Activity 30: Composition of Topsoil
Maine Geological Survey

Objectives:

To give the student knowledge of the four basic soil components; to show how these components can vary widely within a small geographic area.

Time:

This activity is designed to last one and one-half (1.5) hours, longer if adequate supplies are not readily available and students have to wait to use equipment. This estimate does not include cleanup.

Background:

Soils support much of the world's plant life, which in turn feeds billions of people. When starvation threatens areas such as the Sahl in Africa, and Bangladesh in Asia, or when countries such as the United States experience surplus harvests of grain, the soil involved is largely responsible. Man has had a great impact for both good and bad on various soils throughout history. The "dust bowl" era of the 1930's is a classic example.

All soils are made up of four components: air, water, mineral grains, and organic matter. The percentage of each component in an ideal topsoil is shown in Figure 1.

On an average, it takes about 100 years to produce **ONE INCH** of topsoil; like any other resource soils must be managed, protected, conserved, and maintained if they are to continue feeding the ever hungry peoples of the world. The Maine Soil Conservation

Commission addresses these issues of soil use and management. One of their most useful tools is the Soil Survey Map which is available free of charge from the county office. With very little effort, students can become proficient in the use of these maps and can locate their own soil on the map and obtain information about their soil from the accompanying text.

Crop soils vary widely from this distribution of components depending on geographic area, management techniques, and the time of the year. Students need to realize that all four components are needed in the soil and that these components INTERACT with each other in the soil "laboratory." The role of each component is as follows:

MINERAL GRAINS: Minerals are the main component of soil; they also provide for the slow release of chemical nutrients as individual mineral grains decompose. The mineral grains in a soil are derived from the underlying bedrock (parent material). In Maine, the parent materials are usually granite, schist, gneiss, or meta-sedimentary rocks.

WATER: Besides acting as an acid to help decompose some mineral grains, water also dissolves nutrients from these minerals and other soil materials into what is called the soil solution. This soil solution is the medium of transfer of nutrients into the root hairs of all plants. Soil water also allows for the easy movement of soil bacteria.

AIR: Air allows aerobic bacterial activities to take place which continually provide the soil with nitrogen and other nutrients as well as decaying the large amounts of organic materials that are routinely buried in the soil (see follow-up activities). Air also provides the pore spaces in the soil which act as a reservoir for the immense reserve of ground water. Ground water is the SINGLE largest source of fresh water on the planet.

ORGANIC MATTER (OM): The breakdown of organic matter, that is, the carbon-rich remains of once-living plants and animals, produces a substance known as humus. Humus is dark brown to black and acts as the "glue" of any soil; it binds all of the other components together into a coherent mass. Even though OM averages only 5% of many soils, if that OM component were missing, the soil would dry out and blow away.

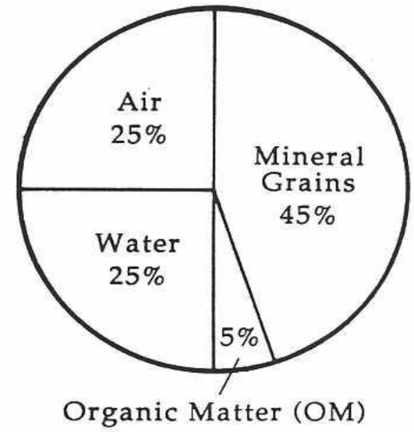

Figure 1. Percentage of air, water, mineral grains, and organic matter in an ideal topsoil.

Materials:

Each student should bring to school a one-pound coffee can filled with a soil sample from their garden, woodlot or lawn. The sample needs to have the student's name and the exact location where the sample was collected written on the cover or taped to the side (see previous activity on soil sampling techniques). This sample will be enough for the several activities listed in this book. Each group of students will need the following:

- 50 ml graduated cylinder
- 250 ml beaker
- 100 ml Coors evaporating dish
- Bunsen burner with hose, burner lighters
- Stirring rod
- Metal scoop
- Beaker/crucible tongs
- Metal ring stands with associated 3 inch diameter rings
- Wire gauze square (4x4) inches
- Notebooks, and pens

Each student will need to wear safety glasses or goggles during the heating portions of this activity. The class as a whole should have access to at least one (two or three would be better) triple beam or electronic balance with a minimum capacity of 300 grams. Paper towels should also be available.

Procedure:

PART I. Have the students use the graduated cylinder to measure out 30 ml of tap water and place this in a 250 ml beaker. Dry the graduated cylinder thoroughly. Place 20 ml of soil into the cylinder just as it comes from the can. Do NOT pack it in. Let it settle naturally by its own weight. Gently add the 30 ml of water to the cylinder and let stand for 3 minutes. Read the level of water in the cylinder (make certain that the students read the bottom of the meniscus); this last reading will be called the final reading. The following calculation will provide a rough idea of the percentage of pore space, and thus the air component, in the soil.

(50 - Final Reading / 20) x 100 = % Air

PART II. Record the weight of an empty evaporating dish. Fill the dish about half full of soil and record the weight. Subtract the weight of the dish from the weight of the dish and soil thus obtaining the weight of the soil. BEFORE HEATING THE SAMPLES, ALL STUDENTS SHOULD DON SAFETY GLASSES/GOGGLES AND SECURE ANY LONG HAIR. Heat the dish GENTLY with the burner on low flame for 5 minutes. Let the evaporating dish cool back to room temperature; weigh it and record the weight. You can tell when the dish is cool without touching it by holding your hand about one fourth inch away from the dish; if you feel no heat this means convection currents are no longer carrying heat away from the dish; hence it is cool. Students should use beaker/crucible tongs to avoid touching the dish after heating. The weight loss due to this heating equals the loss of moisture.

((Total weight before heating - Total weight after heating)/Original weight of the sample) x 100 = % water

PART III. Using the dried sample from Part II above, heat the sample again. This time, play the burner flame directly onto the soil itself. Stir the soil gently while doing this. Notice the smell; also notice the little sparks that fly away from the soil. You may also see some ash from larger root segments and so on. These materials that look like tiny coals are the pieces of organic matter from the sample. Continue stirring and burning for five minutes. Be careful not to let gas pressure from the burner blow any of the sample out of the dish. At the end of 5 minutes, stop heating, and allow the dish to cool to room temperature. When cool, weigh the dish and perform the following calculation.

((Total weight at end of PART II - Total weight at end of PART III)/Original weight of the sample) x 100 = % OM

PART IV. The weight of the mineral grains is the weight of the final mass of material left in the evaporating dish at the end of Part III. The percent of mineral grains is found as follows:

((Total weight at end of PART III - Total weight at end of crucible)/Original weight of the sample) x 100 = % of mineral grains

Special Safety Procedures:

Students need to be careful in all aspects of this activity which involve heating. Safety glasses/goggles must be worn at all times during the heating process. Long hair and loose clothing need to be tied back or secured during the heating. If this activity is NOT taking place in a regular lab room, a fire extinguisher and fire blanket should be temporarily available.

Follow-Up:

The questions at the end of the student sheet form the basis for a good class discussion about soils. Emphasize the interactive relation between components. What if a soil had no water? (drought). What if the air spaces in a soil were all filled with water? (flood). What if a soil had no bacteria or organic matter? (wind erosion, also no decay).

Activity #30: Composition of Topsoil

Activity #31: Determining a Soil's Textural Classification

Activity #33: Soil Horizons

To **DEMONSTRATE** the amazing action of soil bacteria, bury (carefully mark the exact location) a small dead fish from the aquarium or local pond in an active, moist, warm terrarium. After 4-5 weeks at a constant terrarium temperature of 75-80 degrees Fahrenheit, excavate the remains and examine. Discuss. If the conditions are right and the fish is only 2-3 inches long you may not find any visible remains. See National Geographic, May 1991, Vol. 179, number 5, for article entitled "Once and Future Landfills" that discusses why this type of decay is NOT taking place in the nation's landfills. Also see Ward's Landfills and the Environment Activity; this was first released in the fall of 1991.

If a soil scientist is locally available, have this person visit the class and discuss local soil management practices, problems, and issues. This can be very valuable in areas with any type of agricultural activity.

Name___________________________

Activity 30: Composition of Topsoil
Maine Geological Survey

Student Sheet

Purpose:

In this activity, for your sample of soil, you will determine the amounts of the four basic components of all soils: air, water, organic matter (OM), and mineral grains.

Materials:

Each student should fill a one (1) pound coffee can with a soil sample from their lawn, woodlot, or garden; the sample needs to have your name and the exact location where the sample was collected written on the cover or taped to the side of the can. This sample will be enough for the several activities listed in this book.

Also needed for each pair of students are the following: 50 ml graduated cylinder, 250 ml beaker, 100 ml Coors evaporating dish, Bunsen burner and hose, burner lighters, stirring rod, metal scoop, beaker/crucible tongs, ring stands, 3 inch rings, 4x4 wire gauze, notebooks, and pens. Each student will need to wear safety glasses or goggles during the heating portions of this exercise. The class as a whole should have access to at least one (two or three are better) triple beam pan balance with a minimum 300 gram capacity.

PART I. AIR

Using the graduated cylinder, measure out 30 ml of tap water and place this in the 250 ml beaker. Dry the graduated cylinder thoroughly. Place 20 ml of soil into the cylinder just as it comes from the can. Do not pack it in, but let it settle naturally by its own weight. Gently add the 30 ml of water to the cylinder and let stand for 3 minutes. Read the level of water in the cylinder (make certain that you read the bottom of the meniscus); this will be called the final reading. The following calculation will provide a rough idea of the percentage of pore space, and thus air, in the soil. Do the calculations and record data.

(Final reading - 30 ml) / 50 ml x 100 = % Air

% Air in soil: ____

Observations:

PART II. WATER

Weigh and record the weight of an empty evaporating dish. Fill the dish about half full of soil and record the weight. Subtract the weight of the dish from the weight of the dish and soil and obtain the weight of the soil.

<u>BEFORE HEATING SAMPLE, PUT ON YOUR SAFETY GLASSES/GOGGLES AND SECURE ANY LONG HAIR</u>. Heat the dish GENTLY with the burner on low flame for 5 minutes. Let the evaporating dish cool back to room temperature, weigh it, and record the weight. You can tell when the dish is cool without touching it by holding your hand about one fourth inch away from the dish; if you feel no heat, this means convection currents are no longer carrying heat away from the dish; hence it is cool. You should use beaker/crucible tongs to avoid touching the dish after heating. The weight loss due to this heating is the loss of moisture. Record the data and do the calculations.

Weight of empty evaporating dish: __________________________________

Weight of evaporating dish and soil before heating: ______________________________

Weight of soil sample: __________________________________

Weight of crucible and soil after heating: __________________________________

Weight of water lost: __________________________________

((Weight before heating-weight after heating)/original weight of sample)x100 = % water

% Water in sample: __________________________________

Observations:

PART III. ORGANIC MATTER (OM)

Using the dried sample from Part II above, heat the sample again. This time direct the burner flame at the soil itself. Stir the soil gently while doing this. Notice the smell; also notice the little sparks that fly away from the soil as you heat it. You may also see some ash from larger root segments and so on. These materials that look like tiny coals are the organic matter of the sample. Continue stirring and burning for 5 minutes. Be careful not to let gas pressure from the burner blow any of the sample out of the dish. At the end of 5 minutes, stop heating and allow the dish to cool to room temperature. When cool, weigh the dish, record data and observations, and perform the calculation.

Total weight at the end of PART II: __________________________________

Total weight at the end of PART III: __________________________________

Original weight of soil sample: __________________________________

((Weight at end of PART II - Weight at end of PART III) / Original weight of soil sample) x 100 = % OM

% Organic Matter in sample: __________________________________

Observations:

PART IV. MINERAL GRAINS

The weight of the mineral grains is the weight of the final mass of material left in the evaporating dish at the end of Part III. The percent of mineral grains is found as follows.

Weight at end of PART III: ____________________________________

Weight of empty crucible: ____________________________________

((Total weight at end of PART III - Total weight of evaporating dish) / Original weight of sample) x 100 = % mineral grains

% of Mineral Grains in sample: ____________________________________

Observations:

Questions:

1. Compare the percentages of the four components in your sample to the values of other groups in your class. Are these values all the same? If not, what do you suppose caused the variations?

2. Add up the four percentage values from your calculation and record the total. This number should be approximately 100 ('10). If this is NOT the case, which of your values seems to be greatly out of line? What do you think caused this?

   TOTAL VALUE: ___________________________%

3. Suppose you analyzed a soil sample from 10-15 feet below the surface of the ground; what changes in component values would you expect to see and why; use the following chart to help organize your answer.

Component	Topsoil Value	Subsoil Value	Cause of Change
Air	~25%		
Water	~25%		
OM	~5%		
Mineral Grains	~45%		

4. Describe your soil from the end of Part IV. Compare it to your original sample. What do you think the role of water and organic matter are in the soil? Justify your answer.