Research seeks solution to PFAS chemicals in waste

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Ridding waste and wastewater of difficult-to-degrade 'forever chemicals' like PFAS prevents potential exposure to them in the future, whether through drinking water, recreation in lakes and rivers or from irrigated crops. Credit: Sam Craft, Texas A&M AgriLife

Texas A&M AgriLife Research scientists are looking for a better way to remove or degrade stubborn pollutants, also called forever chemicals, from waste before they impact human and animal health.

Eunsung Kan, Ph.D., associate professor and AgriLife Research biological engineer in the Texas A&M Department of Biological and Agricultural Engineering, published a study focusing on the fundamental understanding for biological treatment of waste containing per- and polyfluoroalkyl substances, or PFAS, which are difficult to degrade through biological means.

PFAS are found in a variety of synthetic chemicals used across a range of industries that produce countless products including appliances, foams, textiles and food packaging.

"We believe this study helps address basic questions about pollutants that are difficult to remove or degrade," Kan said. "PFAS present a challenge that could impact long-term sustainability and health. That makes this type of research incredibly important and impactful."

Dealing with difficult PFAS

Kan's study, "Effects of perfluorooctanoic acid and perfluorooctane sulfonic acid on microbial community structure during anaerobic digestion," appears in *Bioresource Technology*. The major experiments were conducted by Kan's post-doctorate researcher Gyucheol Choi, Ph.D., in Kan's lab.

Kan is based at the Texas A&M AgriLife Center at Stephenville. His research focuses on conversion of agricultural waste, including dairy manure and crop residues, into biofuels, bioproducts and biochar for agricultural, environmental and energy sustainability.

Because PFAS are difficult to degrade, there are great concerns that accumulation of toxic PFAS compounds could impact soil and water quality and subsequently human, plant and animal health. Current physical and chemical techniques used for PFAS treatment in wastewater and solid waste require high levels of energy and chemicals. These treatment methods are costly and do not completely degrade PFAS.

Kan said this lack of PFAS degradation is a serious problem for existing systems, which produce a sludge containing PFAS compounds. The sludge is then taken to landfills, but there is concern that these pollutants might enter the surrounding environment or watershed by a runoff rain event.

Most solid waste and wastewater sludge is treated through biological means called anaerobic digestion, or AD. Complex microbial communities in AD systems break down and transform solid waste into biogas while undigested sludge is disposed of or applied to land.

The study showed how two commonly known and difficult-to-degrade PFAS compounds—perfluorooctanoic acid, PFOA, and perfluorooctane sulfonic acid, PFOS—are degraded by AD systems. The researchers also sought to understand the effects of the chemicals on the microbial communities.

Kan believes the study will help guide designs for AD systems that use various technologies to holistically deal with stubborn PFAS.

"Degrading PFAS using different means, including high temperatures, high pressure and high doses of chemicals is not really practical," he said. "The motivation was to find a cost-effective way to degrade these 'forever chemicals' to prevent them from accumulating in the soil and water. It's important, based on the findings, that we create a more complete treatment system."

Study focused on two common, difficult PFAS chemicals

Choi's experiments found that the anaerobic digestion was greatly inhibited and the microbial communities were negatively impacted by the presence of the PFOA, especially as PFOA concentrations increased.

While all PFAS compounds are difficult to degrade, the results of this study highlight the varying degrees of difficulty and toxicity among individual chemicals. Compared to PFOA, PFOS had very little impact on the AD efficiency and microbial communities, with only up to a 7% reduction at high concentrations. The AD process was able to degrade PFOS by 30%–80%, depending on pollutant concentrations, while there was no degradation of PFOA.

These data collected during the study are foundational information scientists can utilize in additional research and to inform design of waste, wastewater and water treatment technologies needed to completely degrade PFAS before they are introduced to the environment.

"This study showed that we need to rethink how we treat these specific PFAS compounds," Kan said. "For instance, there may be combinations of other technologies—heat, sunlight, chemicals—to help these AD systems degrade pollutants in more efficient ways and reduce the potential for them to enter the environment."

More information: Gyucheol Choi et al, Effects of perfluorooctanoic acid and perfluorooctane sulfonic acid on microbial community structure during anaerobic digestion, *Bioresource Technology* (2023). DOI: 10.1016/j.biortech.2023.129999

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