Acid Rain

Rain more acid than normal. Natural rain and snow is slightly acidic (pH 5.6) because of the carbon dioxide dissolved in it. But over recent decades, rain in North America and Europe downwind of industrial areas has had a pH close to 4.5 and sometimes as low as 2.1 (equivalent to lemon juice).

Sulfur dioxide

The evidence is very strong that most of this acidity is caused by sulfur dioxide released from the smokestacks of coal-burning power plants and other industrial sources. The sulfur dioxide is converted into sulfuric acid. This may be carried to the ground in rain or snow, but often particles containing sulfuric acid settle out of dry air. So the problem of acid rain is really one of acid deposition in dry weather as well as wet.

Nitrogen oxides

Nitrogen oxides ("NO_x"), which are converted into nitric acid, also contribute to acid deposition. Automobile exhaust accounts for 50% or more of the nitrogen oxides in polluted air.
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Types of damage

Acid rain has been held responsible for damaging buildings and statues made of limestone (true - view an example), damaging aquatic life in lakes (true), causing a decline in the vigor of U.S. and European forests (may be partially responsible), and harming human health (doubtful).

Sensitive areas

There is solid evidence that lakes in certain "sensitive" areas of North America and Europe have become more acid in recent decades. Sensitive areas are downwind of major industrial areas and where the underlying rock is granite rather than limestone. In North America, the Adirondacks of New York, the mountains of northern New England as well as large areas of southern Quebec have been particularly hard hit. Both the plant and animal life in a lake become altered as the pH drops. The productivity of the lakes, and their content of desirable fish, decline.

The role of smokestacks

Coal burning by heavy industry was going on long before the lakes of northeastern North America began to show signs of damage. Their acidification seems to have coincided with the trend to build very tall smokestacks (often more than 500 feet high). This was done to reduce local air pollution, but the result has been simply to transfer the problem further downwind.

Polluted air masses can cross political boundaries

Acid rain does not respect political boundaries. The lakes of Norway and Sweden suffer from the air pollution generated by the industrial areas to their south and southwest. Canadians are distressed by the damage from the air pollution generated by the industrial heartland of the U.S. The U.S. is not entirely to blame for their problems, however. Sensitive areas in Quebec are also downwind of the smelters in Sudbury, Ontario, which have the dubious distinction of generating more sulfur dioxide pollution than any other place in the entire world.

Current trends

Since the early 1980s, emissions of sulfur dioxide have been reduced in both Europe and North America. Even though nitrogen oxides have not been reduced proportionally, the result has been a reduction in the amount of acid deposition. This seems to have stopped the acidification of lakes but not yet reversed it. The technology exists to generate electricity from coal with greatly reduced emissions and as this technology comes into use, that aspect of the problem should improve.

What about forests?

Not enough is yet known to be certain, but my guess is that sulfur dioxide will turn out to have only a supporting role to play and that the major culprit will turn out to be **ozone**. Air pollution by ozone, like that by nitrogen oxides, is largely a matter of automobile exhaust.

Sandstone figure over the portal of a castle in Westphalia, Germany, photographed in 1908 (left) and again in 1968 (right). Acid rain produced by air pollution generated in the heavily industrialized Ruhr region of Germany probably accounts for the severe damage. The castle was built in 1702. (Photos courtesy of Herr Schmidt-Thomsen.)

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