

Acid Precipitation

Objectives

- ▶ Explain the causes of acid precipitation.
- ▶ Explain how acid precipitation affects plants, soils, and aquatic ecosystems.
- ▶ Describe three ways that acid precipitation affects humans.
- ▶ Describe ways that countries are working together to solve the problem of acid precipitation.

Key Terms

acid precipitation
pH
acid shock

Imagine that you are hiking through the forests of the Adirondack Mountains in New York. You come to a lake and sit down to rest. You are amazed at how clear the water is; it is so clear that you can see the bottom of the lake. But after a few minutes you feel uneasy. Something is wrong. What is it? Suddenly, you realize that the lake has no fish.

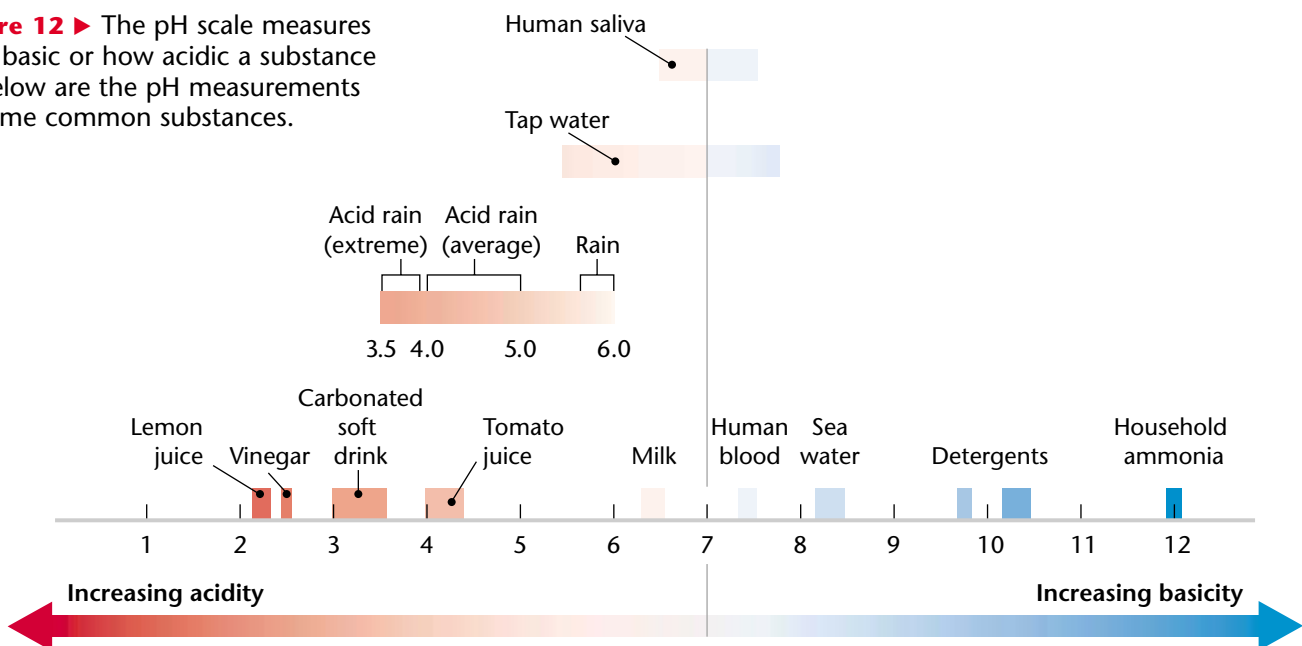
What Causes Acid Precipitation?

This lake and thousands of lakes throughout the world are victims of acid precipitation, which is also known as acid rain.

Acid precipitation is precipitation such as rain, sleet, or snow that contains a high concentration of acids. When fossil fuels are burned, they release oxides of sulfur and nitrogen. When the oxides combine with water in the atmosphere, they form sulfuric acid and nitric acid, which fall as acid precipitation. This acidic water flows over and through the ground, and into lakes, rivers, and streams. Acid precipitation can kill living things, and can result in the decline or loss of some local animal and plant populations.

A **pH** (power of hydrogen) number is a measure of how acidic or basic a substance is. A pH scale is shown in **Figure 12**. As you can see from the scale, the lower the pH number is, the more acidic a substance is; the higher a pH number is, the more basic a substance is. Each whole number on the pH scale indicates a tenfold change in acidity.

Figure 12 ▶ The pH scale measures how basic or how acidic a substance is. Below are the pH measurements of some common substances.



Pure water has a pH of 7.0. Normal precipitation is slightly acidic, because atmospheric carbon dioxide dissolves into the precipitation and forms carbonic acid. Normal precipitation has a pH of about 5.6. Precipitation is considered acid precipitation if it has a pH of less than 5.0. **Figure 13** shows how acid precipitation forms.

The pH of precipitation varies between different geographic areas. For example, Eastern Europe and parts of Scandinavia have precipitation with a pH of 4.3 to 4.5, whereas the remainder of Europe has precipitation with pH values of 4.5 to 5.1. The pH of precipitation in the eastern United States and Canada ranges from 4.2 to 4.8. The most acidic precipitation in North America occurs around Lake Erie and Lake Ontario. It has a pH of 4.2.

How Acid Precipitation Affects Soils and Plants

Plant communities have adapted over long periods of time to the acidity of the soil in which they grow. Acid precipitation can cause a drop in the pH of soil and water. This increase in the concentration of acid is called *acidification*. Acidification changes the balance of a soil's chemistry in several ways. When the acidity of soil increases, some nutrients are dissolved and washed away by rainwater. Increased acidity causes aluminum and other toxic metals to be released and possibly absorbed by the roots of plants. Aluminum also causes root damage. Sulfur dioxide in water vapor clogs the openings on the surfaces of plants. **Figure 14** shows the harmful effects of acid precipitation on trees.

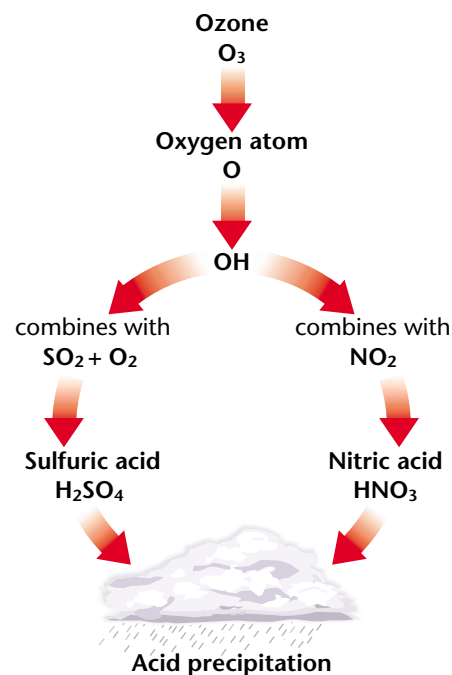


Figure 13 ► Sulfur oxides and nitrogen oxides combine with water in the atmosphere to form sulfuric and nitric acids. Rainfall that contains these acids is called *acid precipitation*.



Figure 14 ► The trees in this forest in Poland show the dramatic effect that acid precipitation can have on plants. Damage to more than 16 million acres in nine European countries has been linked to acid precipitation.



Figure 15 ► Fish are vulnerable to acid shock, a sudden influx of acidic water into a lake or stream that causes a rapid change in pH.

QuickLAB



Neutralizing Acid Precipitation



Procedure

1. Pour 1/2 Tbsp of **vinegar** into one cup of **distilled water**, and stir the mixture well. Check the pH of the mixture by using **pH paper**. The pH should be about 4.
2. Crush one stick of **blackboard chalk** into a powder. Pour the powder into the vinegar and water mixture. Check the pH of the mixture.

Analysis

1. Did the vinegar and water mixture become more or less acidic after the powdered chalk was poured in?

Acid Precipitation and Aquatic Ecosystems

Aquatic animals are adapted to live in an environment with a particular pH range. If acid precipitation falls on a lake and changes the water's pH, acid can kill aquatic plants, fish, and other aquatic animals. The change in pH is not the only thing that kills fish. Acid precipitation causes aluminum to leach out of the soil surrounding a lake. The aluminum accumulates in the gills of fish and interferes with oxygen and salt exchange. As a result, fish are slowly suffocated.

The effects of acid precipitation are worst in the spring, when acidic snow that accumulated in the winter melts and rushes into lakes and other bodies of water. This sudden influx of acidic water that causes a rapid change in the water's pH is called **acid shock**. This phenomenon causes large numbers of fish in a population to die, as shown in **Figure 15**. Acid shock also affects the reproduction of fish and amphibians. They produce fewer eggs, and these eggs often do not hatch. The offspring that do survive often have birth defects and cannot reproduce.

To counteract the effects of acid precipitation on aquatic ecosystems, some states in the United States and some countries spray powdered lime (calcium carbonate) on acidified lakes in the spring to help restore the natural pH of the lakes. Because lime has a pH that is basic, the lime raises the pH of the water. Unfortunately, enough lime cannot be spread to offset all acid damage to lakes.

Acid Precipitation and Humans

Acid precipitation can affect humans in a variety of ways. Toxic metals such as aluminum and mercury can be released into the environment when soil acidity increases. These toxic metals can find their way into crops, water, and fish. The toxins then poison the human body.

Acid precipitation can lead to other human health problems. Research has indicated that there may be a correlation between large amounts of acid precipitation received by a community and an increase in respiratory problems in the community's children.

The standard of living of some people is affected by acid precipitation. Decreases in numbers of fish caused by the acidification of lakes and streams can influence the livelihood of commercial fisherman and people involved in the sport-fishing industry. Forestry is also affected when trees are damaged by acid precipitation.

Acid precipitation can dissolve the calcium carbonate in common building materials, such as concrete and limestone. Some of the world's most important and historic monuments, including those made of marble, are being affected by acid precipitation. For example, sulfur dioxide has caused black crusts to form on the carbonate stones of historic Greek monuments.

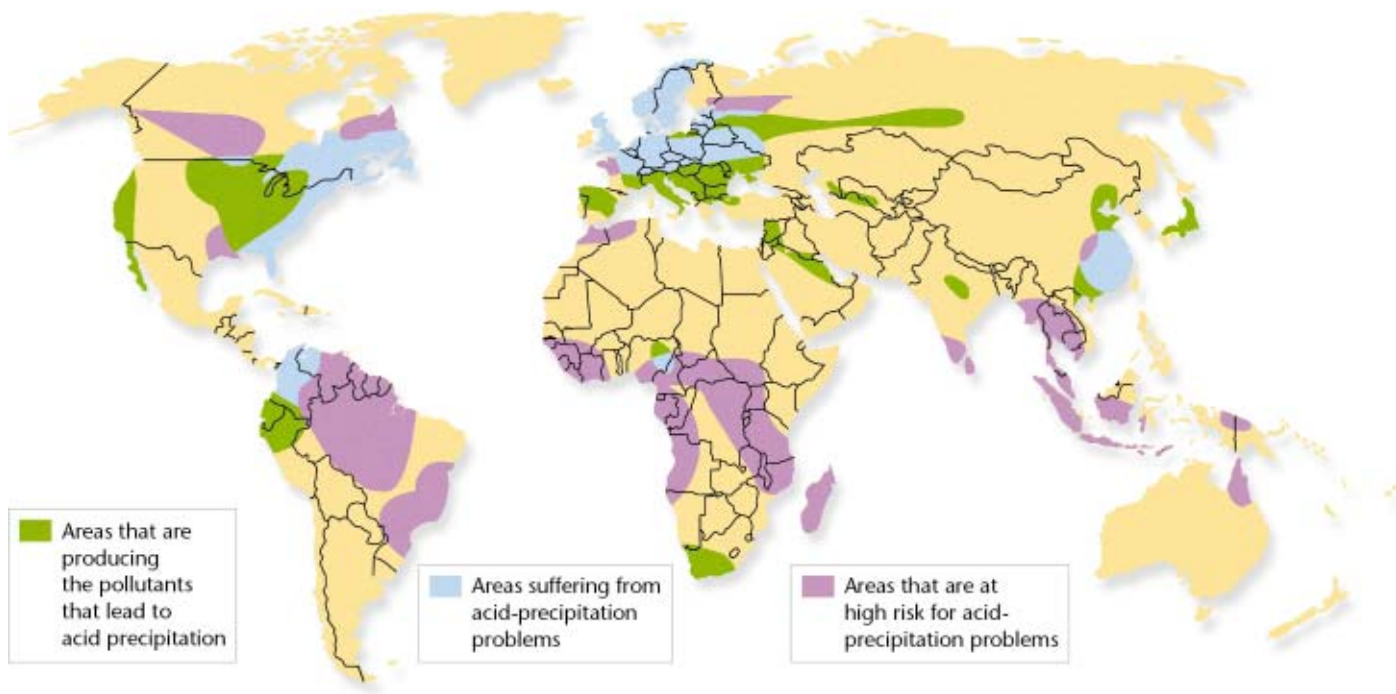


Figure 16 ▶ Acid precipitation is a global problem.

International Conflict and Cooperation

One problem in controlling acid precipitation is that pollutants may be released in one geographical area and fall to the ground hundreds of kilometers away. For example, almost half of the acid precipitation that falls in southeastern Canada results from pollution produced in Ohio, Indiana, Pennsylvania, Illinois, Missouri, West Virginia, and Tennessee. **Figure 16** shows areas of the world that produce pollutants and areas which are then affected by acid precipitation.

Because acid precipitation falls downwind, the problem of solving acid precipitation has been difficult, especially on the international level. In the spirit of cooperation, Canada and the United States signed the Canada–U.S. Air Quality Agreement in 1991. Both countries agreed to reduce acidic emissions that flowed across the Canada–U.S. boundary. More international agreements such as this may be necessary to control the acid-precipitation problem.

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SECTION 3 Review

1. **Explain** how acid precipitation forms.
2. **Describe** the harmful effects that acid precipitation can have on plants, soils, and aquatic ecosystems.
3. **Describe** three ways in which acid precipitation can affect humans.
4. **Describe** a way in which countries are working together to solve the problem of acid precipitation.

CRITICAL THINKING

5. **Inferring Relationships** In addition to negatively affecting forestry and the fishing industry, how might acid precipitation affect local economies?
6. **Analyzing Viewpoints** Write a short essay in which you discuss whether or not a country that releases significant amounts of pollutants into the air that fall as acid precipitation in another country should be expected to pay some of the costs of cleanup. **WRITING SKILLS**