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Soil Analysis: Physical Characteristics

Introduction:

Soil serves many essential functions including decomposing dead organic material for recycling into plants and animals, filtering water for purification, and providing essential nutrients for plant growth (and indirectly animal growth.) For humans, soil also serves as an engineering material for constructing buildings and roadways, an agricultural medium, and a waste receptacle. Soil differs from area to area, and different soils are not equally suited to all of the above activities.

In general, soil is a mixture of weathered rocks and minerals and decomposed organic matter. The sizes and chemical identity of the rock fragments, the relative amount of organic matter, and the environmental conditions under which the decay occurred all affect the nature of the soil. Soil is constantly developing and changing; though the time scale for the process is so slow humans do not normally observe it.

Physical features of soil such as particle size and arrangement, nature of the soil layers, soil texture, and land slope determine how well a soil holds water, how freely water passes through it, how easily it permits root growth, and how readily oxygen permeates it. These physical characteristics not only profoundly influence the ability of a soil to support plant life, but also determine its sustainability for such things as supporting materials for buildings and roads, and hosting landfills and septic tank systems.

Soil Texture, Structure, and Consistence

Soil texture is determined by the ratio of sand, silt, and clay in the sample. Sand, silt, and clay are all mineral components of soil, and are defined by their particle size. Particles with a diameter greater than 0.05 mm are considered sand; between 0.002mm and 0.05mm, silt; and less than 0.002 mm, clay. (By definition, organic matter does not contribute to soil texture.) Soil scientists group soil into three broad classes based on textures: the sands, the clays, and the loams.

A common field test method to determine texture is the ribbon test. In this test, a small amount of soil is moistened, formed into a ball, then squeezed and pinched to form a ribbon. The behavior of the sample during the test (for example, whether it forms a ball or a ribbon- and, if so, how long of a ribbon) determines its classification.

Soil Structure:

Primary soil particles (sand, silt, and clay) are arranged into secondary units called *peds.* The shape of the peds and the way in which they aggregate in a soil is referred to as *soil structure.* Soil structure affects how easily air, water, and plant roots move through soil. Human activity such as repeated trampling or plowing when we wet can alter it.

Soil that separates easily into rounded peds are called granular. Granular soils have high permeability and therefore do not pack tightly. They are usually found near the soil surface where organic matter is abundant. Granular soils are particularly suitable for plant growth, because their structure permits air, water, and plants roots to easily penetrate the soil. Clay and loamy soils often have blocky peds, which are angular and somewhat irregular in shape. Their irregularity ensures that soils composed of blocky peds contain pores that permit passage of air and water. Soils with plate-shaped peds, which can resemble stacked sheets of ice, are tightly packed and difficult for air and water to penetrate. Platy soils usually have high clay content and tend to be found in frequently flooded areas. These soils are often called “clay-pan.” On the other hand, sand itself is a structure-less soil. The particles do not aggregate but instead fall apart.

Soil Consistence:

The degree to which soil resists pressure is referred to as its *consistence*. Farm and construction machinery and even a herd of cattle can put of great deal of pressure on the soil, so consistence is important when considering how land should be managed. The terms *sticky*, *plastic, loose, friable, soft*, *firm, very firm,* and *hard* are used to describe the consistence of the soil and how well the soil resists effects of wind, water, and machinery.

Put samples of clay, sand, and your assigned soil into cups and take them to your lab station. Fill the spray bottle with tap water. Go through the procedures with the clay, sand, and soil samples. Be sure to label and record every piece of data you are asked to measure!

Pre-Lab Questions

1. Describe the function of soil.
2. What are the three primary soil particles?
3. What words are used to describe soil consistence and does it help indicate about the soil?
4. List several human activities that affect the physical characteristics of soil.

PROCEDURE:

Be sure to label your answer sheet with the headings of each test and record any data/notes in that area.

A: Determination of Soil Texture: Texture by Feel Analysis Directions:

Take a handful of soil in the palm of your hand. Mist it with tap water from the spray bottle. Soak up any excess water by adding more soil in a pinch at a time.

Squeeze the sample. Does it form a ball? In no, add more water. In no again, you have sand and you can stop. If yes, continue below.

Once you have formed a ball the size of one or two large marbles, knead it until all aggregates are broken up. Then, make a ribbon by squeezing the dirt flat between your thumb and forefinger. At the same time, push upward with your thumb until it forms a ribbon. The ribbon should run past your forefinger and may be between 1 cm and 5 cm in length. Measure the ribbon and **record its length on your lab sheet.**

Use the clay sample for practice. It should form a ribbon that is at least 5 cm long before it breaks. If you have trouble getting a 5 cm ribbon, make sure your ribbon is uniform in thickness. If you have a thick area of soil at the end of the ribbon, it will serve as weight and cause the ribbon to break prematurely. Similar problems may occur if you make an area in the middle of the ribbon thinner than the rest. Practice with clay until you can confidently make a ribbon, then use this technique on your soil sample.

If your sample did not form a ribbon, you have *loamy sand.*

If the sample made a ribbon less than 2.5cm long and feels gritty to the touch, you have *sandy loam.*

If it feels smooth rather than gritty, you have *silt loam.*

If there is no gritty or smooth feeling, you have *loam.*

If the sample made a ribbon of 2.5 cm to 5.0cm long and feels gritty to the touch, you have *sandy clay loam.*

If not gritty, but smooth, you have *silty clay loam.*

If there is no definite gritty or smooth feeling, *clay loam.*

If the sample made a ribbon of 5.0 cm long or more, and feels gritty to the touch, you have *sandy clay.*

If not gritty, but smooth, you have *silty clay.*

If there is not definite gritty of smooth feeling, you have *clay.*

Record the texture on your lab sheet.

B. Determination of Soil Consistence

Again, test sand, clay, and your soil. Consistence is determined when the soil is dry (loose, hard or soft), when it is moist (loose, friable, or firm), or when it is wet (sticky, non-sticky, plastic, or non-plastic). Start with dry soil and get a sample with fairly intact structure (if possible.) Follow the procedure below to determine the consistence.

- Hold and squeeze the soil in between your thumb and forefinger until it breaks apart.
- When dry, is it loose (the structure falls apart easily and peds are not easily definite?) Or is it soft or hard?
- Moisten the soil with the spray bottle. It is loose? Is it friable (breakable once a small amount of pressure is applied)? Is it firm (requires significant pressure to break)?
- Thoroughly wet the soil with the spray bottle. Is it sticky or non-sticky? Plastic or non-plastic?

Record the consistence of each sample analyzed.

C. Observation of Soil Structure

Rub some of your dry soil sample between your fingers. Does it fall apart easily into roundish lumps? Does it tend to stick together in angular clumps? Is it platy? Record what you believe to be the structure.

D: Particle Size Distribution:

You will analyze the distribution of particle size within your soil sample to determine the percent clay, sand, and silt present.

In this procedure, your soil sample must settle overnight for interpretation the following day,

1. After breaking up any large clods, fill a clear cup half full with your soil.
2. Add tap water to just below the rim of jar.
3. Stir the solution for 30 seconds. Add 1 drop of dish detergent to the cup of soil to settle the particles.
4. Allow the sample to settle until next class.

5. On the basis of the other characteristics of your soil, make a general prediction about the particle size distribution you expect to see in your sample.

Next Class:

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6. Place a piece of white paper behind the cup and observe the layers.
7. Label each layer (organic matter, clay, silt, sand or gravel) on the outside of the cup. Use the control samples of sand and clay for comparison.
8. Measure the thickness of each layer (cm) with a ruler and record it.
9. Calculate particle size distribution:
    a. Divide the depth of each soil layer by the total depth of soil and record your data. Multiply by 100. Calculate the percentages of clay, silt, and sand in your soil.

Determine the soil type from the soil triangle:

1. Each corner of the triangle represents 100% of one of the three classes of soil: silt, sand, and clay. Locate these. Loam soil is a mixture of all three and found in the center of the triangle. Point your finger to loam.
2. Follow the arrows on the sides of the triangle. The right side of the triangle indicates percent silt, the bottom of the triangle indicates percent sand, and the left side indicates percent clay.
3. Find the percent silt of your soil on the right side of the triangle and point to it
4. Find the percent sand of your soil on the bottom of the triangle and point to it.
5. Move your fingers toward each other until they intersect. Keep one finger at this intersection point.
6. Find the percent of clay of your soil on the left side of the triangle and point to it. Drag this finger across to meet your other finger. This point of intersection is the soil's texture class. In cases where the lines intersect on a boundary line, choose the soil type that makes up the most area.
7. **Record the soil type.**

Lab Conclusion Questions:

1. What are the approximate diameters of sand, silt, and clay?
2. What industries would find it important to know the structure of the soil?
3. Do you find any relationship between texture and consistence? Explain
4. How might the consistence of soil affect the growth of plants? Think about both wet and dry conditions.
5. Which soil texture would be the best to grow crops in? Why?
6. Imagine a slopping field of very sandy soil and sloping field with very high clay content, each with an identical drainage ditch at the bottom. In a prolonged heavy downpour, do you think one ditch will be more likely to flood then the other? Why?