Name: Date: Class:

Are You Feeling Neutralized? Activity Sheet

Introduction: How Acid Rain Forms & Why It Damages Copper Piping

Acid rain forms when pollutants released into the air—especially sulfur dioxide (SO_2), nitrogen oxides (NO_x), and certain organic acids—combine with water vapor in the atmosphere. These pollutants can come from car exhaust, factories, burning fossil fuels, and even natural sources such as volcanic eruptions. When these pollutants mix with moisture in the air, they create diluted acids such as sulfuric, nitric, or acetic acid. Eventually, this acidic moisture falls back to the ground as **acid rain**.

When acid rain enters water systems (e.g., rivers, lakes, plumbing lines, or household pipes) it can begin to corrode metals. **Copper piping**, commonly used in water systems, reacts with acidic water because acids dissolve the protective oxide layer on the copper's surface. As the acidic water continues flowing, it can:



- Cause the copper metal to break down.
- Release copper ions into the water supply.
- Weaken pipes over time.
- Discolor water and produce blue-green staining.
- Increase copper concentrations in drinking water, which at sufficiently high levels can pose health concerns.

In this hands-on challenge, you will become an environmental engineer! Your mission is to design and build a water filter that can filter and neutralize "acid rain." This activity simulates how acidic water can interact with copper piping and challenges you to design a filter that not only reduces contaminants and turbidity but also neutralizes its acidity to reduce corrosion.

In this activity, you will:

- Create a filtration system using simple household materials such as a water bottle, cotton, gauze, pebbles, and cloth, and include a neutralizing material (baking soda or antacid tablets) to counteract acidic runoff.
- Create your own "acid rain" polluted water source to test against your filter.
- Determine the filtration and neutralization quality of your filter by testing its flow rate, the pH and clarity of the filtered water, and the filtered water's ability to reduce copper corrosion.

Name: Date: Class:

MATERIALS		
Per Group	**Group Choice (up to 5)**	**Pre-Selected Per Group**
500 mL water bottle (with cap)	1-5 scoops* (teaspoons) of rice	1-5 scoops* of baking soda or antacid tablets
1 pair of scissors	1-5 scoops* of sand	150 mL of 5% vinegar or 5% citric acid solution±
1 ruler	1-5 scoops* of gravel	
1 ring stand (base & pole)	1-5 scoops* of large pebbles	
1 hot plate	1-5 scoops* of activated charcoal	
1 “large” beaker (400 – 500 mL)	4-7 cotton balls	
1 “small” beaker (100-150 mL)	1 coffee filter	
1 pair of heat mitts (or beaker tongs)	1 paper towel	
1 thermometer	gauze material**	
1 pH meter (or 3-4 strips of universal pH paper with pH color chart)	cloth material**	
1 wash bottle	sponge material**	
7 mouthwash cups	other material (teacher choice)	
1 marker		
2 pennies		
1 stopwatch or timing device		

Note: * 1 scoop using a standard plastic spoon = roughly 1 teaspoon (tsp) = 5 mL. Groups cannot exceed 25 mL of any scoop-based material.
** These materials cannot be larger than 3 in x 3 in.
± Groups will also obtain 150 mL of hydrogen peroxide and 3 scoops of organic material.

Name: **Date:** **Class:**

PROCEDURE

This activity should be completed in student pairs.

PPE: Wear gloves, safety goggles, and an apron throughout the activity (provided).

Part 1A: Creation of Your Water Neutralization Filter

1. Obtain a 500 mL water bottle. This will be the housing for your filter.
   Specifications (see image below):
   - 500 mL bottle height: ~8 in (20.3 cm); diameter: ~2.5 in (6.35 cm)
   - Bottle (upside down) must be cut to a height of 7 in (17.8 cm)
   - Filter material cannot exceed 6 in (15.2 cm) in height from the bottle mouth upward
   - Bottle cap may be used or removed, but the filter must allow water to flow through it

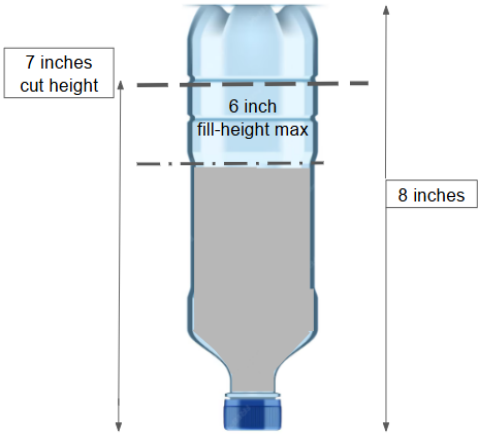
2. Select filtration materials (e.g., cotton, sponge, coffee filter, activated charcoal, gauze, rice, pebbles, etc.), placing materials into the small mouthwash cups to transport to your table.
   - You may **use up to 5** different filtration materials.
   - You may obtain up to **5 spoonfuls** of rice, sand, gravel, pebbles, or charcoal.
   - You may obtain **1 coffee filter and/or 1 paper towel segment.**
   - You may obtain **4-7 cotton balls**.
   - You may obtain **no more than one 3 in x 3 in square segment** of sponge, gauze, and/or cloth material each.
   - You may alter materials (cut, shape, etc.) but must stay within the 6-inch (15.2 cm) fill limit (**see image below**).

3. Obtain from your teacher **one neutralizing agent** to treat the acidic runoff:

   - Baking soda (sodium bicarbonate) or crushed antacid tablets containing calcium carbonate (e.g., Tums)

   - You may obtain up to **5 spoonfuls** of your neutralizing agent.

   - **Neutralizing agent:** _____



4. Sketch the layers of your filter and the order in which you will arrange them on the Bottle Filter Sketch Diagram given to you by your teacher. Label each material and indicate where you will place your neutralizing agent.

5. Layer your chosen filtration materials and neutralizing agent inside the bottle according to your design.

6. If using the bottle cap, create openings that allow water to pass through. If not using it, ensure your materials do not fall out of the bottle opening.

7. Secure the filter to a ring stand or have a partner hold it during testing. Ensure the filter is stable and positioned above the collection beaker before pouring any liquid.

Part 1B: Creation of Your Simulated Contaminated Acid Rain (SCAR) Water Solution

1. Obtain from your teacher **one acid "pollution" source**:
   - 5% vinegar (acetic acid), or 5% citric acid solution
   - **Acid "pollution" source**:_____

2. Pour 150 mL water into a "large" beaker.

3. Add 150 mL of 3% hydrogen peroxide to the breaker, bringing the total volume to 300 mL.

4. Heat the solution to **50–70°C** using a hot plate. Allow to cool for 1 minute.

5. Test and record the pH of your SCAR water. Using your pH meter or pH paper, measure the pH of the solution. **pH =** _____. Place this value in Section B for Trial 1 in your data table.

6. Place a penny (or copper material) in a mouthwash cup and add some of your SCAR water.

7. Determine the reactivity of your solution. Wait for 5 minutes and observe and record any changes to the copper or solution. (Note: Your solution should change to a bluish or blue-green color if your corrosion reaction is successful).

8. Add **3 spoonfuls of** organic debris supplied by your teacher. (You may observe fizzing due to hydrogen peroxide reacting with and eliminating microorganisms.)

Name: **Date:** **Class:**

Part 2: Test Your Filtration Device

1. Position your filter above a clean "small" collection beaker.
2. Place the copper material into the collection beaker.
3. Observe the color/clarity of your acid runoff water (this is called **turbidity**). Using the turbidity standard chart, place your turbidity observation rating in Section A for Trial 1 in your data table.
4. Slowly pour the acid runoff water through your filter.
5. Pour **half** of your runoff and **time the flow** (with a timing app) from first drip until it finishes (stop if it reaches 80 mL). Record:
    - **Filtered liquid time:** _____
    - **Filtered liquid volume:** _____ mL
6. If the time was longer than 60 seconds (add 1 min for each 30+ secs), convert minutes to seconds by multiplying Step **#5** x 60 secs = _____ total secs.

    (*Note*: *If your filter does not allow water to flow at all, you've encountered a design fail. Reconstruction is needed.)*

7. Use the formula **Flow Rate = Volume / Time:** Divide total mL (**Step #5) /**total secs **(Step #5 or #6)**. Place in Section C for Trial 1. **Flow Rate:** _____ mL/sec
8. Measure and record the pH of the filtered solution. **pH** = _____. Place in Section D for Trial 1 in your data table.
9. Observe the turbidity of your filtered water. Using the turbidity standard chart again, place your observation rating in Section E for Trial 1.
10. Observe copper corrosion in the beaker. Pour out filtered water until **only 10 mL remains** in the beaker and wait for **3 min**. Place your observation answer in Section F for Trial 1 in your data table.
11. Obtain from your teacher an "Are Your Feeling Neutralized? Product Quality Rubric" and use your data from the tests conducted to score the quality of your neutralization filter.

Name: **Date:** **Class:**

DATA TABLE							
Trial	**(A)** Turbidity of SCAR Water (rating 1-10)	**(B)** pH SCAR of Water	**(C)** Flow Rate (mL/sec) between 1.4-0.33 mL/sec	**(D)** pH of Filtered Water	**(E)** Turbidity of Filtered Water (rating 1-10)	**(F)** Copper Corrosion (yes/no)	**(G)** Notes
1							
2							
Avg							

Product Rubric and Trial 2

1. As time permits, repeat activity to increase your product's engineering quality (Trial 2).
2. Repeat Parts 1A, 1B (if more SCAR water needs to be made), and 2, and record data on the row for **Trial 2.**
3. Complete your Product Quality Rubric for **Trial 2**. Note any experimental changes between trials and **average your trial results** for your final reading. Now complete your group's Product Quality Rubric using your **average.**