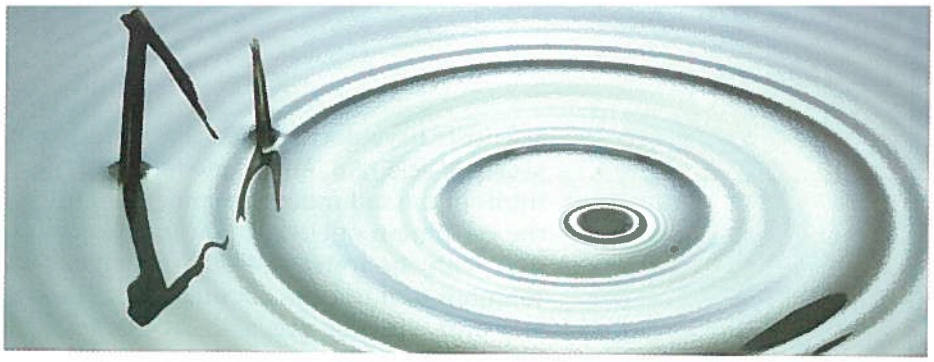
INVESTIGATION

28



Acid Rain

Lab

PURPOSE

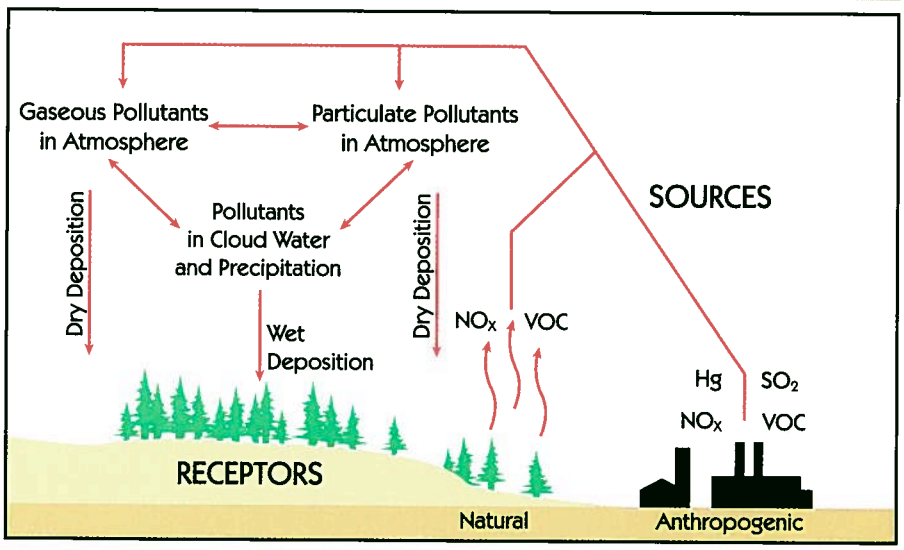
- Measure and compare pH levels in precipitation at several sites over an extended time period
- Analyze and account for varying concentrations of oxides and pH readings in precipitation

INTRODUCTION

Acid rain is a general term that describes how acids fall out of the atmosphere. A better term would be **acid deposition**, which occurs two ways: wet and dry. Acid rain, fog, and snow are known as wet deposition. Dry deposition is made up of acidic gases and particles, and these constitute about 50% of all acidic fallout from the atmosphere. The particles get blown by the wind onto cars, buildings, bridges, forests, etc. When it rains, these particles dissolve in the water, and the runoff becomes more acidic than the rainfall itself.

Fig. 28-1

The Sources and Kinds of Acid Deposition



Scientists have documented that oxides of nitrogen and sulfur are the main source of acid rain. About one-fourth of the oxides of nitrogen (NO_x) and two-thirds of the sulfur dioxide come from using fossil fuels, coal in particular, for the generation of electric power. These gases chemically react with and combine with the water and other chemicals in the atmosphere to form dilute solutions of nitric and sulfuric acids. These chemicals mix in the atmosphere and drift with the prevailing winds to be deposited many miles away. The chemicals often cross state and sometimes international borders.

Even if there were no humans on Earth to alter the atmosphere, rainfall would still be acidic because atmospheric carbon dioxide and water combine to form carbonic acid, which has a **pH** of about 5.6. Remember that pH is a measure of the acidity of solutions on a logarithmic scale. It ranges from the very strongly acidic 0, to the neutral 7 of pure water, to very strongly alkaline 14. Tomato juice has a pH of 4 and vinegar and stomach acid have a pH of 3. Precipitation with a pH less than 5 is considered acid rain.

Materials

beakers (1 per precipitation sample)

pH meter (or CBL and pH probe, or titrant)

Internet access

Procedure

Step 1 Wait for a day when it starts to rain or snow, preferably a storm of some duration. To get the maximum effect, it is best to begin this lab on the first day of precipitation.

Step 2 Take very clean, dry beakers and set them outside away from any buildings and trees to collect precipitation. If you are collecting snow, let the beaker fill up, so as to have enough liquid when the snow melts. (If necessary, add snow to the beaker, using a clean scoop and taking only snow from the upper layer that has fallen.)

Step 3 Bring the beakers into the classroom or lab for testing.

Step 4 Use a pH meter or other method to measure the pH of the precipitation. Record your values.

Step 5 Repeat the collection process for different times during the storm, possibly an hour apart.

Step 6 Conduct identical tests for several rainfalls or snowstorms over several months and compare the results.

1. How did the pH values compare as the storm progressed? Why?

2. How did the values compare over the more extended period of time? Why?

3a. What is the primary source of sulfur dioxide emissions?

b. Describe three ways these emissions can be lowered.

Questions

c. Study **Fig. 28-2**. Why are the highest values in the Midwest in southeast Ohio?

d. Why are the values so low west of the Rocky Mountains?

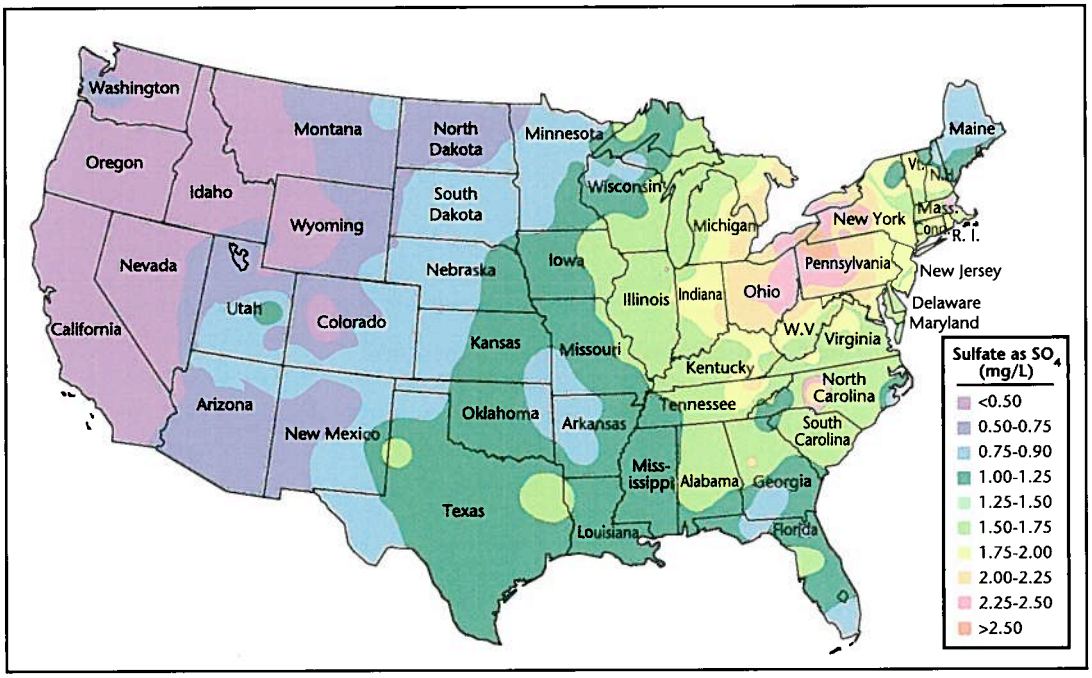


Fig. 28-2: Atmospheric Sulfate Concentrations in the U.S. for the Year 2000 (in mg/L)

Questions

4a. What is the primary source of NO_x emissions?

b. Use **Fig. 28-3** (see next page). Where are the highest concentrations on this map, and why?

c. Why are the values so low in rural central and northern California but higher east of the urban San Francisco Bay area?

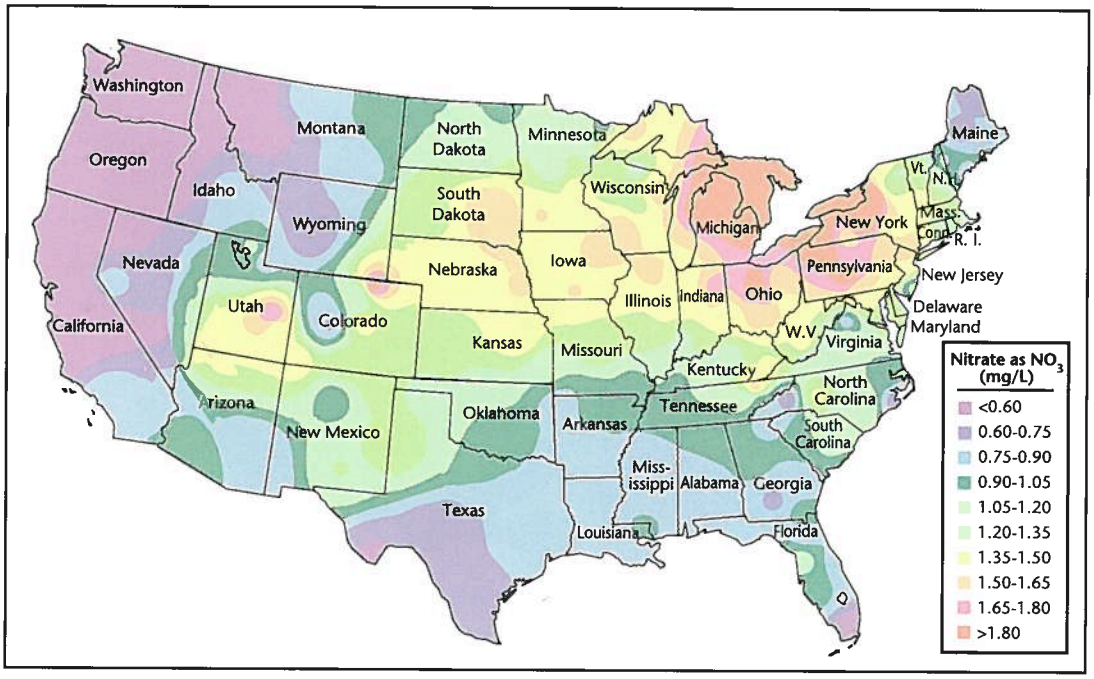


Fig. 28-3: Atmospheric Nitrate Concentrations for the Year 2000 (mg/L)

5a. How do the maps in Questions 3 and 4 point out the differences in the sources of sulfates and nitrates?

b. Explain how weather patterns and geology help distribute these substances.

6. Using **Fig. 28-4** (see next page), comment on the national patterns of acid rain pH.

a. Why are the lowest pH (most acid) values generally in the Northeast?

b. Suggest a reason for the pH to be low along the Arizona-New Mexico border compared to the surrounding region.

Questions

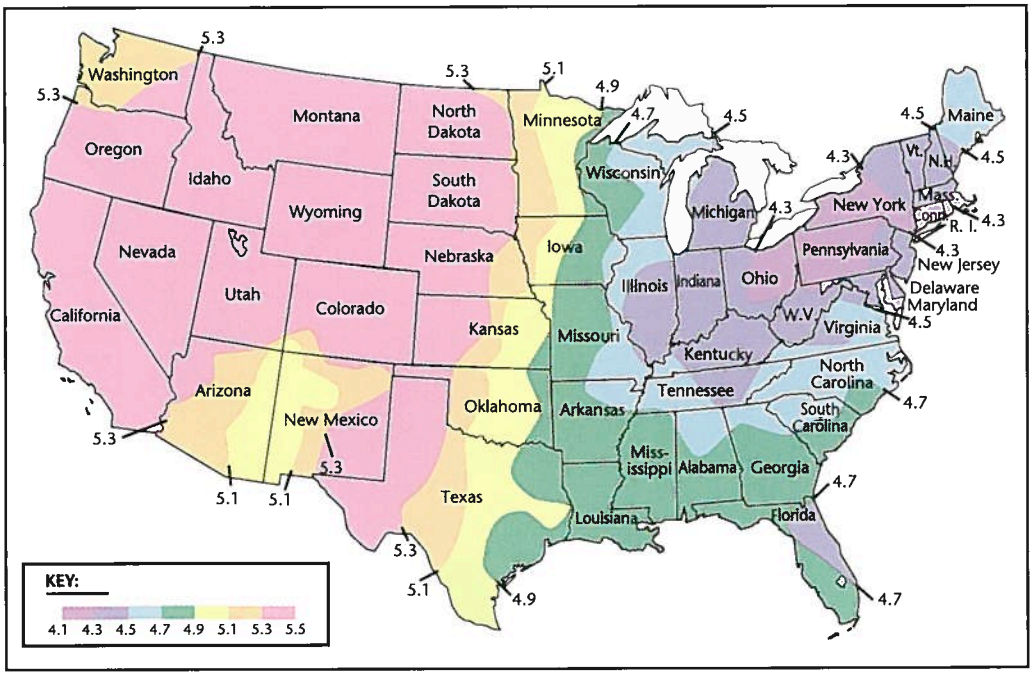


Fig. 28-4: Acidic Concentrations in Rainfall in the U.S. for 1992

7. Describe four ways acid rain hurts the economy of the United States.

8. One market-based incentive for reducing pollution is called Tradable Emissions Limitations, or emissions trading for short. The approach used by the EPA is called Allowance Trading, or cap and trade. Research current approaches to reducing industrial pollution and prepare a brief report addressing these topics:

- How does the EPA's allowance trading work for sulfur dioxide trading?
- Where has this approach been tried, and why was that area selected?
- How effective is the program?

Questions