Name _____ Class _____ Date_____

Soil Solutions

Exploring Ions Found in Soil

Questions Which ions will be dissolved when soil is mixed with water? How do the amounts of these ions vary in soils from different locations?

Lab Overview In this investigation you will collect and test soil from two locations. One sample will be soil you predict to be high in nutrients important to plants, and the other will be soil you predict to be low in these nutrients. You will use a soil testing kit to find out if your predictions were correct.

Introduction In this lab you will compare levels of certain plant nutrients in soils from different areas near your home or school. You will collect two samples of local soil and use a soil testing kit to identify and determine the amounts of plant nutrients available as dissolved ions in each "soil solution."

Background Soil is made up of weathered rock particles, clay, and decaying organic material called humus. As you'll observe in this lab, when you place soil and water in a cup, the rock and clay particles sink and the humus floats. Meanwhile, ionic compounds dissolve in the water and form a solution. Some of these dissolved ions contain elements that are required for a plant to be healthy. For example, plants need nitrogen (N) to make chlorophyll, a molecule that plays an important role during photosynthesis. Without nitrogen and certain other elements from soil, such as phosphorus (P) and potassium (K), plants cannot survive. Plants obtain these elements by absorbing the ions NH_4^+ (ammonium), PO_4^{3-} (phosphate), and K^+ (potassium) from the soil.

The type of particles that make up the soil affects the soil's ion levels. For example, humus and clay particles are negatively charged. These negatively charged particles attract positive NH_4^+ and K^+ ions, but repel negative ions such as PO_4^{3-}. As a result, soils that are particularly high in humus and clay particles compared to rock particles tend to have high levels of NH_4^+ and K^+ ions.

Prelab Activity A farmer has several fields of corn planted in different areas. Most of the farmer's cornfields contain healthy plants, but three have sickly plants. The farmer had the soil tested in these three fields as well as in a field with healthy plants. The results of the soil

tests are summarized in Table 1. Use the test results to help guide you in choosing sites where you might find soil with high or low levels of N, P, and K for your own investigation.

Table 1: Farmer's Soil Testing Results

Field #	Level of N	Level of P	Level of K	Description of Plants
1	high	high	high	This field contains a good crop: tall, strong plants with dark green leaves.
2	low	high	high	Older leaves are yellowish.
3	high	low	high	Older leaves are purplish in color, especially at the outer edges.
4	high	high	low	Leaves are yellowed at the outer edges. Some of the leaf tips appear burned.

Prelab Questions

1. Fill in the chart below about plant nutrients found in soil.

Plant Nutrients in Soil

Element Name	Symbol for Element	Chemical Formula of Ion	Name of Ion
a. _____	b. _____	NH_4^+	c. _____
Phosphorus	d. _____	e. _____	f. _____
g. _____	h. _____	i. _____	Potassium

2. Your goal in choosing the sites to sample is to find soil that is high in N, P, and K and soil that is likely to be low (deficient) in at least one of these plant nutrients. How might you use the information you learned in the Background and the Prelab Activity as clues to finding nutrient-deficient soil?

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3. Based on the information you read in the Background, explain how you will separate the ions from the soil during your investigation.

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Materials

- ruler
- garden trowel or small shovel
- small self-sealing plastic bag
- marker
- masking tape or labels
- soil testing kit (rapitest® Soil Kit or LaMotte Soil Testing Kit)
- cups
- bottled or distilled water

Procedure

Part A: Choosing Your Soil Collection Sites

1. You will need to collect two soil samples. One soil sample should come from a site that you think may be high in the plant nutrients nitrogen (N), phosphorus (P), and potassium (K). The other soil sample should come from an area that you think may be low in N, P, and K. Follow your teacher's instructions about where to find soil collection sites—around your school, near your home, or in a nearby park, wooded area, or other open space. (**NOTE:** *Do not collect soil from private property unless you have specific permission from the property owner.*)

   When choosing your soil collection sites, consider the following questions:

   - What are some clues that might indicate that a site has high levels of these plant nutrients? (*Hint:* Would you look near lush plant growth, areas where crops are grown, sandy soil, soil rich in humus, soil near water, or rocky soil?)
   - What are some clues that might indicate that a site has low levels of these plant nutrients? (*Hint:* Remember what you learned about the appearance of plant leaves.)

Record observations about your sites in Data Table 1 below.

Data Table 1

	Site A	Site B
Name of site		
Description of site		
Do you think this site is high or low in plant nutrients? Explain your hypothesis.		

2. After you have chosen your sites, obtain a garden trowel or small shovel, marker, and two self-sealing plastic bags. Then prepare to collect samples following the directions in Part B.

Part B: Collecting Your Soil Samples

1. To collect a soil sample at your first collection site, begin by scraping off the top layer of soil with a garden trowel to remove any sticks, leaves, or other debris.
2. Dig an 8-cm-deep hole into the soil and collect your sample. Fill a self-sealing plastic bag about half-full. Label the bag with the site name. **CAUTION:** *Soil can contain disease-causing microorganisms. Wash your hands thoroughly with soap after handling soil.*
3. Go to the second collection site. Repeat Part B, steps 1 and 2.
4. Bring the two labeled bags with your soil samples to your classroom lab.

Part C: Testing Your Soil Samples

1. To test your soil samples, read the directions in the soil testing kit. Then use the kit to test your soil samples. **CAUTION:** *Handle test kit solutions carefully to avoid getting any on your skin or clothing. These solutions may be acidic and/or contain permanent dyes.*

Name _____ Class _____ Date _____

2. After testing each sample, record the levels of N, P, and K in Data Table 2.

Data Table 2

Site Name	N Level	P Level	K Level

Analysis and Conclusions

1. Compare the results from your two sites. Did they support your hypotheses about which site was likely to be high in nutrients and which was likely to be low?

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2. Plant roots can only absorb dissolved ions. For example, plant roots cannot absorb the compound KNO_3 (potassium nitrate). However, when this compound dissolves in water, the ions K^+ and NO_3^- (nitrate) form. Plants can absorb these ions. What property of water is most important for plants to obtain these ions?

a. It takes a lot of heat to change the temperature of water.
b. Water is less dense when it is frozen than when it is liquid.
c. Hydrogen bonding of water creates surface tension.
d. Water molecules are polar with partial negative and partial positive charges.

Explain.

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3. Collaborate with your classmates to determine which locations were the source of the soil samples with the highest and lowest levels of N, P, and K.

a. Describe any patterns that you observe for sites with high and low levels of the nutrients.

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b. Develop hypotheses that could explain why these areas have high or low levels of the nutrients.

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4. Table 2 below provides a list of some organic fertilizers that contain N, P, and K. Based on your soil testing results, which fertilizer (or combination of fertilizers) do you think would be best to add to your soil in order to provide adequate amounts of N, P, and K? Explain why you think this is the best choice.

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Table 2: Percentages of Nutrients in Various Fertilizers

Fertilizer	N	P	K
Alfalfa meal	2	0.5	2
Bat guano (droppings)	10	3	1
Cotton seed meal	6	2	1
Kelp meal	1	0.1	2
Blood meal	13	0	0
Bone meal	3	15	0

Extension

The pH of soil affects how easily plants can obtain nutrients from soil. If the pH is too high or too low, the ionic compounds do not dissolve as easily in water and are less available to plants. Most plants require the soil pH to be between 6 and 7. Design an experiment to determine whether adjusting the pH of your soil samples could increase their levels of dissolved nutrients. You can alter the pH of the soil by adding an acid such as vinegar, or a base such as limestone. (**NOTE:** *Be sure to check with your teacher before carrying out any investigations.*)