Acid Rain

Content Adapted from the U.S. Environmental Protection Agency1.

Background

Acid rain and **acid precipitation** are broad terms referring to deposited material from the atmosphere that contains higher than normal amounts of nitric and sulfuric acids. These deposits come from a mixture of wet sources, such as rain, fog, and snow, and dry ones, including dust and smoke.

Most acid rain forms from man-made sources, primarily emissions of sulfur dioxide (SO_2) and nitrogen oxides (NO_x) from fossil fuel combustion, although it can occasionally form from natural sources, such as volcanoes and decaying vegetation. Acid rain is typically measured with pH. The lower a substance's pH, the more acidic it is. Pure water has a pH of 7.0. However, normal rain is slightly acidic because carbon dioxide (CO_2) dissolves into it forming weak carbonic acid, giving the resulting mixture a pH of approximately 5.6. Acid rain that contains sulfur dioxide or nitrogen oxide emissions may have a much lower pH. As of the year 2000, the most acidic rain falling in the U.S. had a pH of about 4.3.

In the United States, roughly 2/3 of all SO_2 and 1/4 of all NO_x come from electric power generation that relies on burning fossil fuels, such as coal. Acid rain occurs when these gases react in the atmosphere with water, oxygen, and other chemicals to form various acidic compounds. The result is a mild solution of sulfuric acid and nitric acid. When sulfur dioxide and nitrogen oxides are released from power plants and other sources, prevailing winds blow them across state and national borders, sometimes over hundreds of miles, where they are deposited onto the landscape and drain into lakes.

Where Acid Rain Falls

Acid rain flows into streams, lakes, and marshes after falling onto forests, fields, buildings, and roads. Acid rain also falls directly onto aquatic habitats. Most lakes and streams have a pH between 6 and 8, although some lakes are naturally acidic even without the effects of acid rain. Acid rain primarily affects sensitive bodies of water, which are located in watersheds with soils that have a limited ability to neutralize acidic compounds (called "buffering capacity"). Lakes and streams become acidic (the pH values go down) when the water itself and its surrounding soil cannot buffer the acid rain enough to neutralize it. In areas where buffering capacity is low, acid rain also releases aluminum from soils into lakes and streams; aluminum is highly toxic to many species of aquatic organisms.

A recent EPA survey[2] investigated the effects of acidic deposition in over 1,000 lakes larger than 10 acres and in thousands of miles of streams believed to be sensitive to acidification. Of the lakes and streams surveyed, acid rain caused acidity in 75 percent of the acidic lakes and about 50 percent of the acidic streams. The EPA identified several regions of the U.S. that contain many of the surface waters sensitive to acidification. They include the Adirondacks and Catskill Mountains in New York, the mid-Appalachian highlands along the east coast, the upper Midwest, and mountainous areas of the Western United States. In areas like the Northeastern United States, where soil-buffering capacity is poor, some lakes now have a pH value of less than 5. One of the most acidic lakes reported, with a pH of 4.2, is Little Echo Pond in Franklin, New York.

Acid rain effects are experienced in many places around the world. For example, the Canadian government has estimated that 14,000 lakes in eastern Canada are acidic. To find out more about lakes near your home or other locations, visit the U.S. EPA's "where you live" webpage.

How Acid Rain Affects Fish and Other Aquatic Organisms

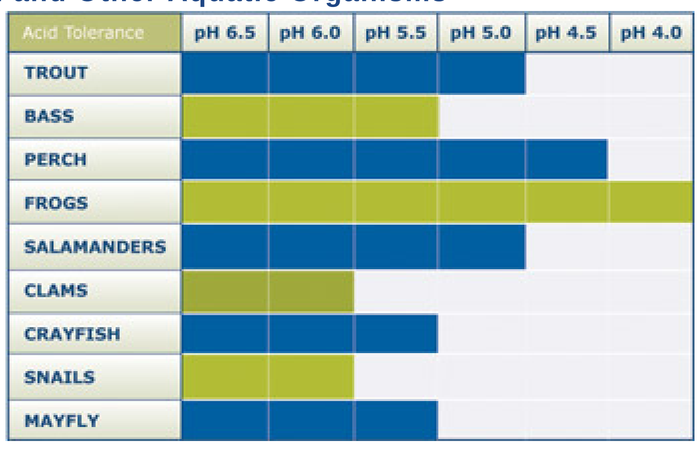

Figure 1: Organisms vary in their tolerance of acid rain, with some species unable to survive in water with a pH less than 6.0. Effects of losing some organisms from acidified lakes can cascade through food webs and reduce water quality.

Acid rain causes a cascade of effects that harm or kill individual fish, reduce population numbers, completely eliminate species from a lake, and decrease biodiversity. As acid rain flows through soils in a watershed, it releases aluminum from soils into the lakes and streams located in that watershed. Thus, as pH in a lake or stream decreases, aluminum levels increase. Both low pH and increased aluminum levels are directly toxic to fish. In addition, low pH and increased aluminum levels cause chronic stress that may not kill individual fish but leads to lower body weight and smaller size, making fish less able to compete for food and habitat.

Some types of plants and animals are able to tolerate acidic waters. Others, however, are acid-sensitive and will perish as the pH declines. Generally, the young of most species are more sensitive to environmental conditions than adults. At pH 5, most fish eggs cannot hatch. At lower pH levels, some adult fish die. Some acid lakes have no fish; figure 1 shows that not all fish, shellfish, or the insects that they eat can tolerate the same amount of acid; for example, frogs can tolerate water that is more acidic than trout.

Acid Rain Effects on Ecosystems

Together, biological organisms and the environment in which they live are called an ecosystem. The plants and animals living within an ecosystem are highly interdependent. For example, frogs may tolerate relatively high levels of acidity, but if they eat insects like the mayfly, they may be affected because part of their food supply could disappear. Because of the connections between the many fish, plants, and other organisms living in an aquatic ecosystem, changes in pH or aluminum levels affect biodiversity as well. Thus, as lakes and streams become more acidic, the numbers and types of fish and other aquatic plants and animals that live in these waters decrease. Generally, ecosystems with higher biodiversity have a greater ability to deal with environment stressors, whether it be acid rain, climate change, or pollution. This means acid rain can make an ecosystem more susceptible to other stressors such as pollution by reducing biodiversity.

Controlling Acid Rain

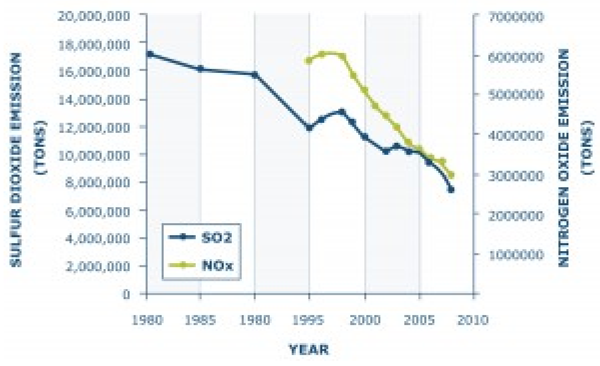

Figure 2: The 1990 Clean Air Act Amendments were responsible for regulating the emissions of sulfur dioxide and nitrogen oxide compounds, the two compounds most responsible for causing acid rain. While emissions of these compounds have been reduced, acid rain is still a threat to lake ecosystems and water quality in many regions.

Acid rain control produces significant benefits by reducing the impact of acid rain on lakes and other freshwater resources. If acidic deposition levels were to remain constant over the next 50 years (the time frame used for projection models), the acidification rate of lakes in the Adirondack Mountains that are larger than 10 acres would rise by 50 percent or more.

Emissions of sulfur dioxide and nitrogen dioxide compounds are regulated in the U.S. under the Clean Air Act Amendments of 1990[3]. While the Clean Air Act Amendments enacted a maximum cap on sulfur dioxide emissions, no such cap was created for nitrogen dioxide. After 1990, acid rain precipitation has been reduced, but not eliminated, as emission rates for sulfur dioxide and nitrogen oxide compounds have been reduced (see Figure 2). Fully eliminating acid rain, however, may be decades away.

The effects of acid rain impact human populations by creating a risk of consuming contaminated fish or shellfish, reducing our ability to use and enjoy lake ecosystems, reducing water quality, and causing economic impact on people who rely on healthy lake ecosystems, such as fishermen and those who cater to tourists.

Sources:

1. Environmental Protection Agency. Acid Rain. Retrieved online at: http://www.epa.gov/acidrain/index.html
2. United States Geological Survey. National Water Quality Assessment Program. Retrieved online at: http://water.usgs.gov/nawqa/
3. Environmental Protection Agency. Data and Maps. Retrieved online at: http://camddataandmaps.epa.gov/gdm/

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