Soil Lab

Purpose: To Test and compare soils from around the United States

Background: Unless you are a farmer or gardener, you probably think of soil as “dirt” or something you do not want on your hands, clothes or carpet. Yet, your life and the lives of most other organisms, depends on the soil. Soil is not only the basis of agricultural food production, but is essential for the production of many other plant products such as wood, paper, cotton, and medicines. In addition, soil helps purify the water we drink and is important in the decomposition and recycling of biodegradable wastes.

Nations, including the United States have been built on the riches of their soils. Yet, since the beginnings of agriculture people have abused this vital, potentially renewable resource. In fact, entire civilizations have collapsed because of mismanagement of the topsoil that supported their civilizations. Today, we are not only facing loss of soil from erosion, we are also depleting nutrients in some soils and adding toxins to others.

Hypothesis: Describe where your soil came from. Rate the fertility of your soil on a scale of 1 to 5 with 5 being excellent for growing plants. What made you rate the soil the number that you did?

Procedure: You will perform the following lab tests on your soil to determine the plant growing capacity of your soil. You will then rate the soil on a scale of 1 to 5 and compare it to your hypothesis. You will need to pay attention to time and plan your experiments so as to complete all of them in the time allotted.

Part I: Soil Texture
Soil is composed of particles that are categorized into groups according to their size, as shown in the table below. One method of classifying soils is to measure the relative amounts of sand, silt, and clay in a soil sample, then use a soil triangle to determine the soil type. In this lab, the textural classification of a soil sample will be determined by measuring the relative amounts of sand, silt, and clay particles, then using a soil triangle to determine the soil type. The comparative volumes of sand, silt, and clay will be determined based upon the fact that the different sized particles will settle out of a mixture at different rates.

<table>
<thead>
<tr>
<th>Clay</th>
<th>&lt; 0.002 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silt</td>
<td>0.002 – 0.06 mm</td>
</tr>
<tr>
<td>Sand</td>
<td>0.06 – 2.0 mm</td>
</tr>
<tr>
<td>Gravel</td>
<td>&gt; 2.0 mm</td>
</tr>
</tbody>
</table>

Materials

☐ safety goggles  ☐ distilled water  ☐ Calgon
☐ lab apron  ☐ 100-mL graduated cylinder  ☐ soil sample
☐ 250-mL beaker  ☐ rubber stopper for cylinder

Procedure

1. Bring in approximately 200 grams (1 cup) of soil from around your home. Do not take soil in such a way that it will negatively affect the aesthetic appeal of your home’s landscaping.
2. In a group of four make and share a 5% Calgon solution as follows. Dissolve 10 g of Calgon in 200 mL of distilled water to make approximately 200 mL of 5% Calgon solution.
3. Add approximately 25 mL of soil to a 100-mL graduated cylinder. Add 5% Calgon solution to fill the cylinder to the 50 mL mark. Mix well (until all of the soil has been moistened) and allow the mixture to stand for 15 minutes.
4. Insert a rubber stopper in the graduated cylinder, wrap a paper towel around the stopper, and by inverting the cylinder, mix the solution for 10 minutes. Keep a hand over the stopper to secure it while mixing. Do not force the stopper into the cylinder to prevent leaking, as the cylinder may break; some of the mixture will leak out of the cylinder this is unavoidable.
5. Label the cylinder and leave it undisturbed for 23 hours.
6. After 23 hours, the lines that divide the sand, silt, and clay columns will be visible. Sand will be on the bottom, silt in the middle, and clay on the top. Measure and record the volume of the sand column, the volume of the silt column, the volume of the clay column, and the total volume of soil in the cylinder
7. Calculate and record the percent sand, silt, and clay in the soil sample.
8. Use the soil textural triangle to determine the texture of the soil sample.

**Procedure for Use of the Soil Triangle**

The soil triangle is used to determine textural classes of soil from the percentages of sand, silt, and clay in the soil. To determine soil texture using the soil triangle, the lines from each side must be extended in the correct direction. Proceed as follows:

- Clay—extend line horizontal from the percent clay (parallel with side labeled sand)
- Silt—extend line downward from percent silt at 60° (parallel with side labeled clay)
- Sand—extend line upward from percent sand at 120° (parallel with side labeled silt)

For example, if a soil is 40% sand, 30% silt, and 30% clay, the texture is clay loam.
Part II: Soil pH

The pH of soil is an important factor in determining which plants will grow because soil pH controls which nutrients are available for plants to use. The actions of plants, animals, and microbes that inhabit soil, along with physical factors, especially the characteristics of rainfall in the area, affect soil pH. Contrary to popular belief, rainwater does not have a pH of 7.0. As raindrops fall through the troposphere, carbon dioxide (CO$_2$) is absorbed and dissolves in the rainwater, as a result the raindrops become acidic as CO$_2$ reacts with water to form carbonic acid (H$_2$CO$_3$), as shown below.

$$\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3$$

Since air has always contained CO$_2$, rain has always been acidic. Today, the pH of rain can be 5.0 or lower if it is contaminated with oxides of sulfur and nitrogen which can form sulfuric and nitric acids respectively. In this lab activity, the pH of a soil sample will be determined.

Materials

- safety goggles
- 100-mL beaker
- Vernier LabPro
- lab apron
- balance
- pH probe
- plastic fork

Procedure

1. Weigh out 20g of soil in a 100-ml beaker.
2. Add 40 mL of distilled water and stir for 30 seconds every 3 minutes for 15 minutes.
3. During the intervals between stirring the soil mixture, connect a calculator to the LabPro and prepare the pH probe for measurement using the stored calibration.
4. After the final stir of the soil mixture, remove the fork, and allow the mixture to settle for 5 minutes.
5. Carefully, measure and record pH of the liquid phase of the soil-water mixture using the pH meter.
6. Rinse the pH probe thoroughly with distilled water.
7. Rinse and return the plastic fork.

Part III: Water Infiltration (percolation rate).

The infiltration and retention of water in soil are also important to plant growing capacity of soil. Soils with low infiltration are more likely to have high runoff after rain and the potential for flooding. On the other hand, these soils can retain a good deal of water. Soils with high infiltration rates cannot retain much water, resulting in leaching and loss of nutrients. These soils are more likely to be infertile and the leachate can have high concentrations of nutrients and pesticides, polluting both the water table and adjacent rivers and lakes. The level of clay in the soil helps to determine the infiltration rate and water retention rate. High clay soils make it difficult for plant roots to get oxygen. Soils that allow for quick infiltration and drainage contain pore spaces that provide air for gas exchange.

Procedure: Water Infiltration

1. Take two funnels and place a coffee filter in the bottom of each.
2. Fill one funnel up halfway with soil.
3. Quickly pour 100ml of water into the funnel.
4. Record the time required for all the water to drip through the soil by starting the timer when you pour and ending when most of the water has percolated through the soil (disappeared).
5. Repeat the procedure with pure sand and record the data.

Data: Time/Soil: ____________

Time/Sand: ______________
Questions:

1. How do the percolation times compare in the soil and the sand?
2. What does this tell you about your soil?
3. What type of soil has the fastest infiltration rate? Sand, silt or clay?

Part IV: Soil Porosity

The spaces that exist between soil particles, called pores, provide for the passage and/or retention of gasses and moisture within the soil profile. The soil’s ability to retain water is strongly related to particle size; water molecules hold more tightly to the fine particles of a clay soil than to coarser particles of a sandy soil, so clays generally retain more water (Leeper and Uren, 1993). Conversely, sands provide easier passage or transmission of water through the profile. Clay type, organic content and soil structure also influence soil water retention (Charman & Murphy 1977). The maximum amount of water that a given soil can retain is called field capacity, whereas a soil so dry that plants cannot liberate the remaining moisture from the soil particles is said to be at wilting point (Leeper & Uren 1993). Available water is that which the plants can utilize from the soil within the range of field capacity and wilting point.

1. Fill a 250ml beaker with soil to the 200ml mark. Tamp down.
2. Fill a 100ml graduated cylinder with 100ml of water.
3. Gently pour all the water onto the surface until it is completely saturated and begins to pool on the surface.
4. Measure the amount of water left in the graduated cylinder. The amount of water used is the amount of pore space in your sample.

Volume of soil: 200 ml Volume of water used:______

%porosity=volume of water used/volume of soilx100%=______

Questions:

1. What soil texture will result in the most oxygen for roots? Sand, Silt or Clay?
2. Rate your soil as poor, medium or good in terms of porosity. The higher the percentage, the greater the water loss and the lower the water holding capacity, but the better aeration.

Part V: Nutrients

Test 1: Nitrogen

Nitrogen is a part of every living cell. As a component of amino acids, the building blocks of proteins, nitrogen is a vital link in the world’s food supply. Nitrogen is directly involved in photosynthesis. It stimulates above ground growth and produces the rich green color characteristics of healthy plants. Nitrates, the available form of soil nitrogen, are produced through the decomposition of organic matter, the application of nitrogen fertilizers, and the fixation of atmospheric nitrogen by microorganisms in the roots of legumes. Soil nitrogen is depleted through harvesting crops, leaching by rainwater and denitrification.

Methods: Follow the procedure in the soil test kit.

Data: Nitrogen level:__________________

Questions:
1. Why do you think you got the results you did on the nitrogen test?
2. What could you do to fix it?

**Test 6: Phosphorus**

Young plants absorb large amounts of phosphorus, which speeds seedling development and promotes early root formation. Rapid, early growth means hardier, stronger plants. In mature plants phosphorus is vital to the development of healthy seeds and fruit which contain large amounts of this essential nutrient. Only a small percentage of soil phosphorus is in available form and these phosphates move more slowly through the soil than other nutrients.

**Methods:** Follow the instructions in the soil test kit.

**Data:** Phosphorus Level:_______________________

**Questions:**
1. What does mean to say that the phosphorus is not in an “available” form?
2. Why is phosphorus often a limiting factor in ecosystems?

**Test 7: Potash (Potassium)**

Potassium acts as a catalyst, a chemical agent that facilitates a number of chemical processes in the plant. Potassium promotes various aspects of plant metabolism – photosynthesis, efficient use of water and the formation of strong roots and stems. Well described as a “tonic” for plants, potassium strengthens natural mechanisms for the resistance of disease and extreme weather.

**Methods:** Follow the instructions in the soil test kit.

**Data:** Potash Level:____________________

**Questions:**
1. Besides fertilizer, how does potassium get into the soil.

**Postlab Questions—**Write out and respond to the following questions.

1. Use the soil triangle to determine the type of soils with the following particle sizes
   a. 20% silt, 10% clay, 70% sand
   b. 30% sand, 10% clay, 60% silt
   c. 10% silt, 50% sand, 40% clay
   d. 30% clay, 30% sand, 40% silt
   e. 60% clay, 10% sand, 30% silt
   f. 40% sand, 10% silt, 50% clay

2. List and describe three ways in which soil pH affects an ecosystem.
3. What types of vegetation does soil of the type and pH you sampled best support?
4. What would be the ideal type and pH of soil to have around a home?
5. What would be the ideal type and pH of soil for agriculture?
6. How do farmers adjust the pH of soils?

**Conclusion:**

Was your hypothesis correct? Discuss and include data to support hypothesis.