Poop to power? New research puts wastewater to work, as a source of both water and electricity

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Washington University researchers have developed a filter that treats wastewater and also generates electricity—an advance that could reshape energy use at treatment plants.

The new system uses bacteria as a "bio-catalyst" to produce an electric charge while breaking down organic material otherwise seen as waste. The findings from the lab of Zhen He, a professor of energy, environmental and chemical engineering, were detailed in this month's cover story for the academic journal *Environmental Science: Water Research & Technology*.

The research fits into a growing set of technologies that push back against the notion of wastewater as waste, and look instead to put it to beneficial use. The hope is that the Washington U. technology could eventually be used to reduce—if not reverse—the massive energy footprint of wastewater treatment, which, combined with drinking water systems, uses 3% to 4% of all energy consumed in the U.S.

"It's an energy-intensive process," said He in a recent interview with the Post-Dispatch. "And energy always means money."

Depending on how thoroughly it is treated, recovered water can be repurposed for anything from "nonpotable" uses like irrigation, to drinking water—as illustrated in places like Southern California, where there are expanding plans for "toilet to tap" wastewater recycling.

The Washington U. team's new filter, however, provides an added bonus in the form of energy.

The system uses a cloth to collect organic matter from the wastewater and to provide bacteria with a place to colonize. Then, as bacteria consume the organic materials, electrons are released and gathered by the cloth, creating electricity. Stainless steel around the filter transfers the electric current from the "bacteria fuel cell" to an external circuit.

That two-way function is what makes the electrode unique, He said. Some may scoff at the low electric output.

"We fight back by saying, 'Can your fuel cell filter wastewater?'" He asked.

Treating 1 cubic meter of wastewater could, in theory, generate 20 watts of power for an hour. That means a larger-sized unit or a collection of units could power lights or larger electrical devices, He said.

It's a considerable improvement from when He was a Washington U. graduate student about 15 years ago and helped create a small fuel cell using the emerging technology that could only glean trace amounts of electricity—not yet enough to power a light bulb.

Next steps

The technology next aims to scale up and make the leap into the real world. Ideally, He would love to see the filters used by municipal wastewater treatment utilities, like the Metropolitan St. Louis Sewer District—which currently spends about $15 million annually on energy costs.

But He says a more likely, intermediate step could be for the filters to first catch on at a smaller scale, in individual industrial facilities that have wastewater to treat.

"I try not to overpromise and say we're going to turn wastewater treatment into a power plant," he said.

The first big-picture milestone, he says, would be to make wastewater treatment "energy neutral," if users can generate enough power from the electrodes to offset their consumption.

But the ultimate aim is to flip wastewater treatment from an energy user into a power source.

The concept of harnessing value—and energy—from "wastewater" certainly isn't new.

Anheuser-Busch, for instance, recovers biogas from its wastewater.

And in cities like Denver, billion-dollar project developers are looking to the local sewer system as a source of heat—helping offset how much energy is required in buildings above ground.

While that thermal energy offers vast opportunity of its own, He notes that its potential can be seasonally and geographically dependent, packing the most punch in colder places.

Turning to wastewater for electricity—instead of heat—could be more universally applicable.

Each approach demonstrates the potential locked in wastewater.

"Is it really a waste?" He asked. "Or can we treat it as a resource?"

More information: Fubin Liu et al, Enhancing the performance of a microbial electrochemical system with carbon-based dynamic membrane as both anode electrode and filtration media, *Environmental Science: Water Research & Technology* (2021). DOI: 10.1039/D0EW01027H