polyfluoroalkyl substances, or PFAS, in their land and water. Also known as forever chemicals because they are difficult to destroy, PFAS have been incorporated in various products, including food containers, clothing, rugs, teflon pans, fabrics and dental floss, for decades. Emerging research, however, has linked PFAS to several health issues, including weakened immune systems, increased risk of obesity and multiple cancers, developmental problems in children and harm to negative effects on reproduction.

Onur Apul, assistant professor of environmental engineering at the University of Maine, is researching how to eliminate PFAS. He is one of many UMaine faculty members studying these forever chemicals and ways to mitigate them, and providing technical assistance to Maine farmers and other stakeholders. In Episode 4 of Season 7 of "The Maine Question," Apul elaborates on the origins of PFAS, the threats they pose and efforts to stop their widespread contamination.

Transcript

[background music]

Onur Apul: It's everywhere. 200 million Americans are exposed to PFAS through drinking water. It's in floss. It's in nonstick pans. It's in food containers. It is in nonstick fabric, nonstick carpets, firefighting foams. It has been used as a commercial product for a long time.

Ron Lisnet: That's Onur Apul, assistant professor of environmental engineering, talking about PFAS, also known as a forever chemical.

I'm Ron Lisnet. This is "The Maine Question" podcast.

PFAS. It's an acronym for a wide range of chemicals that are all around us in today's world. They became popular in a vast array of applications precisely because they are virtually indestructible. When it comes time to throw away that Teflon pan or the rug that's treated with a fire resistant substance, that is when the trouble begins.

These toxic chemicals don't break down. They get into our drinking water or into the air and cause serious health problems. Farmers are finding them on their land, and in some cases, have to cut back on their crop or animal production, or stop altogether.

Apul is one of many researchers at UMaine looking at PFAS. He and his team are researching ways to break down these chemicals into harmless byproducts and keep them out of the environment. His work is getting attention and funding to try and solve this intractable problem. More help may be on the way in this battle.

THE MAINE QUESTION

Recent Episodes

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Published: May 04, 2023

S8E9: What's the music scene like at UMaine?
Published: April 27, 2023

S8E8: How will AI impact our lives?
Published: April 20, 2023

S8E7: How can Indigenous and western knowledge help preserve the planet?
Published: April 06, 2023

be on the way in this battle.

Congress is considering funding for a lab that will analyze PFAS contamination in Maine and provide guidance to farmers and others. The work is still in the early stages, but it does show promise, providing us a way to get yet another dangerous chemical out of our lives.

Thank you so much for taking the time to talk to us. It seems you can't turn on a news report or open the newspaper and see something about PFAS these days. I imagine you're pretty busy.

Onur: Thank you for having me, Ron. Yes, PFAS is keeping me very busy nowadays.

Ron: Maybe let's start there, defining some terms. What is PFAS? How do you pronounce the name of what it actually is?

Onur: PFAS is a good way to pronounce it. It's an acronym. It's a mouthful. It's per-and polyfluoroalkyl substances. It has substances in the definition. It's a plural acronym. It's unusual. PFAS stands for about 5,000, 6,000 different chemicals. It's an umbrella term.

Anything that has a carbon fluoride bond in a chain-like structure saturated with fluorine ion elements is PFAS.

Ron: They're known as forever chemicals. You maybe can talk about that. Why are they so dangerous? Why do they persist so much in our world? How do they affect our health?

Onur: PFAS is a favorable compound because of its relatively hard to destroy chemical properties. They are thermally resistant. They are resistant to biodegradation. They are resistant to typical weathering processes in the environment. They stay around.

We like it so much because of its properties. Teflon pans or nonstick surfaces make them very favorable for everyday products. When it's time to get rid of them, it becomes problematic. The chemical makeup of the class of chemicals making them so difficult to destroy and the toxicity of them, the public health hazards, the environmental implications still undergoing.

Every day, we are discovering new ways that the toxicity of these chemicals could harm people. So far, we know it causes kidney damage, testicular problems, cancer, damage to pregnant ladies. There is a lot of ongoing research on toxicity. It's not my field, but we know it's not good for us. We can see from the federal response from how we have to eliminate this from our bodies.

Ron: You talked about Teflon pans, but this stuff is everywhere. I heard it's even in dental floss, and certainly, in drinking water. Is it really pervasive in our world?

Onur: It's everywhere. 200 million Americans are exposed to PFAS through drinking water. It's in floss. It's in nonstick pans. It's in food containers. It is in nonstick fabric, nonstick carpets, firefighting foams. It has been used as a commercial product for a long time. It's been produced domestically even a few decades ago.

It is a very prevalent compound. It's everywhere. It is not being produced domestically at massive scales anymore, but we still have it circulating around and in our daily lives.

Ron: Give us the cocktail napkin pitch. What are your basic research questions you're going after?

Ron: I try to understand how these forever circular patterns of PFAS are. There is an engineering water system. We purify water, we flush it down the toilet, we use it. There's a natural water cycle in rivers, lakes, rainwater, groundwater.

These circles, these circular motion of water coincide. Engineer-built and natural water systems. PFAS is moving in those systems. Of course, we contribute through solid waste. We contribute through commercial products. Industry contributes. Firefighting foams contributes. There are point and nonpoint sources.

Long story short, I'm trying to understand where PFAS naturally accumulates because it's much easier when something is concentrated on some medium. This could be a dead-end street in a landfill leachate or it could be on a water filter that accumulates PFAS. Try to resolve the problem when the PFAS is concentrated on this particular medium.

Ron: Are you looking to neutralize it, eliminate it, sequester it away? How do you hope to deal with it and get it out of our lives in this way?

Onur: Removing it from water is not very difficult. It is just another chemical. We know how to deal with removing chemicals. The problem becomes its circular motion. If you remove it, then what happens to the filter medium you used? What happens to the membrane, the activated carbons that you used?

I focus on destroying PFAS when it's adsorbed onto filter medium, particularly granular activated carbon.

Ron: Your novel approach, how are you approaching this than other folks are doing?

Onur: I'm trying to integrate PFAS destruction into the existing engineering systems. The regeneration of used activated carbon is an existing network of industrial operation. European companies are powerful in that realm. They regenerate carbon and then they compete with new materials so they can recover activated carbon and sell it as a product.

I'm trying to integrate this existing infrastructure of carbon recovery and regeneration into PFAS destruction. Particularly when PFAS is adsorbed onto activated carbon, we think there is a catalytic reaction that decreases the temperature of destruction for PFAS.

We want to exploit this, and while we are taking advantage of the existing carbon recovery infrastructure.

Ron: Obviously, these chemicals are useful in many ways. Are there any less harmful alternatives or is this it for the applications that PFAS has?

Onur: No. I think it's a very good research question to find an alternative compound that is as good. We have made some mistakes and replaced PFAS with short-chain PFAS, and then realized they may be also problematic. I think it's an ongoing long-term process to find safer alternatives.

The term safer shouldn't be subjective. It should be also going through the same legislations and the procedures that are regulating the compounds in our environmental systems.

Ron: What, if anything, can a homeowner do to protect themselves, filters or other ways to get it out of their lives? Anything?

Onur: Water filters that we use, like the point-of-use type pitchers, carbon filters, under the sink type of filters generally work well. I would recommend being on top of replacing the cartridges, maintaining their water filters. They have a certain capacity. PFAS eventually will break through.

My advice would be being on top of your water quality.

Ron: The other big project you're involved with involves something called nanobubbles. What are they? What potential do they hold?

Onur: The idea we had was we are dealing with these contemporary water problems. We have a lot more water demand, a very complicated water source. We have a cocktail of pollutants now. We still rely on technologies dating back to Victorian era.

The idea came to utilize this probably 10, 15 years old technology of using nanoscale bubbles to purify water. Nanobubbles are just tiny bubbles in water. They are very, very small. That makes them stable. You create a biphasic fluid, both gas and water. The bubbles don't rise up to the surface. You create a permanently porous liquid.

We are trying to understand if we could remove PFAS or other pollutants from water with the use of nanobubbles. It's a relatively new idea and a relatively new project aspiring to shift the paradigm of water treatment.

Ron: Just for us non-scientists that are listening, nano, how small is that?

Onur: Nano is a unit that is one-billionth of any metric quantity. Nanosecond is one-billionth of a second. Nanometer is very, very small. If you compare the size of the Earth to a basketball, you'd be making a fairly similar comparison between the same basketball and a nano particle.

making a fairly similar comparison between the same basketball and a nano particle.

Ron: How do the nanobubbles…What is it about their properties that allow them to remove and do the things you're hoping it can do?

Onur: They're very tiny. When they are very tiny, the same amount of gas constitutes a lot of surface area. Their size and stability is promising. They also have a surface charge. They may contribute to the partitioning of these pollutants into gas phase.

Then if we find a way to remove bubbles, we are using ultrasonic cavitation, then we may be able to remove these pollutants. In brief, they're miniscule size and high surface area.

Ron: Regular bubbles can't do the same thing.

Onur: Regular bubbles are too buoyant and not stable enough to stay long enough in water.

Ron: Talk a little bit about working with other folks on campus to do the work and testing you're doing. There's talk about high-altitude balloons, satellite launches. How will those things help in your work?

Onur: Nanobubble project, it's a very futuristic idea. As I mentioned, we are trying to shift the paradigm from Victorian era technologies like sand filters into using nanotechnology in water treatment.

The idea was picked up by NASA. They are aspiring to utilize nanobubbles in water treatment systems in International Space Station, in space exploration. It's a very forward-looking technology.

NASA is interested in understanding the stability of these bubbles in rocket launch conditions. There is a lot of vibrations, zero gravity, microgravity, sudden shift in G-force. That's why we are utilizing the existing UMaine infrastructure for high-altitude ballooning, as you mentioned.

We have a local aerospace company helping us to simulate rocket launchers. Eventually, we are getting advice from our NASA mentors to see if nanobubbles are applicable in space. Of course, I just want to reiterate, space exploration is the aspiration. Along the way, we may be making discoveries that are helpful for order treatment on Earth.

Ron: This is just getting going. Do you anticipate putting experiments up into space? How far into the future is that going to happen?

Onur: We have a pending project proposal with NASA. It's a Zero-G flight proposal. We put together the proposal today, actually. If the project is selected, then we'll be sending a crew for a parabolic flight. It's also known as Vomit Comet.

We'll put these nanobubbles into the zero gravity conditions as they start to see if our initial testing in the laboratory is also valid in zero gravity in space.

Ron: This all comes under the heading of environmental engineering. What drew you to this field? Why are you interested in it?

Onur: Environmentalism was very popular in 1990s. It was a new thing. People were talking about, "We have to protect the environment, protect the planet." I never realized that protecting the planet is a very ambitious goal. We have to protect our own species, let alone the planet.

I was drawn to the environmentalism pretty much in elementary school. I was recycling batteries for my classmates, recycling juice boxes. I'm talking about age six, seven. That's how it started that I became the environmental advocate in my cohort.

When it was time to choose an engineering branch, I realized environmental engineering is utilizing the tools, technology, and science with a very noble cause, in my opinion, to help the environment.

Ron: Are students involved with your research?

Onur: Yes. We have graduate and undergraduate students. A relatively large number of students are helping us, of course.

Currently, the nanobubble project is hiring a new PhD student from Ghana. For the PFAS project, we have a few other graduate students that are already working in their degrees in UMaine.

Ron: If all this goes the way you realistically hope it does, where do you see us in 5 to 10 years with this work you're doing? Will PFAS be still as omnipresent in our lives or less of a danger? Are the nanobubbles going to be out there and doing their thing?

Onur: It's hard to predict the future. At the pace and the resources that are spent for PFAS mitigation, I see a light at the end of the tunnel. Meaning that we may be understanding the pathways better. We may find better mitigation technologies. We may be slowly phasing out the fear of PFAS with the knowledge-building.

Of course, I'm assuming the investment and the resources are continuing in the next 5 to 10 years. Nanobubbles is very, very hard to predict. One, because it's a baby technology. We did not believe nanobubbles could exist 20 years ago because of simple mathematical equations would predict their internal pressure extremely high and unstable.

About 10, 15 years ago, we were able to see them under a microscope. That shifted the paradigm. We didn't really compute their surface curvature or electrostatic charges. Now we are accounting for them. They could actually be stable. Hard to predict.

I think they are going to take off, considering the needs of gas-liquid mixing in aquaculture, gas-liquid mixture mixing in industry, in agriculture, in horticulture, in wastewater treatment. There's a lot of venues that this could take off. I view this is going to be the next chapter in water treatment.

Ron: How do you make nanobubbles? I assume you don't put a straw in the water and blow, right?

Onur: Kind of. There are different ways. These companies who we work with are keeping their secrets trade secrets. For the most part, principally, either you could apply some energy by mixing or you could take advantage of the pressure jumps like a Venturi type system and create cavitation bubbles.

Either statically without putting any energy. Very similar to blowing bubbles with a straw, but straw is designed for nanobubble production. You can put a little bit energy. We have both static systems and dynamic systems. We can generate nanobubbles through mixing, through chemical addition, electrostatically.

[background music]

Onur: Again, I'm not very comfortable with the way they are produced, but I'm comfortable with the principle to how they are produced.

Ron: We wish you well in your research. Hope you have great success. Thank you for taking the time to talk to us.

Onur: Thank you for having me, Ron.

Ron: Thanks for joining us. As always, you can find all of our episodes on Apple and Google podcasts, Spotify, Stitcher, SoundCloud, UMaine's Twitter, YouTube and Facebook pages, as well as Amazon and Audible. Questions or comments, send them along to mainequestion@maine.edu.

This is Ron Lisnet. We'll catch you next time on The Maine Question.

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