Teacher Background information TDP

From the EPA - http://www.epa.gov/region1/eco/acidrain/intro.html

Introduction

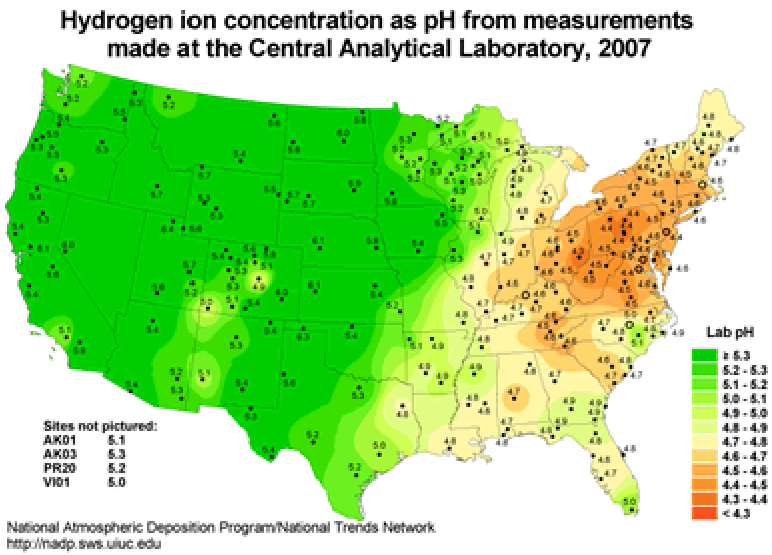
Acid rain is rain with a higher concentration of positively charged atomic particles (ions) than normal rain. Acid rain and its frozen equivalents, acid snow and acid sleet, are part of a larger problem called acid deposition. Acid deposition also includes direct deposition, in which acidic fog or cloud is in direct contact with the ground; and dry deposition, in which ions become attached to dust particles and fall to the ground.

On this website, unless otherwise indicated, the term "acid rain" will refer to all types of acid deposition.

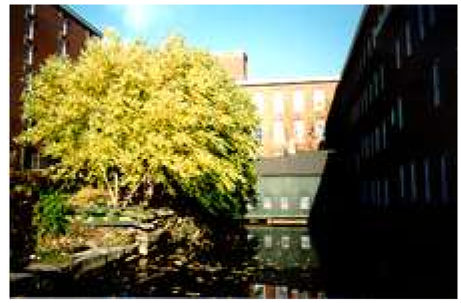
Acid rain is one type of atmospheric deposition. Atmospheric deposition includes any precipitation, airborne particles or gases deposited from the atmosphere to the Earth's surface. Other forms of atmospheric deposition may also be by wet or dry methods. Much of the material in atmospheric deposition may be a nuisance, but does not harm the environment. Some air pollutants, such as those in acid rain, can cause environmental problems. Over many decades, the combined input of contaminants to sensitive environments can lead to widespread environmental problems. Most smaller particles with a diameter of 10 microns (.004 inches) or less are too light to be deposited, and so remain in the atmosphere where they can cause health problems. They pose a different problem, and are regulated as particulates, or PM.

Acid rain occurs when sulfur dioxide and nitrogen oxides are emitted into the atmosphere, undergo chemical transformations and are absorbed by water droplets in clouds. The droplets then fall to earth as rain, snow, or sleet. This can increase the acidity of the soil, and affect the chemical balance of lakes and streams. Decades of enhanced acid input has increased the environmental stress on high elevation forests and aquatic organisms in sensitive ecosystems. In extreme cases, it has altered entire biological communities and eliminated some fish species from certain lakes and streams. In many other cases, the changes have been more subtle, leading to a reduction in the diversity of organisms in an ecosystem. This is particularly true in the northeastern United States, where the rain tends to be most acidic, and often the soil has less capacity to neutralize the acidity. Acid rain also can damage certain building materials and historical monuments. Some scientists have suggested links to human health, but none have been proven.

Acidity is measured on the per-hydrogen, or pH scale. This is a measure of the concentration of positively charged ions in a given sample. It ranges from 14 (alkaline or negatively charged ions) to 0 (acidic or positive ions). Pure water has a pH of 7 (neutral). Most rainwater is slightly acidic (pH about 6). A change in the pH scale of one unit reflects a tenfold (10X) change in the concentration of acidity. Generally rain with a pH value of less than about 5.3 is considered acid rain. As the map below shows, most of the rainwater which falls in the eastern United States has a pH between 4.0 and 5.0. This is generally lower (more acidic) than the national average.



A Brief History



Acid rain was first observed in the mid 19th century, when some people noticed that forests located downwind of large industrial areas showed signs of deterioration. The term "acid rain" was coined in 1872 by Robert Angus Smith, an English scientist. Smith observed that acidic precipitation could damage plants and materials.

Acid rain was not considered a serious environmental problem until the 1970s. During that decade, scientists observed the increase in acidity of some lakes and streams. At the same time, research into long range transport of atmospheric pollutants such as sulfur dioxide, indicated a possible link to distant sources of pollution. Many power plants use coal with a relatively high concentration of sulfur as fuel. Scientists realized that sulfur dioxide emitted from many of these plants could be transported to the Northeast. When we began to see acid rain as a regional, rather than a local, problem, the federal government had to become involved.

In 1980, the U.S. Congress passed an Acid Deposition Act. This Act established a 10-year research program under the direction of the National Acidic Precipitation Assessment Program (NAPAP). NAPAP looked at the entire problem. It enlarged a network of monitoring sites to determine how acidic the precipitation actually was, and to determine long term trends, and established a network for dry deposition. It looked at the effects of acid rain and funded research on the effects of acid precipitation on freshwater and terrestrial ecosystems, historical buildings, monuments, and building materials. It also funded extensive studies on atmospheric processes and potential control programs.

In 1991, NAPAP provided its first assessment of acid rain in the United States. It reported that 5% of New England Lakes were acidic, with sulfates being the most common problem. They noted that 2% of the lakes could no longer support Brook Trout, and 6% of the lakes were unsuitable for the survival of many species of minnow. Subsequent Reports to Congress have documented chemical changes in soil and freshwater ecosystems, nitrogen saturation, decreases in amounts of nutrients in soil, episodic acidification, regional haze, and damage to historical monuments.

Meanwhile, in 1990, the US Congress passed a series of amendments to the Clean Air Act. Title IV of these amendments established a program designed to control emissions of sulfur dioxide and nitrogen oxides. Title IV called for a total reduction of about 10 million tons of SO_2 emissions from power plants. It was implemented in two phases. Phase I began in 1995, and limited sulfur dioxide emissions from 110 of the largest power plants to a combined total of 8.7 million tons of sulfur dioxide One power plant in New England (Merrimack) was in Phase I. Four other plants (Newington, Mount Tom, Brayton Point, and Salem Harbor) were added under other provisions of the program. Phase II began in 2000, and affects most of the power plants in the country. Click here to see a list of affected power plants in New England.

Emissions of nitrogen oxide and nitrogen dioxide, generally called NO_x, have been reduced by a variety of programs required under the Clean Air Act. NO_x is emitted by anything burning fuel, such as power plants, large factories, automobiles, trucks, and construction equipment.

In New England, between 1990 and 2000, we have seen a 25% decrease in NO_x emissions from all sources (from approximately 897,000 tons to 668,000 tons). Between 2000 and 2006, NO_x emissions from Acid Rain affected power plants in New England have further decreased by more than 31,000 tons. During that same period, SO_2 emissions from those power plants have decreased by 54% (from approximately 211,000 tons to 96, 500 tons).

During the 1990s, research has continued, and we are gradually developing a better understanding of acid rain and its effects on the environment. We are looking more closely at soil chemistry, and are seeing how acid rain has changed the balance of calcium, aluminum, and other elements.

The success of the Acid Rain Program has led to consideration of other programs based on setting an emissions cap. The NO_x budget program which began in 1999, places a limit on NO_x emissions from power plants and some other sources during the warmer months of the year. Its purpose is to control ground level ozone, but it will have some effect on acid rain also. Massachusetts, New Hampshire, and Connecticut have designed their own programs to further limit emissions of NO_x and SO_2. Connecticut's rule contributed to a 68% decrease in SO_2 emissions from large sources from 2001 to 2002.

On March 10, 2005, EPA issued the Clean Air Interstate Rule (CAIR) . This rule provides states with a solution to the problem of power plant pollution that drifts from one state to another. CAIR will permanently cap emissions of SO_2 and NO_x in the eastern United States. When fully implemented, CAIR will reduce SO_2 emissions in 28 eastern states and the District of Columbia by over 70 percent and NO_x emissions by over 60 percent from 2003 levels.

We have made significant progress in reducing acid rain, but we still have much work to do.

Environmental Effects of Acid Rain

The most obvious environmental effect of acid rain has been the loss of fish in acid sensitive lakes and streams. Many species of fish are not able to survive in acidic water. Acid rain affects lakes and streams in two ways: chronic and episodic. Chronic, or long-term acidification results form years of acidic rainfall. It reduces the alkalinity (buffering capacity) and increases the acidity of the water. Chronic acidification may reduce the levels of nutrients such as calcium, which, over time, may weaken the fish and other plants and animals in an aquatic ecosystem. Episodic acidification is a sudden jump in the acidity of the water. This can result from a heavy rainstorm. It also happens in the spring, because the sulfates and nitrates will concentrate in the lowest layers of a snowpack. In the spring, when that snow melts, it will be more acidic than normal. Episodic acidification can cause sudden shifts in water chemistry. This may lead to high concentrations of substances such as aluminum, which may be toxic to fish.

Most of the effects on forests are subtle. Acid deposition may influence forest vegetation and soils. Acid rain weakens the trees' natural defenses, making them more vulnerable to diseases. Acid rain has been cited as a contributing factor to the decline of the spruce-fir forests throughout the Eastern United States. Acid rain may remove soil nutrients such as calcium and magnesium from soils in high elevation forests and cause damage to needles of Red Spruce. Acid rain may also help weaken natural defenses of some trees, making them more vulnerable to some diseases and pests.

Acid rain deposits nitrates that can lead to increases in nitrogen in forests. Nitrogen is an important plant nutrient, but some forest systems may not be able to use all they receive, leading to nitrogen saturation. In the Eastern United States, there is evidence of nitrogen saturation in some forests. Nitrates can remove additional calcium and magnesium from the soils. Continued nitrogen deposition may alter other aspects of the nutrient balance in sensitive forest ecosystems and alter the chemistry of nearby lakes and streams.

Excess nitrogen may cause eutrophication (over nourishment) in areas where rivers enter the ocean. This may lead to unwanted growth of algae and other nuisance plants. As much as 40% of the total nitrogen entering coastal bays on the Atlantic and Gulf Coasts may come from atmospheric deposition. Table I shows estimates of the percentage of nitrogen deposition which comes from the atmosphere.

TABLE I

Nitrogen Input from the Atmosphere (as % of Total Nitrogen Input) to Selected New England Bays and Estuaries

Bay	Atmospheric Contribution
Casco Bay (ME)	About 40%
Massachusetts Bay (MA)	5-27%
Waquoit Bay (MA)	29%
Narragansett Bay (RI)	4-12%
Long Island Sound (CT)	About 20%

(Source: EPA's Great Waters Report)

Acid rain can react with aluminum in the soil. Trees can not absorb naturally occurring aluminum, but acid rain may convert it to aluminum sulfate or aluminum nitrate. These can be absorbed by the trees, and may adversely affect them.

Acid rain has not been shown to be harmful to human health, but some of the particles which can be formed from sulfate and nitrate ions can affect respiration. They can be transported long distances by winds and inhaled deep into people's lungs. Fine particles can also penetrate indoors. Many scientific studies have identified a relationship between elevated levels of fine particles and increased illness and premature death from heart and lung disorders, such as asthma and bronchitis.

Acid deposition has also caused deterioration of buildings and monuments. Many of these are built of stone, that contains calcium carbonate. Marble is one such material. The acid rain can turn the calcium carbonate to calcium sulfate. The calcium sulfate can crumble and be washed away. (related to embedded task)