Research helps power plants recycle water using wastewater from oil and gas mining

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A West Virginia University chemical engineering student analyzes water samples as part of research that uses two different forms of industrial wastewater to purify each other. Although the sample sizes are small, a new process systems analysis shows stakeholders, like power plant operators, what to expect when cotreatment happens at a much larger scale. Credit: WVU Photo/Paige Nesbit

Simulations from West Virginia University researchers demonstrate their use of two kinds of industrial wastewater to decontaminate each other has the potential to slash a power plant's total water use.

The researchers from the WVU Benjamin M. Statler College of Engineering and Mineral Resources modeled various scenarios for using "cooling tower blowdown" and "produced water" to treat each other. Cooling tower blowdown is wastewater produced by thermoelectric power plants, while water is produced by hydraulic fracturing mining for oil and gas.

The cotreatment process yields valuable byproducts as well as water that's clean enough to be reused in power plant cooling operations. The study's findings were published in the journal Desalination.

According to lead author Hunter Barber, a doctoral student in chemical engineering from Fairchance, Pennsylvania, no other industry in the U.S. uses as much water as thermoelectric power generation.

"Our cotreatment process reduces demand for chemicals to soften wastewater," Barber said. "The treated water also has very high potential for reuse—treated water can be directly reused after cotreatment to make up 99% to 100% of the original volume of blowdown water, and that's without optimizing or exploring different designs."

Presently, power plants draw fresh water from a surface water or groundwater source, run it through the cycle to generate steam and electricity, then minimally treat it and discharge it back to the surface or groundwater.

"Our approach is looking to close that cycle," Barber said. "Instead of discharging the water, we treat it, and instead of drawing from fresh water, we recycle treated water back through."

They're reducing the amount of purifying chemicals needed to treat the power plant's cooling blowdown with produced water, the oil and gas industry's largest wastewater byproduct by volume. One current method for dealing with produced water from fracking is to inject it right back into the earth.

"In the Southwest especially, but also in the Marcellus Shale and Appalachian regions, you have oil and gas wells drilled deep into the ground," Barber said. "Once you pull all oil and gas from a well, it's just an open cavity in the earth. You have polluted produced water that will take a high effort to treat, or you can inject it back into that reservoir. However, injecting it involves seismic activity risk and contamination risk from heavy metals leaching into the ground."

Co-author Lian-Shin Lin, professor and chair of the Wadsworth Department of Civil and Environmental Engineering, has led the development of the cotreatment process. He pointed out that produced water is saltier than ocean water. "Treating or disposing of that water is difficult and expensive. An energy producer's business is focused on producing shale gas and oil—they don't want to care about water. It's a liability for them," Lin said.

"This cotreatment scheme offers a way to manage produced water and recover resources from it. For the energy industry, that means, essentially, their produced water problem can disappear."

Lin's lab works with produced water from a shale gas well near Morgantown and a cooling tower blowdown from Longview Power Plant. Because the experimental samples Lin uses are small relative to the volume of water a power plant requires, Fernando Lima, associate professor of chemical engineering, said they saw a need for a techno-economic, environmental and process systems analysis that would "scale the cotreatment concept up as much as possible, so it can be integrated into power plants or other wastewater treatment solutions and optimized with regard to operating costs, capital costs and energy utilities."

Through process modeling, the researchers have been able to consider changes to power plant design and topology and evaluate different types of wastewater treatment processes before trying them in the lab. Simulations for different treatment processes allow them to optimize both the economics and the technical aspects of cotreatment.

"Collaborative research joining process modeling and experimentation is critical for the future of wastewater treatment because not a lot of detailed work has been done in modeling and optimizing these cotreatment processes, which involve very specific water chemistries that aren't simple to capture," Lima said.

Barber said he believes their model demonstrates plenty of upsides for power plants looking to implement wastewater cotreatment.

"A power plant likely already has dedicated personnel and equipment for treating its cooling blowdown. By becoming self-contained, they no longer have to draw from a water source. When they close the cycle, they no longer have to deal with potential negative economic consequences from discharging water that wasn't clean enough according to EPA regulations," Barber said.

"Instead, they can utilize the waste to make something beneficial and cost-effective. In terms of progressing the sustainability of many of our water demands, I think blowdown reuse is on the horizon for a lot of these facilities."

More information: Hunter Barber et al, Synergistic cotreatment of cooling tower blowdown and produced waters: Modeling strategies for a comprehensive wastewater treatment simulation, *Desalination* (2023).

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