TEACHING KATE
TEACHING KIDS ABOUT THE ENVIRONMENT

RAIN DROPS KEEP FALLING ON MY SOIL

Grade Level: 11-12 **Time Required:**

SC Science Standards

This lesson plan was correlated with only the grade level specified unless otherwise noted.

9-12th:
I. B. 1, 2, 4, 7, 9, 10
I. D. 1
II. D. 5. a, d
IV. C. 2. a, c
IV C. 3. a. 1, 2, 3, 4, 6

Purpose

To study several soil samples with regard to pH, the soil's pH after fertilizer is added, the soil's ability to absorb acid rain and the effect of acid rain on the availability of plant nutrients.

Skills

Analyzing, comparing patterns, concluding, interpreting, measuring.

Concepts

Different types of soils have different pH's. Adding fertilizer changes the pH of the soil. Certain crops grow better at a certain pH. Acid rain changes the pH of the soil. Certain soil types are better at absorbing acid rain than other types. Acid rain affects the availability of plant nutrients.

Materials

0.01M $NaHCO_3$ (0.84g $NaHCO_3$ /L solution)
0.001M $NaHCO_3$ (0.084g $NaHCO_3$ /L solution)
Several Types of Soil Samples (dry)
Soil Samples Mixed With Fertilizer - (dry)
Transparent Straws or Glass Tubing Cut to 8" Lengths
24-Well Plate
Bereal Pipettes
Ringstand With Clamp to Hold Straw/Tubing
Universal Indicator Solution
Fresh Lemon
Cotton
Antacid Tablets, Mortar and Pestle
1 Wash Bottle Containing Distilled Water
Toothpicks for Mixing
O.lM $Fe(NO_3)_3$ (2g $Fe(NO_3)_3$ / 50 ml H_2O)
0.5M KSCN (2.4g KSCN / 50 ml H_2O)
O.lM $CaCl_2$ (0.5g $CaCl_2$ / 50 ml H_2O)
O.lM $HC_2H_3O_2$ (0.3 ml $HC_2H_3O_2$ [glacial acetic acid] / 50 ml H_2O)
O.lM $(NH_4)_2C_2O_4$ (0.5g $(NH_4)_2C_2O_4$ /50 ml H_2O [or substitute sodium oxalate]).

Definition of Terms

Acid Rain — Rainwater with a high acid content (pH 5.6) that results from the reaction of water in the air with oxides of nitrogen and sulfur.

Acidic — The quality of water solutions that contain a high concentration of hydrogen ions. Acidic solutions have a pH less than 7.

Alkaline — The quality of water solutions that contain a high concentration of hydroxide ions. Alkaline solutions have a pH greater than 7.

Basic — Alkaline

Buffer — Substance that resists a change in pH.

Fertilizer — A substance added to soil to supplement its nutrient content.

Leaching — Loss of plant nutrients from soil as they dissolve in water that soil cannot hold.

pH scale — A scale of numbers from 1 to 14 used to indicate how acidic or alkaline is a substance. A pH of 7 is considered neutral. A pH below 7 is acidic and a pH above 7 is basic.

Precipitate — A solid that forms when a substance will not further dissolve in a solvent.

Before the Session

Collect soil samples. Be sure the samples are dry because if they are wet the packing in the straws will be too tight and it will take forever for the water to flow through the sample. A good source for transparent straws are fast food restaurants. Prepare all chemical solutions. Collect all materials and supplies. Some fertilizers are basic and some are acidic. Samples of each type of fertilizer should be used.

Background Information

Clay, silt, and sand are the three types of mineral particles found in the soil. A good mixture of soil should contain sand, clay and silt. If soil particles are relatively large, the soil is classified as sandy soil. If the particles are very fine, the soil is classified as clay soil. Soil with a mix of sand, silt and clay is called loam. Loam is a good type of soil for plant life.

Normal rainfall is usually slightly acidic. It is acidic because water in the air reacts with carbon dioxide in the air. This produces carbonic acid.

$$H_2O + CO_2 \rightarrow 2\ H_2CO_3 \text{ (carbonic acid)}$$

Oxides of sulfur and nitrogen emitted from power plants, various industries, and automobiles also react with atmospheric moisture and form acids. This chemical process has, at times, lowered the pH of rainwater to 4-4.5 in the northeastern United States. The key reactions are:

$$H_2O\ (l) + SO_2\ (g) \rightarrow H_2SO_3\ (aq) \text{ (Sulfurous acid)}$$

$$H_2O\ (l) + SO_3\ (g) \rightarrow H_2SO_4\ (aq) \text{ (Sulfuric acid)}$$

$$H_2O\ (l) + 2NO_2\ (g) \rightarrow HNO_3\ (aq)\ HNO_2\ (aq)$$
(Nitric acid) (Nitrous acid)

Occasionally the levels of these oxides in air produce enough acid to lower the pH to 3. (A pH of 4 to 4.5 is about the acidity or orange juice; a pH of 3 is about that of vinegar.) As of July, 1994 there have been no documented cases of damage to crops from acid rain in South Carolina.

Changes in pH may drastically affect the availability of plant nutrients. The pH range suitable for growth of various fruits and vegetables is shown in the following chart.

Plant	pH Range	Plant	pH Range
Blueberries	4.0 - 5.5	Cauliflower	5.5 - 7.5
Cranberries	4.2 - 5.0	Tomatoes	5.5 - 7.5
Potatoes	4.8 - 6.5	Onions	6.0 - 7.0
Strawberries	5.0 - 6.5	Peas	6.0 - 7.5
Peppers	5.5 - 7.0	Asparagus	6.0 - 8.0

The pH of soil can also be affected by the types and amounts o fertilizers that a farmer or gardener may use and chemicals used to control pests or weeds. Soils that are too acidic to grow crops can be reconditioned. Lime (calcium hydroxide) can be added to soils to neutralize their acidity.

Plants need sixteen chemical elements to grow. Among the most important are nitrogen, phosphorus, potassium, carbon, oxygen, sulfur, calcium, iron, and chlorine. Before plants can use an element, it must be placed in a solution that the plant can absorb. If acid rain makes the soil too acidic, it interferes with the plant's ability to absorb nutrients from the soil. Depending on the geology of an area, the effects of acid rain on the soil may be neutralized. This may happen, for example, in areas with an abundance of limestone.

Suggested Lesson Plan

After reading the background material, guide the students in performing the following activities using the described procedures.

HAZARDS

Wear safety goggles and use normal precautions when handling chemicals. Dispose of all chemicals as directed by your teacher.

Procedure 1

1. Prepare a data table for each soil sample. (See sample data table.)

2. Plug the straw/tubing on one end with a pinch of cotton. The purpose of the cotton is to just hold the soil in the straw/tube. Too much cotton increases the time it takes the water to flow through the straw/tube.

3. Loosely pack each soil sample in a separate straw/tube to 4 inches above the top of the cotton. When the soil is tightly packed, it takes forever for the solution to flow thru the soil.

4. Place the column into a 24-well plate. Use the ringstand and clamp to hold the straw/tube upright. Using a pipet add water on top of the column until it is filled. Collect the water that flows from the bottom of the column into the 24-well plate. (Be sure to check the pH of the water you are using, so that you know if it changes as it passes through your soil sample.)

5. Test the water collected in the well to determine its pH by adding 1-2 drops of universal indicator. If the water is pH 7 or greater, proceed to step 7. If the water pH is less then 7, proceed to step 6.

6. Divide the sample of water that was collected into two wells. To one sample add, one drop at a time, the 0.01M $NaHCO_3$. Carefully count the number of drops needed to reach a reading of pH 7. If you reach pH 7 using only one drop of that concentration of sodium bicarbonate, repeat the procedure using the 0.001M $NaHCO_3$ solution.

7. Squeeze the juice from one lemon. Measure the volume of juice collected. Dilute the juice with an equal volume of water. Test a small sample of the diluted juice to determine its pH.

8. Place two drops of the diluted lemon juice into the soil column and then add water to fill the column. (This will simulate acid rain falling on the soil.) Use the same procedure as in 4. above to collect the water as it goes through the column of soil and test its pH.

9. Grind one antacid tablet and mix with about 2 tablespoons of fresh soil. Be sure it is the same type of soil tested above. Place the soil-antacid mixture into a straw/tube and repeat steps 4 - 8.

10. Place each soil-fertilizer mixture in a straw/tube and repeat steps 4-8.

Procedure 2

Iron(III) Ion Test (Fe^{3+})

1. Place 5 drops of Iron (III) Ion Reference Solution [$Fe(NO_3)_3$] in the clean cell identified as "reference."

2. Add one drop of KSCN solution to the cell.

3. Mix the cell contents thoroughly.

4. Record the results in your data table. The reaction that takes place can be represented as follows:

Fe^{3+} (aq)	+	SCN^- (aq)	$\rightarrow$	$FeSCN^{2+}$ (aq)
Reference		Reagent		Iron(III) thiocyanate (red color)

5. Repeat this test on 5 drops of water from each soil sample, each acidified soil sample, each sample with fertilizer and each soil sample with antacid. Record the results in your data table.

Procedure 2

Calcium Ion Test (Ca^{2+})

1. Place 5 drops of Calcium Ion Reference Solution ($CaCl_2$) into a clean cell identified as "reference".

2. Add one drop of dilute acetic acid ($HC_2H_30_2$) to the cell.

3. Now add one drop of ammonium oxalate solution [$(NH_4)_2C_20_4$] and mix the contents of the cell. Record your results. The reaction that takes place can be represented as follows:

Ca^{2+} (aq)	+	$C_20_4^{2-}$ (aq)	$\rightarrow$	CaC_20_4 (s)
Reference		Test reagent		Precipitate

4. Repeat this test on 5 drops of water from each soil sample, each acidified soil sample, each sample with fertilizer and each soil sample with antacid. Record the results in your data table.

Application

1. What types of fruits and vegetables would be suitable for each type of soil you tested?

2. What causes the red color in "Georgia Red Clay"?

3. Why is limestone (calcium hydroxide) added to very acidic soil?

4. How did the type of soil affect the rate at which the water flowed thru it?

Answers to Applications

1. Use the chart in the background information to match the plant with the pH of the soil tested.

2. The red color is an indication of the presence of Iron Oxide. Remember the red color in the test for iron.

3. Limestone (calcium hydroxide) is basic and neutralizes the acid.

4. The water flowed very quickly through sandy soil. Water flowed very slowly through soil with a high clay content.

Resources Available

Applied Biology/Chemistry. 1992. Natural Resources.

ChemCom Chemistry in the Community. 1993. Kendall/Hunt Publishing Company.

Woodrow Wilson Chemistry Institute. 1989. Linda Padwa and Lance Rudiger.

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DATA TABLE — 1

Name: Date:

I. pH of water _____

II. Soil sample # _____

III. pH of soil sample _____

drops of $NaHCO_3$ to bring to pH 7 _____

IV. pH of acidic fertilizer sample _____

drops of $NaHCO_3$ to bring to pH 7 _____

V. pH of basic fertilizer sample _____

VI. pH after adding lemon juice _____

drops of $NaHCO_3$ to bring to pH 7 _____

VII. pH of antacid tablet sample _____

drops of $NaHCO_3$ to bring to pH 7 _____

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DATA TABLE — 2a-b

Name: Date:

I. Data Table 2a

Iron Reference	Color (yes/no)	Precipitate
Soil Sample # _____		
Acidic Soil Sample		
Acidic Fertilizer Sample		
Basic Fertilizer Sample		
Soil Sample with Antacid		

II. Data Table 2a

Calcium Reference	Color (yes/no)	Precipitate
Soil Sample # _____		
Acidic Soil Sample		
Acidic Fertilizer Sample		
Basic Fertilizer Sample		
Soil Sample with Antacid		

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QUESTIONS

Name: Date:

I. Did the different types of soil have different pH's?

II. What characteristics of the soil might account for different pH's?

III. How did the soils tested react to "acid rain?"

IV. What effect did the antacid have on the soil's reaction to "acid rain?"

V. Why do different types of soil differ in buffering capacities?

VI. Why does "acid rain" affect lakes more than soils?

VII. What effect did the "acid rain" have on the amount of iron and calcium removed from the soil?

VIII. From the results of this experiment can you deduce the effect of acid rain on the local environment where the different types of soil are found? Explain your deduction.