

## Physical and Chemical Properties of Soil

### Objectives

1. Soil Sample Collection
2. Measurement and understanding of physical properties including texture, particle size and porosity.
3. Measurement and understanding of chemical composition including essential nutrients, water, calcium carbonate and organic matter.

### Introduction

Soil makes up the “thin” layer of the earth where we live. The soil supports the plants that provide us with food, fiber, and forest products. Because the soil is located at the interface where the atmosphere and land meet, the soil acts like a policeman directing traffic by determining the amount of the rain that runs off and the amount of the rain that enters the soil. The soil stores and purifies water. Many waste products and chemical pesticides are destroyed by soil microorganisms. Soil that wanders about as sediment in waters or as dust in the air contributes to the pollution of our environment. Since the production of our food and the quality of our environment are so importantly related to the wise use of the soil, it is very important that all of us know some basic facts and ideas about the soil.

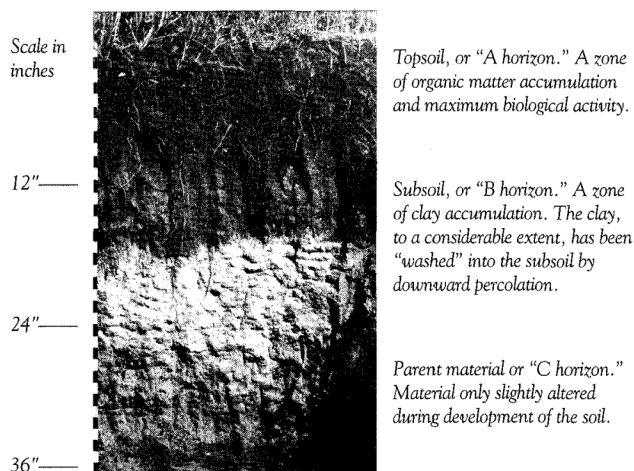
### The Formation of Soil

Everywhere on the land surface there is either rock formation or soil exposed. When rocks that were formed deep in the earth are uplifted and exposed to the earth’s atmosphere, the rocks adjust to the new environment. The chemical and physical changes that occur in the rock are called weathering. Weathering includes such physical processes as freezing, and thawing, and the action of wind, moving water and glacial ice. Chemically, minerals in the rock decompose. The loose mantle produced by weathering is soil.

The weathered soil is about one foot thick. Depending on the chemical composition and hardness of the rock, the formation of a foot of soil could require as little as 100 years or as many as 100,000 years or more. We can also note that soil has a wide range in size of particles. Some particles are large rock fragments. Some particles are sand sized, like those in sand dunes. Particles of silt and clay size are usually so small they feel smooth and cannot be seen with the naked eye. Further, we see that plants are growing on the soil. The plants produce organic matter in the soil. Plant growth and weathering usually occur together in soil formation. In soil formation the plants roots excrete carbon dioxide that dissolves in the soil water and forms carbonic acid. This acid speeds up chemical weathering. Chemical weathering, on the other hand, causes elements that are essential to the growth of the plants to become soluble. In turn, chemical weathering contributes to the growth of the plants. Weathering and plant growth operate as a “team” in soil formation.

In most climates, water movement through the soil transports very small sized mineral particles, such as clay particles. The clay particles tend to be moved downward out of the topsoil and deposited in the subsoil layer. This causes subsoils to be enriched with clay particles and have a higher clay content than the surface soil.

## Physical and Chemical Properties of Soil



**Figure 1**

Figure 1 is a soil profile formed directly in thick sediment. Plant roots and water readily penetrate the soil so that development of soil horizons is not directly dependent on weathering of bedrock. This dark-colored topsoil is indicative of a soil developed under Prairie grasses and well suited for agriculture.

In relation to the overall size of the planet, the topsoil and subsoil layers of the earth are quite thin - so thin in fact that there are many areas where the soil layers have been eroded by water and wind, to expose parent rock formations. Other areas that have not been subjected to serious erosion may have apparently deep layers of soil; however, these thicker layers are only equivalent to one one-millionth of the earth's diameter.

Imagine a gigantic apple that has a diameter of 200 feet. The skin on this gigantic apple is the same thickness as the skin on an ordinary apple. The relationship of the relatively thin skin to the gigantic apple is the same relationship that exists between the combined top and subsoil layers of soil on the earth's surface to the size of the earth itself.

From this brief study of soil formation, we can see that only an infinitesimal part of the earth's mass is available for the organized cultivation of crops.

Of the surface of this planet, approximately seventy-five percent is covered with water and the remaining twenty-five percent is land area. Of the land area, approximately three-fifths is either desert, frozen wasteland or too mountainous to support the cultivation of plant life. This leaves approximately one-tenth of the earth's surface available for growing the plants we need for food (vegetables and grains), for clothing (cotton), for shelter (timber), and for industrial raw materials (rubber, bean oils, etc.).

## Physical and Chemical Properties of Soil

### The Components of Soil

We have just seen that weathering and plant growth usually occur together during soil formation. Thus, soils are usually a mixture of both mineral matter and organic matter. Further, we can observe weathering of hard, dense rocks produces smaller particles which have spaces between them. Thus soils have pore space. The various components of the soil and their relationship to plant growth are summarized in Figure 2. Perhaps you would be surprised to see that a soil in a park, garden or in a lawn at your school may be about half pore space.

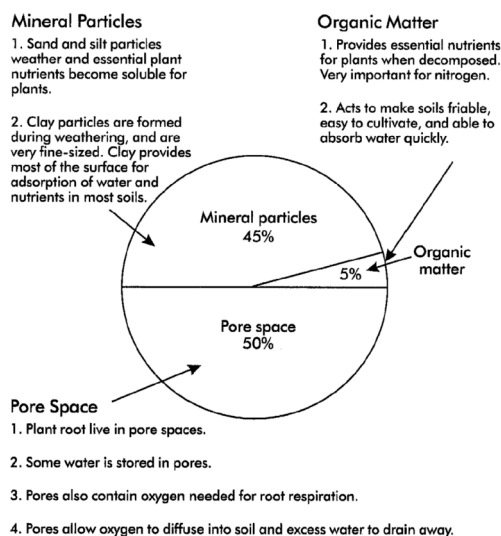


Figure 2

### Essential Plant Nutrients

If almost all types of soil can mechanically support plant life with equal ease, why are some lawns greener than others, why do some gardens produce larger flowers or vegetables than others and why do certain farms produce higher yields than others? It is the presence of available plant nutrients that may determine if the plants will grow to a lush, full maturity or whether the plant will develop as a stunted, off-color miniature of what it should be. A fertile soil is one that is able to supply the complete dietary needs of the growing plant. You know the importance of well-balanced meals in your own welfare. The same balance of proper nutrients is also very important to the healthy growth of plants. This means that a wide variety of ions must be available to the plant's root system and these ions must be available in correct proportions. Each nutrient has a specific function to perform in the life of the growing plant. If some essential nutrients are absent, the plant will show some characteristic sign of deficiency in its development. To the trained botanist or the experienced farmer the visible evidences of plant nutrient deficiencies are known as "hunger signs." A chemical examination of the soil will provide information that can be used to determine what essential nutrient is needed and how much fertilizer should be applied.

## Physical and Chemical Properties of Soil

Plants are capable of absorbing and assimilating as many as forty or fifty different chemical elements. Sixteen of these chemical elements have been found to be essential to the growth of most plants.

Knowledge of the chemical characteristics of soil is essential to the successful growth of all plant life. This is true whether it is the professional raising of crops for commercial purposes or an amateur enterprise such as the raising of a lawn, shrubbery or a garden for decorative purposes. Soils are tested to determine if essential plant nutrients are present and if the soil reaction or pH value is correct for raising the desired plants. If the correct conditions do not exist, the soil tests tell what must be done to provide the correct balance of the necessary nutrients and to provide the proper soil reaction.

Since certain known plant nutrients are essential, why is it not reasonable to add the essential plant nutrients automatically so that you will know that there will be sufficient amounts of these plant nutrients present? First, this would be an extremely costly method of soil treatment, particularly in farming operations. Secondly, it is possible to have too much of a certain plant nutrient so that it causes an imbalance in feeding. For example, a great abundance of one plant nutrient may cause the plant to ignore a second plant nutrient that is present in sufficient quantities under normal conditions. The key that unlocks the door to successful plant culture is in the “balanced” abundance of essential plant nutrients.

### Sample Collection and Preparation

<b>Field Soil Sampling Kit:</b>	Soil Sampling Tube	Soil Thermometer
	Plastic soil collection bags	Gloves
	Data recording notebook	Copy of “Sample Collection”

Follow carefully the rules given here for collecting and preparing soil samples. When taking a soil sample in a lawn, a person should take a sample from the upper two or three inches of soil. In the case of garden and farm crops, the sample should be taken from the upper six to eight inches of soil. When analyzing a specific area of soil (a lawn, a garden or field) take the samples from several different locations within the area and mix them together. The resulting sample will provide an average value that will be representative of the entire area.

1. A clean soil sampling tube is used to obtain the samples.
2. Measure the temperature of the soil with the soil thermometer and record the site details.
3. Press the tube into the soil to the desired depth. The saw-toothed cutting edge is tapered so that the core is removed from the ground when the tube is extracted.
4. Place the soil samples in the plastic sampling bag and label the location of the sample.
5. The soil should not be touched with the hands any more than is absolutely necessary.

## Physical and Chemical Properties of Soil

6. Repeat steps 1-5 to collect a second sample.

7. Return to lab. One sample is to remain sealed in the sample bag. The second sample should be spread out on a piece of clean paper or plastic. The soil should be allowed to dry in the air for several hours or overnight. Do not bake the soil to accelerate drying.

### Materials Needed

Chemicals	
10% HCl	
Equipment	
<ul style="list-style-type: none"> <li>• Mortar and Pestle</li> <li>• 3 Plastic wide short stem Funnels</li> <li>• Cotton Plug</li> <li>• 50 mL graduated cylinder</li> <li>• 6 100 mL Beakers</li> <li>• Sieves</li> <li>• Soil Analysis Kit</li> <li>• Crucible tongs</li> </ul>	<ul style="list-style-type: none"> <li>• pH probes</li> <li>• Crucible</li> <li>• Bunsen Burner</li> <li>• Aluminum pans</li> <li>• Stopwatch</li> <li>• Drying oven</li> <li>• Dessicators</li> </ul>

### I. Physical Properties of Soil

**A. Physical Description:** *Using the sample that is sealed in the sample bag*, describe with respect to color, texture (pebbles, sand, and mud) moisture and organic content. Mix your soil sample well, form a cone, and divide the cone into quarters. Remove opposing quarters. Form a new, smaller cone and repeat the process until you obtain what you consider to be a representative sample of approximately 20 g. This process is called the cone and quarter method for obtaining a representative sample from a larger sample. Repeat this process to obtain a second 20 g sample. These samples will be used in Part IIA

Perform the following tests using the sample you allowed to dry overnight on the paper/plastic:

#### Sample Preparation:

1. All foreign matter (leaves, roots, stones, etc.) should be removed.
2. All lumps should be crushed until the largest clumps are not larger than 1/8 inch diameter.

#### B. Soil Texture (% Sand, Silt and Clay)

1. Place the three Soil Separation Tubes in the rack.
2. Add the soil sample to Soil Separation Tube "A" until it is even with line 15.

## Physical and Chemical Properties of Soil

**NOTE:** Gently tap the bottom of the tube on a firm surface to pack the soil and eliminate air spaces.

3. Use the pipet to add 1 mL of Texture Dispersing Reagent to the sample in Soil Separation Tube “A” Dilute to line 45 with tap water.

4. Cap and gently shake for two minutes, making sure the soil sample and water are thoroughly mixed.

The sample is now ready for separation. The separation is accomplished by allowing a predetermined time for each fraction to settle out of the solution. Be sure that you continue to gently shake the separation tube up to the time of the first separation (Step 5).

5. Place Soil Separation Tube “A” in the rack. Allow to stand undisturbed for exactly 30 seconds.

6. Carefully pour off all the solution into Soil Separation Tube “B”. Return Tube “A” to the rack, Allow Tube “B” to stand undisturbed for 30 minutes.

7. Carefully pour off the solution from Soil Separation Tube “B” into Soil Separation Tube “C”. Return Tube “B” to the rack.

8. Add 1 mL of Soil Flocculation Reagent to Soil Separation Tube “C”. Cap and gently shake for one minute.

9. Place the Soil Separation Tube “C” in the rack and allow to stand until all the clay in suspension settles. This may require up to 24 hours.

10. Read Soil Separation Tube “A” at top of soil level.

11. Read Soil Separation Tube “B” at top of soil level.

### C. Determining Particle Size Composition by Sieve

The screen sieves should be arranged with the largest screen size on top, proportionately decreasing in screen size to the close-bottom container. Place your soil sample in the uppermost sieve, cover it, and lightly shake it using a back-and-forth motion. The particles are then carefully removed from each sieve, and their separate weights obtained. The sieves should contain the following particles.

1st sieve - #5 mesh - gravel  
2nd sieve - #10 mesh - fine gravel  
3rd sieve - #60 mesh - coarse sand  
4th sieve - #230 mesh - fine sand  
bottom pan Silt and clay

## Physical and Chemical Properties of Soil

Determine the total mass in each particle size. Convert the mass of each particle size into a percentage by dividing the previously obtained total mass into the mass of each individual size and multiply by 100.

### D. Permeability and Capillary Water

Arrange the screen sieves in the same order as they were assembled in Part C. A quantity of mixed sand should be placed in the top chamber, and shaken gently for several minutes. The cover should be used to prevent excessive dust.

The particles should then be taken from the second sieve (fine gravel), the third sieve, (coarse sand), and from the bottom container (silt and clay). The particles in the first and fourth sieves are not used in this investigation. Three funnels should be placed side by side with a loose wadding of cotton in the neck of each. (They should be tested beforehand to see if water effectively drains through each.) Place equal amounts of the fine gravel in the first funnel, the coarse sand in the second funnel, and the silt and clay particles in the third funnel. Three separate beakers should be filled with 50 milliliters of water.

The speed with which water moves through a material is termed *permeability*. This speed can be determined with the aid of a stopwatch by measuring the length of time it takes the water to drain through each funnel. Measure the amount of water in the beaker below. By subtracting the amount left in each beaker from the original 50 milliliters, the amount of water trapped between the particles as capillary water or soil water can be determined. The results should be organized into a chart.

## II. Chemical Properties of Soil

**A. Water,  $\text{CaCO}_3$  and Organic Content** Use one of your 20 g samples to determine water content, and the other to determine water plus  $\text{CaCO}_3$  content.

### Water Content:

- Place one of your 20 g samples in a preweighed aluminum pan, weigh, and place in an oven at  $110^\circ\text{C}$ . The sample will be dry after overnight heating, however you can leave it in the oven until lab next week.
- Cool the sample for 20 minutes in a dessicator at room temperature before weighing to determine the weight loss, which is the percent water. Some volatile organic compounds might also be lost in this drying step.

### $\text{CaCO}_3$ Content

- Weigh the second 20 g sample, place it on filter paper in a funnel and remove carbonates by washing with 10% HCl. When no more bubbling of carbon dioxide occurs, rinse with deionized water.
- Place the sample in a preweighed aluminum pan to dry in the  $110^\circ\text{C}$  oven along with the sample for percent water determination.
- After a week in the oven, place the sample in a dessicator for 20 minutes to cool.
- Weigh the dried sample.

## Physical and Chemical Properties of Soil

### Organic Content

- Transfer the sample from which carbonates have been removed to a preweighed crucible, and combust it over a burner to red heat.
- Cool in a dessicator and weigh. Determine the organic content by weight change (loss on ignition, LOI). (Removal of carbonates prior to ignition is necessary because calcium carbonate decomposes at temperatures required for combustion of soil organic material (550 - 800°C).)

**B. Soil pH with probe:** Mix a new soil sample with deionized water in equal proportions to form a slurry. Use a calibrated pH probe to measure pH.

Perform the remaining tests using the sample you allowed to dry overnight on the paper/plastic:

### Colorimetric Soil pH

- Fill test tube to line with Tricon Flocculating Reagent.
- Use 0.5 g spoon to add three level measures of soil. Cap and gently mix by inverting the tube back and forth slowly for one minute. Allow soil particles to settle.  
**NOTE:** The amount of time required for a soil to settle varies with texture; clay soils may require additional time, but in most instances the solution will be clear in several minutes.
- Add 9 drops of \*Tricon Soil pH Indicator. Cap and invert the test tube gently one time to mix the contents. Allow soil to settle.
- Place test tube in the Tricon pH Comparator. Match sample color to a color standard. Record as soil pH.

### C. Essential Nutrients

#### Potassium

Potassium has much to do with the vigor and vitality of the plant, encouraging the development of a healthy root system and offsetting the harmful effect of excessive nitrogen. Potassium also tends to counteract a delay in ripening and thereby exerts a balancing effect on excessive nitrogen levels. Potassium appears to play a role in the nitrogen levels. Potassium appears to play a role in the synthesis of starch and the translocation of carbohydrates within the plant.

- Fill a test tube to line 7 with Universal Extracting Solution.
- Use the 0.5 g spoon to add four level measures of soil. Cap tube and shake for one minute.  
**NOTE:** When adding samples with high concentrations of carbonates to Universal Extracting Solution, swirl tube to mix for 30 seconds before capping to allow gases to

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escape.

3. Fold a piece of filter paper in half. Fold in half again. Gently push corners together to form a cone. Place cone in funnel.
4. Place funnel in clean filtrate tube and filter suspension through the filter paper. The clear solution is the extract used in the test.
5. Fill a clean test tube to line 3 with soil extract.
6. Add one Potassium Reagent B Tablet. Cap and shake until tablet disintegrates.
7. Add Potassium Reagent C to line 7. Allow it to run slowly down the side of the tube. Cap and mix gently. A precipitate will form if potassium is present.
8. Place a Potash Tube "B" on the Potash Reading Plate directly over the black line.  
**NOTE:** Face a window or some other source of daylight.
9. Use a pipet to add the treated test sample slowly to Tube "B" allowing it to run down the sides of the tube while observing the black line through the solution. Continue until the line just disappears.
10. The height of the column of test sample is measured against the potassium scale on the tube. Record as pounds per acre potassium.  
**NOTE:** For extremely high readings, dilute the filtered extract and retest. Add the soil sample filtrate to line 3 of a clean test tube. Dilute to line 6 with Universal Extracting Solution. Test following the procedure beginning with Step 5. Multiply final reading by 2.

**PRECAUTION:** Large amounts of ammonium salts will produce a precipitate similar to that obtained with potassium. If fertilizer containing ammonium salts has recently been added to the soil, or if the soil pH is low (pH 4.0-5.0), a test should be made for ammonium compounds. Equivalent quantities of ammonium salts will produce about one-fourth as much precipitate as obtained from potassium salts.

### Nitrogen

Nitrogen is the element which stimulates above-ground growth and produces the rich green color that is characteristic of a healthy plant. It also influences the quality of the plant's fruit and it increases the fruit's protein content. The plant's utilization of other major elements is stimulated by the presence of nitrogen in the plant.

1. Fill a test tube to line 7 with Universal Extracting Solution.
2. Use 0.5 g spoon to add four level measures of soil. Cap and shake for one minute.

### Physical and Chemical Properties of Soil

**NOTE:** When adding samples with high concentrations of carbonates to Universal Extracting Solution, swirl tube to mix for 30 seconds before capping to allow gases to escape.

3. Fold a piece of filter paper in half. Fold in half again. Gently push corners together to form a cone. Place cone in funnel.
4. Place funnel in clean filtrate tube and filter suspension through the filter paper. The clear solution is the extract.
5. Use the 1 mL pipet to transfer 1 mL of soil extract to one of the depressions on the spot plate.
6. Use pipet to add 10 drops of Nitrate Reagent #1.
7. Use the 0.5g spoon to add one measure of Nitrate Reagent #2. Stir thoroughly with plastic rod. Wait five minutes.
8. Match sample color to a color standard on Nitrate-Nitrogen Color Chart. Record as lb/acre nitrate-nitrogen.

### Phosphorus

Phosphorus is abundant in the fruits of plants and seeds and also in the parts of the root which are involved in the rapid uptake of water and nutrients, such as the root hair section. Phosphorus plays a major role in plants in those processes requiring a transfer of energy. An example of the need of the plant for energy is the formation of fats. Energy is also utilized by the plant to translocate food from one part of the plant to the other.

**NOTE:** This test is very sensitive to contamination. The work area, materials and hands should be clean. Avoid exposure to fertilizer dust.

1. Fill a test tube to line 7 with Universal Extracting Solution.
2. Use the 0.5 g spoon to add four level measures of soil. Cap tube and shake for one minute.  
**NOTE:** When adding samples with high concentrations of carbonates to Universal Extracting Solution, swirl tube to mix for 30 seconds before capping to allow gases to escape.
3. Fold a piece of filter paper in half. Fold in half again. Gently push corners together to form a cone. Place cone in funnel.
4. Place funnel in clean filtrate tube and filter suspension through the filter paper. The clear solution is the extract used in the test.

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5. Fill the Phosphorus “B” Tube to the mark with the soil extract.
6. Add 6 drops of Phosphorus Reagent #2. Swirl to mix.
7. Add one Phosphorus Reagent #3 Tablet. Cap and swirl until the tablet disintegrates.
8. Remove cap. Hold tube ½” above the white area of the Phosphorus Color Chart. Looking down through the solution, match sample color to a color standard. Record as lbs/acre phosphorus. The color comparison should be done in natural light.

**NOTE:** Do not allow the solution to stand for more than 10 minutes before making the color comparison.

Adapted from LaMotte Test Kit and “Chemical Analysis of Soils” by Joan D. Willey (Journal of Chemical Education, Dec 1999).

## Physical and Chemical Properties of Soil

Name: \_\_\_\_\_

Date: \_\_\_\_\_

### Sample Site and Collection Data:

Date: \_\_\_\_\_ Time: \_\_\_\_\_ Soil Temperature: \_\_\_\_\_

Site Description:

### I. Physical Properties of Soil

#### A. Physical Description:

#### B. Soil Texture

Soil Separation Tube "A" \_\_\_\_\_

To calculate the percentage of sand in the soil: divide reading by 15. Multiply by 100.

**EXAMPLE:**

Soil Separation Tube "A" reads 2.

$$\text{Percent Sand} = \frac{\text{Reading A} * 100}{\text{Total Volume}} = \frac{2 * 100}{15} = 13\%$$

Percent sand \_\_\_\_\_

Soil Separation Tube "B" \_\_\_\_\_

To calculate percentage silt in the soil, divide reading by 15. Multiply by 100.

**EXAMPLE:**

Soil Separation Tube "B" reads 8.

$$\text{Percent Silt} = \frac{\text{Reading B} * 100}{\text{Total Volume}} = \frac{8 * 100}{15} = 53\%$$

Percent silt \_\_\_\_\_

## Physical and Chemical Properties of Soil

Due to the colloidal nature of clay in solution and its tendency to swell and form a gel, the portion of clay remaining in Tube "C" is not used to determine the clay fraction present in the soil. The clay fraction is calculated by adding the sand and silt fractions and subtracting this total from the initial volume of soil used for the separation.

**EXAMPLE:**

Tube "A" Sand	2	Initial Volume	15
+ Tube "B" Silt	+8	-Total "A"&"B"	-10
Total "A" & "B"	10	Clay	5

Volume of Clay \_\_\_\_\_

To calculate percent clay in the soil, divide value by 15. Multiply by 100.

**EXAMPLE:**

$$\text{Percent Clay} = \frac{\text{Calculated Volume} * 100}{\text{Total Volume}} = \frac{5 * 100}{15} = 33\%$$

Percent Clay \_\_\_\_\_

Since the scientific basis of the test is the particle size and mass, as related to its settling time when dispersed in solution, the following table is included for reference.

<u>Soil Particle</u>	<u>Diameter (nm)</u>
Very Coarse Sand	2.0-1.0
Coarse Sand	1.0-0.5
Medium Sand	0.5-0.25
Fine Sand	0.25-0.10
Very Fine Sand	0.10-0.05
Silt	0.05-0.002
Clay	Less than 0.002

Sandy soil is described as soil material that contains 85% or more sand. The percentage of silt plus 1.5 times the percentage of clay shall not exceed 15.

Silt soil is described as soil material that contains 80% more silt and less than 12% clay.

Clay soil is described as soil material that contains 40% or more clay, less than 45% sand and less than 40% silt.

How would you describe your soil sample?

## Physical and Chemical Properties of Soil

### C. Determining Particle Size Composition by Sieve

	Mass	Percent
Gravel	_____	_____
Fine Gravel	_____	_____
Coarse Sand	_____	_____
Fine Sand	_____	_____
Silt and Clay	_____	_____
Total	_____	_____

Do the results from Parts B and C agree? Which method do you think is better for classifying the texture of soil? Explain your answers.

### D. Permeability and Capillary Water

Funnel	Permeability (seconds)	Volume of water in beaker (mL)	Capillary water (mL)
Fine Gravel			
Coarse Sand			
Silt & Clay			

Questions:

1. The funnel with which particles takes the shortest time to drain? What does this illustrate about the permeability of the particles?
2. Why does this happen?

### Physical and Chemical Properties of Soil

3. Which of the materials has the greatest amount of capillary water remaining?
4. Why would crops have difficulty growing in an area of sand and gravel?
5. Provided all other conditions are equal, if the three types of particles in this investigation formed the ground cover for three different areas, under which would the ground water be the highest? Which would experience the most surface flooding or runoff?

## II. Chemical Properties of Soil

### A. Water Content

Mass of wet sample \_\_\_\_\_

Mass of dry sample \_\_\_\_\_

Mass of water \_\_\_\_\_

Percent water \_\_\_\_\_

### CaCO<sub>3</sub> Content

Initial sample mass \_\_\_\_\_

Final sample mass \_\_\_\_\_

CaCO<sub>3</sub> + Water mass \_\_\_\_\_

Determine the percent CaCO<sub>3</sub> by subtracting the percent water obtained from the first sample.

Percent CaCO<sub>3</sub> \_\_\_\_\_

**Physical and Chemical Properties of Soil**  
**Organic Material Content**

Crucible Mass \_\_\_\_\_

Initial Crucible + Sample \_\_\_\_\_

Final Crucible + Sample \_\_\_\_\_

Loss on Ignition (LOI) \_\_\_\_\_

Percent organic material \_\_\_\_\_

**B. Soil pH with probe** \_\_\_\_\_

**Colorimetric Soil pH** \_\_\_\_\_

1. If the homeowner wishes to grow Germaniums in the location from which this sample was collected, what would be your recommendation regarding the application of lime or alum to the soil (express in units of lbs/acre)?
  
  
  
  
  
  
  
  
  
  
2. If the pH test reading was 4.0, what would be your recommendation?
  
  
  
  
  
  
  
  
  
  
3. If the pH test reading was 8.0, what would be your recommendation?
  
  
  
  
  
  
  
  
  
  
4. What is the chemical formula for Hydrated Lime?
  
  
  
  
  
  
  
  
  
  
5. If limestone is unavailable to the homeowner, but hydrated lime is available, how would your recommendation in the above cases be altered?

## Physical and Chemical Properties of Soil

6. What conditions are assumed by the Average Rates provided in the tables?

### C. Essential Nutrients

**Potassium** \_\_\_\_\_

**Nitrogen** \_\_\_\_\_

**Phosphorous** \_\_\_\_\_

1. What is your recommendation regarding fertilizer application for the location from which this sample was collected?
2. If the sample was collected from an area where several shrubs were growing, will your recommendation vary? If so, how?
3. How many square feet are in an acre? If a mixture is used, how many pounds of the mixture should be applied to a homesite that is 0.20 acre?