8. ACID RAIN

How do human-made pollutants affect the pH of rainfall? How does polluted rainfall affect plants?

Objectives

- Describe the impact of human-caused acid rain on ecosystem resources.

Materials and Equipment

- Data collection system
- pH sensor
- Graduated cylinder, 25-mL
- Beaker or cup, 50-mL
- Beaker, 500-mL
- Stirring rod
- Disposable pipets (6), 1-mL
- Storage containers for "acid rain" (2), 500-mL
- Wash bottle filled with distilled water
- Baking soda ($NaHCO_3$), small container
- Sodium bisulfite ($NaHSO_3$), small container
- 0.025 M Sulfuric acid (H_2SO_4), 15 mL
- Vinegar, small container
- Distilled water, 400 mL
- Small potted plants
- Scissors
- Marking pen
- Tape or labels

Safety

Follow these important safety precautions in addition to your regular classroom procedures:

- Wear safety goggles at all times.
- Use only the amounts indicated; larger amounts can create harmful products.
- Work in a well-ventilated room or under a fume hood.

Procedure

Part 1 – Produce carbon dioxide (CO_2) gas and determine its effect on water pH

1. Select Sensor Data in SPARKvue. Connect the pH sensor to your device.
2. Choose the Graph template.
3. Label the 6 pipets as follows: 1A; 2A; 1B; 2B; 1C; 2C.
4. Cut pipets 1A and 2A to a 1-cm length stem as shown in Figure 1.
5. Squeeze and hold the bulb of pipet 1A. Place the pipet stem in the container of baking soda and release the bulb. The pipet should now have a small amount of the solid substance inside of it.
6. Squeeze and hold pipet 1B. Place the pipet stem in the container of vinegar. Release the bulb to draw vinegar into the pipet.

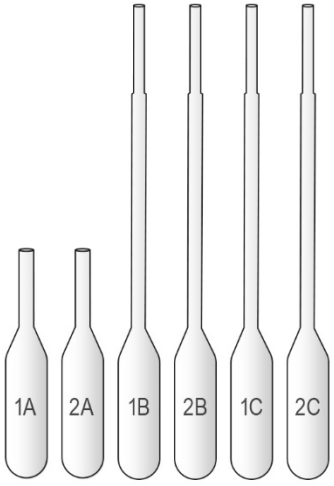

Figure 1: Prepare six pipets

7. Insert pipet 1B into the opening of pipet 1A as shown in Figure 2. Slowly add 20 drops of vinegar into the bulb of pipet 1A. Note the production of carbon dioxide (CO_2) gas from the chemical reaction between baking soda and vinegar.

8. Set aside pipet 1B. Squeeze and hold pipet 1C. Insert pipet 1C into the opening of pipet 1A as shown in Figure 3. Release the bulb to collect some of the CO_2 gas into pipet 1C.

9. Set aside pipet 1A. Add 25 mL of distilled water to a small beaker or cup. Place the pH sensor into the water. Take care to prevent the cup from tipping over when the sensor is placed in it. The bulb at the end of the pH probe should be completely submerged in water.

10. Select Start to begin collecting data. Scale the graph and wait for the pH reading to stabilize. Record the initial pH in Table 1.

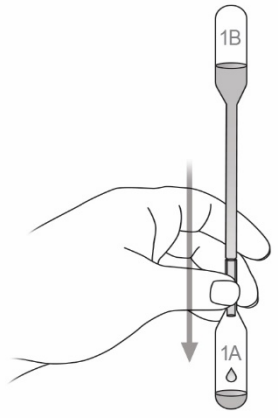

Figure 2: Squeeze 20 drops from 1B to 1A

11. Place the stem of pipet 1C into the distilled water. Slowly squeeze the pipet bulb to release the collected CO_2 gas into the water as shown in Figure 4. Gently swirl the water as the gas is bubbled into it and hold the pH sensor steady. Continue swirling during data collection.

12. Stop collecting data when pH stabilizes. Record final pH in Table 1.

13. Remove the pH sensor from the solution and rinse it thoroughly with distilled water. Dispose of the solutions in the pipets and beaker or cup according to your instructor's directions.

14. Rinse the beaker thoroughly with tap water, and complete a final rinse with distilled water. Dry the beaker.

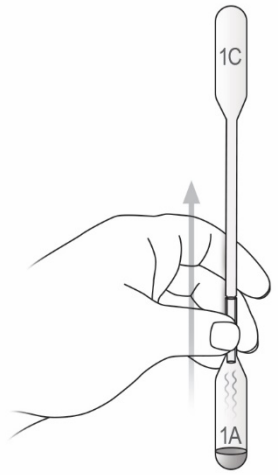

Figure 3: Gas rises to 1C

Part 2 – Produce sulfur dioxide (SO_2) gas and determine its effect on water pH

1. Collect a small amount of solid sodium bisulfite in pipet 2A.

2. Collect vinegar in pipet 2B. Connect pipets 2A and 2B to add 20 drops of vinegar to the solid.

Note: A chemical reaction may not be apparent, but it is occurring.

3. Set aside pipet 2B. Squeeze and hold pipet 2C and insert the pipet into the pipet 2A opening. Release the bulb to collect some of the sulfur dioxide (SO_2) gas created in the reaction into pipet 2C.

4. Set aside pipet 2A. Add 25 mL of distilled water to a small beaker or cup. Place the pH sensor into the water making sure the cup does not tip over and the sensor bulb is completely covered by water.

5. Start collecting data. Scale the graph. Record the initial pH in Table 1 when pH is stable.

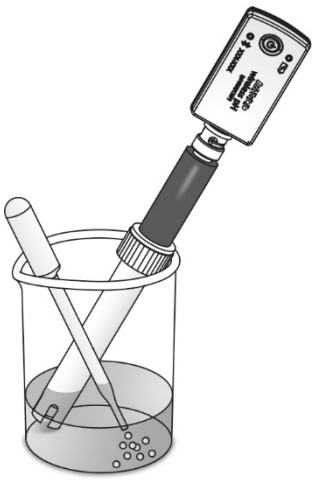

Figure 4: Deliver gas to water

6. Place the pipet 2C stem in the distilled water. Slowly squeeze the pipet bulb to bubble the collected SO_2 gas into the water. Gently swirl the water as the gas is bubbled into it and hold the pH sensor steady. Continue swirling during data collection.

7. Stop collecting data when the water pH stabilizes. Record the final pH in Table 1.

8. Remove the pH sensor from the solution and rinse it thoroughly with distilled water. Dispose of the solutions in the pipets and beaker or cup according to your instructor's directions.

9. Use the following equation to calculate pH change. Record the result in Table 1:

   Change in pH = Final pH - Initial pH

Part 3 – Create "acid rain"

1. Add about 250 mL of distilled water to a 500-mL beaker. Add 5 mL of sulfuric acid to the beaker and stir. Place the pH sensor in the beaker.

2. Start collecting data.

3. Slowly add more distilled water to the beaker and stir until the pH of the solution measures between pH 3-4. Avoid striking the sensor with the stirring rod.

Note: If the pH is above 4, add a very small amount of stock solution to decrease the pH to below 4.

4. Stop recording data. Record the solution pH in the Acid Rain 1 column header in Table 2.

5. Pour the “acid rain” solution you just created into the storage container provide by your teacher. Label the storage bottle as "acid rain 1: pH ____" and write the solution pH in the space.

Note: If you have “acid rain” solution that does not fit in the bottle, give the excess to your teacher.

6. Repeat the procedure above to create an “acid rain 2” solution with a pH value of 4.5-5.3.

7. Measure the pH of tap water. This water represents the control, representing ordinary rainfall that does not contain added sulfur compounds.

Part 4 – Monitor plant growth

1. In your group, or as a class, determine a method and procedure for watering small potted plants for one week (or more). Record the method and procedure on a separate paper and attach it.

2. Based on your teacher’s instructions, obtain one or more small plants. Label each plant container with the names of students in your group. Include the type of rain the plant will receive (acid rain 1, acid rain 2, or tap water) on the label.

3. Record your initial observations of the plants in Table 2.

4. Predict how each plant will change based on your watering method and procedure. Write your predictions on your paper below the procedure.

5. Place the plants in a location where they will receive adequate sunlight.

6. Starting today (Day 1), water the plants with their appropriate solution each day for at least one week according to your method and procedure. Record observations in Table 2 each day.

Data Collection

Table 1: pH of water with gaseous pollutants added

Gas	Initial pH	Final pH	Change in pH
Carbon dioxide (CO_2)			
Sulfur dioxide (SO_2)			

Table 2: Observations of plant growth

Day #	Control (pH = _____)	Acid Rain 1 (pH = _____)	Acid Rain 2 (pH = _____)
1			
2			
3			
4			
5			

If additional days of observations are collected, continue the table on a separate paper and attach it.

Questions and Analysis

1. What effect did the gases (CO_2 and SO_2) have on the pH of water? Why did this occur? Support your answer with data.

2. Which gas (CO_2 or SO_2) is present in the atmosphere primarily due to man-made pollution? Explain your answer.

3. Which gas (CO_2 or SO_2) could potentially cause the most damage to an ecosystem? Support your answer with evidence from this investigation.

4. Coal from the western United States has a lower percentage of sulfur impurities than coal found in the eastern United States. Which region would you expect to experience more problems related to acid rain? Explain.

5. Summarize the changes that you observed in the plants over the course of the experiment. How did the changes compare to what you predicted?

6. In addition to affecting plant growth on land, acid rain can also affect plant and animal life in lakes, ponds, and other bodies of water. Identify at least two ways that acid rain would make its way into these bodies of water.