New system could remove two water pollutants from agricultural fields

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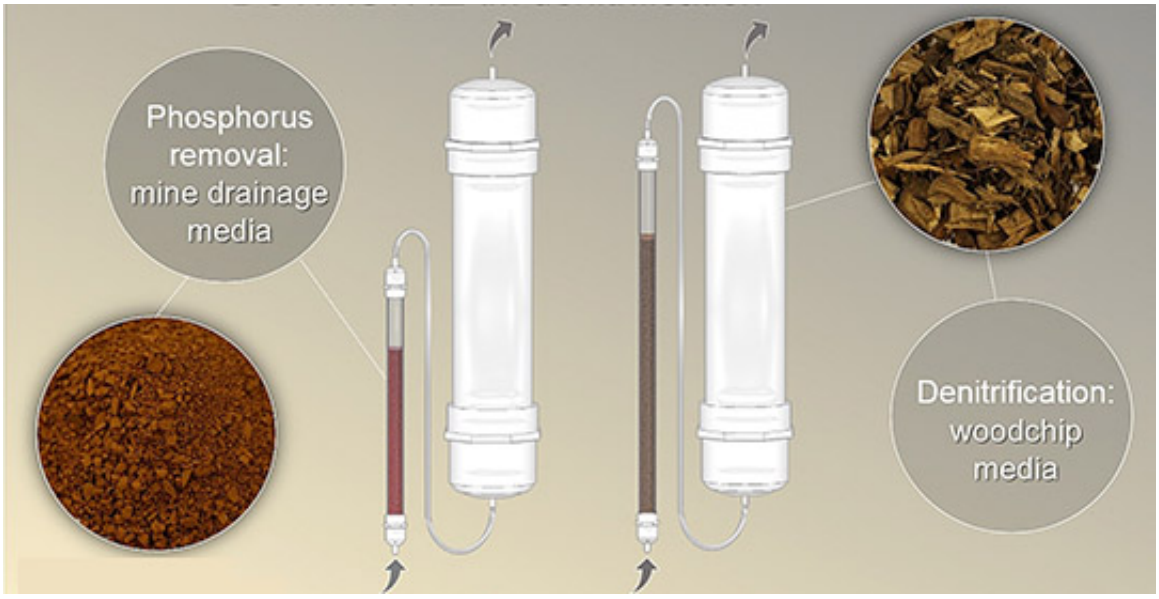

Experimental setup of the lab-scale bioreactor and P-filter. Credit: Laura Christianson

Algae blooms in the Gulf of Mexico use up the majority of the oxygen in the water, leading to massive "dead zones" that cannot support fish or other wildlife. The culprit? Nitrate, running off agricultural fields through tile drainage systems. But nitrate is only part of the problem. Algae in freshwater lakes and ponds flourishes when exposed to a different pollutant, phosphorus, and the tiniest amount is enough to trigger a bloom.

Illinois and the 11 other states that send the majority of the water to the Mississippi River set aggressive goals to reduce nitrate and phosphorus pollution in the Gulf of Mexico. To achieve those goals, large point sources of phosphorus, such as wastewater treatment plants, will need to invest in new infrastructure. But new research suggests there could be a role for farmers, as well.

Laura Christianson, assistant professor of water quality in the Department of Crop Sciences at the University of Illinois, is an expert in woodchip bioreactors. She has done extensive work to demonstrate the potential of the woodchip-filled trenches in removing nitrate from tile drainage water in Illinois croplands.

"The woodchips and the nitrate are necessary for the bacteria to complete their life cycles. As they consume the nitrate, it is removed from the water. It's a biological process," Christianson explains.

In a recent study, Christianson and several colleagues looked at whether they could also remove phosphorus by adding a special "P-filter" designed to trap the fertilizer-derived pollutant. The team tested two types of industrial waste products in the P-filters: acid mine drainage treatment residual (MDR) and steel slag. Phosphorous binds to elements such as iron, calcium, and aluminum contained in these products, removing it from the water.

Dr. Laura Christianson stands in front of a farm-scale woodchip bioreactor in Illinois. Credit: Debra L. Larson

Rather than mixing MDR or steel slag with woodchips in one big nitrate- and phosphorus-removing machine, the team placed a separate P-filter upstream or downstream of a lab-scale bioreactor. They ran wastewater from an aquaculture tank through the system and measured the amount of nitrate and phosphorus at various points along the way.

Nitrate removal was consistent, regardless of P-filter type and whether the P-filter was upstream or downstream of the bioreactor. But MDR was far superior as a phosphorus filter. "It removed 80 to 90 percent of the phosphorus at our medium flow rate," Christianson says. "That was really, really good. Amazing."

Steel slag, on the other hand, only removed about 25 percent of the phosphorus. "But steel slag is a lot easier to find in the Midwest. And according to the Illinois Nutrient Loss Reduction Strategy, we're only trying to remove 45 percent of the phosphorus we send downstream. Since agriculture is only responsible for half of that, 25 percent would be pretty good," Christianson says.

The system clearly shows potential, but several unknowns remain. Paired bioreactors and P-filters have yet to be tested in real-world conditions, although a handful have been installed in the United States. Perhaps more importantly, researchers don't have a good handle on how much phosphorus is running off agricultural fields in tile drainage.

"We suspect our tile drainage in Illinois doesn't have much phosphorus in it, but we know there is some," she says. "We're getting a better handle right now on just how much phosphorus we have.

"We know that phosphorus moves more readily in surface runoff. When you have soil eroding and the water is murky and brown, there's generally phosphorus attached to the soil. The easy way to sum it up is if you have tile drainage, you should be more concerned about losing nitrate in that water, but if you have hillier land, you should be more concerned about soil erosion and losing phosphorus."

More information: Laura E. Christianson et al, Denitrifying woodchip bioreactor and phosphorus filter pairing to minimize pollution swapping, *Water Research* (2017). DOI: 10.1016/j.watres.2017.05.026

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