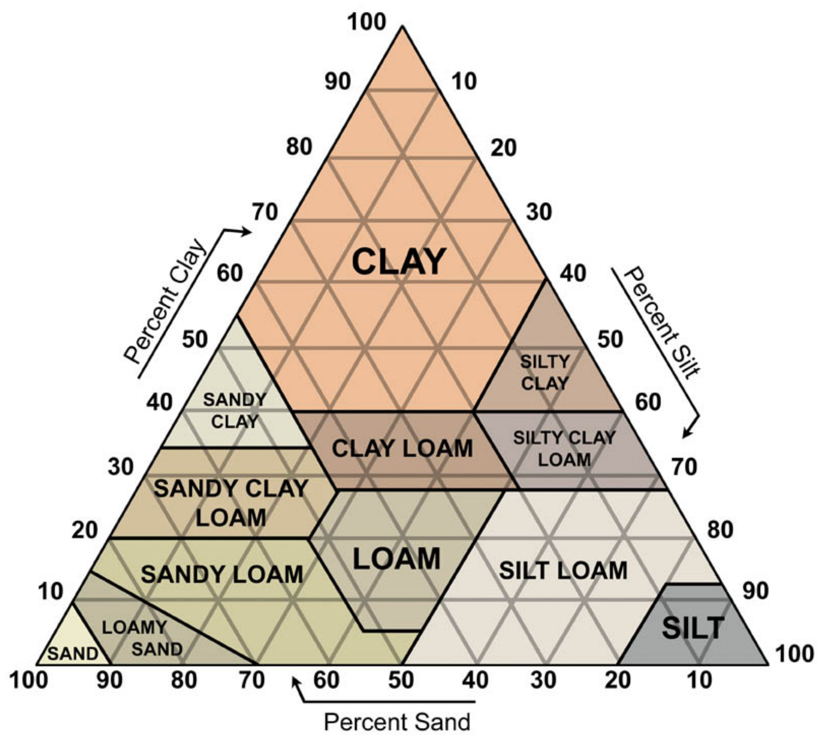
Soil Analysis

Soil is not exactly the same from two different places. Although it may be similar in any particular area, there will still be variations in composition and nutrients.

Soil is composed of three particle classes: **sand** (0.05-2.0 mm diameter) which gives soil its gritty feel, **silt** (0.0002-0.05 mm diameter) which has the feel similar to talcum powder, and **clay** (less than 0.002 mm diameter) which ranges from sticky and plastic when wet to harsh and hard when dry. Anything larger than 2.0 mm diameter is called **gravel** and is not considered to be part of the soil. In addition, soil contains organic material made up of undecomposed and partially decomposed residues of plants and animals and the tissue of living and dead microorganisms. The relative proportions of sand, silt, and clay define a soil's texture which is classified according to a soil Textural Triangle (see below).



To use the triangle: Assume that a sample of soil contains 15 percent clay, 70 percent silt, and 15 percent sand. First, consider the clay. Start at the bottom of the triangle 0 percent clay. Read up the left side of the triangle to 15 percent clay. Draw a pencil line starting at the 15 percent point for clay, parallel to the base line of the triangle. Next, consider the silt. Read down the right side of the triangle to 75% percent silt, and draw a line parallel to the zero line for silt (this will be parallel to the *left side* of the triangle). You will note that the lines cross in the area designated *Silt loam*. This is the class name of the soil. To check on your accuracy, draw a line for the sand. Read to the left along the bottom of the triangle to 15 percent sand. Draw a line parallel to the zero line for Sand (this will be parallel to the *right side* of the triangle). All three lines cross at the same point.

If *sand* or *sandy* is part of the name, it is necessary to state whether there is a predominance of very coarse sand, coarse sand, medium sand, fine sand, or very fine sand. The type of sand which occurs in an amount greater than any other component is used to indicate the name; for example, fine sandy loam indicates a predominance of fine sand.

In case lines cross on a line between two class names, it is customary to use the name that favors the finer fraction. For example, if the lines all cross at 40 percent clay, the name *clay* is used rather than *clay loam*.

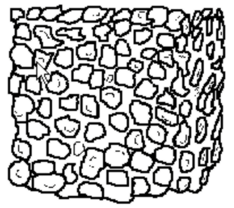
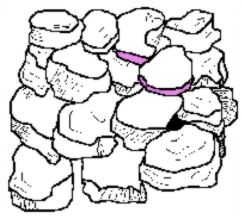
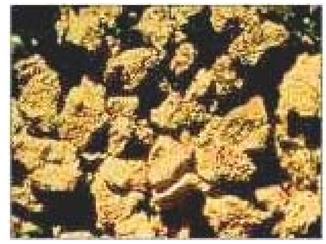
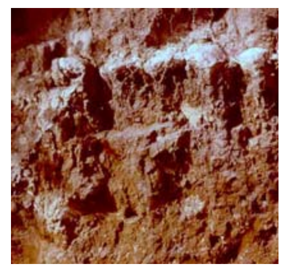
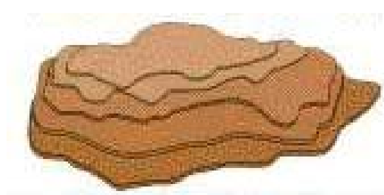
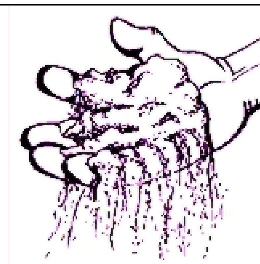
Soil color of soil is an important feature in recognizing different soil types and is also an indicator of certain physical and chemical characteristics. Color in soils is due primarily to two factors, humus content and the chemical nature of the iron compounds present in the soil. **Humus** has a dark brown, almost black, color. A very high content of humus may mask the color of the mineral matter to such an extent that the soil appears almost black regardless if the color status of the iron compounds.

Iron is an important color material because iron appears as a stain on the surfaces of mineral particles. About 5 percent or more of mineral soils is iron. In unweathered soils where the iron exists as an unweathered mineral, it has little or no influence on color. The iron that has the greatest effect on color is that which has weathered from primary minerals and exits in the oxide or hydroxide form. The following table depicts the forms and colors of iron in weathered soils:

Form	Chemical formula	Color
Iron(II) oxide (ferrous oxide)	FeO	Gray
Iron(III) oxide (ferric oxide)	Fe_2O_3	Red
Hydrated iron(III) oxide (hydrated ferric oxide)	$2Fe_2O_3 \cdot 3H_2O$	Yellow

There are various degrees of hydration, and the color varies between red and yellow. It is important to note that the yellow iron s in oxidized form as well as hydrated. This means that a supply of oxygen must be associated with moist conditions to cause yellow colors to form. Too much water and an absence of oxygen cause anaerobic microorganisms to reduce the ferric iron to ferrous form, and a gray color would be the result. The red color is associated with good aeration, and a generally lower amount of water is present than is found in yellow materials. Soil colors are not limited to dark brown or black with gray, red, or yellow or their intermediates. There are some soils with various other shades, generally as a result of other minerals present in the parent materials.

Soil structure refers to the arrangement of soil particles. Soils made up of practically all sand or all silt do not show any appreciable structural arrangement because of a lack of the binding properties provided by clay. A well-developed structure usually indicates the presence of clay. Soil structure is classified into various classes. There are three major classes and several sub-classes: Structureless which includes *Single grain* and *Massive*; With structure which includes *Granular*, *Platy*, *Wedge*, *Blocky*, *Prismatic*, and *Columnar*; and Structure Destroyed which includes *Puddled*. The important structures are shown in the following table.

Granular soil resembles cookie crumbs and is usually less than 0.5 cm in diameter. This is commonly found in surface horizons where roots have been growing.		
Blocky soil consists of irregular blocks that are usually 1.5 – 5.0 cm in diameter.		
Columnar and Prismatic soil consists of vertical columns that might be a number of cm long. Columnar soil usually has a salt cap at the top and is found in arid regions.		
Platy soil consists of thin horizontal flat plates. This is usually compacted soil.		
Single grained soil is usually broken into individual particles that do not stick together. Commonly found in sandy soils.		

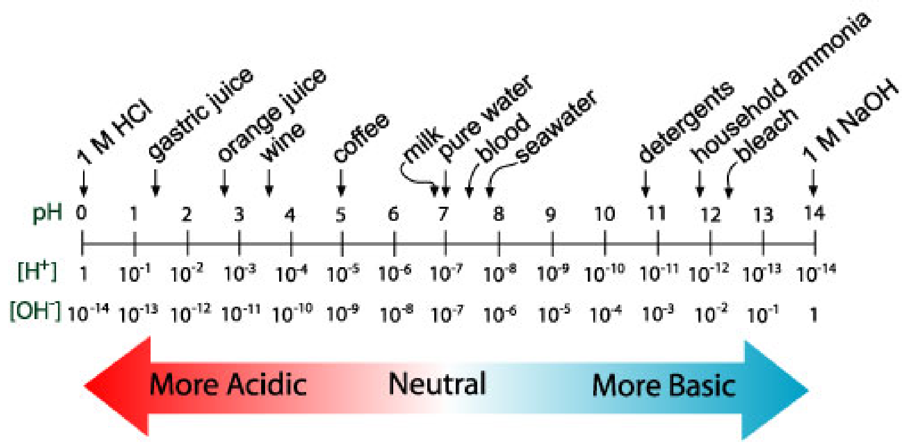
Soil structure is of particular importance in the absorption of water and the circulation of air. A desirable structure should have a high proportion of medium-sized aggregates and an appreciable number of large pores through which water and air can move. Structure of both the B horizon and the A horizon is very crucial to proper drainage, infiltration, and productivity. In soils with poor structure, root penetration is limited thus reducing the plants access to water and nutrients. Structure of the A horizon has received a great deal of attention because of its relation to (a) seedbed preparation, (b) erosion potential, (c) aeration, (d) water infiltration, and (e) overall soil health.

In the laboratory, a soil profile can be created for dried soil samples. A soil profile will contain a particle size distribution, a density profile, pH determination, and a determination of the soil nutrients.

Since soil varies in its composition, a density column is useful in determining information about its components. A density column is created by placing very dense liquids on the bottom of a tall cylinder and then layering less dense liquids carefully on top of the more dense liquids. When an object is dropped into a density column, the object will sink to the place where its density just equals the density of the surrounding liquid. If the object sinks completely, it is more dense than the most dense liquid in the column. If the object floats on the surface, it is less dense than the least dense liquid in the column. If different soil types (different particles of different densities) are placed into a density column, they will have different settling patterns. When one soil is compared to another, identical soils will have nearly identical settling patterns. These patterns can be used as an analysis tool in profiling soil samples.

In addition to density, other soil tests can be conducted to contribute to the soil's total profile. In this experiment, three other variables will be tested—pH, soil nitrogen, and soil phosphorus.

pH is a measure of how acidic or basic things are. From previous studies, recall that the pH scale runs from 0 to 14 with pH 7 being neutral, greater than pH 7 being basic, and less than pH 7 being acidic. The pH of some common materials is shown below.



The pH of soil is actually a measure the pH of the soil in solution. Most aquatic organisms require a pH range between 6.5 and 8.2. At pH levels below 5 larval stages of insects and other small aquatic organisms may die off rapidly. Water with abundant algae and vegetation growth usually has a significantly high pH. This is due to the fact that rapidly growing algae and vegetation remove carbon dioxide from the water during photosynthesis. At pH levels above 9, fish may have a difficult time excreting ammonia from their bodies.

The pH of the soil solution affects how much soil nutrients are available to plants. When soil is too acidic or too basic, important soil nutrients, like nitrogen and phosphorus, are not available to plants. The pH of soil can be altered by adding limestone, $CaCO_3$, or hydrated lime, CaOH, to make it more basic, or aluminum sulfate, $Al_3(SO_4)_2$, to make it more acidic.

Phosphorus is a vital element of life and is usually found naturally in water as phosphate ions. Phosphate originates from fertilizers, wastewater of domestic origin, such as human, animal, and plant residue, and from wastewater of industrial origin. Phosphates are also added to farm and city water systems to control water hardness. Phosphates from detergents can result in overgrowth of algae (also known as algae blooms), which in turn will cause the algae to die at a high rate and undergo decomposition. This decomposition process depletes oxygen from the water and results in increased fish kill.

Phosphorus is necessary in plants for root growth and development. It helps plants grow strong and helps in the production of flowers and fruit. Phosphorus is especially important in crops where we eat the root part of the plant, such as beets, potatoes, carrots, radishes, etc. Testing for phosphorus usually requires dilution since the phosphorus test is very sensitive.

Safety Precautions

Goggles are required for this experiment.

Do not handle soil samples with your bare hands. Chemical-resistant gloves should be worn for this procedure. A lab apron or lab coat is recommended.

TesTabs® contain chemicals which may irritate skin or be harmful if swallowed. A single TesTabs® tablet is a very low health hazard, however, handle them with care.

Wash hands with soap and water upon completion of the lab work.

Part 1. Appearance

Materials Needed

- Soil samples, air dried, with larger particles crushed by hand. All stones removed.
- Sand samples
- Clay samples
- Screen Sieve set consisting of 4 sieves mesh sizes #5, #10, #60, #230, and a bottom pan
- Plastic weighing boats
- Plastic spoons
- Microscopes – dissecting, 30x to 40x
- Microscope slides
- Small crystallizing dishes or clear plastic cups

Procedure

Separating the soil samples

1. Measure 50 g of one soil sample.
2. Place the soil sample in the top part of sieve set. Cap the sieve and shake with a sideways motion for 1 minute.
3. The sieves will contain the following particles:
    a. 1st sieve - #5 mesh – gravel and any large organic matter.
    b. 2nd sieve - #10 mesh – fine gravel and small organic matter
    c. 3rd sieve - #60 mesh – coarse sand and some coarse soil
    d. 4th sieve - #230 mesh – fine sand and soil particles
    e. Bottom pan – fine silt and clay
4. Collect the particles from each sieve and the bottom pan in separate pre-weighed plastic weighing boats or containers. Label each container. Determine the mass of each fraction.
5. Clean out the sieves by first shaking them over a large waste container. Wipe out large particles with a dry paper towel or tissue. Then finally wipe with a damp paper towel and allow to dry. Take care not to damage the screens.
6. Repeat the separation with another soil sample.

Examining the separated soil samples

1. Examine the soil fractions you collected carefully. How would you describe and characterize each of the fractions? Records your observations on the Data and Results pages.
2. Place samples from each fraction of soil under a stereoscope microscope and examine each soil sample carefully.
3. Examine some sand under the microscope.
4. Examine some clay under the microscope/
5. Where applicable, compare the sand and clay particles with your soil fractions.
6. Record your microscopic observations on the Data and Results pages.
7. Save the soil samples for use in Part 2.
8. Repeat your examination with another soil sample.

Part 2. Soil Tests

Materials Needed

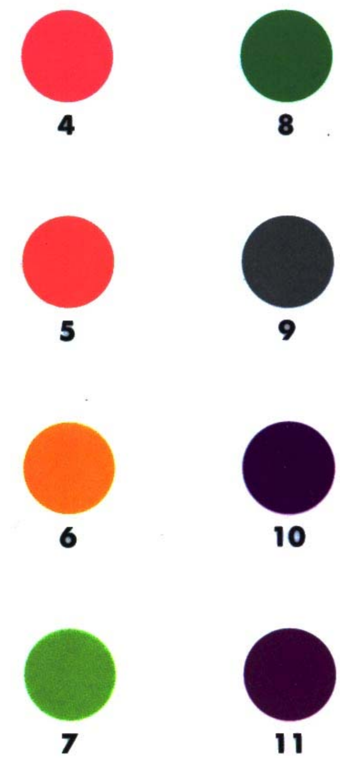
Soil samples, separated, from part 1
Soil testing test tubes
TesTabs® for pH
TesTabs® for phosphate
Distilled or deionized water
Color charts for pH and phosphate testing

Procedure

Soil Tests should be run on the fractions collected in the 3rd sieve (60 mesh)

pH Test

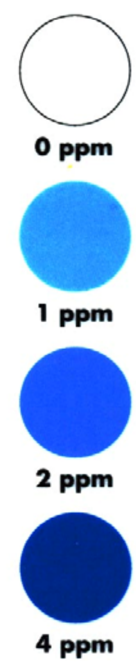
1. Add soil up to the 1-mL mark on the test tube.
2. Add distilled water to each of the tubes up to the 10-mL mark on each test tube.
3. Add a pH TesTab® tablet to the test tube.
4. Screw a top onto the test tube and shake vigorously for 30 seconds.
5. Place the tube in a test tube rack and let it sit undisturbed for one minute.
6. Observe the color of the liquid in the test tube. Compare the color of the liquid in the test tube to the Color chart on the right or to a Color Comparator Chart for pH and record the pH
7. Rinse thoroughly and dry the four test tubes for the next tests.



pH Color Chart

Phosphate Test

1. Add soil to the 1-mL mark on the test tube.
2. Usine a Beral pipet, add vinegar up to the 2-mL mark.
3. Add distilled water up to the 10-mL mark on the test tube.
4. Cap the test tube and shake for one minute.
5. Let the tube sit for at least five minutes to let the soil particles settle.
6. Decant 5 mL of the solution from the tube into a clean test tube.
7. Add one Phosphorus TesTab® tablet to the second test tube.
8. Screw a top onto the test tube and shake vigorously for at least one minute or until the TesTab® disintegrates.
9. Stand the tube in a rack and let it sit undisturbed for at least 5–10 minutes.
10. Observe the color of the liquid in the tube and compare the color to the Color chart on the right or to a Color Comparator Chart for phosphate. Record the phosphate concentration.



Phosphate color chart

Part 3. Soil Density Profile

1. Your instructor will set up a soil density gradient for each of the soil samples using a #10 screened sample from each soil sample.
2. Do not touch or disturb the density gradients.
3. Observe the gradients and draw a sketch of each gradient on the Data and Results pages.

Soil Analysis

Data and Results

Name____ Course/Section ________________

Partner's Name (if applicable) ___________________________ Date ________________

Soil Samples Used

Soil Sample #1 Source: ____

Color: ____

Odor: ____

Soil Sample #2 Source: ____

Color: ____

Odor: ____

Soil Sample #3 Source: ____

Color: ____

Odor: ____

Soil Sample #4 Source: ____

Color: ____

Odor: ____

Part 1. Appearance

Mass of fractions

	Soil sample #1	Soil sample #2	Soil sample #3	Soil sample #4
1st Sieve				
2nd Sieve				
3rd Sieve				
4th Sieve				
Bottom pan				

Appearance of Fractions: Tell color, texture, any plant or animal debris, and other debris

	Soil sample #1	Soil sample #2	Soil sample #3	Soil sample #4
1st Sieve				
2nd Sieve				
3rd Sieve				
4th Sieve				
Bottom pan				

Microscopic Examination: Tell color, texture, uniformity of size, and appearance of particles. Where applicable, compare particles to those of sand and clay samples provided.

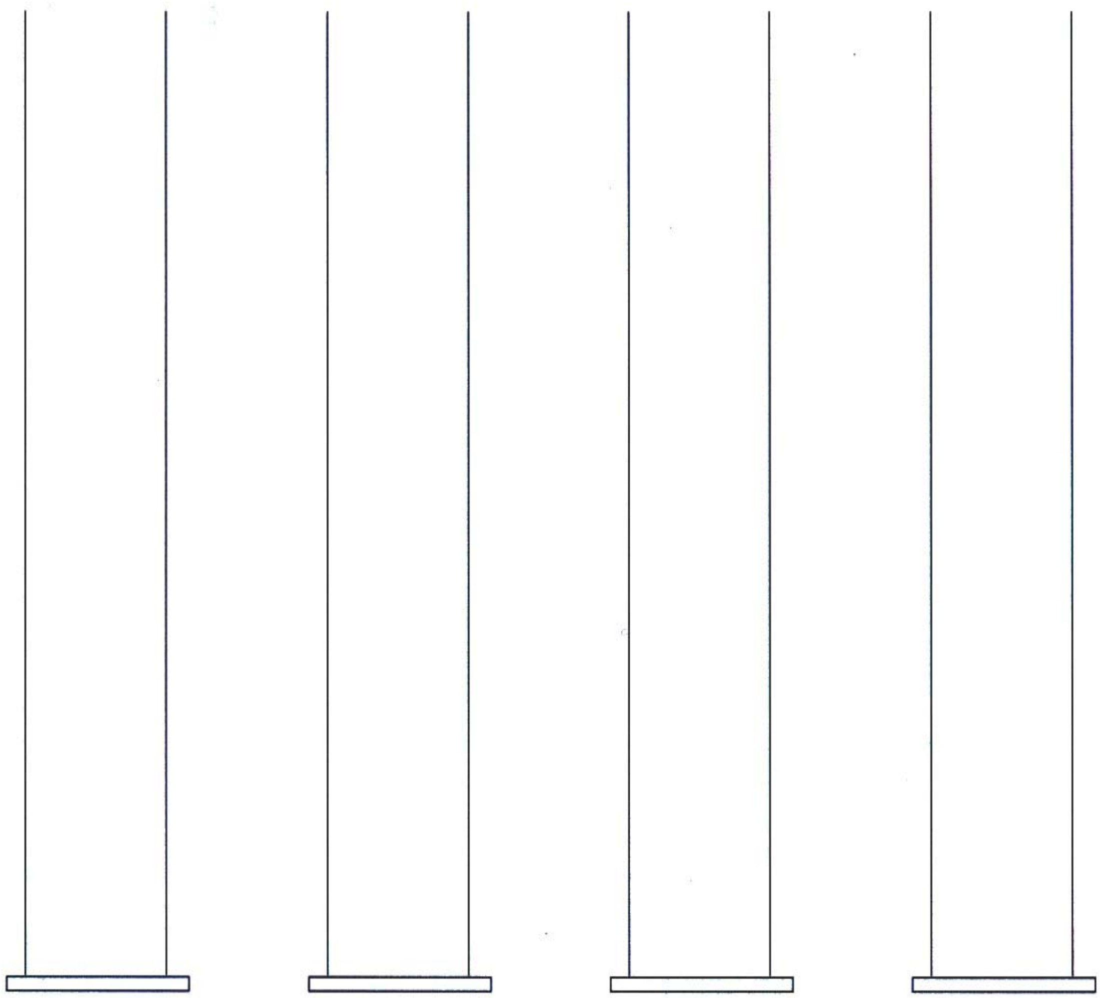
	Soil sample #1	Soil sample #2	Soil sample #3	Soil sample #4
1st Sieve				
2nd Sieve				
3rd Sieve				
4th Sieve				
Bottom pan				

Part 2. Soil Tests

	Soil sample #1	Soil sample #2	Soil sample #3	Soil sample #4
pH				
Phosphate				

Part 3. Soil Density Profile

Draw a sketch of the soil density profile for each soil sample.



Soil Sample #1 **Soil Sample #2** **Soil Sample #3** **Soil Sample #4**

Questions

1. Describe any differences in the soil samples based on your observations and the results of the analysis in this experiment. Are these differences, or lack thereof, consistent with your expectations based on the sources of these soils?

2. Rank the soil samples in terms of which would provide the best to worst growing environment for plants. Include your reasons for this ranking.