87-399

WATER FACT SHEET

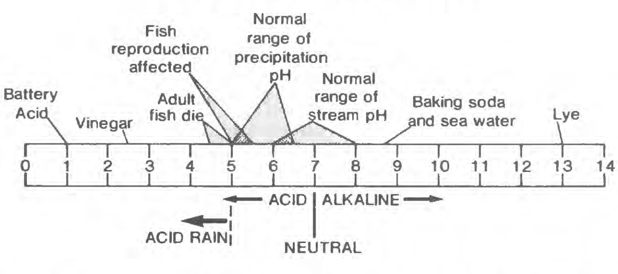
U.S. GEOLOGICAL SURVEY, DEPARTMENT OF THE INTERIOR

ACID RAIN

WHAT IS ACID RAIN?

The term "acid rain" commonly is applied to all forms of atmospheric deposition of acidic substances. It includes rain, snow, fog, dew, acidic particles, and acid-forming gases. Acids form when certain atmospheric gases, primarily carbon dioxide, sulfur dioxide, and nitrogen oxides, come in contact with water in the atmosphere or on the ground and are chemically converted to acidic substances. Oxidants play a major role in several of these acid-forming processes. Carbon dioxide dissolved in rain is converted to a weak acid (carbonic acid); other gases, primarily oxides of sulfur and nitrogen, are converted to strong acids (sulfuric and nitric acids). Strong acids can decrease the pH of precipitation to less than 5.6, the pH of pure water in equilibrium with atmospheric carbon dioxide. Although rain is naturally slightly acidic because of carbon dioxide and natural emissions of sulfur and nitrogen oxides and certain organic acids, human activities can make it much more so. Occasional pH readings of well below 2.4, the acidity of vinegar, have been reported for rain and fog in large cities and highly industrialized areas.

MEASURING ACIDITY--pH SCALE



WHERE DOES ACID RAIN COME FROM?

The principal natural phenomena that contribute acid-producing gases to the atmosphere are emissions from volcanoes and from biological processes that occur on the land, in wetlands, and in the oceans. Principal manmade sources are industrial and power-generating plants and transportation vehicles. The gases may be carried hundreds of miles in the atmosphere before they are converted to acids and deposited. The effects of acidic deposition unrelated to man have been detected in glacial ice thousands of years old in remote parts of the globe.

Since the industrial revolution, emissions of sulfur and nitrogen oxides to the atmosphere have increased. Industrial and energy-generating facilities that burn fossil fuels, primarily coal, are the principal sources of increased sulfur oxides, and those same sources, plus the transportation sector, are the major sources of the increased nitrogen oxides. Volatile organic compounds, which produce oxidants that convert the sulfur and nitrogen oxides to sulfuric and nitric acid, come from industrial processes involving organic chemicals and from the transportation sector, as well as from significant natural sources. The problem of acid rain has not only increased with population and industrial growth, but it has also become more widespread. The use of tall smokestacks to reduce local pollution has contributed to the spread of acid rain by releasing gases into regional atmospheric circulation. The same remote glaciers that provide evidence of natural variability in acidic deposition show in their more recently formed layers the increased deposition caused by human activity during the past half century.

WHAT ARE THE EFFECTS OF ACID RAIN?

Preliminary scientific investigations suggest that acids in atmospheric deposition may damage the environment by:

- Acidifying lakes, streams, and ground water in sensitive watersheds, resulting in damage to fish and other aquatic life;
- Affecting human health indirectly through contamination of drinking water and food supplies by toxic metals leached from soils, pipes, and other metal-bearing substances; and
- Contributing to the deterioration of manmade structures such as buildings and statues, exposed metal surfaces, and possibly paint or other surface coatings.

Although long-term exposure to acid rain may be detrimental to forests already under stress from other sources, much of the observed forest damage originally thought to be due solely to acid rain appears to be due to oxidants, such as ozone and hydrogen peroxide, in combination with other stresses such as disease, drought, insect infestation, and other air pollutants. The same combination of stresses appears to affect agricultural crops.

Many of the field studies designed to verify a connection between acid rain and deterioration of the environment have yielded ambiguous results to date because of the complexity of the processes involved and the absence of high-quality historical and long-term data on the composition of atmospheric deposition. However, substantial progress has been made as a result of intensified research by government agencies, universities, and private industry since the problem was generally recognized in the early 1970's.

WHAT CAN BE DONE ABOUT ACID RAIN?

Natural emissions from volcanoes, forests, and oceans cannot be prevented, but emissions from some of the other sources can be reduced. For example, conserving energy, use of fossil fuels that have a low sulfur content, removal of sulfur from coal prior to combustion, use of improved combustion techniques and equipment, and application of methods to prevent release of volatile organic compounds to the atmosphere can help control the sources of acid rain.

Beneficial effects of the Clean Air Act of 1970 have moderated the extent of the acid-rain problem in the United States. Manmade emissions of sulfur dioxide have decreased by about 28 percent since reaching a peak in 1973. In the Northeast, sulfur-dioxide emissions from coal-fired power plants have decreased by 19 percent even though coal consumption has increased by 24 percent. Significant progress has been made in reducing automobile emissions of nitrogen oxides and volatile organic compounds through the use of emission control devices on newer cars. Further progress can be expected as the older cars are replaced by the newer, more stringently controlled vehicles. Emissions of nitrogen oxides and volatile organic compounds leveled off in the early 1970's after rising sharply since the 1940's. Provisions of the Clean Air Act are commonly given credit for preventing continuation of that rise in spite of increases in power production and the number of motor vehicles in use.

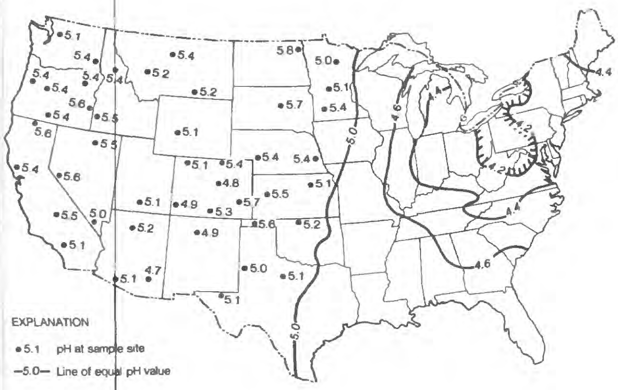
Some lakes and soils are naturally resistant to the effects of acid rain because they are underlain by limestone or other carbonate rocks that react rapidly to neutralize acids. Small lakes and ponds in more sensitive areas might be treated to counteract the effects of acid rain. However, ecological interactions are complex and the consequences of prevention and treatment measures are difficult to predict.

In order to make effective decisions about further efforts to control acid rain, public officials need to know more about the long-range transport of atmospheric pollutants and about the quality and distribution of precipitation. They also need more information about the geological and biological factors that determine sensitivity and tolerance of watersheds and vegetation to acid rain, and the relationships between the causes of acid rain and the ways in which it affects the environment.

HOW IS THE U.S. GEOLOGICAL SURVEY MONITORING ACID RAIN?

The U.S. Geological Survey (USGS), in cooperation with other Federal, State, and private agencies, collects and interprets data and provides public officials with information required to make management decisions about controlling emissions that can produce acid rain.

The USGS was selected by the Interagency Task Force on Acid Precipitation to be the lead Federal agency for monitoring atmospheric deposition and air quality under the National Acid Precipitation Assessment Program (NAPAP). As part of this responsibility, a National Trends Network of precipitation-collection sites has been designed to monitor the chemical composition of precipitation. The network consists of 150 precipitation-collection stations in the United States. Unlike previous precipitation networks, the National Trends Network includes geographically distributed sites that represent each major ecosystem in the country. The USGS, in cooperation with Federal, State, and local agencies, also operates an extensive water-quality monitoring network on lakes and streams in which parameters that are related to the effects of acid rain are measured. At several of these monitoring sites, comprehensive studies of all sources of water in each watershed are being conducted to define the hydrologic and geochemical processes by which acid rain affects water quality.



Volume-weighted annual average pH of precipitation—1986. (Based on data from the National Atmospheric Deposition Program and the National Trends Network.) Decimal point indicates approximate location of sample site; not all sites are shown.

The USGS also is the lead agency under NAPAP for research on the effects of acid rain on manmade materials. Studies are being conducted to determine the processes by which acid rain contributes to the deterioration of monuments and buildings constructed of limestone and marble, and to develop a basis for quantifying that damage.

Information on water quality and bedrock type gathered over many years by the USGS was used to identify and map terrains expected to have a limited capability for neutralizing acid rain and thus to contain the lakes and streams that are most susceptible to acidification.

In the northern parts of the country and in high mountain areas where much of the annual precipitation is snow, the USGS has measured the chemical composition of the snow and the acidity of the snowmelt. Acids and toxic metals accumulate in snowfall, are stored in the winter snowpack, and are released early in the spring runoff. The concentrated release of acid may produce environmental shock comparable to that from the cumulative effect of several years of acid rain.

The effects of manmade emissions on acid rain and of acid rain on environmental quality are being addressed by the USGS in these studies. The results will help public officials make better decisions on acid rain policy issues.

For further information on technical reports, overview reports, and hydrologic data contact:

Hydrologic Information Unit
U.S. Geological Survey
419 National Center
Reston, Virginia 22092

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R.J. Pickering
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