Properties of Soil

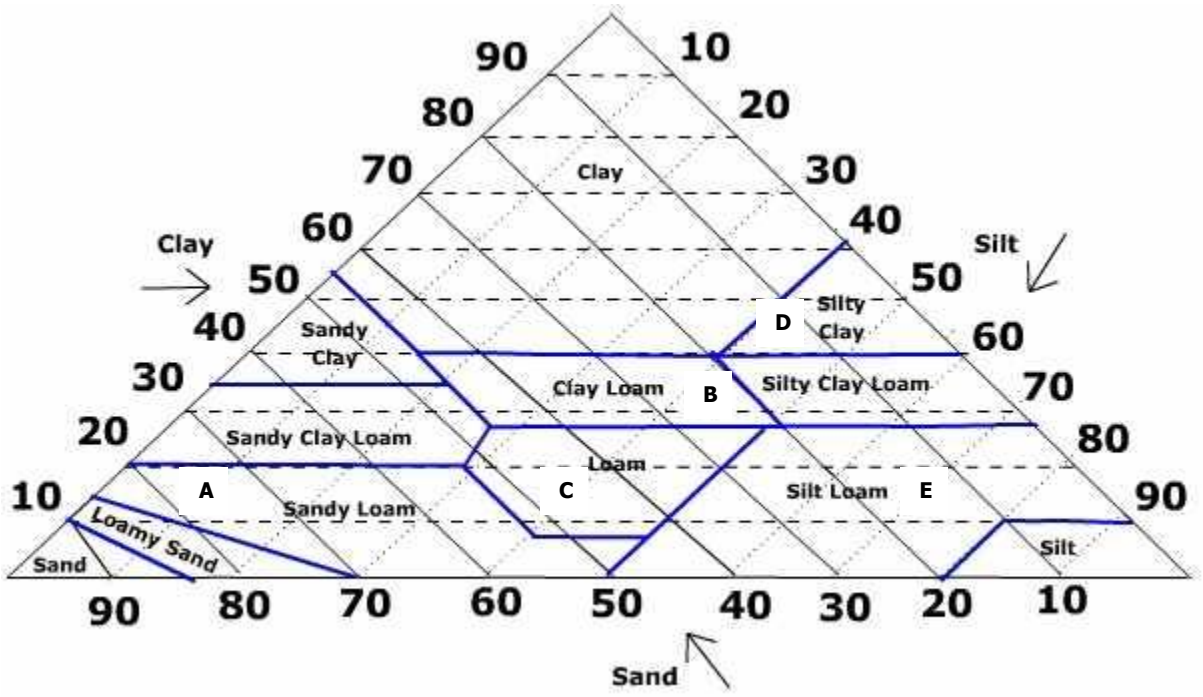
Purpose: To examine the physical and chemical properties of various soil types, including a local, unknown sample, and to discuss how the various properties of soil affect its ability to sustain plant life.

Procedures:

Soil Texture

Texture refers to the proportions of sand, silt and clay particles. These proportions determine water infiltration rates, permeability rates, and water holding capacity. There are 2 ways to determine soil texture – we will experiment with both of these techniques.

First practice using the soil texture triangle to identify types of soil:



Point A: Sandy Loam
75% sand, 10% silt, 15% clay

Point B: _____
_____% sand, _____% silt, _____% clay

Point C: _____
_____% sand, _____ % silt, _____ % clay

Point D: _____
_____% sand, _____ % silt, _____ % clay

Point E: _____
_____ % sand, _____ % silt, _____ % clay

A. Soil Texture by Fractionation:

Sand particles are larger and will settle out faster in suspension, silt particles are next in size so they settle next, and clay has the smallest particles so they settle on top.

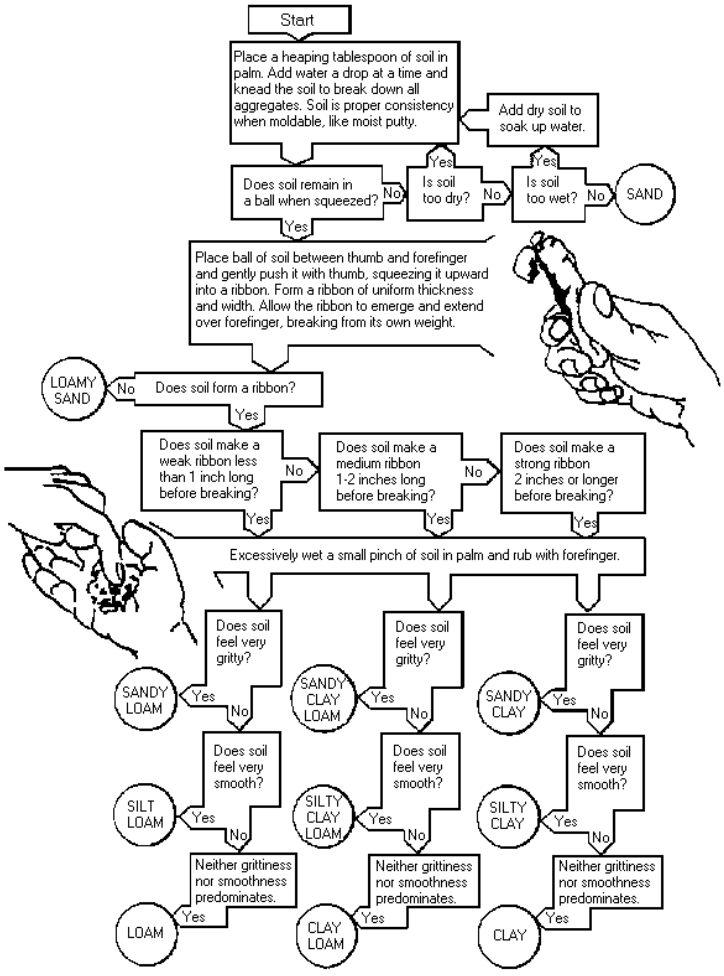
1. Fill a graduated cylinder with 25 ml of your soil sample.
2. Add water until there is 75 ml in the cylinder.
3. Cover the cylinder with parafilm and invert several times. Allow to settle for at least 30 minutes.
4. Measure the volume of each layer, and the total volume of the sample. Do not count the water as part of the total volume.
5. Calculate the percentage of each component:
   $\frac{\text{Amt. of each component}}{\text{Total volume of soil}} \times 100 = \%\ \text{component}$
6. Identify the type of soil by using the Soil Texture Triangle.

NOTE: Use the water in the fractionation column for the nutrient tests!

Layer	**Volume**	**Total Volume**	**% component**
Sand			
Silt			
Clay			

B. Soil Texture by Feel

Use 25 g of your sample to do the following experiment, following the instructions carefully.



Observations:

a. What type of soil did you get by fractionation? _____
b. What type of soil did you get by feel? _____
c. Which method do you think is more accurate? Why? _____
_____

Soil Porosity

Soil porosity is the percentage of the total soil volume which is not occupied by solid particles. In dry soils the pores are filled with air whereas in moist soils they contain both air and water. If a soil is thoroughly wetted and then allowed to drain, the amount of smaller pores, called micropores, will largely determine the water content and the larger pores or macropores will largely determine the air content.

The average soil has a porosity of about 50%. Porosity values for sands are usually less, while those of clays and organic soils are usually higher than this figure. The distribution of pore size is more important than the total porosity. The ideal situation for most plants, is to have the total pore space equally divided between micro- and macropores. If micropores are predominant the moisture holding capacity of the soil will be high, but water and air movement may be inhibited due to the lack of adequate macropores. The reverse situation may produce excessive drainage and aeration at the expense of adequate water holding capacity.

Soil bulk density is the mass per unit bulk volume of soil that has been dried to a constant weight at 105 degrees C. Particle density is the mass per unit volume of soil particles. Both of these terms are usually expressed in g/cc. If both bulk density and particle density are known, the total porosity can be calculated using these values.

(information from http://cropsoil.psu.edu/courses/turf434/lab1method.html)

A. Bulk Density Determination
   1. Add 20ml sand to a graduated cylinder
   2. Compact the soil by tapping the base of the cylinder on the palm of your hand
   3. Add about 20ml more sand and compact as above
   4. Repeat step 3 until 80 ml of the soil is in the cylinder
   5. Record the soil level as volume in cc (1ml = 1cc)
   6. Weigh the soil and record the weight.
   7. **Calculate** bulk density
   8. Repeat steps 1-7 for clay and your sample

Sample	**Weight (g)**	**Volume (cc)**	**Density (g/cc)**
Sand	**152.8**	**80**	**152.8/80 = 1.91**
Clay	**86.5**	**80**	**86.5/80 = 1.08**
Your sample			

B. Particle Density Determination

1. Add exactly 70 ml water to a 100ml graduated cylinder
2. Using a mortar and pestle, grind about 30g soil to destroy aggregates.
2. Weigh the sample and record the weight.
3. Using a funnel, pour the weighed sample into the cylinder containing the pre-measured amount of water
4. Shake gently to release any entrapped air bubbles
5. Read and record the new water level – the change in the water level is the volume of water displaced by the soil, and therefore the volume of the soil particles.
6. **Calculate** particle density

Sample	**Weight (g)**	**Volume of water displaced (cc)** (water level after – water level before)	**Particle Density** Weight of dry soil (g) / Volume displaced (cc)
Sand	**30**	**10**	**30/10 = 3**
Clay	**30**	**15**	**30/15= 2.04**
Your sample			

C. Soil Porosity Determination

% Porosity = [1 – (bulk density / particle density)] x 100

Observations:

a. **Calculate** soil porosity for:
   Sand **__36.3%_____** **[1 - (1.91 / 3)] x 100**
   Clay **__47.1%_____** **[1 - (1.08 / 2.04)] x 100**
   Your sample _____
b. As the bulk density of a soil increases, total porosity _____.
c. What is the relationship between texture and porosity?_____
   _____

Water-holding Capacity of Soil / Permeability

Permeability of soil is determined by the rate at which water moves through a sample. A soil with high permeability will have decreased water-holding capacity. Permeability and water-holding capacity influence plant growth

1. Fold a piece of filter paper and place it in a funnel.
2. Add 20 ml of sand to the funnel.
3. Hold the funnel over a beaker, and pour 20 ml of water into the funnel. TIME EXACTLY HOW LONG IT TAKES FOR THE WATER TO PERCOLATE THROUGH THE SAMPLE. The time interval indicates the permeability or hydraulic conductivity of the soil.
4. **Calculate** the rate of water movement by dividing the amount of water that actually percolated through the sample by the time (in seconds) that it took.
5. Repeat steps 1-3 for the clay and your sample.

Sample	**Rate of water to move through sample** (Rate = volume of water / time)
Sand	**10 ml / 18 sec = 0.56ml/sec**
Clay	**4 ml / 430 sec = 0.009 ml/sec**
Your sample	

Observations:

a. Which soil had the greatest water-holding capacity?_____
b. What is the relationship between particle size and percolation rate? _____
   _____
c. Compare and contrast permeability and porosity. _____
   _____
   _____

Nutrient Retention

pH of soil affects nutrient retention and uptake by plants.

Test your soil sample for pH using the soil pH meter. Test for Nitrogen and Phosphorus using the soil test kits.

Sample	**pH**	**Nitrogen**	**Phosphorus**
Your sample			

Summary:

Type	Porosity	Permeability	PH	Nitrogen	Phosphate
Sand			NA	NA	NA
Clay			NA	NA	NA
Sample (_____)					

Discussion Questions:

1. Explain why loamy soil (a mixture of all 3 soil particles) is the most desirable soil texture for optimal plant growth.

2. Human beings in developed countries generate large amounts of garbage that must be disposed of in some manner. The most common method of disposal is burial in a landfill. One concern with landfills is that water penetrating the soil might leach potentially toxic chemicals from the landfill into the groundwater. Given this concern, what would be the best type of soil in which to place a landfill? Explain.

3. After a downpour of rain in our area, there are frequently puddles of water that collect on the surface of the soil, particularly in areas where there is little vegetation. Explain why this happens.

4. Explain why a pH between 6 and 7 is optimal for nutrient retention and plant growth.

5. In clear-cut logging – still a standard industry method- a company brings heavy machinery to the logging site, drives it into the woods, and cuts down and removes every single tree. Discuss the effects clear-cut logging would have on the soil in the logged area and how this would subsequently affect the re-growth of vegetation.

6. Evaluate the suitability of your group's soil sample for growing crops. Consider the results of each of the tests that you performed on the sample.\