

# Acid Rain

## Objectives:

The student will do the following:

1. Observe and explain a demonstration of the reaction of acid precipitation on limestone and granite materials.
2. Predict the possible effects of acid precipitation in our natural environment.

## Subjects:

Ecology/Environmental Science, Earth Science, Physical Science, General Science, Chemistry

## Time:

1 class period (plus optional exercise)

## Materials:

- crushed limestone (enough to fill a 2-liter container; available at garden supply)
- crushed granite (enough to fill a 2-liter container; available at garden supply)
- (2) 3-liter soda bottles or 1-gallon plastic containers
- 1-gallon plastic bottle
- (2) clear 1-pint collecting containers
- sulfuric acid
- pH indicator solution
- distilled water
- water test kit or pH meter
- optional student sheet (included)

## Background Information

Normal rainfall is slightly acidic (pH 5.6, where 7.0 is neutral) because of reactions with atmospheric carbon dioxide which form carbonic acid. Rainfall with a pH of less than 5.6 is referred to as acid rain. Acid precipitation contains sulfuric and nitric acids. The sources of these acids are both natural and man-made. Acid rain is produced naturally through geothermal emissions and biological processes, but our heavy use of fossil fuels is the most significant contributor by far. Emissions from automobiles and other vehicles and from utilities and industries are the chief sources of acid-forming sulfur and nitrogen oxides. These compounds react with water to form acids. These acids reach the ground in rain and snow, finding their way into surface and groundwater systems. Sometimes the particles of oxidized material fall directly to the earth in dry form and combine with surface water to produce acids.

Acid deposition is a problem in much of the United States (U.S.), but the degree to which an area suffers from it varies according to the total acidity deposited and the area's sensitivity to that acidity. One factor in sensitivity is the geology of a particular area. In areas where the bedrock is limestone, acid precipitation can be neutralized to some degree by acid-base reactions; limestone's buffering action lessens its impact. In mountainous areas, the bedrock is usually granite, which does not neutralize acid. In such areas, acid rain enters surface and groundwater systems virtually unneutralized, causing the acidity of these systems to increase and affecting sensitive plants and animals.

## Procedure

- I. Prepare a demonstration of the reaction of acid precipitation with limestone and granite.
  - A. Cut off the bottoms of two clean 3-liter soda bottles (or 1-gallon plastic milk containers). Turn them upside down and support them so that they are stable. (These will be filled with rocks, so strong supports are needed.) Place about two liters of crushed granite in one container and the same amount of crushed limestone in the other. Place a 1-pint collecting container beneath the neck of each bottle.
  - B. Prepare simulated acid rain.
    1. Distill one gallon of tap water (or purchase a gallon of distilled water) and pour it into the clean container. Determine its pH (using a water test kit or pH meter).
    2. Carefully mix sulfuric acid into the distilled water to achieve a pH of 4.3 to 4.5. This will approximate the average range of acidities of rainfall in the Tennessee Valley.
- II. Share the background information for this activity with the students.
- III. Demonstrate the effects of the two rock materials on the pH of the simulated rainfall.
  - A. Place pH indicator solution in both collecting containers.
  - B. Slowly pour one-half of the "acid rain" solution into each container of crushed rock. Observe as the solution infiltrates the crushed rock and as the leachate flows into the collection containers.
  - C. Using the same means of determining pH as was used above, determine the acidity of the liquid in each collecting container.
  - D. Have the students record the data using a table like the following:

pH of acid rain	_____
pH of water after passing through the granite	_____
pH of water after passing through the limestone	_____

IV. Discuss the demonstration with the students. Make sure they understand what they have observed.

- A. Ask if there was a color change in the collection containers. If so, have the students explain this observation.
- B. The non-neutralized and the neutralized "acid rain" solutions were different colors, indicating different acidities resulting from contact with the rocks.
- C. Ask if there was a significant pH change in either container. If so, why do they think this has occurred?

The pH values obtained from the indicator chart show that there is a difference. Remember also that pH values are logarithmic, not linear, values and that a change from 5 to 6 means a power of 10 difference. A change from 5 to 7 means a power of 100 difference. The limestone neutralized some of the acid, but the granite did not.

V. You may want to have your students research the chemical formulae of limestone and the components of granite. This may enable some students to write the chemical equations for the neutralizing reaction and to see why the granite has no buffering action.

VI. Continue with the follow-up below.

## Follow-Up

I. Ask the students how acidic precipitation could affect water quality.

Even a slight change in pH of an aquatic habitat can have a significant effect on the small organisms which form the basis of aquatic food chains. In this way, wildlife can be greatly affected. Additionally, a pH change can change the normal concentrations of nutrients and other chemicals in the water. This too can have significant impacts on wildlife.

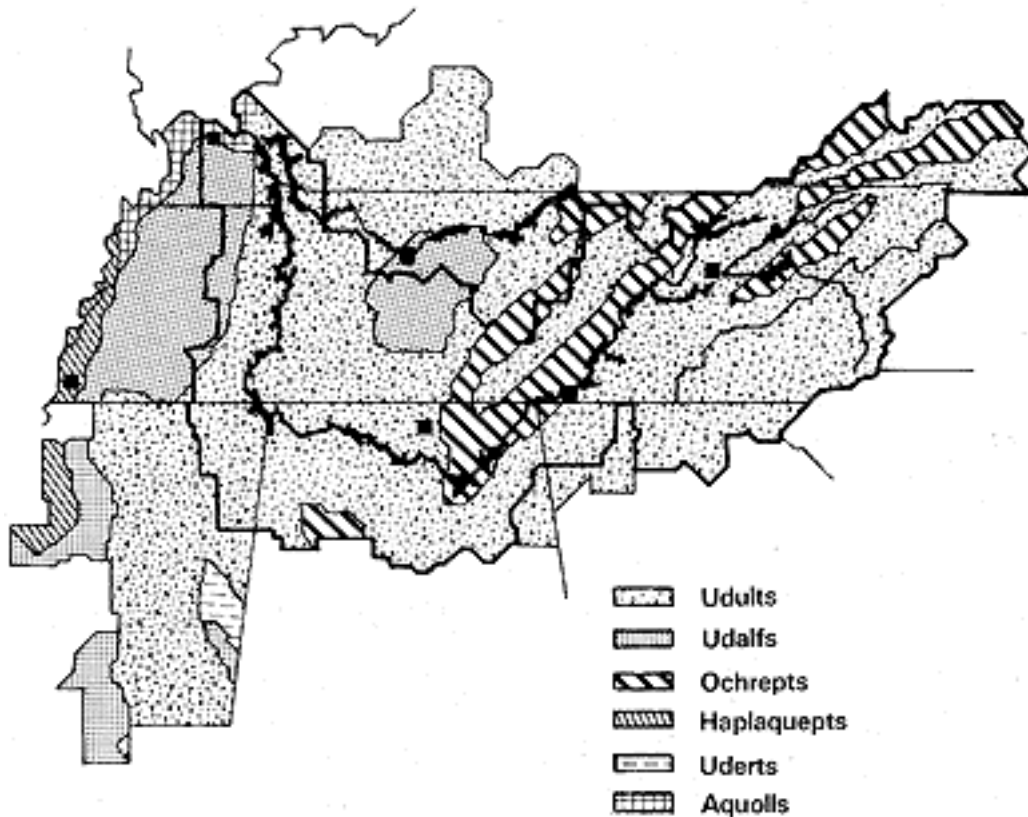
II. Ask the students to compare (from their knowledge and experiences) general trends in acid precipitation in the U.S. and abroad. Are they aware of the results of eastern and midwestern industrialization on the eastern U.S. and Canada? Can they explain the role of prevailing winds? Are they aware that Europe's problems with acid rain are worse than ours?

III. Extension

- A. What are the major sources of acid precipitation? Exactly how is it transmitted? Have the students contact the National Oceanographic and Atmospheric Administration (NOAA) for information on acid precipitation monitoring in the U.S. and in Canada. What do the students believe to be the best approach for reducing or eliminating acid rain?

- B. Collect some local bedrock samples for use in the above activity. Repeat the demonstration to determine if your local bedrock is an acid neutralizer. Regions with limestone rock have a natural ability to neutralize acid rain or other acidity and so are not generally affected as much as some other areas. On the other hand, regions with mostly granite rocks tend to be more sensitive to increases in the acidity of the environment.
- C. Using the student sheet "SOILS OF THE TENNESSEE VALLEY" (included), have the students predict the effects of acid rain on areas within the Valley region. Which area(s) is (are) most susceptible? They will need to look up more information on the soils, particularly the soils' parent materials (i.e. the bedrocks from which the soils were formed). This serves as an excellent introduction to the field of soil science.

## SOILS OF THE TENNESSEE VALLEY



Soils of the Tennessee Valley are usually moist, but they may become dry during summer. The predominant soil type is Udult, which is also the predominant soil type throughout the South. There are smaller proportions of Udalfs, Ochrepts, and Haplaquepts, as well as isolated areas of Uderts and Aquolls.

Udults (Order Ultisols) are moist, low-alkaline soils that have relatively low levels of organic matter below the surface. They are dry for very short periods, if at all. Udults are good soils for general farming, woodland, pasture, cotton, and tobacco.

Udalfs (Order Alfisols) are found in temperate and tropical regions. Although usually moist, Udalfs may become dry for short periods during the summer. Udalfs, found primarily in middle and west Tennessee, are good soils for row crops, small grains and pasture.

Ochrepts (Order Inceptisols) are soils that were formed from crystalline clay minerals. These light-colored soils, found in eastern Tennessee, northern Alabama, and the southwest corner of Virginia, support woodland, pasture, wheat, sorghum, hay, silage, and corn.

Haplaquepts (Order Inceptisols) are seasonally wet soils that have high levels of organic matter and sodium. Because these soils occur in association with the Mississippi River, they are found only along the extreme western border of the region. The Haplaquepts are used for pasture, hay, woodland, and (where drained) hardy vegetables.

Uderts (Order Vertisols) are usually moist soils. They have wide deep cracks that often open and close several times a year; however, these cracks do not stay open continuously for more than two months. Uderts are good soils for cotton, corn, small grain, pasture, and rice.

Aqolls (Order Mollisols) are seasonally wet soils that have a thick black surface horizon and gray subsurface horizons. Aqolls are used for pasture and, where drained, for small grains, corn, and potatoes.

Adapted from:

Tennessee Valley Authority. The First Fifty Years: Changed Land, Changed Lives. N.p.: Author, 1983.