Water-cleaning bacteria can produce health, economic benefits

By Monique Clement, ASU News
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Bruce Rittmann has made a big name for himself by thinking small — quite literally.

At ASU, he and his research group have teamed up with some of the tiniest creatures on Earth to tackle the colossal challenge of cleaning up our water supply.

Rittmann leads the Swette Center for Environmental Biotechnology in ASU's Biodesign Institute. For more than 20 years at ASU, Rittmann has been creating and refining a technology that uses microbes like bacteria to remove harmful substances from water. The technology is called membrane biofilm reactor, or MBfR.

The International Water Association recently recognized Rittmann's pioneering work, presenting him with the Ardern-Lockett Award at the 2025 Microbial Ecology and Water Engineering Conference.

"Understanding and managing microbial communities — that's called microbial ecology — is my life. The award is a recognition of exactly what I do, so it's perfect," says Rittmann, who is also a Regents Professor in the School of Sustainable Engineering and the Built Environment, part of the Ira A. Fulton Schools of Engineering at ASU.

The award is named after chemist Edward Ardern and his wastewater treatment plant coworker William Lockett. In the early 1900s, Ardern and Lockett discovered the bacteria-based wastewater treatment process called activated sludge that is the foundation of today's methods for treating wastewater.

More than 100 years later, scientists are still finding ways to work with tiny organisms to solve water challenges. Rittmann is also finding ways to use bacteria to realize health and economic benefits for society.

A leading wastewater innovator

Bruce Rittmann's groundbreaking work in environmental biotechnology also earned him the prestigious Stockholm Water Prize. This award is sometimes referred to as the Nobel Prize for water.

Removing the 'forever' from 'forever chemicals'

PFAS, or per- and polyfluoroalkyl substances, are a group of thousands of chemicals used to make things nonstick, grease resistant, waterproof and heat resistant. The properties that make them useful for many everyday products also make them so durable they don't break down on their own. That is why they are called “forever chemicals.”

Forever chemicals are now found in the environment, food, water and even in people's blood. PFAS exposure has been linked to health problems including increased cancer risks, reduced ability to fight infections, reproductive and child developmental effects, obesity and more.

Current methods for PFAS removal separate PFAS molecules from water. That causes a new problem: What to do with the collected PFAS? Destroying the chemicals often requires extreme, expensive measures.

PFAS molecules are hard to break down because they have a long chain of carbon atoms connected by very strong bonds to the element fluorine. Rittmann's powerful little partners can't break down fluorine bonds on their own, so he found a way to help them.

His team developed the membrane catalyst-film reactor, or MCfR, to support the bacteria in the MBfR. The MCfR uses a metal called palladium to break the fluorine bonds in the chain. This step allows the microbes to finish the job of turning harmful PFAS into its harmless components.

Rittmann says the combined MBfR and MCfR system works on the top six PFAS chemicals targeted by the EPA in drinking water. It can also work on others that are of concern to environmental and human health.

Startup employs microbes to clean up PFAS

Metrics Water Catalyst is a startup company that has signed an option agreement with ASU toward an exclusive license for the MBfR and MCfR techniques. The company is helping commercialize the technology to remove PFAS from the water supply. The work supports its mission to secure clean water resources for future generations.

Ali Shambayati, president and CEO of Metrics Water Catalyst, says municipal water distribution and industrial wastewater treatment markets have shown the most interest in the microbe-based solution. These industries do not have a cost-effective solution to remove or destroy PFAS on-site.

PFAS contamination has been detected across the country. Bringing the technology to market offers widespread benefits in the U.S. and globally.

“Major clean-up of the water supplies will directly affect public health," Shambayati says. "We plan to roll out water treatment stations — both mobile and stationary — to install in heavily populated areas first, and then as a standard part of any water treatment facility globally."

Microbes mine metal from muck

Palladium doesn't only help microbes destroy forever chemicals. It's also a valuable metal that the MBfR can harvest from wastewater.

Palladium is one of six platinum group metals. These metals are vital to industrial and chemical manufacturing, catalytic converters in cars, medical devices and treatments, and electronics like microchips.

The U.S. has limited sources of platinum group metals. Some of the metals must be imported from other countries because the domestic supply is too small. They can also be very expensive.

These valuable metals often get washed down the drain in industrial wastewater. In addition to being environmentally harmful, this is a waste of money for companies.

But the MBfR microbes are hungry to help solve this issue. Their metal meal has gotten a little spoiled from getting marinated in waste. But add a little hydrogen “sauce” to the reactor and they’re ready to eat.

The microbes chemically reduce the waste metals into solid nanoparticles. They deposit the metal nanoparticles in the biofilm that forms in the MBfR. From there, the metal can be easily harvested and turned into a valuable resource.

The research team demonstrated that the technology works. They’ve also shown it is cost effective. Rittmann says the system can currently pay for itself in less than two years. After that, it’s all profit. They’re now trying to improve that payback period to even less than a year.

The technology also can be applied to other materials. For example, it can create a new domestic supply of expensive rare earth elements that are primarily mined in China.

Additional membrane biofilm reactor uses

The membrane biofilm reactor technology is versatile. Its modular design means it can be used in small communities and also scaled up as needed. And it can be used far beyond applications in PFAS removal and palladium harvesting, including:

Selenium/selenate

The element selenium is used widely for industrial and semiconductor applications. Certain activities, such as coal mining and burning, turn selenium into selenate. Selenate is environmentally harmful, particularly to aquatic ecosystems. The MBfR technology can remove selenate contamination and produce elemental selenium for further use.

Uranium

The U.S. is working to expand its nuclear energy capacity. Nuclear power plants are fueled by uranium 235, which is found only in about a dozen U.S. states. Arizona is one of them. Uranium mining has contaminated groundwater in northeastern Arizona. Rittmann’s team has demonstrated that the MBfR technology works to clean water samples from the region.

Nitrate and perchlorate

Major sources of nitrate are fertilizers and domestic wastewater. Perchlorate is used in a variety of products, from fireworks and rocket propellants to cleaning supplies and food containers to batteries and air bags. Both chemicals can get into groundwater, streams and lakes, where they harm fish and aquatic habitats. Nitrate-contaminated drinking water can cause potentially deadly blue baby syndrome. It is also linked to reproductive and thyroid problems as well as some cancers. Perchlorate can cause thyroid problems. The MBfR technology works reliably over the long term to remove these contaminants from water.

Precient Technologies, a startup company where Rittmann serves as chief science officer, is looking for industry partners to help further develop and deploy the metal-recovery technology.

(Video: {https://www.youtube.com/watch?v=3oK1hwPtfBo})

Funding needed for further impact

The team has demonstrated that their technology can have a huge impact on human health and the economy. But that's not enough to get it out into the real world. The Biodesign Institute, Metrics Water Catalyst and Precient Technologies all need continued funding to help realize these benefits.

For Metrics Water Catalyst, the technology is almost ready to help remove forever chemicals in municipal water and industrial wastewater sources. But to be more attractive to potential partners, Shambayati says they still need to develop more durable MCfR and MBfR modules at a lower price point.

Rittmann and Precient Technologies need to conduct successful field tests to better attract private investors.

"When we talk to the investors they say, 'Oh, that looks really interesting. Now come back to us when you've tested in the field,'" he says. "But to test in the field, we need a million dollars."

It's a big investment to do a good field study. But it can mean the difference between the solution helping communities and languishing in a lab.

Government funding typically supports research and development through its early stages, with some opportunities to also fund the final phases of extensive testing and scalability improvements. Once a technology has passed these hurdles, private investors can then bring it to market.

"If we get the investment and can go out and demonstrate it, the technology is going to work. Then we're going to get a lot of interest," Rittmann says. "Potential customers will have proof that the technology works; they'll feel confident to actually purchase the full-scale system."

Why this research matters

Research is the invisible hand that powers America's progress. It unlocks discoveries and creates opportunity. It develops new technologies and new ways of doing things.

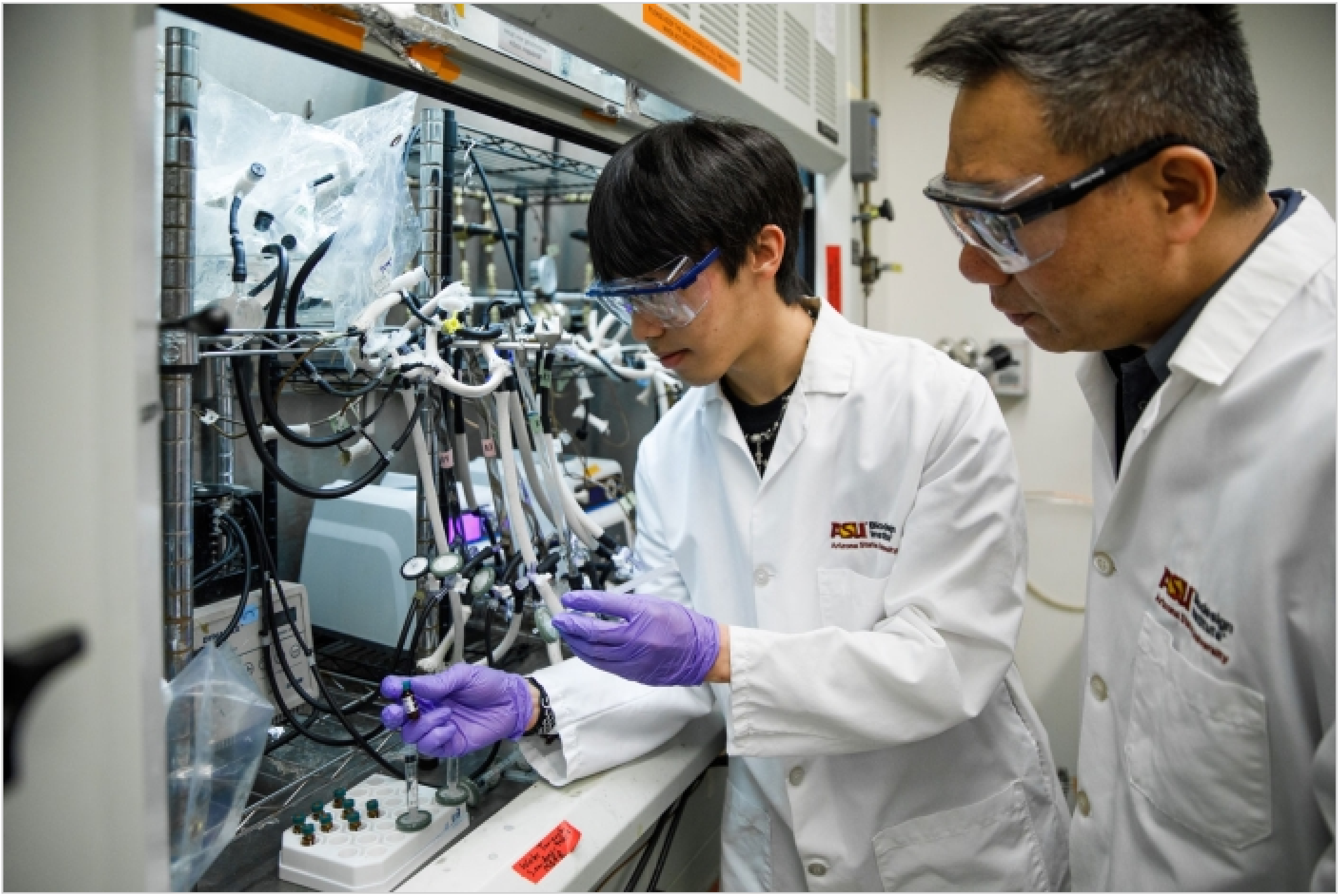
Learn more about ASU discoveries that are contributing to changing the world and making America the world's leading economic power at researchmatters.asu.edu.

This story originally appeared on ASU News.

Main image

Bruce Rittmann, Arizona State University Regents Professor and director of the ASU Biodesign Institute Swette Center for Environmental Biotechnology, is developing a technology that uses bacteria to remove contaminants from water and recover valuable metals that would otherwise go to waste. Photo illustration by photographer Andy DeLisle/ASU and Andy Keena/ASU

Text image(s)



Winter Taniguchi, a biological design doctoral student, and Research Assistant Professor Yen-Jung Lai collect samples from membrane biofilm reactors to determine PFAS breakdown at the Biodesign Swette Center for Environmental Biotechnology. Photo by Andy DeLisle/ASU