

Acid Rain and Its Effect on Surface and Ocean Water

Acid rain can be very harmful to the environment. It can kill fish by lowering the pH of lakes and rivers. It can harm trees and plants by burning their leaves and depriving them of nutrients. It can also weather away stone buildings and monuments. It can dissolve coral reefs. But why is it more of a problem in some places than others?

To answer this question, let's first look at how rain becomes acidic. Carbon dioxide, CO_2 , is a gas found naturally in the air. When CO_2 dissolves into rain droplets, it produces a weak acid called carbonic acid, H_2CO_3 . This makes rain slightly acidic naturally. Rain of pH 5 to 6 is common and does not generally cause any problems. When fossil fuels are burned, however, gases such as sulfur dioxide, SO_2 , are released into the air. When sulfur dioxide dissolves into rain droplets, sulfuric acid, H_2SO_4 , is formed. This rain can be as acidic as pH 4. Figure 1 shows the trend of rain pH in the United States in a typical year. Notice that the most acidic rain occurs over and downwind from heavily populated and industrialized areas.

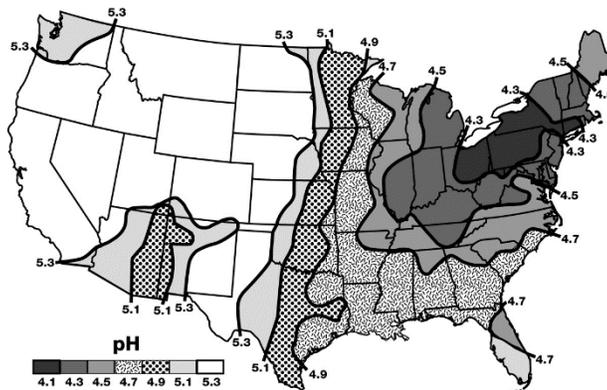


Figure 1: Typical rain pH in United States.

Acid rain is more harmful to some areas than others. This is because some water resists changes in pH better than others. Water that resists a change in pH is said to be *buffered*. Depending on the *buffering capacity* of the surface water, one area could be heavily damaged by acid rain that does not seem to harm another at all.

In Part I of this experiment, you will study how rain naturally becomes acidic due to CO_2 in the air. You will monitor the pH of water as you add CO_2 by blowing through a straw. In Part II, you will study the effect of acid rain has on the pH of different water types. The pH will be recorded as sulfuric acid is added dropwise to several different types of water.

OBJECTIVES

In this experiment, you will

- Use a pH Sensor to measure pH.
- Study the effect of dissolved CO_2 on the pH of distilled water.
- Study the effect on pH of dissolving H_2SO_4 in various waters.
- Learn why some bodies of water are more vulnerable to acid rain than others.

MATERIALS

LabQuest
LabQuest App
Vernier pH Sensor
2- 100 mL beakers
dilute H₂SO₄
waste beaker
dropper
scale
eggshells

ring stand
utility clamp
straw
wash bottle with distilled water
soft water
hard water
seawater
buffer solution

PROCEDURE

Part I CO₂ and Water

1. Obtain and wear goggles! **CAUTION:** The sulfuric acid used in Part II of this experiment is a strong acid. Contact with sulfuric acid will damage your skin, eyes, and clothing!
2. Connect the pH Sensor to LabQuest and choose New from the File menu. If you have an older sensor that does not auto-ID, manually set up the sensor. **Important:** For this experiment your teacher already has the pH Sensor in pH soaking solution in a beaker; be careful not to tip over the beaker when connecting the sensor to the interface.
3. On the Meter screen, tap Rate. Change the data-collection rate to 1 sample/second and the data-collection length to 60 seconds. Select OK.
4. Add 50 mL of distilled water to a clean 100 mL beaker.
5. Lower the pH electrode into the beaker so that the water is covering the glass bulb.
6. Give a straw to the group member who will be blowing into the water.
7. Start data collection. After one data pair have been collected, begin blowing through the straw into the distilled water. You may take breaths as needed, but try to keep a fairly constant stream of air going into the water. Data collection will stop after 60 seconds.
8. Determine the maximum and minimum pH values.
 - a. Choose Statistics from the Analyze menu.
 - b. Record the maximum and minimum pH in the Part I data table.
9. Print the graph if directed by your teacher.

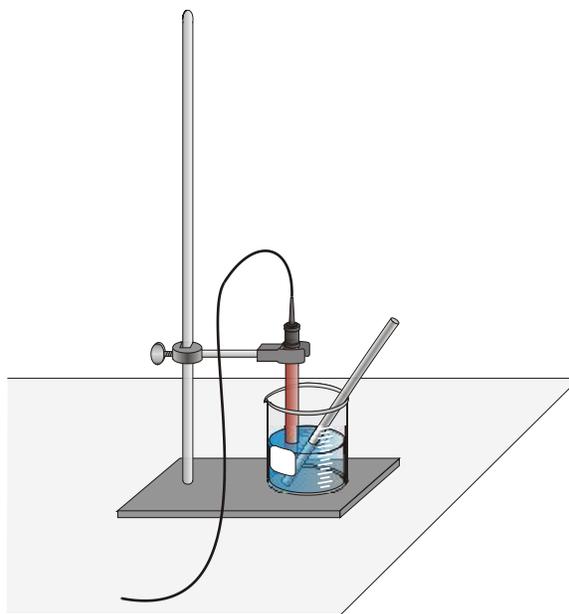


Figure 2

Part II Effects of Acid Rain on Surface and Ocean Water

Acid Rain in Distilled Water

1. Set up LabQuest for data collection in the Event with Entry mode.
 - a. On the Meter screen, tap Mode. Change the data-collection mode to Events with Entry.
 - b. Enter the Name (Drops) and leave Units field blank. Select OK.
2. Rinse the pH electrode thoroughly with distilled water.
3. Wash and dry the 100 mL beaker. Get a new 50 mL portion of distilled water. Lower the pH Sensor into the distilled water.
4. Start data collection.
5. When the pH reading displayed on the screen stabilizes, tap Keep. Enter **0** (the number of drops). Select OK to save this data pair.
6. Add 1 drop of sulfuric acid to the water. **CAUTION:** Handle the sulfuric acid with care. It can cause painful burns if it comes into contact with skin, eyes, or clothing.
7. Stir thoroughly. When the pH is stable, tap Keep. Enter the number of drops of acid added to the beaker and select OK.
8. Repeat Steps 6–7, adding 1 drop at a time, until you have added 10 drops of acid.
9. Stop data collection.
10. To examine the data pairs on the displayed graph, tap any data point. As you tap each data point, the pH and drop number values are displayed to the right of the graph.
11. Record the # of drops of acid it took before the pH changed, and the maximum and minimum pH values in the Part II data table.
12. Store the data from the first run by tapping the File Cabinet icon.

Acid Rain in Soft Water

13. Repeat Steps 2–12 using 50 mL of soft water instead of distilled water.

Acid Rain in Hard Water

14. Repeat Steps 2–12 using 50 mL of hard water instead of distilled water.

Acid Rain in Ocean Water

15. Repeat Steps 2–12 using 50 mL of ocean water instead of distilled water. **Important:** Do not store this final run.
16. It is often helpful to view all three runs on one graph for comparison.
 - a. Tap Run 4 and select All Runs.
 - b. Print the graph or sketch it in the space below, labeling each line with the type of water used.

DATA

Part I CO₂ and Water

Table 1		
Maximum pH	Minimum pH	Δ pH

Part II Effects of Acid Rain on Surface Water

Table 2				
	Distilled Water	Soft Water	Hard Water	Ocean Water
# of drops before pH changed				
Maximum pH				
Minimum pH				
Δ pH				

PROCESSING THE DATA

1. Calculate the change in pH (Δ pH) for the water in Part I and record in the Part I data table.
2. Calculate the change in pH (Δ pH) for each of the Part II trials and record in Part II data table.
3. Compare the Δ pH values. Which test gave the largest pH change? Which test gave the smallest pH change?
4. Which type of water resisted changing pH the longest? (Which needed the most # of drops before pH changed?)
5. Hard water and ocean water are said to be “naturally buffered.” From the result of this experiment, explain what this means.

6. Many aquatic life forms can only survive in water with a narrow range of pH values. In which type of water—ocean, hard, or soft—would living things be more threatened by acid rain? Explain.

7. What two factors affect whether organisms will be effected by acid rain? (You may need to look back at the introduction to answer this.)

8. Figure 3 shows the general trend in hard and soft water in the United States. There are numerous coal-burning electric power plants in Illinois that produce sulfur dioxide. As the prevailing winds carry the pollutants northwestward, they contribute to acid rain over the northeast. Based on what you have learned in this lab, do you think that Ohio and New York will be affected the same by this acid rain? Why or why not?

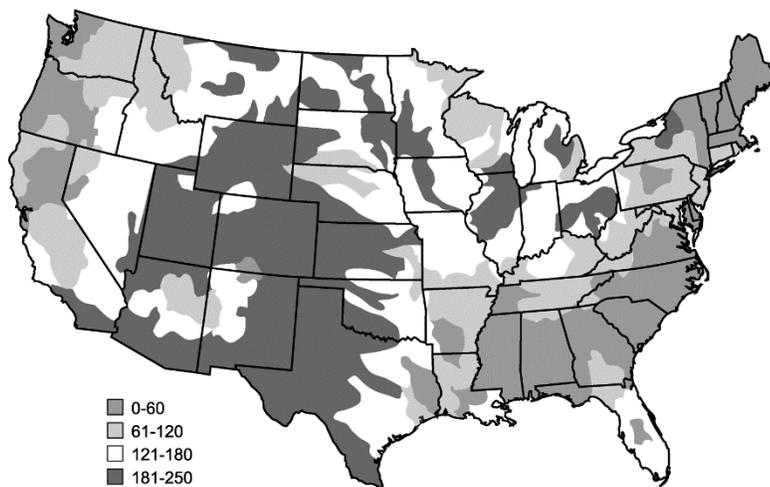


Figure 3: Typical water hardness as mg/L calcium carbonate

9. A similar situation exists in Europe where air pollutants from highly industrialized Germany are more harmful to Scandinavian water life than to water life in Germany. Use the results of this experiment to predict the relative hardness and softness of Germany and Scandinavia's water.

Part III Effects of changes in ocean pH on marine organisms

Now you will explore how changes in ocean pH affect marine organisms that rely on shells for protection (plankton, clams etc) or habitat (coral reefs). Typical ocean pH is approximately 8.1. Some areas of the ocean are seeing a lower pH of 7.9. That doesn't seem like much, but let's see how it affects our marine organisms.

PROCEDURE

1. Wash and dry the two 100 mL beakers. Get one new 50 mL portions of ocean water and label it "Average pH".
2. Get 25mL of ocean water in the second beaker and add 25mL of vinegar. Label it "Ocean acidification".
3. Take two pieces of eggshell, blot them dry, and record each mass in Table 3. Make notes on their appearances – look at their edges and both sides.
4. Place one eggshell into the Average pH beaker, and one into the Ocean Acidification beaker.
5. The next time you are in class, you will take notes on appearances and masses.

DATA

Table 3			
		Average pH eggshell	Ocean Acidification eggshell
Day 0 (before placing in water)	Mass		
	Notes		
Day 1 (24 hours in water)	Mass		
	Notes		
Day 2 (48 hours in water)	Mass		
	Notes		
Day 3 (72 hours in water)	Mass		
	Notes		

PROCESSING THE DATA

How did the eggshells change in the Average pH water? In the Ocean Acidification water?