Acid Deposition

What Is Acid Deposition?

Acid deposition includes acid rain, snow, fog, humidity and dust with an acidity level lower than pH 5.6. Normal rain, which has a pH of about 5.6, is about 25 times more acidic than "pure," neutral water. The acidity results from the conversion of atmospheric carbon dioxide in water vapor to carbonic acid, a weak acid. Most acid precipitation has a pH between 4.6 and 5.6, but scientists occasionally have measured pH values in acid rain in the eastern U.S. as low as 2.1 and 3.0, which is about 10,000 to 80,000 times more acidic than pure water.

From Where Does It Come?

Nearly 95% of the acidity below pH 5.6 comes from atmospheric sulfur dioxide and nitrogen oxides, which are products of fossil fuel combustion. Acidified rainwater contains combinations of sulfuric and nitric acids that form when water vapor, and sulfur dioxide and nitrogen oxides react. Most of the acid deposition in the eastern U.S. is attributed to the release of large amounts of sulfur dioxide and, to a lesser extent, nitrogen oxides from big mid-western power plants that burn coal. Paper and wood pulp processing plants also contribute to sulfur dioxide pollution. In the U.S. and Canada, sulfur dioxide contributes much more to acid deposition than nitrogen oxides, which come mainly from automotive emissions, but over the next few decades, nitrogen oxides may catch up. Sulfur and nitrogen oxides may be transported by the wind in the atmosphere for many miles, crossing regional and international boundaries, before falling to Earth.

What Are Its Effects?

The effects of acid rain may not be immediately apparent. For example, at a glance, a lake might look clear and beautiful, but a closer look may reveal few living organisms. Some species of fish cannot reproduce in water with a pH of less than 5. Clams, snails, crayfish and other crustaceans, brook trout, walleyed pike and bullfrogs are especially sensitive to acidification. However, the detrimental impact of acidification to animal life is not necessarily caused directly by the acidity. Trace metals such as aluminum, mercury, manganese and cadmium, which are leached from sediment and rocks by the increased acidity, are toxic to life. Thus, the pH does not have to decrease very much before fish kills can occur. Because many insects cannot survive in strongly acidic streams and lakes, birds and mammals that depend on insects for food may suffer abnormally high mortality. Acidification also interrupts normal decomposition of dead plant and animal material in lakes and streams because many of the bacteria that assist in decomposition perish. Without the usual decomposition processes, dead material settles to the bottom, making the water look crystal clear.

The damaging effects of acid deposition on forests and other terrestrial systems are less well understood than on aquatic systems. Acid deposition can alter soil chemistry, nutrient availability and plant growth. In their weakened condition, trees and shrubs become vulnerable to insects, diseases and fungus infestations.

Although the Norwegians were the first to bring acid rain to the world's attention in the 1940s, one of the most severely impacted areas of the world is the industrialized Ruhr Valley in West Germany. There, white fir trees became defoliated and died in the early 1970s. Diseases in spruce and other sensitive conifers soon followed, and by 1985, the number of German trees visibly affected by acid deposition had risen to 52%. Forests in other parts of the world also display acid deposition damage. For example, the dominant tree in Vermont's Green Mountains, the red spruce, is suffering severe mortality and parts of the mountain range have become denuded. Sugar maples all over the northeastern U.S. and Canada are declining. In the Shenandoah and Great Smokey Mountains of the southeastern U.S., spruce and fir are failing to reproduce and are dying. Pine also are impacted.

How Do We Recognize It?

Particulate matter containing atmospheric sulfur dioxide and nitrogen oxide account for over 50% of the visibility problems in the eastern U.S. In the West, these particles have been blamed for reducing visibility in the Grand Canyon of the Colorado River and other areas. Acid deposition contributes to the corrosion of metals and the deterioration and soiling of the stone and paint on buildings, statues, and other structures of cultural significance.

How Do We Reduce Its Effects?

The U.S. federal government has undertaken a wide range of research programs, many through the National Acid Precipitation Assessment Program, to study the complex processes associated with acid rain. To measure acid deposition quantity and chemistry, scientists collect rainfall samples at monitoring stations throughout the U.S. Monitoring dry deposition such as acid dust is difficult and, consequently, has not been as extensive as that for wet deposition.

The Clean Air Act Amendments of 1990 established an Acid Rain Program to reduce emissions of sulfur dioxide and nitrogen oxides at the lowest cost to society. To achieve reductions of 10 million tons of sulfur dioxide by the year 2010, the Act requires a two-phase tightening of the restrictions placed on fossil-fuel-fired power plants. Phase I began in 1995 and affects 110 coal burning electric utilities in 21 mid-western and eastern states. Phase II began in 2000 and tightens annual emissions on the large plants and also sets restrictions on smaller, cleaner plants burning coal, oil and gas. To achieve reductions of 2 million tons of nitrogen oxides by 2000, the Act requires coal-fired utilities to install low-nitrogen-oxide technologies on their burners.

To reduce sulfur dioxide emissions, fossil fuel burning plants can burn low-sulfur coal, install flue-gas desulphurization equipment (scrubbers) and implement clean combustion technologies. Low-sulfur coal contains about 1% sulfur by weight and is found mainly in the western U.S. High-sulfur coal contains sulfur in excess of 3% and is geographically concentrated in the Appalachians where coal utilization is greatest. Scrubbers are effective at reducing air pollution, but the sludge they produce creates a disposal problem. Also, they are expensive to build and operate. Clean combustion technologies involve mixing fuels with compounds that react with sulfur and either collect it or convert it to a marketable product that does not enter the stack. Many of these innovative technologies have the added advantage of removing nitrogen oxides as well. Because emissions from motor vehicles are a major source of nitrogen oxides, catalytic converters are used to reduce nitrogen oxides from automotive sources.

Source: Project A.I.R.E., U.S. Environmental Protection Agency, http://www.epa.gov/region01/students/teacher/aire.html.