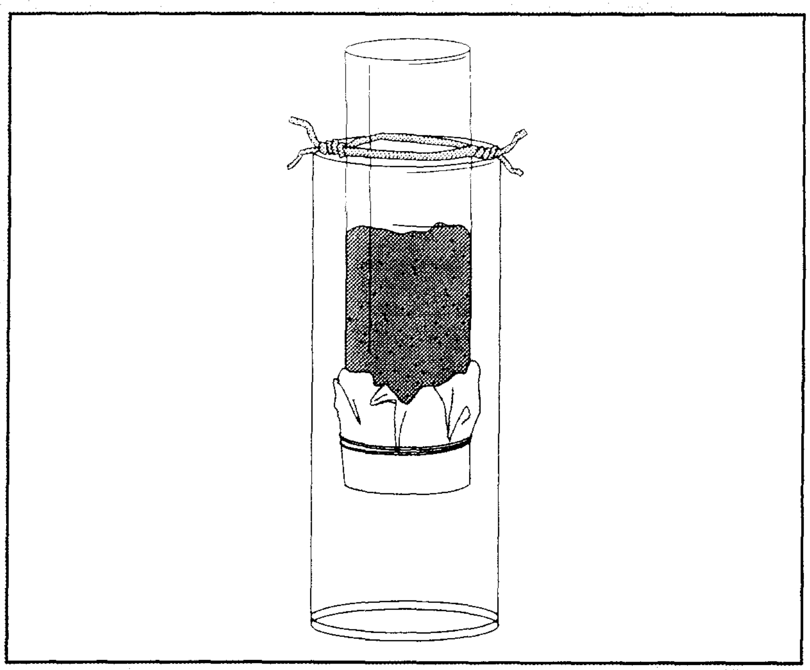
CAROLINA
Teamed with Teachers

ADVANCED PLACEMENT

Environmental Science

18-1048

Physical Characteristics of Soil



STUDENT INSTRUCTIONS

Physical Characteristics of Soil

This laboratory unit addresses physical characteristics of soil: structure, texture, particle size, consistence, bulk density, water holding capacity, capillary action, and permeability. The first and last activities described are field activities. The first activity involves observing and sampling soil horizons in a soil pit; the last is determination of the slope of land. The other activities are laboratory exercises in which you will analyze the physical properties of isolated soil components (sand, clay, and humus) and of soil samples from the pit and/or various locations around their environment. At the end of the unit, you are asked to think about what you have learned to predict how physical characteristics of soil might affect plant growth and various land uses.

Objectives

After completing the activities, you should be able to

- Perform both field and laboratory tests to determine soil type.
- Determine the consistence of soil.
- Define and determine capillary action and relate this characteristic to particle size.
- Define and determine permeability and relate this characteristic to particle size.
- Discuss how particle size, consistence, capillary action, and permeability affect the ability of soil to sustain plant life and a variety of human activities.
- Describe how soil interacts with water and how the interactions relate to plant growth.

Discussion

Soil serves many essential functions including decomposing dead organic matter 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 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 that humans do not normally observe it.

Soil Organization

Soil is organized in layers, a product of how it is formed. Soil formation typically starts with the weathering of bedrock to produce very fine particles.

In time, plants may begin to grow in this material. As these plants die, their remains add organic material to the weathered rock, which brings bacteria, fungi, and microscopic animals to feed on the organic material. Their physical activities and decayed remains further alter the soil; in time, a reasonably thick, dark-colored soil layer is formed. Rain washes dissolved minerals and very fine particles through this layer, often forming a clay layer below it. And over time, major geologic factors such as glaciers or floods may introduce new layers of soil.

The bottom soil layer rests on bedrock; the point at which the soil is saturated with water is called the *water table*, and its depth varies per location and season.

Characteristics of Soil

The ability of a specific soil to support different activities depends on both the chemical and physical aspects of its composition. Chemical features of soil include pH, ion content, and ion-holding capacity and are determined by factors such as the chemical nature of soil particles and bedrock. These characteristics affect how well a particular soil can supply essential minerals to plants and filter ions out of wastewater.

Plant roots require air and water. Just as a plant can die from lack of water, it can die in waterlogged soil from lack of air. Soil must retain water, allow for easy plant root penetration, and provide physical support for the plant.

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 suitability for such things as supporting materials for buildings and roads, and hosting landfills and septic tank systems. In the exercises described below, you will assess the physical characteristics of local soil.

Conducting the Activities

Your group will be analyzing and recording data on a single soil sample and on isolated components of soil. After each activity, your group should share the data on its soil sample with the rest of the class, and fill in the comprehensive data table at the end of this section. You will discuss and analyze data from this table to draw some conclusions about appropriate uses of soils.

Activity 2: Soil Texture, Structure, and Consistence

You will learn how to determine soil texture and judge the cohesive and adhesive properties of a soil sample.

Background

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 0.002 mm and 0.05 mm, 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 texture: the sands, the clays, and the loams (a mixture of sand, silt, and clay).

A common field-test method to determine texture is the ribbon test (see Soil Analysis Card). 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 a ribbon) determines its classification. You will be trying this field method in this exercise.

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 wet can alter it.

Soils that separate 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 plant 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 a 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 structureless soil; the primary 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 a 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.

A. Determination of Soil Texture

Your teacher will assign your group a specific soil to test. You will be testing this soil throughout the unit and, at the end, you will compare your soil sample and your classmates' soil samples. Find out as much as you can about the site from which your soil was collected and record the information.

Put separate samples of clay, sand, and your assigned soil into cups and take them to your work station. Fill the spray bottle with tap water. Read the procedure on the side of the Soil Analysis Card or follow the steps below to determine soil texture. (See the diagram of a ribbon on the right side of the card.) Go through the procedure with the clay, sand, and soil samples.

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 a pinch at a time.

Squeeze the sample. Does it form a ball? If no, add more water. If no again, you have *sand.*

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 in your notes.

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 a 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 the clay until you can confidently make a ribbon; then use this technique on your soil sample.

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

If the sample made a ribbon of less than 2.5 cm 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 5.0 cm 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 no definite gritty or smooth feeling, *clay.*

If your teacher instructs you to, use the same procedure to analyze the texture of samples collected from each of the layers in your soil pit.

Record the texture in Table 2.

B. Determination of Soil Consistence

Again, test sand, clay, and your assigned soil. If your teacher directs you to, also test a sample of soil from each layer in the soil pit. Consistence is determined when the soil is dry (loose, hard, or soft), when it is moist (loose, friable, or firm), and when it is wet (sticky, nonsticky, 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 defined). Or is it soft or hard?
- Moisten the soil with the spray bottle. Is it loose (the structure falls apart easily and peds are not easily defined)? 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 nonsticky? plastic or nonplastic?

In Table 2, 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? If a stereomicroscope is available, observe some of your soil. Record what you believe to be the structure in Table 2.

Laboratory Questions

1. Considering all the samples analyzed by your class, do you find any relationship between texture and consistence?
2. How might the consistence of soil affect the growth of plants? Think about both wet and dry conditions.

Table 2: Texture and Consistence

Sample	Source	Texture	Consistence	
			Wet	Dry

Activity 3: Particle Size Distribution

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

Procedure

In this procedure, your soil sample must settle overnight for interpretation the following day. Someone in your class will set up tests with sand and clay samples to serve as interpretation guides. In addition to looking at your own sample, you will be looking at all the other samples after they have finished settling.

1. After breaking up any large clods, fill a clear jar half-full with your assigned soil.
2. On the outside of the container, identify the soil with a wax marker. Characterize the location from which it was taken. Has it ever been plowed? Is it used for pasture? Is it used to grow crops or a garden?
3. Add tap water to just below the rim of the jar and tighten the lid.
4. Shake the jar for 30 seconds. Add 1 drop of dish detergent to the jar of soil to settle the particles.
5. Allow the sample to settle overnight.

Laboratory Question

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

Next Day

Note: Do not shake the container or otherwise disturb the layers.

1. Place a piece of white paper behind the jar and observe each layer.
2. Label each layer (either organic matter, clay, silt, sand [both fine and coarse] or gravel) on the outside of the jar with the wax marker. Use the control samples of sand and clay for comparison.
3. Measure the thickness of each layer (cm) with a ruler and record it in Table 3.1.
4. Calculate particle size distribution:

   Divide the depth of each soil layer by the total depth of soil and record your data in Table 3.1. Multiply by 100. Calculate the percentages of clay, silt, and sand in your sample.

Determine the soil type from the soil triangle on the Soil Analysis Card.

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 is 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 of the triangle indicates percent clay.
3. Find the percent silt (calculated above) of your soil sample on the right side of the triangle and point to it.
4. Find the percent sand of your soil sample 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 clay of your soil sample 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 takes up the most area.
7. Record the soil type below Table 3.1.

Observe the samples analyzed by your classmates. Note the sources of the samples and their composition in Table 3.2.

Laboratory Questions

1. Which collection site had more organic matter, clay, silt, fine sand, coarse sand, and gravel?
2. Which soil would be the best to grow crops in? Why?
3. What happened to the soil particles in the jar overnight? Explain.
4. Compare your sample's particle size distribution with your classmates'. If you analyzed soil from different sites, is there a difference due to where the soil was collected? Do the differences correlate with the characteristics of the site? Explain.
5. Did the particle size analysis of the various samples tested by your class correlate with the results of the texture-by-feel analysis?

Table 3.1: Particle Size Distribution

Sample	Depth of clay layer	Depth of silt layer	Depth of sand layer	Total depth	% clay	% silt	% sand
	_____(cm)	_____(cm)	_____(cm)	_____(cm)	____%	____%	____%

Soil Type: ________________________________

Table 3.2: Particle Size Distribution

Sample	Source	% clay	% silt	% sand

Activity 4: Bulk Density

You will calculate bulk density of clay, sand, and your soil sample and compare these results to those from the particle size and texture analyses.

Discussion

Bulk density (BD) expresses how much a soil weighs per unit volume. Soils contain soil particles and pore space, and the bulk density depends both on the amount of pore space in a particular soil and the density of the soil particles. Determining bulk density is simple: mass a sample of soil and measure its volume. Bulk density is expressed as mass/volume.

The aspect of bulk density that is important for understanding other properties of soil is *porosity*, the volume percentage of the total pore space. Soil contains both large and small pores (spaces between soil particles) that are occupied by both air and water.

To determine porosity, a core of soil with a known volume is oven dried and then massed. A core of identical size is placed in a pan of water until it is completely saturated and is then massed. The difference in the mass of the saturated core and the oven-dried core indicates the mass of water the core can hold, which indicates the volume of pore space in the soil.

For example, assume a 200-cc soil core weighs 260 g when oven dry and 360 g when saturated. The core can hold 100 g water, which is 100 cc water. Total pore space is 100 cc, and porosity is 100 cc/200 cc × 100%, or 50%. A 50% total pore space is rather typical for medium-textured soil.

By definition, sand has a larger particle size and coarser texture than loam, silt, or clay. Because there are fewer particles in a given volume of sand, there are fewer pore spaces than in finer-textured soil. Sand typically has a porosity of around 40%, though this varies with particle size. Fine-textured soils usually have a variety of particle sizes and shapes, which do not pack tightly. A clay-textured A horizon with granular structure may have 60% porosity.

In our everyday experience with soil, we know that water usually runs through sandy soil faster than through soil with a high percentage of clay. The explanation for this fact is that most pores in sandy soil are large and permit air and water to pass easily through the soil. Clay has more total pore space than sand, but the pores are much smaller, and water cannot pass through them as quickly. In the upcoming sections of this unit, we will further explore the effect of pore size on water retention and mobility.

Bulk density can be used to calculate porosity if the **particle density (PD),** the density of the individual soil particles themselves, is known.
The formula follows:

$$\text{Porosity} = 100\% - [\text{BD/PD} \times 100]$$

The BD/PD ratio gives the fraction of the soil volume occupied by solids. As bulk density decreases (PD remaining the same), the total pore space increases and the volume occupied by solids decreases.

Compaction

Just as soil structure can be changed by disturbance, so can porosity. If soil subjected to pressure, pores can collapse and total pore space decreases. Studies have shown that a single pass of a motorcycle in the Mojave Deser increased the bulk density of loamy sand soils from 1.52 to 1.60 g/cc. Soil fi the area around picnic tables and tent sites in Rocky Mountain National P. was found to have a bulk density of 1.60 g/cc, as compared to 1.03 g/cc in l traveled areas of the park. Compaction reduces permeability of soil to wate and air.

Source: Foth, H. D. *Fundamentals of Soil Science*. 7th ed. John Wiley and S 1984.

Procedure

Before beginning the determination of bulk density, use particle size data predict the relative densities of the different soils being analyzed by your c

1. Collect a sample of soil in your plastic cup.
2. After breaking up any clumps, place a paper towel on your bench and empty the soil onto it.
3. Tare the plastic cup; then weigh out 70 g of your soil sample.
4. Return your extra soil (on the paper towel) to the proper container, or dispose of it.
5. Place a funnel in the mouth of the graduated cylinder.
6. Carefully dump the 70 g soil into the funnel. As the soil is sifting thr the funnel, tap the bottom of the graduated cylinder on the work sur to pack the soil.
7. Record the volume of the soil.
8. Empty the cup and repeat the activity with sand and clay. Be especially sure to break up all the clumps of clay.

Laboratory Questions

1. Calculate the bulk density for each sample and record it in Table 4. D the volume of the soil by its mass (70 g) and record the value as gram cubic centimeter (g/cm^3).
2. Compare the bulk densities of soils with different particle size distribu and textures. Is there any correlation between particle size, texture, and bulk density?
3. Compare the predicted relative densities to the measured densities.
4. Calculate the particle density for the soil with 50% porosity described in the Discussion. Rearrange the equation for porosity to solve for particle density.
5. Demonstrate mathematically why BD/PD gives the fraction of soil volu occupied by particles.

Table 4: Bulk Density

	Clay	Sand	Humus	Soil
Volume of 70-g sample				
Bulk density (70g/volume)				

Activity 5: Water-Holding Capacity and Capillary Action of Soil

You will determine the capillary action and water-holding capacity of sand, clay, humus, and your assigned soil. You will compare this data with information on particle size and porosity from Activities 3 and 4.

Discussion

The way in which water moves through and is held by soil is of critical importance both to plant life and human activities. Soil particles have electrically charged sites on their surfaces. Most of these sites are negatively charged, but some are positive. Water molecules, though not charged, are strongly polar and form hydrogen bonds with one another. When water molecules encounter perfectly dry soil particles, the strong attraction of the electrically charged soil particles for the polar water molecules results in the spreading of a thin film of water molecules over the surface of the soil particles.

This water is called *adhesion water* and is several molecular layers thick. The adhesion water molecules rarely move and are thought to exist in an almost crystalline array, similar to the structure of ice. Under normal conditions, adhesion water is always present on soil particles, even dust in the air. Adhesion water is not available to plants. To remove it requires oven heating.

Since water molecules are strongly attracted to one another by hydrogen bonding, the regular array of adhesion water molecules provides sites for additional water molecules to associate. Further away from the charged soil particle, these molecules are held only by hydrogen bonding. They have more energy than the adhesion water molecules and move about more. This water is called *cohesion water*. Cohesion water fills and coats soil particles about 10–15 molecules more thickly than adhesion water and fills micropores because surface tension (provided by hydrogen bonding) is sufficient to hold it there. Cohesion water constitutes the major source of water for plant growth.

Cohesion water and adhesion water are retained in the soil by forces that exceed gravity. Water in macropores, however, is less strongly held and moves down and out of the soil unless an impermeable barrier stops it. Macropore water is called *gravitational water* because gravity attracts it more strongly than does soil. When soil is saturated, as in the determination of total pore space, all its macropores are full. If the soil is allowed to drain, the macropores will lose their gravitational water, but the waters of cohesion and adhesion will be retained. In a field or pasture, once the gravitational water has drained, the area is said to be at *field capacity*; you will determine the water-holding capacity of samples of soils in small columns.

Water flow in soil

When the soil is saturated, all pore space is filled with water. The water moves rapidly through larger pores and more slowly through smaller pores. The situation is analogous to water flow from a tank on the roof of a house down through a pipe to a faucet. The flow is a function of the height of the roof (gravitational potential difference) and the size of the pipe (conductivity). Water flow in pipes and pores is directly related to the fourth power of the radius. Thus water can flow 10,000 times faster through a pore with a radius 10 times greater than another one. If water draining down through a relatively permeable soil layer encounters a relatively impermeable layer, it will collect in the permeable layer. The rate of gravitational flow through soil is sometimes referred to as the infiltration rate.

Soils with a high rate of infiltration are easily leached, losing nutrient ions from the layers of soil where roots are the most abundant. Such soils can quickly become infertile without the addition of chemical fertilizers. The *leachates* (liquid that has passed through the soil) may contain fertilizer salts and pesticides that pollute the water table and rivers.

In addition, water can move through soil independent of gravity. Since there is a strong attraction between soil particles and water molecules, water can be drawn upward from the water table by capillary action when the soil becomes dry. For this to take place, soil particles must be packed closely enough to provide a continuous film of surface for water molecules to climb. On the other hand, as pore sizes become smaller, the rate of capillary movement will slow. Soil with a high rate of capillary action loses water more quickly through evaporation than does soil in which capillary action is slower.

Permeability and soil compaction

Soil compaction primarily affects macropores, and thus can have significant effects on permeability and drainage. One study showed the permeability of soil on a logging road in Washington was only 8% of the permeability of undisturbed soil. By eliminating macropores, compaction reduces availability of both air and water to plants; by decreasing permeability, compaction also makes soils more vulnerable to water runoff and erosion.

Permeability and septic tanks

Homes that are not connected to municipal sewage treatment systems rely on septic tanks for purifying waste from drains. A septic tank is a large, buried tank into which waste flows at one end. In its middle, a dividing wall reaches nearly to the top of the tank. Since most solid material in the waste stream sinks, the dividing wall traps most of it in the first half of the tank. A rich community of bacteria breaks it down. The mostly liquid waste that flows (slowly) over the dividing wall settles again in the second chamber.

Near the top of the second septic chamber is a one-way outlet to a system of underground, perforated pipes called field lines. The now mostly clear liquid from the septic tank trickles out of the perforations into the soil. Soil microbes break down remaining organic material and ions are absorbed on the surface of soil particles. As the liquid drains through the soil, it is purified.

If soil into which a septic tank were placed were highly impermeable, the liquid trickling from the field lines might not be absorbed into the soil and instead might accumulate and ooze out of the ground. Such a situation would obviously be highly undesirable, if not potentially a health hazard. Consequently, health departments ensure that any proposed septic tank site has adequate soil permeability. Sometimes this is done by considering the composition of the soil. Other times, health department workers go to the proposed site and conduct what is called a *perc test*. What do you suppose *perc* stands for in this context?

Procedure

Before you begin, use the information on bulk density, particle size, etc. of the sand, clay, and humus, and soil samples to predict relative rates of capillary action and permeability.

1. Obtain clay, sand, humus, and your assigned soil in the cups provided.
2. Cut two squares of double-thickness cheesecloth that will fit securely over the end of the small plastic column. Secure the cheesecloth over the end of a column with a rubber band. Use just enough cloth to cover the end: you will need to see the soil in the column and also minimize the amount of water absorbed by the cheesecloth. Do the same for three more columns.
3. Label the columns: *Clay*, *Sand*, *Humus*, and *Soil*.
4. Lay the columns side by side, and make a mark 7 or 8 cm (approximately 3 inches) up the column from the end covered by cheesecloth. The mark must be at the same level on each column.
5. Weigh each empty column and record the data.
6. Pour some clay out onto a paper towel and carefully crush every lump. Fill the *Clay* column to your mark with this clay. Fill the *Sand* column to the mark with sand and the *Humus* column with humus.
7. Pour some of your soil sample onto a paper towel and carefully crush any lumps. Fill the *Soil* column with this soil.
8. Weigh the columns containing the dry samples and record the data.
9. Put 10 mL water into each of four plastic vials.
10. Have one of your group members watch a timer with a second hand.
11. Place the cylinder of sand into one of the vials of water so that the bottom of the cylinder rests on the bottom of the vial (Figure 1). Time how long it takes the water to travel up the column by capillary action. Record the data in Table V.
12. Repeat the procedure with the clay, sand, and humus columns. If the column is not completely saturated by the end of the laboratory period, record the height to which the water has risen and estimate the time it should take to saturate the column if it continues to rise at that rate.
13. Add a little more water to each vial and let the columns sit overnight. Cover them if you are concerned that the water will evaporate.

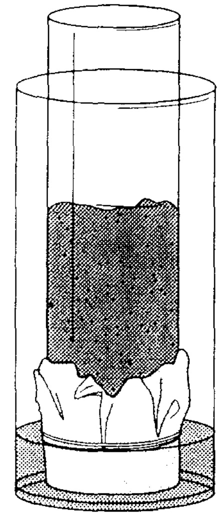


Figure 1.

Next Day

All of the soil columns should now be saturated. Remove the columns from the vials and hold them until dripping stops.

Weigh the columns. Record the weight in Table 5. Save the saturated columns for the next test.

Laboratory Questions

1. Determine the water-holding capacity in mL water per mL soil. Calculate the volume of each sample (clay, sand, humus and soil), using its mass and the bulk density calculated in Activity 4.
2. Observe the other groups' results for the other soil samples and complete the data table. Is water-holding capacity the same for all the soils sampled?
3. Compare the predicted relative rates of capillary action with the class data. Explain any discrepancies.
4. What characteristic of soil is most important in determining water-holding capacity? Defend your answer.

Table 5: Capillary Action and Water-Holding Capacity

	Clay	Sand	Humus	Soil
Weight of empty column				
Weight of column and dry soil				
Weight of dry soil				
Weight of column and saturated soil				
Weight of water				
Water-holding capacity (g H_2O/mL soil)				
Distance traveled by water (mm)				
Time required for that distance to be traveled				
Rate (mm/time)				

Activity 6: Determination of Permeability

You will determine the dry permeability and wet permeability of sand, clay, humus, and your assigned soil.

Procedure

1. Use the same procedure as described in Lesson 5 steps 1–8 to prepare fresh columns of sand, clay, humus, and soil. The soil columns should be of the same height and should contain no lumps. Weigh the empty columns and the columns with soil, as before.
2. Use the twist ties to suspend these new, dry columns and the water-saturated columns from the previous day in plastic vials. The cheesecloth should be about an inch above the bottom of the vial (Figure 2).
3. Put 10 mL of water in the 60-cc cup.
4. Designate one member of the group as the timekeeper and one as the recorder. When everyone is ready, pour the water onto the dry sand column. The timer should time how long it takes until the first drop of water comes out of the bottom of the column. Record this time in Table 5. The recorder should record the start time, for reference. Watch the column until there is no more water standing on top of the column of sand, and no more dripping through the column. Record this time as well.
5. Repeat this procedure with the wet sand column.
6. Repeat with the remaining columns. If percolation through a column is slow, record the start time and set up another column. You will have to keep an eye on the slow columns so that you won't miss the first drop or the final one.
7. Record all the times in Table 6.1.

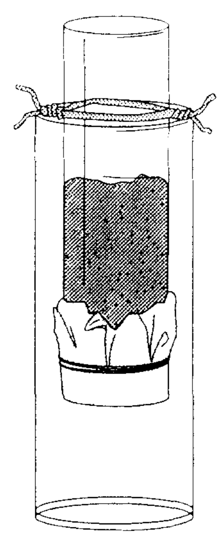


Figure 2.

Laboratory Questions

1. Observe the other groups' results and complete Table 6.2 for all six cla soils.
2. Is there a relationship between particle size and percolation rate?
3. Imagine a sloping field of very sandy soil and a sloping field of soil with very high clay content, each with an identical drainage ditch at the bottom. In a prolonged, heavy downpour, do you think one ditch would more apt to flood than the other? Why or why not?
4. If you had two fields of crops, one in which the soil was mostly sand and the other mostly clay, which one would you have to water most often and why?
5. Compare and contrast permeability and porosity.

Table 6.1: Permeability

	Dry Soil		Wet Soil	
	Time for first drop	Time for entire sample	Time for first drop	Time for entire sample
Sand				
Humus				
Clay				
Soil				

Summary Data

Transfer your data from previous tables (2–6.1) onto Table 6.2. Obtain data compiled by your classmates for their soil samples (not their clay, sand, and humus data) and record it in Table 6.1.

Table 6.2: Summary of Soil Data

Identify each soil sample in the space below the sample number.

%C = % Clay
%S = % Silt
%Sa = % Sand

Soil sample	Color	Texture	Consistence		Particle size %C, %S, %Sa	Bulk density	Capillary action, time to saturation	Water holding capacity	Permeability			
			Wet	Dry					Time to first drop		Total time	
									Wet	Dry	Wet	Dry
Sand		Sand										
Clay		Clay										
Humus												
Sample 1												
Sample 2												
Sample 3												
Sample 4												
Sample 5												
Sample 6												