Power Plants and Acid Rain

Environmental Issues

What is acid rain?

Acid deposition—the proper and more comprehensive term for what is commonly called "acid rain"—can occur when airborne sulfur oxides (SO_x) and nitrogen oxides (NO_x) undergo chemical reactions in ambient air to produce sulfates and nitrates. These sulfates and nitrates can exist in the atmosphere as mildly acidic gases or particles. Sulfates and nitrates can settle on the vegetation and ground with rain or snow (wet deposition or acid precipitation); alternatively, sulfates and nitrates may settle without any precipitation (dry deposition).

Where does it come from?

Cars, trucks, and stationary sources burning fossil fuels (such as power plants) contribute to acid deposition. SO_x, emitted from coal and oil (including diesel) combustion, can transform into sulfates; NO_x, emitted by combustion of all fossil fuels, can transform into nitrates. Power plants account for approximately one-quarter of NO_x emissions and over half of SO_x emissions in the United States.

What are the effects of acid deposition?

Acid deposition does not adversely affect human health at ambient levels found in North America. [The potential health effects associated with fine sulfate and nitrate particles are addressed under regulations for fine particles (see the Electric Power Research Institute (EPRI) *environmental issues* sheet, *Power Plants and Particulate Matter*).]

In most cases, acid deposition does not harm aquatic and forest ecosystems. Under some circumstances, however, forest and aquatic ecosystems are susceptible to damage. For example, lakes that are naturally low in buffering capacity (ability to neutralize acidity) in some regions of the Northeast have exhibited signs of acidification since the dawn of the industrial era. Some high-elevation, slow-growing spruce-fir forests in the Northeast are sensitive and could be affected if soil naturally high in nitrogen approaches or reaches nitrogen saturation. Conversely, tree growth in some nitrogen-deficient forests may increase in response to elevated nitrogen deposition. (Nitrogen deposition is also influenced by the deposition of ammonia gases and particles.) The gradual leaching of soil nutrients from sustained acidic inputs could eventually impede forest growth in several areas. The potential risks depend upon several factors, including deposition, soil properties, age of forest, weathering rates, species, and disturbance history. Acid deposition may also affect forest health by increasing the mobility of toxic aluminum compounds due to higher soil water concentrations and by reducing the frost hardiness of red spruce. Episodic high surface-runoff flows (e.g., snowmelt) can cause problems in fish populations inhabiting adjacent streams. Overall, the magnitude and extent to which forest and aquatic ecosystems may have been affected (or continue to be) by acid deposition remain uncertain. Acid deposition, especially dry deposition, may also speed the weathering of statues, monuments, and other structures, particularly those made of limestone and marble.

What trends are occurring in acid deposition and its effects?

Over the past 15 years, reductions in sulfur-oxide emissions by power plants and other sources have significantly reduced the acidity and the sulfate concentration of precipitation falling at deposition monitoring sites throughout the eastern half of the country. Modest reductions in nitrate concentrations have occurred in the Northeast and Mid-Atlantic sites, but other regions in the eastern United States have not shown much improvement.

Overall, lake and stream acidity has decreased in response to lower emissions of SO_x and NO_x. There is evidence of recovery from acidification in Adirondack and Upper Midwest lakes, as well as in Northern Appalachian streams; however, the acidity levels in the New England lakes have remained fairly constant. Surface-water acidity results from many environmental factors, including: atmospheric deposition, soil properties, geology, vegetation, hydrology, land-use history, aquatic ecology, and climate.

The Clean Air Act Amendments of 1990 established programs to reduce SO_x and NO_x emissions.

During the 1960s and 1970s, researchers from the United States, Canada, and Europe associated acid deposition with forest damage and lake acidification. Between 1980 and 1990, significant resources were spent by federal agencies (chiefly through the National Acid Precipitation Assessment Program, or NAPAP) and by others, including EPRI, on research, field monitoring, and assessment of the effects of acid deposition on the environment. Results of those studies helped lead to the Clean Air Act Amendments of 1990, which established a limit on the total amount of SO_2 emissions in the United States (virtually all sulfur oxides are emitted as SO_2) as well as a goal for the reduction of NO_x emissions. Rules emanating from the legislation allocated SO_2 "allowances" among emitters and established provisions for banking and trading of such allowances. This market-based approach has enabled power producers to individually choose their optimal combination of technology retrofits, fuel switching, and participation in the allowance market, thereby lowering the cost of compliance.

Power plants have made considerable reductions in SO_2 and NO_x emissions.

By 2002, power plants had reduced SO_2 emissions by more than 40% relative to 1980 levels (the reference year cited in the 1990 Clean Air Act Amendments) and had reduced NO_x emissions by more than one-third, all while increasing power-plant output by over 60%. As a result of these reductions in emissions, scientists have observed a decrease in the acidity of precipitation falling at the more than 100 government monitoring sites throughout the eastern half of the United States. Power-plant emissions will continue to be reduced throughout the remainder of the decade as the acid rain provisions of the Clean Air Act are fully implemented and in response to new regulations.

Questions remain regarding the extent and timetable for recovery of complex ecosystems due to the reduction in acidic deposition.

Since 1990, minimal research on acidic deposition has taken place in the United States. Evidence of lake and forest recovery from acidification exists in some places but not in others. To better understand this phenol-menon, research is needed to further investigate acid deposition impacts and recovery pathways for a variety of complex ecosystems.

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