Study: 'Legacy' phosphorus delays water quality improvements in Gulf of Mexico

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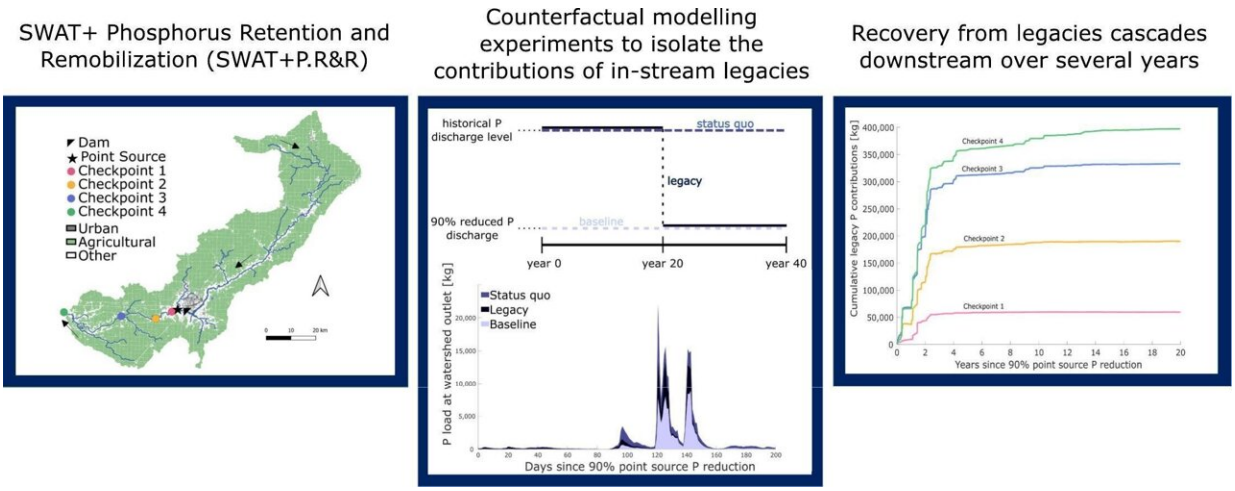

Graphical abstract. Credit: *Science of The Total Environment* (2023). DOI: 10.1016/j.scitotenv.2023.168711

The same phosphorous that fertilizes the thriving agriculture of the Midwest is also responsible for a vast "dead zone" in the Gulf of Mexico near the Mississippi Delta. Efforts to reduce the amount of phosphorus that enters the Mississippi River system are underway, but research led by the University of Illinois Urbana-Champaign suggests that remnants of the contaminant are left behind in riverbeds for years after introduction and pose an overlooked—and lingering—problem.

Phosphorus from wastewater and agricultural runoff flows downstream

to the Gulf of Mexico, where it unintentionally fertilizes plankton. As the plankton eventually die and decompose, the process depletes the Gulf's water of oxygen—a condition called hypoxia—and creates a dead zone for sea creatures like fish and shrimp.

The federal Gulf of Mexico Hypoxia Task Force aims to achieve a 25% reduction in phosphorus flows to the Gulf by 2025. This target relies on individual states to achieve a 25% reduction and assumes that those reductions will quickly lead to the desired outcome.

The study by civil and environmental engineering professor Ximing Cai, former Illinois graduate student Kevin Wallington, and University of Wisconsin-Madison professor Margaret Kalcic questions how remnants of phosphorus that entered the Mississippi River system in the past but remain buried in waterway sediments—called legacy phosphorus—may delay phosphorus reductions at the Gulf of Mexico, long after Midwest states have met their discharge-reduction goals.

The findings are published in the journal *Science of the Total Environment*.

"Our watershed model simulates how phosphorus travels through rivers. But what makes our study different is that it also accounts for how phosphorus can interact with river beds at large spatial scales," Cai said. "We capture the processes that cause phosphorus to repeatedly stop in some river locations and start traveling downstream again at some point in the future. This process could result in long periods before old phosphorus can flush out of the river system, especially for large rivers."

Using their model, the researchers investigated a hypothetical future where a wastewater treatment plant along the Sangamon River in Decatur, Illinois, stops discharging phosphorus into the river.

"We chose Decatur because it is located in a very typical Midwestern agro-industrial watershed, making it an ideal case study for our model," Wallington said. "Additionally, the location is actively exploring plans for large-scale phosphorus removal from its waste streams."

The researchers found that it would take up to nine years for the Sangamon River to return to pre-contaminant, or baseline, phosphorus levels.

"Our model indicates that it takes much longer to recover at locations further downstream from the point of remediation," Wallington said. "It would only take two to three years to recover at a location 5 kilometers downstream from the Decatur treatment plant, but it would take nine years to recover at a point 70 kilometers downstream. The Gulf of Mexico is 2,640 kilometers downstream, so the reductions there might lag far behind remediation efforts."

However, the researchers acknowledge that their results, which only extend 70 kilometers downstream, cannot be directly extrapolated all the way to the Gulf of Mexico, and further research is needed at the scale of the entire Mississippi River basin.

"One of the primary goals of this study is to inform the public and regulators that even when states like Illinois meet their phosphorus remediation goals, it could be years, even decades before the same results are seen in the Gulf," Cai said.

More information: Kevin Wallington et al, Evaluating the longevity of in-stream phosphorus legacies: A downstream cascade of recovery following point source remediation, *Science of The Total Environment* (2023). DOI: 10.1016/j.scitotenv.2023.168711

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