Study finds declining sulfur levels

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Power plants burned coal that released sulfur into the atmosphere, but coal use has declined. Today, coal plants use scrubbers to remove sulfur, or burn low-sulfur western coal. This has led to a large decrease in sulfur emissions, and less atmospheric deposition of sulfate to agricultural fields--and consequently, declining sulfate concentrations in rivers. Groundwater can be another source of sulfur in rivers when it comes in contact with underground coal or pyrite seams. In this sample from an Illinois mine, pyrite is visible as gold flecks in the center of the coal. Credit: Debra Levey Larson

Air pollution legislation to control fossil fuel emissions and the associated acid rain has worked - perhaps leading to the need for sulfur fertilizers for crop production. A University of Illinois study drawing from over 20 years of data shows that sulfur levels in Midwest watersheds and rivers have steadily declined, so much so that farmers may need to consider applying sulfur in the not too distant future.

"We don't think there are actual sulfur deficiencies yet, but clearly more sulfur is coming out of the soil and water than what is going in," says U of I biogeochemist Mark David. "As the Clean Air Act and amendments have taken effect there has been a reduction in sulfur emissions from coal combustion, so that the amount of atmospheric sulfur deposited each year is only 25 percent of what it used to be. At some point, farmers are going to have to fertilize with sulfur."

David says farmers whose fields have fine-textured soils that are high in organic matter have less of a concern. "For many, it could be 10 or 20 years from now, but for some, particularly those farming on poorer soils, it'll be sooner. Farmers whose fields have poorer soil or notice a yield reduction may want to have their soil tested for sulfate. If it registers low, they can consider applying fertilizer."

David explains that sulfur in soil comes from two main sources. It's in the air from fossil fuel combustion and in groundwater where water has come in contact with coal or pyrite seams. It comes out of the soil through tile-drained fields and it is taken up into plants as they grow and are then harvested. Most fields in Illinois do not receive fertilizers containing sulfur. Some in the Embarras and Kaskaskia watersheds apply ammonium sulfate, which adds not just nitrogen, but also sulfur.

In their study, David and his team analyzed data from three rivers in east-central Illinois at times when the flow was high and low from the field drainage tiles and the rivers. Sulfate concentrations were greatest in the

Salt Fork River, followed by the Embarras, and then the Kaskaskia Rivers.

"As we go from northeast to southwest across this part of Illinois, the sulfate that we think is from groundwater near coal seams, decreases. In the Tuscola and Atwood areas, we don't think there are any groundwater sulfate inputs. When we looked at a whole variety of fields with tile drainage systems, we found that some had very low sulfate concentrations - just a few milligrams per liter. One farm in our study had applied bed ash from a power plant. We saw high concentrations of sulfate in that field. There's no doubt that it boosted the level of sulfur. But over the next three or four years most of it had washed out through the tile system," co-author and U of I agronomist Lowell Gentry says.

The long-term nature of the study allowed the team to do watershed balances and look at the inputs and outputs of the sulfur "budget" for the area.

"That balance is negative, with greater outputs from harvest and leaching, than inputs from atmospheric deposition and fertilizers, so what is missing is coming from the soil. There is a lot of sulfur in soil in organic forms and that's being slowly depleted. At some point, there won't be enough to keep up with what the crop needs. That's when farmers will need to add fertilizer," Gentry says.

David began his career in the 1980s studying the effects of acid rain - a main ingredient of which is sulfur. "Back then no one ever thought about fertilizing with sulfur because there was always plenty of atmospheric sulfur available from burning coal."

The samples David collected over the past two decades were primarily used to track nitrates that enter the rivers via drainage tiles in agricultural fields, and eventually reach the Gulf of Mexico. He says that unlike

nitrate, "sulfate is not a problem in Midwestern streams and rivers. It's not like other chemicals that cause problems downstream and in the Gulf."

David believes that this is the first study looking at long-term trends in sulfur in agricultural areas. "Most of the studies about atmospheric deposition in sulfur have been in forested watersheds in the northeast where lakes were acidified, such as in the Adirondack Mountains in New York and in streams in the Appalachian Mountains, areas that were sensitive to acid rain. Sulfate is more of a problem in the northeast in forest soils," he says.

More information: "Riverine response of sulfate to declining atmospheric sulfur deposition in agricultural watersheds" is published in the Journal of Environmental Quality and is available online through open access at dl.sciencesocieties.org/public … /0/0/jeq2015.12.0613

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