**CHEMISTRY READING #2: The Return of Acid Rain**

**STEP 1: Read AND ANNOTATE the following article.**

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

By [Michael Tennesen](http://www.scientificamerican.com/author.cfm?id=1660)  | Monday, June 21, 2010 | 13

The [acid rain](http://www.scientificamerican.com/article.cfm?id=acid-rain-linked-to-bird) falls 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. In the first round, sulfur emissions from power plants mixed with rain to create sulfuric acid. The current problem stems primarily from [nitrogen emissions](http://www.scientificamerican.com/article.cfm?id=nitrogen-dioxide-highway-monitoring-pollution) mixed with rain to create nitric acid.

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"Both are strong acids, and both create serious problems for the environment," says William Schlesinger, president of the [Cary Institute for Ecosystem Studies](http://www.ecostudies.org/people_president.html) in Millbrook, N.Y. Acid rain breaks down cement and limestone as well as takes away critical soil nutrients, which injures plants. It also frees 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](http://www.epa.gov/air/caa/overview.txt), which set reduction targets for both sulfur dioxide (SO2) and nitrogen oxides. However, while sulfur dioxide emissions decreased almost 70 percent from 1990 to 2008, the emissions of nitrous oxides went down by only 35 percent for that same period.

Nitric acid rain is created 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 a process, which took nonreactive nitrogen from the air (N2) and converted it into reactive, usable ammonia (NH3). Most of the nitrogen harvested by this process has been used in fertilizers, which is commonly used in farming. "Agriculture is creating serious water, soil, and air problems," says Viney Aneja, a professor at [North Carolina State University](http://www.meas.ncsu.edu/faculty/aneja/aneja.html) in Raleigh.

Nitrous oxides also escape from power plants as a product of [coal combustion](http://www.scientificamerican.com/article.cfm?id=chinas-energy-paradox). 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.

Nitric oxide (NO) now rises from farms, power plants and vehicles. For instance, in the upper Midwest and drifts toward New England forests nitric acid (HNO3) in the rain takes away important plant nutrients like potassium, calcium and magnesium from the soil. Researchers at [Hubbard Brook Experimental Forest](http://www.hubbardbrook.org/) in White Mountain National Forest, N.H., found evidence of this rain and reported that it may cause a reduction in strength of the forest trees. 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.

In the U.S. there are no laws or 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. 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.

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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. 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.

**STEP 2: SUMMARY**

In one paragraph, write a summary of what this article discussed. Your summary should include the title, author, date and source of the article. This paragraph should also include the who, what, when, where and why of the article.

**STEP 3: REFLECTION**

In a second paragraph, write a reflection focused on your thoughts and opinions on what you just read. Your reflection could (but does not have to) answer the following questions:

* What is your initial reaction to this article?
* What opinions do you have about what was discussed in this article? Do you agree or disagree with what was said in the article?
* What connection can you draw between this article and yourself or something else you have learned?
* What next steps could scientists take with what they have learned in this article?
* How could these next steps influence YOUR future?