10. Soil Characteristics

What's the Dirt on Soil pH?

Driving Question

Why is it important to know the pH of soil?

Materials and Equipment

For each student or group:

- ☐ Data collection system
- ☐ pH sensor
- ☐ Beakers, 250 mL (4)
- ☐ Balance
- ☐ Rinse bottle, with distilled water
- ☐ Stirring rod
- ☐ Measuring spoons (optional)
- ☐ Re-sealable plastic bags (3)
- ☐ Permanent marker
- ☐ Soil samples, 60 mL (3 different types)
- ☐ Gardening sulfur (from garden store), ~5 g each
- ☐ Gardening lime (dolomite or dolomitic limestone)
- ☐ Distilled water, 250 mL (for soil samples)

Safety

Add these important safety precautions to your normal laboratory procedures:

- Wear safety glasses and lab coats or aprons.
- Wear gloves when handling sulfur and lime.

Thinking about the Question

If you have ever helped plant and care for a garden, you know that plants prefer certain types of soils, and that each type of plant has its own requirements in order to produce the best fruit, or flowers, or leaves.

Most plants thrive within a narrow range of soil pH conditions. If the soil pH is above or below this range, soil conditions may not allow plants to grow ideally. Plants may suffer from poor health in such soil. For example, the roots may be unable to take in the necessary nutrients or anchor the plant properly in the soil, the stems may not be able to grow strong enough, the leaves may not develop fully, and the flowers or fruits may not be able to complete the plants' reproductive cycle. Soil that is too acidic can cause some naturally occurring metals, such as iron, nickel, aluminum, and manganese, to become too concentrated for plants' healthy growth, while also making it difficult for the plants to absorb the phosphorus, calcium, or magnesium that they need to grow properly. This can affect agricultural practices, such as applying fertilizers and pesticides. Because a change in pH can alter the fate of an agricultural crop, pH has become an invaluable tool for measuring soil fitness.

The pH range that crops can tolerate varies. Corn, cucumbers, and cotton may be able to grow in soils as acidic as pH 5.5. Lettuce, beans, and onions won't grow well at all in soil that is more acidic than 6.0. Peanuts, peppers, and strawberries don't grow well in soil that has a pH higher than 6.5. Cabbage, carrots, and spinach prefer pH neutral soil which is neither acidic nor basic.

Some crops can tolerate a wider range of pH than others. For example, potatoes are relatively intolerant of variation, growing best in soil that is acidic, between pH 5.0 and 5.25. Alfalfa on the other hand, which is a crop used to feed livestock and other animals, is relatively tolerant to variations in pH. It can grow in soils that range from pH 5.2 to 7.8.

Discuss with your group members the different ways that gardeners and farmers amend, or improve, the soil for their crops. Be prepared to share your thoughts with the class.

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In this activity you will investigate the pH of different soil samples. You will decide which soils are best suited to which types of plants, and also determine how to change the pH of a soil that is too high or too low.

Sequencing Challenge

☐ **The steps below are part of the Procedure for this lab activity. They are not in the right order. Determine the proper order and write numbers in the circles that put the steps in the correct sequence.**

Remove large particles such as rocks, twigs, and leaves from collected soil samples.	Place soil samples in beakers, and add 60 mL distilled water to each beaker.	Crush soil samples in re-sealable plastic bags.	Use the pH sensor to measure the pH of each soil sample.	Make sure each lab group member is aware of safety rules and procedures for this lab.

Investigating the Question

☐ **Note:** When you see the symbol "❖" with a superscripted number following a step, refer to the numbered Tech Tips listed in the Tech Tips appendix that corresponds to your PASCO data collection system. There you will find detailed technical instructions for performing that step. Your teacher will provide you with a copy of the instructions for these operations.

Part 1 – Making predictions

1. ☐ Write your predictions for the following:

   a. Which soil samples in your group will be higher in pH (more basic) and which will be lower in pH (more acidic)?

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   b. Which soil samples in your class will be higher in pH (more basic) and which will be lower in pH (more acidic)?

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   c. How will the pH of the soil samples collected by your teacher compare to those contributed by the class?

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   d. Will it be possible to change soil pH by adding sulfur or lime to the soil?

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Part 2 – Preparing the soil for testing

2. ☐ Label a beaker for each soil sample as you did with the sample bags.

3. ☐ Remove any rocks, sticks, or foreign objects from the sample bags.

4. ☐ Leaving the soil sample inside the bag, crush the soil with your fingers, or if necessary with a digging tool, and mix the crushed particles thoroughly.

5. ☐ Place 10 g (or 2 tablespoons) of the first soil sample in the beaker labeled for that sample.

6. ☐ Add 60 mL of distilled water to the beaker and mix thoroughly with a stirring rod.

7. ☐ Let the soil-water mixture stand for five minutes prior to data recording to allow the particles of the soil to dissociate into ions.

8. ☐ Repeat the steps to prepare the other two soil samples. Why is it important to crush the soil samples before mixing them with distilled water?

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Part 3 – Testing the pH of the soil

9. ☐ Start a new experiment on the data collection system. ◆1.2

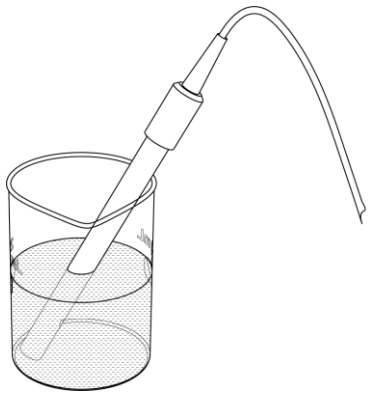
10. ☐ Connect a pH sensor to the data collection system using a sensor extension cable. ◆2.1

11. ☐ Display pH in a digits display. ◆7.3.1

12. ☐ Remove the plastic bottle from the pH electrode, and set the bottle aside.

13. ☐ Using the wash bottle, rinse the pH sensor with distilled water over the empty beaker. This beaker will hold waste rinse-water.

14. ☐ Monitor live data. ◆ (6.1)



15. ☐ Lower the sensor into the first soil-water mixture, and gently stir the solution with the sensor during data collection.

16. ☐ Wait for the reading to stabilize (as much as 60 seconds).

17. ☐ Record the pH in Table 1 below.

18. ☐ Remove the sensor and rinse it with distilled water.

19. ☐ Repeat the previous steps for the other two soil samples.

20. ☐ Stop data monitoring. ◆ (6.1)

21. ☐ Mark the pH value on each resealable bag with the permanent marker.

Part 4 – Adjusting the pH of the soil

22. ☐ Select a soil sample that measured outside the 6.5 to 7.2 range of pH. If none of the samples was outside this range, select the sample whose measured pH was farthest from a neutral pH of 7.0. If your goal is to bring this soil sample's pH back to neutral, will you to raise or lower its pH? Which substance will you need to add to the soil sample to achieve this goal?

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23. ☐ As appropriate, select lime to raise the pH (decrease acidity) or sulfur to lower the pH (increase acidity). Your teacher will make these materials available to you.

    ☐ **Note:** Avoid breathing the dust from sulfur or lime as it may cause irritation.

24. ☐ Rinse the sensor with distilled water.

25. ☐ Monitor live data. (6.1)

26. ☐ Lower the sensor into the soil-water mixture and gently stir the solution with the sensor during data collection.

27. ☐ Wait for the reading to stabilize (as much as 60 seconds).

28. ☐ Add either the lime or sulfur, beginning with 0.2 g (1/8 of a teaspoon) and stirring with the pH sensor until the reading stabilizes.

29. ☐ Continue adding the lime or sulfur in 0.2 gram increments until the soil solution is within the acceptable range of pH. Record the total amount of lime or sulfur added to the soil solution.

    Total amount added: _____ grams

    Substance added: _____

30. ☐ Enter the pH in Table 2 below.

31. ☐ Stop data monitoring. (6.1)

32. ☐ Remove the sensor and rinse it with distilled water. Replace the sensor in its plastic bottle.

33. ☐ Clean up according to your teacher's instructions.

Table 1: Stabilized pH readings for soil samples

Soil sample and Location	1	2	3
pH			

Table 2: pH measurements of soil before and after adjusting mixture with lime or sulfur

Location	**pH before adjusting the mixture**	**pH after adjusting the mixture**	**Substance used to adjust the mixture (lime or sulfur)**	**Amount of substance used**

Answering the Question

Analysis

1. Do you think the soil samples you collected were good for growing plants?

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2. What features near your soil collection sites might have influenced the pH of the soil samples?

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3. Were you able to adjust the pH of the soils to within the acceptable range? What did the sulfur or lime do to the pH of the soil-water mixtures?

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4. Can you adjust the pH of a real garden applying the method you used in this activity?

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5. Suppose you are a farmer planning to plant a large field of blueberries. Blueberries grow on bushes that need relatively acidic soil with a pH of 4.5 to 5.5. After careful analysis of the soil in your field, you learn that its pH is 6.5. Will you be able to successfully grow the blueberry crop in this field as it is, or will you need to make changes to the soil? Describe how you would go about preparing this field for planting your blueberry bushes.

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6. Some gardeners have compost bins or piles to which they add plant clippings, wood chips, and such kitchen scraps as fruit and vegetable peelings and rinds, and even egg shells. Over a few weeks, this material breaks down into a healthy additive for garden soil. Given that egg shells contain calcium carbonate, a key ingredient in garden lime, why might a gardener choose to include more or fewer egg shells in her compost? Explain your reasoning.

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Multiple Choice

☐ **Circle the best answer or completion to each of the questions or incomplete statements below.**

1. When a substance has a pH of 3.7, it is classified as a/an

   A. Neutral substance
   B. Acid
   C. Base

2. Farmers and gardeners need to know the pH of soil in which they grow crops because

   A. Different types of plants have different tolerances for acidic or basic soil
   B. Changes in pH can affect only certain types of crops
   C. Neutralizing acidic soil is important to all crops grown for our food supply.

3. Plants absorb nutrients available in the soil by taking them in through

   A. Photosynthesis
   B. Their leaves
   C. Their roots

4. Which of the following could be caused by a fruit-bearing plant's soil being too basic or alkaline for the plant?

A. A greater than average number of fruits on the plant
B. Poor production of fruits
C. Abundant leaves that appear green and healthy

5. Which of the following is a likely result of adjusting the pH of a garden's soil so it is within the preference of the plants to be grown?

A. A harvest of fruits or vegetables that is at least average and possibly above average
B. A failure of the plants to produce fruits or vegetables
C. Leaves and stems that are yellowish rather than green, indicating that they are unhealthy

6. When testing the pH of a soil sample with the pH sensor, it is necessary to mix the sample with distilled water

A. In case the pH sensor has not been removed from its plastic bottle
B. So that the pH measured is the pH of *only* the water
C. Because the pH sensor cannot measure pH in a dry material

7. Which statement is true about using the pH sensor to test the pH of soil samples?

A. The large parts of a soil sample such as rocks, twigs, or leaves are necessary for the soil's pH to be measured by the pH sensor.
B. The pH of a dry soil sample can be measured as well as a sample that has been added to water.
C. It is important to crush the soil sample so that minerals contained in the sample can dissolve in water.

8. Farmers who produce large crops that provide food for many people analyze the pH of the soil in which they grow crops because

A. This information is helpful during times of drought or water shortage
B. pH is a good indicator of the soil's fitness for a particular crop
C. Potatoes tolerate only a very narrow pH variation in their soil

9. A crop such as blueberries, which needs an acidic soil, would *not* grow well in a field whose soil pH is between

A. 4.5 and 5.5
B. 5.0 and 5.3
C. 6.0 and 6.5

10. A crop such as alfalfa, which tolerates a wider variation of soil pH, would probably grow well in every field *except* one whose soil has a pH of

A. 9.4
B. 7.1
C. 5.8