Computer
8

Soil pH

When you think of pH, you probably think of liquid acids and bases. But soil can be acidic or basic, too. Soil pH, sometimes referred to as soil acidity, can be expressed using the *pH* scale. The pH scale ranges from 0 to 14. Soils with pH above 7 are basic or *sweet*. Soils with pH below 7 are acidic or *sour*. A soil with a pH of 7 is neither acidic nor basic, but is *neutral*.

Plant Nutrients	
Macronutrients	**Micronutrients**
Nitrogen	Iron
Phosphorus	Manganese
Potassium	Zinc
Sulfur	Copper
Calcium	Molybdenum
Magnesium	Cobalt
	Chlorine

The pH of soil is an important factor in determining which plants will grow because it controls which nutrients are available for the plants to use. Three primary plant nutrients – nitrogen, phosphorus, and potassium – are required for healthy plant growth. Because plants need them in large quantities, they are called *macronutrients*. They are the main ingredients of most fertilizers that farmers and gardeners add to their soil. Other nutrients such as iron and manganese are also needed by plants, but only in very small amounts. These nutrients are called *micronutrients*.

The availability of these nutrients depends not only on the amount but also on the form that is present, on the rate they are released from the soil, and on the pH of the soil. In general, macronutrients are more available in soil with high pH and micronutrients are more available in soil with low pH. Figure 1 shows the effect of pH on the availability of nutrients in the soil.

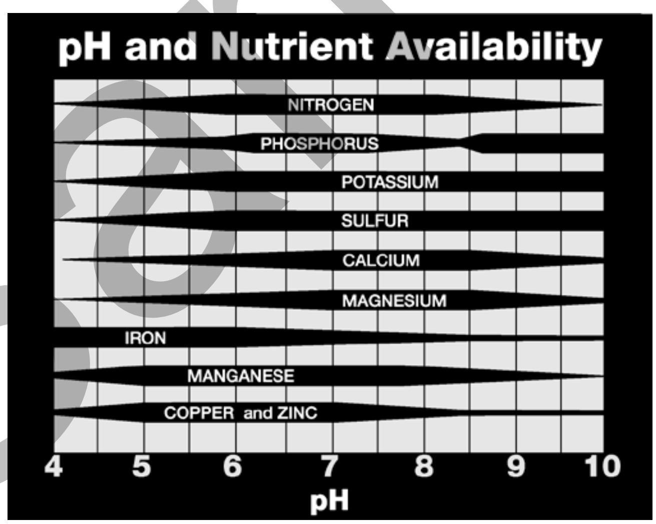


Figure 1

OBJECTIVES

In this experiment, you will

- Use a pH Sensor to measure the pH of soil samples.
- Identify any nutritional problems plants would have in that soil.

MATERIALS

computer
Vernier computer interface
Logger*Pro*
Vernier pH Sensor
100 mL graduated cylinder
waste cup
distilled water
2 soil samples
two 250 mL beakers
wash bottle with distilled water
2 plastic spoons
paper towels

PROCEDURE

1. Prepare the water-soil mixture.
   a. Label two beakers "A" and "B".
   b. Place 50 g of Soil A into Beaker A. To avoid cross-contamination of the soils, leave this spoon in the beaker.
   c. Using a new spoon, place 50 g of Soil B into Beaker B. Leave the spoon in the beaker.
   d. Add 100 mL of distilled water to each beaker.
   e. Stir both mixtures thoroughly.
   f. Stir once every three minutes for 15 minutes.
   g. After the final stirring, let the mixtures settle for about five minutes. This allows the soil to settle out, leaving a layer of water on top for you to take your pH measurement. Continue with Steps 2–5 while you are waiting.

2. Connect the pH Sensor to the Vernier computer interface. **Important:** For this experiment your teacher already has the pH Sensor in pH soaking solution in a beaker; be careful not to tip over the beaker when connecting the sensor to the interface.

3. Prepare the computer for data collection by opening the file "08 Soil pH" from the *Agricultural Science with Vernier* folder.

4. Calibrate the pH Sensor.
   - If your teacher directs you to use the stored calibration, proceed to Step 5.
   - If your instructor directs you to perform a new calibration for the pH Sensor, follow this procedure.

   First Calibration Point
   a. Choose Calibrate ▸ CH1: pH from the Experiment menu and then click Calibrate Now.
   b. Place the sensor tip into the pH-7 buffer. Type **7** (the pH value of the buffer) in the edit box.
   c. When the displayed voltage reading for Reading 1 stabilizes, click Keep.

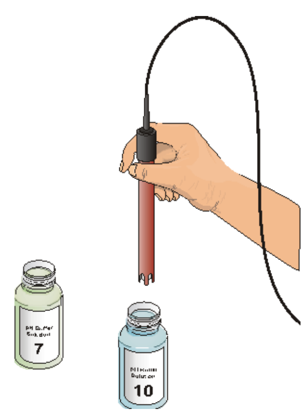


Figure 2

   Second Calibration Point
   d. Rinse the sensor with distilled water and place it in the pH-10 buffer solution.
   e. Type **10** (the pH value of the buffer) in the edit box.
   f. When the displayed voltage reading for Reading 2 stabilizes, click Keep, then click Done.

5. Measure the pH.
   a. Carefully place the tip of the pH Sensor into the liquid part of Beaker A. If your sensor has a glass bulb at the tip, make sure it is covered by the water.
   b. Note the pH reading in the meter.
   c. If the reading is stable, simply record the pH value in the data table.

6. If the reading is fluctuating, determine the *mean* (or average) value. To do this:
   a. Click ▶ Collect to begin a 10 second sampling run. **Important:** Leave the probe tip submerged for the 10 seconds that data is being collected.
   b. When the sampling run is complete, click on the Statistics button, , to display the statistics box on the graph.
   c. Record the mean pH value in your data table.

7. Rinse the pH Sensor with distilled water and repeat Steps 5 and 6 for the sample in Beaker B.

8. Rinse the pH Sensor with distilled water and return it to its storage container.

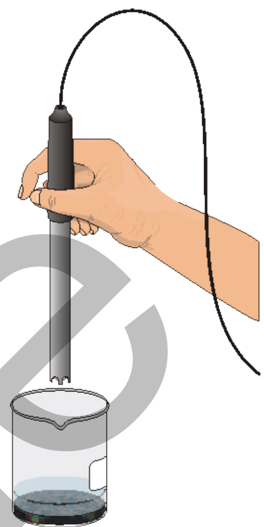


Figure 3

9. Your instructor will tell you whether you should keep the soil for further testing or clean up at this time.

DATA

	Sample A	Sample B
Soil pH		

PROCESSING THE DATA

1. Are the soils acidic, basic, or neutral?

2. Plants growing in these soils might have trouble obtaining enough of some essential nutrients. According to Figure 1, which nutrients might be in short supply for each of the soils?

EXTENSIONS

1. Research the function of each nutrient and what symptoms a plant would have if they were not getting enough.

2. Test soil samples from your backyard or another environment and compare to your first results. Are the results the same or different? Try to explain why.

3. Research how farmers adjust the pH of soils. Design and conduct an experiment to test the effectiveness of their methods.

TEACHER INFORMATION

Experiment 8

Soil pH

1. The student pages with complete instructions for data-collection using LabQuest App, Logger *Pro* (computers), and EasyData (calculators) can be found on the CD that accompanies this book. See *Appendix A* for more information.

2. The “pH soaking solution” used in this experiment is pH 7 buffer solution. It can be purchased from chemical supply companies. Vernier Software & Technology sells a package of capsules for preparing buffer solutions of pH 4, 7, and 10 (Order Code PHB). We recommend that you remove the pH Sensor from its storage bottle before class. If the pH Sensor is soaking in a beaker with pH soaking solution, students will have an easier time taking measurements.

3. The stored calibration for the pH Sensor works well for this experiment. If you want the most accurate results possible, you can have the students perform the 2-point calibration described in the student procedures.

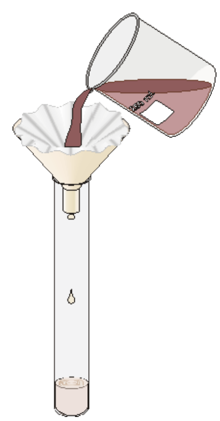
4. You can provide the soil samples, students can bring samples from home, or they can get samples from the schoolyard. Try to get samples of different types of soil to make the results more interesting. One sample could be limed as described in Item 7 to vary the pH between samples.

5. All soil samples should be dry. If you have a drying oven, allow 12 hours at 100°C or 24 hours at 80°C. If air-drying, allow at least 2–3 days depending on moisture content.

6. Water to soil ratios of 1:1, 2:1, 5:1, and even up to 10:1 are used in soil pH field testing. In general, the lower the ratio the better. However, there must be enough water to take a proper reading without harming the glass bulb on the pH electrode. A water to soil ratio of 2:1 is used in the procedure but may easily be changed using the Word files on the CD.

7. Show your students how to properly rinse a pH Sensor using a wash bottle filled with distilled water.

8. Some soil particles may float at the top of the water. This is not a problem as long as the glass bulb at the tip of the sensor is in full contact with the water. If desired, the mixture could be filtered using a funnel and filter paper as shown at right.



9. Soils that are too acidic can be adjusted to a higher pH by using a liming agent. Calcium carbonate, $CaCO_3$, magnesium carbonate, $MgCO_3$, and various oxides of calcium are common liming materials. Ground dolomitic limestone is a popular choice because it contains calcium carbonate and magnesium carbonate. You could lime some soil to vary the results or have students perform an extension to investigate this procedure.

10. The stored calibration for the pH Sensor works well for this experiment. If you want the most accurate results possible, you can have the students perform the 2-point calibration described in the student procedure.

SAMPLE RESULTS

	Sample A	Sample B
Soil pH	5.7	7.2

ANSWERS TO QUESTIONS

1. Answers will vary. For the sample data, Soil Sample A is acidic and Soil Sample B is basic.
2. Answers will vary. For the sample data:

   Soil Sample A probably isn't getting enough phosphorus and may be low in nitrogen and potassium as well. Soil Sample B is probably low in iron and manganese.

ACKNOWLEDGEMENT

We wish to thank Don Volz and Sandy Sapatka for their help in developing and testing this experiment.