Phosphorus runoff studies show importance of stable banks, cover crops

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Jacqueline Todd, left, and Ireyra Tamayo conduct water quality tests from samples taken in the Beaver Lake watershed as part of ongoing water quality studies with Shannon Speir, assistant professor of water quality with the Arkansas Agricultural Experiment Station. Credit: University of Arkansas

Spring rains are great for flowers and kayakers, but the season also prompts concern about algae bloom-causing phosphorus runoff into drinking water sources.

Spring streamflow delivery to Beaver Lake has increased over the past 20 years, delivering more nutrients to the reservoir and increasing the risk of algae blooms during the summer, according to an analysis of U.S. Geological Survey data by Ireyra Tamayo, an environmental, soil and water science student at the U of A.

Tamayo is a student of Shannon Speir, assistant professor of water quality in the Department of Crop, Soil and Environmental Sciences with the Arkansas Agricultural Experiment Station, the research arm of the U of A System Division of Agriculture. Her lab's undergraduate students are conducting studies on the watershed as part of an unofficial partnership with the Beaver Watershed Alliance and the Beaver Water District.

"They are really interested in knowing this information," Speir said. "This was a relatively easy analysis we could do with publicly available data, so we volunteered to jump in and do it."

Speir said she has shared the information with the groups, and her lab's team has continued to do studies to assist in long-range planning efforts to mitigate phosphorus runoff. Phosphorus runoff can lead to algae blooms in bodies of water, which decreases available oxygen for aquatic life.

There are concerns about streambank erosion and increased streamflow in the Beaver Lake watershed because phosphorus binds to floating sediments that creeks carry into the lake.

Tamayo's study looked at the changing delivery of streamflow and water runoff from four tributaries of Beaver Lake: the White River, the West Fork of the White River, War Eagle Creek and Richland Creek.

The Beaver Lake watershed includes all the tributaries that run into the primary source of drinking water for Northwest Arkansas. Speir said the potential for phosphorus runoff in the area prompted her and her students' water quality studies of the tributaries in rural areas.

"Beaver Lake is still in good health, and much of the work is centered around preventing the balance from shifting toward conditions that may cause harmful algal blooms," Speir said. "Once algal blooms start happening, it's hard to turn the dial back and stop them from happening."

Using publicly available streamflow data from the U.S. Geological Survey, Tamayo calculated streamflow discharge and runoff changes and compared runoff across the four tributaries over the past 20 years. She also explored seasonal changes in average discharge among the four tributaries.

The study showed that, in general, Richland Creek had the highest runoff to Beaver Lake over the study period, and War Eagle Creek had the lowest runoff. She observed variable trends in average discharge by season across the four tributaries. The most consistent increase in average streamflow occurs in the spring.

"Climate change is affecting the hydrological cycle, increasing global temperatures and changing precipitation patterns," the study states. "As rain events become more frequent and intense, they are expected to yield higher streamflow and larger peak flows. The increased sediment and nutrient delivery to sensitive downstream systems could lead to water quality problems, such as eutrophication and harmful algal blooms."

Eutrophication is when excess nutrients accumulate in a lake or other body of water, frequently due to runoff from the land, and causes a dense growth of algae and death of animal life from lack of oxygen.

"This was our first cut, but from that, we can start building more management and actionable outcomes," Speir added.

Student researchers from the Speir's water quality resarch team include Jacob Major, junior; Deo Scott, senior; Lilly A. Stults, senior; Ireyra Tamayo, senior; and Jacqueline Todd, junior. Brynnen Beck and Claire Meara, both sophomores, have also recently joined Speir's team. All the undergraduates are environmental soil and water science majors in the Crop, Soil and Environmental Sciences Department.

Erosion and biological impacts

Jacob Major's study highlighted the importance of creek bank stability. Major concluded in his water quality study of Richland Creek and Brush Creek that "sediment-associated phosphorus from bank erosion may serve as a critical downstream phosphorus source to Beaver Lake."

Jacob Major takes stream soil samples in a Beaver Lake watershed tributary as part of ongoing water-quality studies by students in the Department of Crop, Soil and Environmental Science with assistant professor Shannon Speir. Credit: U of A System Photo

Major's study found higher total phosphorus levels in Richland Creek but higher dissolved phosphorus in Brush Creek. Richland Creek runs through mostly forestland and about 40% pastureland. Brush Creek runs through mostly pastureland and about one-third forestland.

Speir noted that the higher concentrations of total phosphorus in Richland Creek could be because of more organic materials like leaf litter in the stream. Soluble reactive phosphorus, however, is more troublesome because the nutrient is more available to create algal blooms downstream.

Major's study won first place in March for undergraduates in the student poster competition at the Arkansas Discovery Farms Conference in Little Rock. In April, his study also won third place in the natural sciences category as part of the U of A's Undergraduate Research Week Poster Competition.

A follow-up study is now underway to better understand the role of sediment in driving downstream phosphorus loss to Beaver Lake.

Jacqueline Todd's study on the Upper White River is complementary to Major's and explores the role of algae in streams removing phosphorus from rivers. She pointed out that while many studies focus on headwater streams, there is a knowledge gap on the interplay of nutrients in rivers.

Her study found that soluble reactive phosphorus uptake was higher in the summer when the flow was slower, and the nutrient uptake was lower in the spring when the flow was faster.

Cover crops retain sediments and phosphorus

Speir's lab also evaluated the impact of cover crops to mitigate phosphorus runoff on agricultural fields.

A study by Lily Stults in Speir's lab showed the importance of cover crops in retaining phosphorus on a site. Stults analyzed data on total flow, total suspended sediment and total phosphorus concentrations from 503 runoff events on cover-cropped and non-cover-cropped cotton fields between 2013 and 2018 at the Arkansas Discovery Farms site in Dumas. The runoff events included rain and irrigation.

While cover crops did not impact the total flow from fields during water runoff events, the total suspended sediment and total phosphorus concentrations were lower in runoff from the cover-cropped field.

Cover crops prevent erosion and sediment loss by increasing the stability of the soil, the study noted.

The study stated that total suspended solid concentrations were consistently lower in runoff from cover-cropped fields. Other data suggest cover crops help retain particulate phosphorus bound to sediments.

Mullins Creek evaluation

A little closer to home, Deo Scott's study titled "Stream restoration effectiveness in Mullins Creek in Fayetteville, Arkansas" concluded that the Watershed Conservation Resource Center restoration in 2012 improved water quality in the restored section. He documented higher dissolved oxygen content, lower temperatures and more diversity of aquatic insects in the restored section of the creek. However, the impacts were variable downstream.

The creek begins as a spring near the Poultry Science building and flows under Razorback Stadium. The restored section of Mullins Creek is between Nolan Richardson Drive and the Gardens on the U of A campus. Samples were taken at five sites along the creek.

Speir said there is more than one way to restore a stream, but the key components are to keep the stream bank from eroding, add native plants to stabilize the soil and restore the stream bottom in some way to slow the water down and make riffles and pools.

"The hope is that naturally, over time, the fish and insects come back as the water quality improves," Speir said. "Another piece in the restoration puzzle, particularly in urban areas, is 'daylighting,' where a buried stream is re-exposed to the world. Many urban streams have become buried, like Mullins Creek, which has a stadium over it."

Scott's results also emphasized the need for more monitoring and management to improve water quality.

Provided by University of Arkansas