Acid Rain

Target Grade Levels
Sixth - Tenth

Time
1 class period

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

Knowledge and Skills (TEKS)
- Science:
  - Scientific inquiry and critical thinking;
  - Ask questions about organism, objects, and events in the environment;
  - The student shall describe changes that occur to objects and organisms in the environment; and
  - Use scientific inquiry methods to plan and implement investigative procedures including asking questions, formulating testable hypotheses, collecting data, making measurements with precision, organize, analyze, predict trends, and communicate valid conclusions.
- Language Arts:
  - Communicate data and information in appropriate oral and written form;

Overview
Students will observe and explain a demonstration of the reaction of acid rain on different materials and predict the possible effects in our natural environment.

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 rain contains sulfuric and nitric acids due to the reaction of the water in the air with sulfur dioxide and nitrogen oxide. The sources of these pollutants are both natural and anthropogenic. Sulfur dioxide and nitrogen oxide are produced naturally through geothermal emissions and biological processes, but our heavy use of fossil fuels is the most significant contributor by far. Emissions from vehicles, from electric power, 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, called acid deposition, and then combine with surface water to produce acids.

Acid deposition, whether through rain, snow, or dust, is a problem in much of the United States, but the degree to which an area suffers from it varies according to the total acidity deposited and the area's sensitivity to that acid. 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

1) Vocabulary
   a) acid
   b) base
   c) buffer
   d) sulfur dioxide
   e) nitrogen oxides
   f) anthropogenic
   g) geothermal
   h) limestone
   i) granite
   j) atmosphere
   k) gas
   l) gaseous
   m) smog
   n) carbon dioxide
   o) pollution

2) Activities
   a) Share the background information for this activity with the students.
   b) Prepare a demonstration of the reaction of acid precipitation with limestone and granite.
      i) 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.
      ii) 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, a major electric power production area.
   c) Demonstrate the effects of the two rock materials on the pH of the simulated rainfall.
      i) Place pH indicator solution in both collecting containers.
      ii) 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.
      iii) Using the same means of determining pH as was used above, determine the acidity of the liquid in each collecting container.
      iv) Have the students record the data using a table like the following:
         (1) pH of acid rain ________
         (2) pH of water after passing through the granite ________
         (3) pH of water after passing through the limestone ________

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

   i) Ask if there was a color change in the collection containers. If so, have the students explain this observation.

   ii) The non-neutralized and the neutralized "acid rain" solutions were different colors, indicating different acidities resulting from contact with the rocks.

   iii) Ask if there was a significant pH change in either container. If so, why?

   iv) Teacher's Notes on Results—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.

e) 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 also see why the granite has no buffering action.

f) Continue with the follow-up below.

3) Review

   a) Discuss the concept of pH with regard to everyday items, such as ketchup, ammonia, baking soda, soda pop, etc. (Reference the ability of ketchup to "clean" off a penny – removing metal and pollution deposits that are then left in the ketchup. If streams are allowed to suffer from acid rain enough that they become as acidic as ketchup, they are more vulnerable to heavy metals pollution, etc.)

   b) Review some other types of rocks (dolomite, basalt, shale, etc.) and discuss how their chemical compositions might make them more or less able to buffer acid deposition. Discuss the type of bedrock in the local area and its buffering capabilities.

   c) Discuss methods for measuring and tracking rain acidity in the local area. Discuss local sources of nitrogen oxides and sulfur dioxides.

   d) Discuss wind patterns that might bring nitrogen oxides and sulfur dioxides here from other parts of the state, nation, and globe.

4) Evaluation

   a) Ask the students how acidic precipitation could affect water quality.

   b) 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.

   c) Ask the students to compare (from their knowledge and experiences) general trends in acid precipitation in the U.S. and abroad.

i) Are they aware of the results of eastern and midwestern industrialization on the eastern U.S. and Canada?

ii) Can they explain the role of prevailing winds?

iii) Are they aware that Europe's problems with acid rain are worse than ours?

5) 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 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 acidity environment.

c) Use acidic water to water both land and aquatic plants

d) Study decomposition of major historical pieces due to acid rain (i.e. Roman statues, pyramids, etc.)

e) Study the major wind patterns across the continental United States, and then research inter-state acid precipitation problems, write a report discussing findings.

Adapted from: “Acid Rain” *Alliance To Save Energy.* www.ase.org/educators/download.htm.