DETERMINING SOIL QUALITY

Driving Question

What is a healthy soil and what physical, chemical, and biological characteristics are needed to grow our food?

Materials and Equipment

- Carbon dioxide sensor and sampling bottle
- Conductivity sensor
- pH sensor
- Beaker, 50-mL
- Beaker (4), 100-mL
- Wash bottle containing distilled or deionized water
- Distilled or deionized water, 300 mL
- Labeling tape
- Waste container
- Pipet, disposable
- Digging tool
- Soil samples (from 3 different locations)
- Graduated cylinder, 100-mL
- Permanent marker
- pH calibration buffers, pH 4 and 10
- 10% Vinegar solution, 12mL
- Plastic bags (4), sealable, about 1-L
- Magnifying glass or dissection microscope

Background

Soil quality, also referred to as soil health, is defined as the continued capacity of soil to function as a vital living agro-ecosystem that sustains plants, animals, and humans. This definition speaks to the importance of managing soils so they are sustainable for future generations. To do this, we need to remember that soil is a complex interaction between biotic and abiotic factors. Soil contains living organisms that when provided the necessities of life - food, shelter, and water - perform functions required to produce food and fiber. Monitoring soil health is essential to maximizing crop yield, managing watersheds, and maintaining soil quality for generations to come.

Soil health and quality can determined through several simple tests including;

- Carbon dioxide production: this can indicate the presence or absence of an active microbial community in the soil which is essential to recycling nutrients. A lack of carbon dioxide production indicates few decomposers.
- pH: soil alkalinity or acidity is critical to plant health, the optimum range depends on the crops being grown. While many plants prefer a slightly alkaline soil most citrus trees prefer a slightly acidic soil. A buffering test performed with a weak acid (vinegar) can be used to determine the buffer capacity of the soil which indicates how resilient the soil will be to changes in pH due to acid rain, runoff, or other factors.
- Conductivity: conductivity can be used to asses the levels of salt ions like sodium, potassium, and chlorine that are present in the soil. Again, the desired range is determined by the crop species and soil types in the area.

Procedure

1. Put on your safety goggles.
2. Collect 3 soil samples by doing the following:
    a. Using a clean trowel or soil sampling probe loosen the soil as deep as 10 centimeters and place about 200 ml into a plastic bag.
    b. Label the bag to indicate the soil's location and seal it.
3. Connect the CO_2 gas sensor.
4. Open the AGR01 Determining Soil Quality.spklab lab file.
    - If the file is not available create an experiment file with a graph of CO_2 versus time, a graph of pH versus time, and a digits display of conductivity, this will require multiple pages.
5. Using the 50-mL beaker, add approximately 40 mL (4 tablespoons) of soil from Soil Sample 1 to the 250-mL sampling bottle. Place the CO_2 gas sensor into the bottle and seal it using the attached stopper.
6. Start recording data. Data collection will stop automatically after 10 minutes. Record the change in CO2 gas in the table 1 below. While data collection is in progress, continue with preparing the next tests on step 8.
7. Repeat the CO2 reading for Soil Samples 2 and 3.

Table 1: Analysis of 3 soil samples

Soil Sample	Data Run	ΔCO_2 Gas (ppm)	Soil Conductivity (µS/cm)	Initial Soil pH	Final Soil pH After Adding 10% Vinegar	ΔpH
1	1					
2	2					
3	3					
4	4					

8. After 40-mL of soil sample has been set aside for the CO_2 gas tests, remove any rocks and sticks from the remaining sample. Crush the reaming soil sample into a fine dust with the end of the handle of your digging tool or other suitable instrument.
9. Place 40 mL of each soil sample into a 100-mL beaker. Label each beaker with the sample number. Mix 40 ml of distilled water into each beaker and shake or stir the mixture for 5 minutes, rinse the rod between each sample
10. Allow the samples to rest for at least 5 additional minutes so the sediment can settle before taking your measurements.
11. After CO_2 data collection has finished for all three samples, disconnect the sensor. Connect the conductivity and pH sensors and begin recording data.
12. Lower the conductivity and pH probes into the soil-water mixture. Very gently stir the solution with the probe during data collection. Wait for the measurement to stabilize (at least 30 seconds).

NOTE: Do not let the probes rest in the sediment, make sure the tip of the probe is in the middle of the water layer. If using a PASPORT (blue) conductivity sensor it may be necessary to adjust the range if the measurement plateaus at 1,000 µs/cm.

13. Enter the soil conductivity and initial pH values in Table 1. Repeat the step 11 for the other two samples, be sure to rinse the probes with distilled water between samples.

14. Rinse and disconnect the conductivity sensor.

15. 40mL of a 10% vinegar solution to the 100-mL beaker for each soil sample.

16. Lower the pH probe into the vinegar solution and gently stir the solution with the sensor during data collection. Determine the final pH of the vinegar solution and record it in table 1.

17. Rinse the pH probe with distilled water and repeat for the remaining samples

18. Place a small sample of soil (no larger than a penny) from each soil sample on a sheet of white paper.

19. Compare the soil color, texture, structure, and apparent moisture level of each sample, and enter your observations in Table 2.

Table 2

Location	
Date/time	
Soil color	
Soil texture/Structure	
Moisture	
Observations	

Analysis & Questions

1. The rate of change of CO_2 gas concentration is indicative of the rate of change in cellular respiration. What kind of soil would you expect to produce CO_2 gas at a faster rate—dark, moist soil or dry, clayey soil? Why?

2. Which of the three soil solutions had the highest conductivity? Explain why it might be higher than the other two samples. Recall the location of the sample.

3. Each plant type possesses an inherent tolerance level to conductivity. In general, a crop should tolerate conductivity levels up to 700 micro Siemens per centimeter (µS/cm), without a decrease in yield; however, some plants tolerate even higher levels of conductivity. If a soil contains more than this level of salt, what types of crops might be successfully grown in it?
4. List some possible remedies for the soil samples that seem to be less capable of supporting plant growth. For example, how might a high (alkaline) soil pH be remediated?