Sour Showers: Acid Rain Returns--This Time It Is Caused by Nitrogen Emissions

Acid rain is now caused by nitric rather than sulfuric acid--and it comes from more sources than the earlier acidic precipitation did

June 21, 2010 |By Michael Tennesen

The acid rain scourge of the '70s and '80s that killed trees and fish and even dissolved parts of statues on Washington, D.C.'s National Mall is back. But unlike the first round, in which sulfur emissions from power plants mixed with rain to create sulfuric acid, the current problem stems primarily from nitrogen emissions mixed with rain to create nitric acid.

"Both are strong acids, and both create serious problems for the environment," says William Schlesinger, president of the Cary Institute for Ecosystem Studies in Millbrook, N.Y. Acid rain degrades cement and limestone as well as leaches critical soil nutrients, which injures plants. It also liberates toxic minerals from the ground that flow into stream runoff where they can kill fish.

Sulfur emissions from power plants were one of the primary motivations for the U.S.'s Clean Air Act Amendments of 1990, which set reduction targets for both sulfur dioxide (SO2) and nitrogen oxides (NOx). However, whereas sulfur dioxide emissions decreased almost 70 percent from 1990 to 2008, emissions of one NOx—nitrogen dioxide (NO2)—went down only 35 percent for that same period, and amendment targets have yet to be made, according to the U.S. Environmental Protection Agency (EPA). "This comes as scientists have grown increasingly aware of the consequences of the remaining nitric acid deposition," Schlesinger says.

Schlesinger is one of a number of scientists calling attention to the problem. On June 8 the Integrated Nitrogen Committee of the EPA's

Science Advisory board held a public teleconference to discuss a draft report of possible solutions to nitrogen problems, including acid rain. A final report is pending.

Nitric acid rain is derived primarily from power plant, car and truck emissions as well as from gases released by fertilizer use. Part of the problem dates back to WWI, when two German scientists invented the Haber–Bosch process, which took nonreactive nitrogen from the air (N_2) and converted it into reactive, usable ammonia (NH_3). Most of the nitrogen harvested via this process has been used in fertilizers, and the runoff from farms has created dead zones in Chesapeake Bay and at the mouths of the Columbia and Mississippi rivers. Some efforts have been made to regulate the agricultural nitrogen runoff, but atmospheric emissions of agricultural ammonia remain virtually unrestricted.

Agri-ammonia vapors also derive from concentrated animal feeding operations in the U.S. South. The gas rises into the air and is deposited dry or in rainfall where in the ground bacteria breaks it into nitrogen and nitric acid, which can kill fish and plants. "Agriculture is increasingly functioning as an intensively managed industrial operation, and that is creating serious water, soil, and air problems," says Viney Aneja, a professor at North Carolina State University in Raleigh. Aneja says that state's concentrated animal feeding operations may also emit particulate matter from swine and chicken manure into the atmosphere, which can carry diseases.
NOx escapes from power plants as a by-product of coal combustion, whereas vehicular engines run at high enough pressures and temperatures to combine nitrogen and oxygen in the air. "Though catalytic converters have decreased the amount of pollution per vehicle, there are more vehicles on the road and more miles driven," Schlesinger says. Emissions from fertilizers are the chief source of atmospheric nitric oxide, but motor vehicles have now overtaken coal power plants as the secondary most critical source of this problem.

The consequences are grave: Nitric oxide (NO) rises from farms, power plants and vehicles, for instance, in the upper Midwest and drifts toward New England forests where nitric acid (HNO_3) in the rain leaches important plant nutrients like potassium, calcium and magnesium from the soil, Schlesinger says. Researchers at Hubbard Brook Experimental Forest in White Mountain National Forest, N.H., found evidence of this rain and reported that it may cause a reduction in cold or stress tolerance in some tree species including red spruce and sugar maple. Similarly, nitric oxide has been documented as rising from similar sources in Kentucky and Tennessee and drifting toward the Great Smoky Mountains, where some of the worst acid rain and forest decline has been observed, Schlesinger says.

Acid in rain also liberates aluminum in the soil, which can be is poisonous to insects and fish if the metal enters stream runoff. And, excess available nitrogen in rain may promote some species of plants as it diminishes others. In fact, researchers at the University of Minnesota reported in 2008 that atmospheric nitrogen deposition reduced plant species numbers in the state's prairie grasslands by 17 percent.

In the U.S. there are neither comprehensive laws nor adequate monitoring devices for regulating atmospheric nitrogen emissions from livestock and farms. Europeans passed the Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-Level Ozone in 1999, a pact signed by 49 countries, but the U.S. has dragged its feet. Schlesinger thinks that national arguments over climate change have allowed the U.S. to ignore the nitrogen problem, which he predicts will be the next big environmental issue. "It's another example of humans upsetting global biogeochemical cycles with unintended consequences," he says. Since Gothenburg, Europe has decreased its nitrogen emissions by a third, whereas U.S. emissions remain flat. And the U.S. has increased its ammonia emissions, an atmospheric component of the nitrogen problem, by 27 percent from 1970 to 2005, according to a 2009 paper in Environmental Science & Technology.

Without intervention, the problem will likely worsen. With world population predicted to grow from 6.5 billion to nine billion by 2050, agriculture must feed more mouths, and that's probably going to require more nitrogen fertilizer, thereby resulting in more nitric acid rain and atmospheric pollution. The Integrated Nitrogen Committee's 247-page draft report discusses inputs, flows and management options for reactive nitrogen in the U.S. environment. It also discusses ways to monitor atmospheric emissions, currently the weak link in the nitrogen control picture.

It's clear that humans are adding nitrogen to Earth's surface. Researchers do not know yet where it all goes, "but we do know that increasing concentrations of nitrogen in unexpected places will cause significant environmental damage that we will all learn to regret," Schlesinger wrote in a 2009 report in Proceedings of the National Academy of Sciences.

Still, Aneja sees promise. Agriculture has adopted modern technologies and science to maximize productivity, but it has not yet been subjected to the same environmental regulations applied to other modern industries, he says. "The Integrated Nitrogen Committee report is an effort to develop more stringent measures," he adds, "and we're not ignoring the atmospheric contribution."

What two types of acid cause acid rain? How do they form?

What are some common sources of nitrogen emissions that we may see in North America?

What are some effects of acid rain on the environment?