Soil Buffering of Acid Rain

Introduction

Acid rain is a term commonly used to refer to all types of precipitation--rain, snow, sleet, hail, fog--that is acidic in nature. A more encompassing term is acid deposition. Rain is naturally somewhat acidic, with an average pH of 5.6-5.7. Precipitation is considered "acidic" if it has a pH lower than the average pH of rainwater.

Rain is naturally acidic because carbon dioxide, found normally in the earth's atmosphere, reacts with water to form carbonic acid. While rainwater has an average pH of 5.6-5.7, actual pH readings will vary from place to place depending upon the type and amount of other gases present in the air, such as sulfur dioxide and nitrogen oxides.

Acid deposition has negative effects on lakes, streams, soils, and the organisms that depend upon these environments.

The degree to which acid deposition will impact plants and aquatic life is affected by the ability of soils to compensate for the acidity of the precipitation.

Some soils are capable of resisting acidification because of the type of minerals they contain. As the acidic precipitation passes through the soil's air spaces it dissolves minerals such as calcite and dolomite. Both of these minerals can be found in limestone which is a sedimentary rock. Both of these minerals are also considered part of the carbonate family. Calcite is composed of calcium carbonate and dolomite is composed of calcium magnesium carbonate. Carbonate compounds tend to release hydroxyl ions when they are dissolved in water or weak acids. Dolomite is not as reactive as calcite. However, under the proper conditions both of these minerals will buffer sulfuric acid and nitric acid, which are components of acid precipitation.

Other soils such as those formed from igneous and metamorphic rocks do not contain minerals that are capable of dissolving in water. The formation of these types of rocks occurs under great heat and pressure. These processes cause chemical reactions that lock the minerals into the rock's structure and leave them unavailable. Therefor, soils that form from or contain a lot of igneous and metamorphic rock are not able to buffer the sulfuric acid and nitric acid contained in acid precipitation. Lakes in areas containing such soils are more likely to become acidic and plants growing in these areas are more likely to suffer from acid precipitation.

Because acid can dissolve metal, acid precipitation can dissolve metal ions present in soil. These metals can then leach into nearby lakes with rainfall and snowfall runoff. A particular problem is caused by aluminum, a very common element present in most soils. Aluminum is toxic to fish because it damages their gill membranes and can damage plants by interfering with their uptake and use of nutrients and water.

In this lab, we will examine the ability of soil to buffer acid rain as reflected in the pH of an artificial lake into which the runoff will flow.

Hypothesis

Soil that contains calcium carbonate will buffer acid precipitation better than soil without calcium carbonate, as evidenced by the pH of an artificial lake receiving the runoff.

Materials

- soil from three sources: potting soil, fill soil, compost
- calcium carbonate ($CaCO_3$)
- tap water (artificial lake water)
- pH 4 simulated acid rain
- coffee filter
- Hach pH test kit
- ring stand
- ring stand clip
- funnel
- 400mL beaker
- 100mL beaker
- spoons

Procedure

1. Work in groups by lab table.
2. Obtain 100g of your assigned soil and divide it into two 50g portions
3. Obtain 5g of $CaCO_3$
4. Set up the apparatus as follows:
   a. attach a ring stand clip to a ring stand
   b. place a funnel in the ring stand clip
   c. place a fresh coffee filter in the funnel
   d. raise the ring stand clip with funnel to a height sufficient to allow the placement of a 400mL beaker under the funnel
5. Place 200mL of tap water into the 400mL beaker (which is under the funnel); this will serve as your artificial lake
6. Measure the pH of the artificial lake water and record in Table 1 and on the transparency.
7. Place 50 g of your assigned soil into the coffee filter (in the funnel).

8. Place 80mL of simulated acid rain in a small beaker.
9. Carefully pour the simulated acid rain over the soil in the filter-lined funnel. Pour slowly and let the simulated acid rain filter slowly through the soil and down into the artificial lake. Be careful not to allow soil to wash over the top of the filter.
10. Use the plastic spoon to gently stir the soil-rain mixture.
11. Allow 5 minutes for the "runoff" to occur.
12. After the simulated acid rain has "runoff" into the artificial lake, use a fresh plastic spoon to stir the "lake" in the beaker to mix the runoff with the lake water.
13. Measure the pH of the artificial lake water with runoff and record it in Table 1 and on the transparency.
14. When you are finished,
    a. discard your soil and coffee filter
    b. wash your filter and rinse it with distilled water
    c. discard your lake water
    d. wash your lake beaker and rinse it with distilled water
15. Reassemble your apparatus as described in step 4 above.
16. "Re-fill" your artificial lake with tap water (as long as you use the VERY SAME TAP you do not need to repeat the pH test).
17. Take the second 50g portion of your assigned soil and mix in the 5g of $CaCO_3$, using a fresh (or cleaned and dried) plastic spoon to stir thoroughly.
18. Repeat steps 8 through 13.

Data Analysis

1. Complete Figure 1 by preparing a bar graph illustrating the mean pH of artificial lake water after runoff of simulated acid rain through three soil types before and after the addition of calcium carbonate.

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Soil Buffering of Acid Rain LAB WRITE-UP: Submit pages 4-8

Student Name: ______________________ Lab Date: __________
Lab Instructor: ______________________ Lab Section: __________

Results (Data)

Table 1:. pH of artificial lake water before and after runoff of simulated acid rain through three soil types before and after addition of calcium carbonate, by group, and pH of simulated acid rain.

Lab Table	Assigned Soil Type	pH of acid rain	pH of lake water before runoff	PH of lake water after runoff through soil: Before addition of $CaCO_3$	PH of lake water after runoff through soil: After addition of $CaCO_3$
1	Potting	4.0			
2	Potting	4.0			
	Mean=	4.0			
3	Fill	4.0			
4	Fill	4.0			
	Mean=	4.0			
5	Compost	4.0			
6	Compost	4.0			
	Mean=	4.0			

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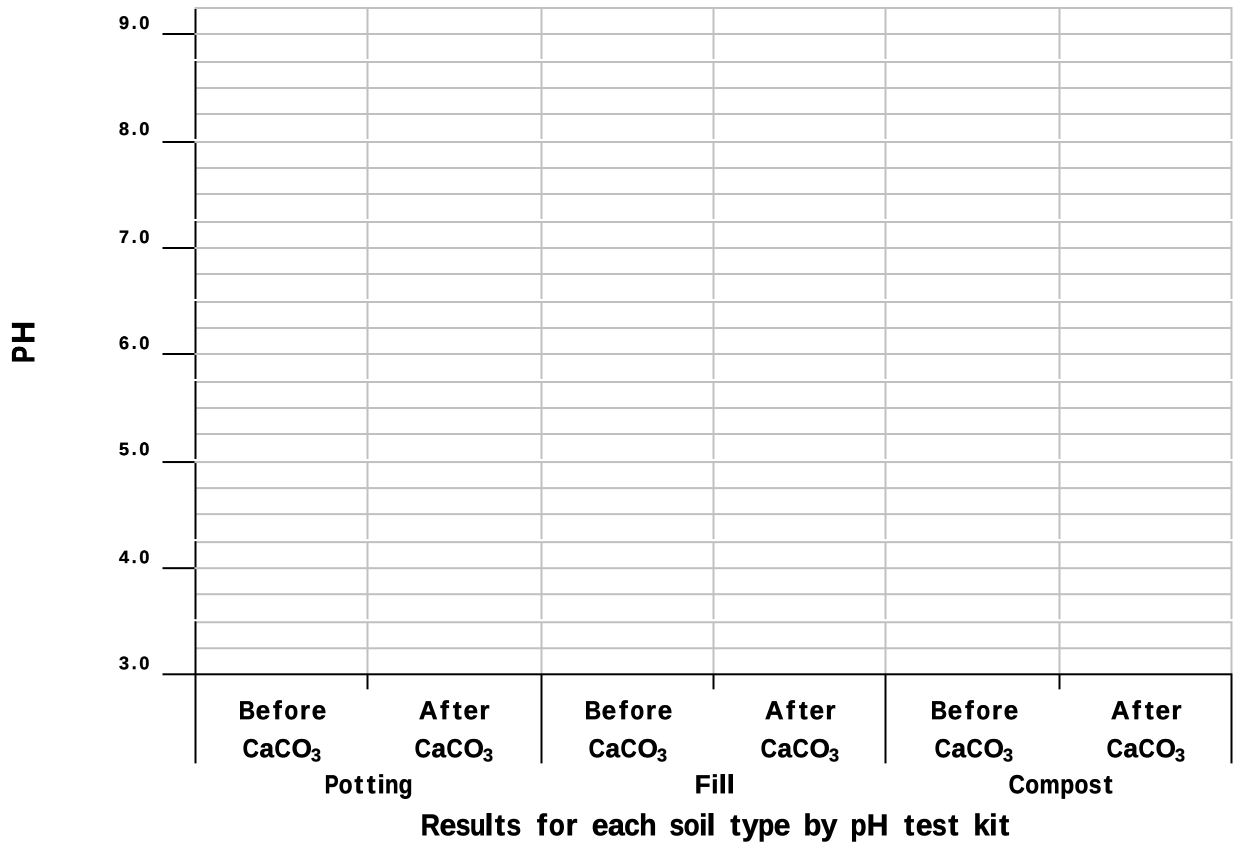
Figure 1. Mean pH of artificial lake water after runoff of simulated acid rain through soil before and after the addition of calcium carbonate, by soil type.



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Conclusions (Questions): *For full credit, these questions should be answered thoroughly, in complete sentences, in legible handwriting.*

1. Which of the three soil types did a better job of buffering the simulated acid rain (as evidenced by the change in pH of the artificial lake) **prior** to addition of the $CaCO_3$? Offer a possible explanation for differences in buffering capacity among the three soil types.

2. Which of the three soil types did a better job of buffering the simulated acid rain (as evidenced by the change in pH of the artificial lake) **after** to addition of the $CaCO_3$?.

3. Based on the acid buffering capacity indicated in this exercise for each soil type (before the addition of $CaCO_3$), which soil do you think would provide the best environment for growing plants?

4. Do you think that the soil's ability to buffer acid rain would have increased even more if a larger quantity of $CaCO_3$ had been added?