Soils: Technically Speaking…

Understanding Physical Soil properties!!

Description

Soils are one of our most important natural resources. An individual soil is a natural body that occurs on the land surface, occupies space, and is characterized by horizons or layers and has the ability to support rooted plants in a natural environment.
Soils are made partly from weathered rock and partly from organic materials. Soils differ in their color, texture, capacity to retain water, and ability to support the growth of many kinds of plants
Soils also are important for the beauty their many colors add to our landscapes. Most of us overlook this natural beauty because we see it every day. Often these colors blend with vegetation, sky, water, etc.
Soils are crucial to life on Earth. Soils will continue to supply us with nearly all of our food (except for what can be harvested from the oceans).
Soil units, particles, properties, characteristics, materials, and behavior are the most important natural consideration when we want to build on earth. Any human structure placed on the surface of the earth needs to account for specific soil properties tied to the soil on which it is developed.
Today we are going to study some very important soil properties and characteristics. We will demonstrate their importance in the ability of soils to perform important ecological functions in the pedosphere

Objectives

Students will be able to:

- Name the various materials that comprise soil,
- Understand and identify the various components of the Soil textural Triangle and their usefulness in the ecological functions soil perform on earth.
- Learn basic techniques in determining the particle and bulk density calculations of a soil by direct methods.
- Learn basic techniques in determining the soil water content and its implication on plant growth.
- Demonstrate the ecological function of soils as a natural purifier of contaminated water
- Understand the principles of soil profiles and soil horizons, and basic techniques in profile delineation.

North Dakota State Standards

9-10.1.1	Explain how models can be used to illustrate scientific principles
9-10.2.1	Explain how scientific investigations can result in new ideas
9-10.2.6	Design and conduct a guided investigation
9-10.2.7	Maintain clear and accurate records of scientific investigations
9-10.2.8	Analyze data found in tables, charts, and graphs to formulate conclusions
9-10.6.3	Explain how emerging technologies may impact society and the environment
11-12.1.2	Identify structure, organization, and dynamics of components within a system
11-12.8.1	Identify the criteria that scientific explanations must meet to be considered valid

Schedule

09:00-09:30	General Organization and Cultural Connection
09:30-10:00	PowerPoint Presentation
10:00-10:30	Activity 1
10:30-11:15	Activity 2
11:15-12:00	Activity 3
12:00-12:45	Lunch
12:45-01:45	Activity 4
01:45-02:30	Activity 5
02:30-02:50	Activity 6
02:50-03:00	Wrap-up activity and Reflection questions

Cultural Connection:

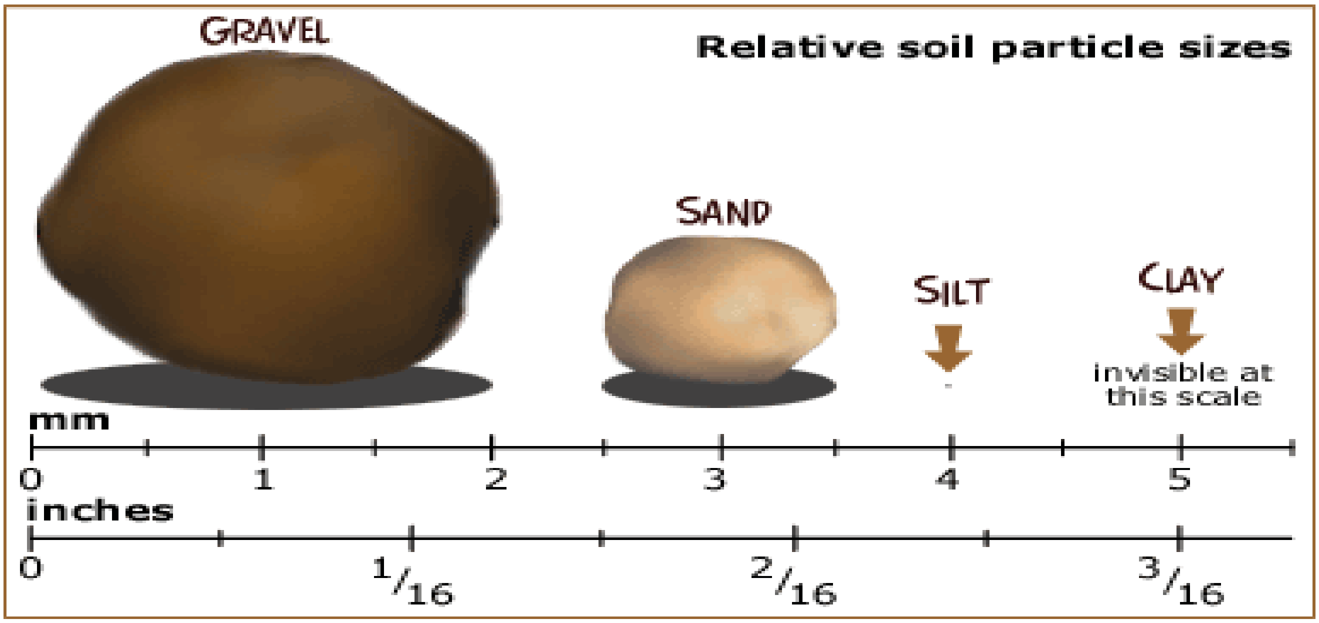
Terminology to Note:

A soil
Biotic and abiotic soil factors
Bulk Density
Clay
CLORPT
Ecological function
Macropores and Micropores
Particle Density
Sand
Silt
Soil Horizons
Soil profile
Soil structure
Soil texture
Soil water content
Soils
Textural class
The soil

Soil Texture

Soil texture is important for determining suitability for various uses of the soil. Texture is considered a basic property of soil because it doesn't change, giving it consistency for comparison. Most soils have a combination of soil particles sizes. Three soil separates are sand, silt, and clay.

- Sand has a gritty feel, can be seen with the naked eye, and leaves no residue on your hand when hand sampling.
- Silt has a powdery smooth feel, flour-like texture when dry and a creamy slick, slippery feel texture when wet. Silt doesn't have a sticky or plastic feel. You can see silt with a hand lens or microscope. When hand sampling, silt will coat your hand, but can be brushed off.
- Clay feels hard when dry and has a sticky, plastic feel when wet. Clay particles can only be seen with an electron microscope. It will stick to your fingers after hand sampling.



Activity 1: *Soil Textural Class Identification Mathematics*

Introduction

In this activity we demonstrate the basic mathematics involved in determining a soil textural class. As mentioned earlier, soils are made up of 3 main particle sizes which combine to form the soil textural classes. These are: CLAY, SILT, and SAND

These particle sizes typically combine to form 100% of the soil in varying ratios depending on the soil type and the location from which you collected your sample.

Example: a soil could be 5% Clay, 45% Silt, and 50% Sand for a total of 100%!!!

Materials: (Each student)

Soil Textural Triangle Sheet

Procedure

We apply the basic mathematics involved in determining a soil textural class. We are going to use percentage calculations to identify the textural class of our hypothetical soils!

Remember, all soils have 3 main particle sizes! Clay, silt, and sand! Usually, you only need 2 numbers to determine the textural class of any soil. Hence a third number may not be necessary because this number is usually easy to figure out!!!!

Table 1: Fill in the right textural class for each soil based on the textural class triangle and the percentages listed below

SOIL #	CLAY	SILT	SAND	Textural Class
1	20%	40%	40%	
2	25%	10%	65%	
3	30%	60%	10%	
4	20%	20%	60%	
5	25%	30%	45%	
6	5%	45%	50%	
7	5%	70%	25%	
8	45%	45%	10%	
9	1%	2%	97%	
10	35%	40%	25%	

Questions

1. How many textural classes are represented in your table?

2. Which textural class is the most common class in your table? How many soils fall in this class?

3. Which textural class is the least common class in your table?

Activity 2: *Particle and Bulk Densities of Local Soils*

Introduction:

In this section, you will learn the importance of bulk and particle density and why high bulk and particle density in the soil can be a concern. The role that texture and structure play in bulk and particle density is explained. You will learn how to obtain an undisturbed soil sample and determine the bulk and particle density of that sample. We will introduce simple mathematical equations to calculate bulk density, and particle density at the time you sampled the soil.

Bulk density of mineral soils commonly ranges from 1.1 to 1.5 g/cm3 in surface horizons. It increases with depth and tends to be high in sands and compacted pan horizons, and tends to be low in soils with abundant organic matter. Tillage operations loosen soils and temporarily lower bulk density, while compaction processes raise bulk density.

Particle density is the volumetric mass of the solid soil. It differs from bulk density because the volume used does not include pore spaces. Particle density represents the average density of all the minerals composing the soil. For most soils, this value is very near 2.65 g/cm3 because quartz has a density of 2.65 g/cm3 and quartz is usually the dominant mineral. Particle density varies little between minerals and has little practical significance except in the calculation of pore space.

Bulk density = Oven dry soil weight / volume of soil solids and pores

Particle density = oven-dry soil weight / volume of soil solids

Materials: (Each group)

3 One-quart plastic bags
Soil sampler (if available) or
Can also use a PVC pipe or sturdy tin can (3 or 4 inches long and about 3 inches in diameter),
A piece of 2 × 4 wooden board
A hammer
Shovels or a tool to dig and scoop soil material
Paper plates
Paper
Pencils
Scale or balance
Oven and oven safe metal pans

Sampling Procedure:

Use 15 minutes to go out into the yard around campus, find a hill and identify 3 location: at the top, middle and bottom of the hill; pick a spot in each location to collect a soil sample.

1. Choose sampling sites from several locations (at least three) and hypothesize about the differences in bulk density you expect to find and WHY.
2. Record descriptions of the sampling locations in the data table.
3. An accurate determination of bulk density starts with *proper sampling* to ensure that the collected sample represents the soil's natural condition!
4. One of the easiest methods for doing this requires a sturdy tin can (3 or 4 inches long and about 3 inches in diameter), a piece of 2 × 4 wooden board, a hammer and a shovel.
5. First, scrape the surface clean of vegetation. Place one end of the can on the soil and put the 2 × 4 flat on the other end; hammer the can into the ground.

6. When the can is completely buried, carefully dig out the can and surrounding soil, being careful to have soil remaining on both ends of the can.
7. Trim this "extra" soil flush with the ends of the can using a putty knife. You now have an "undisturbed" (i.e., non-compacted) soil sample for calculation of bulk density.
8. Now you need to weigh the soil. You can do this while it is still in the tin can, or you can remove the soil from the can.
9. A standard kitchen scale will work, or a laboratory balance at school;
10. Make sure you have the weight of just the soil (if you weigh the soil in a container, subtract the weight of the empty container from the soil).
11. Then you can place the soil into an oven-proof container (a baking dish or a loaf pan).
12. Dry the soil at 105° Centigrade (or about 250° Fahrenheit) for 24 to 36 hours. Let the soil cool, and weigh the soil again.

Determining the volume of Sample

1. Obtain a pure sand sample, for example a bag of sand suitable for a backyard sand box. You will weigh a small quantity of sand, no more than a few tablespoons.
2. Add water to a container with volume markings—a graduated cylinder from chemistry lab would work. Or you can make your own graduated cylinder, see how.
3. With a known amount of water in your graduated container, add the known weight of sand. Stir it briefly to ensure that no air bubbles are trapped in the sand.
4. After a minute, read the new level of water in your container. The difference between your new level of water and the original level is the volume of sand.
5. If you divide the weight of sand by the volume, you will obtain particle density (the density of a mineral material without pore space).
6. The formula is: weight of sand (grams) ÷ volume of sand where volume is measured by taking the new level of water in your container and subtracting the original level, with 1 ml = 1 cm3.

OR

1. Calculate the volume of the cylinder or container holding your sample: $\pi \times r^2 \times \text{height}$

Bulk Density Calculations and Analysis

1. After drying your soil sample to a constant weight (24 hours in a hot-air oven at 105 degrees C).
2. Weigh the sample. Record the dry weight of the soil and calculate the volume of the cylinder or container as above.
3. To calculate bulk density you need the dry weight (in **grams**) of soil and the volume (in cubic **centimeters**) of soil. The **volume of your tin can or cylinder** will be the volume of soil.
4. **Bulk density = dry weight (grams) ÷ volume (cm^3)**

Data Collected	Sample 1	Sample 2	Sample 3
Weight of wet soil (before drying)			
Volume of sampling cylinder			
Weight of drying container			
Weight of oven-dry soil + container			
Weight of oven-dry soil			
Bulk density			

Particle Density Calculations and Analysis

Particle Density for most soils tends to be very negligible except for sandy soils with coarse and large grains. Particle density (as well as bulk density) of a soil can be easily approximated in the laboratory by the following procedure. We are going to use sand to demonstrate this procedure.

1. Weigh 50 g of dry sand and use a funnel to quantitatively transfer to a 100-mL graduated cylinder.
2. Carefully tap the cylinder 4 times to settle the sand. Read the volume and record on your data sheet.
3. Transfer the sand to a container and save.
4. Add approximately 60 mL of water to the 100 mL graduated cylinder. Record the exact water volume (assume the density of water is 1 g /cm^3).
5. Transfer the 50 g of sand from step 3 back into the cylinder. Stir to remove the trapped air.
6. Read and record the volume. Note the difference in the volume and that in step 4, this is the volume of the sand particles.
7. Calculate the particle density by dividing the weight of the sand (50 g) by the volume of the sand particles.
8. **Particle density = oven-dry soil weight / volume of soil solids**

Data Collected	**Sample 1**	**Sample 2**	**Sample 3**
Weight dry sand			
Volume of dry sand			
Bulk density of sand			
Volume of water			
Volume of water and sand solids			
Volume of sand			
Particle density of sand			

Questions

1. What do you understand by bulk density?

2. What do you understand by particle density?

3. Does bulk density differ from particle density?

4. Does soil texture have an impact on bulk density?

5. Does soil texture have an impact on particle density?

6. A highly sandy soil compared to a highly clayey soil – which has a greater particle density?

7. A highly compacted soil at a camp site compared to a highly tilled loose soil on farm – which has a greater bulk density?

Activity 3: *Soil Water Content Analysis*

Introduction:

The soil moisture content may be expressed by weight as the ratio of the mass of water present to the dry to the dry weight of the soil sample, or by volume as ratio of volume of water to the total volume of the soil sample. To determine any of these ratios for a particular soil sample, the water mass must be determined by drying the soil to constant weight and measuring the soil sample mass after and before drying. The water mass (or weight) is the difference between the weights of the wet and oven dry samples. The criterion for a dry soil sample is the soil sample that has been dried to constant weight in oven at temperature between 100 – 110 oC (105 oC is typical). It seems that this temperature range has been based on water boiling temperature and does not consider the soil physical and chemical characteristics

Materials

Oven with 100 –110 0C temperature
A balance of precision of ± 0.001 g
Aluminum weigh tins
Auger or tool to collect soil samples

Procedure

1. Weigh an aluminum tin, and record this weight (tare").
2. Place a soil sample of about 10g in the tin and record this weight as (wet soil + tare).
3. Place the sample in the oven 105oC, and dry for 24 hours or overnight.
4. Weigh the sample, and record this weight as weight of (dry soil + tare).
5. Return the sample to the oven and dry for several hours, and determine the weight of (dry soil +tare).

Calculations

Water content (%) = $[(M_w - M_d) \div M_d] \times 100$

M_w = *Mass of wet soil sample (wet weight - tare weight) (grams)*
M_d = *Mass of dry soil sample (dry weight - tare weight) (grams)*

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Activity 4: *Soil Ecological function: Water Purification*

Introduction

Soils have many important functions. Perhaps the best appreciated is the function to support the growth of agricultural and horticultural crops. Although it is difficult to rate the importance of the different soil functions, since all are vital to some extent, this function of supporting world agriculture and horticulture is a key one in the preservation and advancement of human life on this planet.

Soil is increasingly being recognized as playing a fundamental role in the quality and distribution of our water supply. The soil, coupled with the landscape and its vegetation is responsible for the distribution of all rainwater falling upon it. The nature of the topsoil will influence greatly whether the rainwater will run away across its surface, where it can supplement surface bodies of water, e.g. lakes, rivers, and in extreme situations lead to flash flooding, whether it will infiltrate to become stored in the soil for use by vegetation growing on it and by the soil based organisms, or whether it will flow through the soil to the reach the groundwater and at what rate it will do this. The soil thus holds a key position with respect to our water supply cycle and is now seen as a key element as such by hydrologists.

We are going to demonstrate the ability of soil to purify water. Different soils have different capacities to purify water. Some soils drain water faster than others and thus purify water at different rates. This activity will measure the clarity of water as it goes through your constructed soil profile.

Materials and Preparation::

1. 3 oz and 5 oz solo cups (Put 3-5 holes in bottom of 5 oz cup. A toothpick works well.). The 5 oz cup fits inside 3 oz cup, and then put the toothpick inside, between the cups.
2. Clear plastic cup
3. Flashlight or pointer light
4. White stock cards or paper to capture the light
5. play sand and sand of varying coarseness
6. various finely ground soil samples collected from outside
7. grape Kool-aid
8. other colors, e.g., green, red, blue, orange, yellow food coloring
9. "floaties" or leaves and roots, etc (Optional)

Setup

1. Each group will create 3 pairs of distinct soil profiles to test the filtration capacity of different or murky water.
2. With the exception of you sandy soil profile which will have only one layer, your other 2 pairs of manufactured soil profiles should have at least 2 layers.
3. Sand must always be at the bottom because the sand keeps the topsoil in the cup. Sand has large, rough particles. Topsoil is a mixture of particle sizes.

Sand Soil profile:

4. Take a 5 oz cup with holes in the bottom and fill it half full of sand.
5. Put it inside the 3 oz cup. Put a toothpick between the cups so that air can escape from the bottom cup.
6. Pour some of the water mixture into the top cup
7. The water will take some time to filter through your soil profile.
8. Once you have captured enough filtered or purified water to fill a clear plastic cup, perform the light test (basic turbidity test)
9. Test to see if the light can be captured on a stock card at 7ft, 10ft, and 15ft when it passes through the sample in the cup.
10. Record your observations

Other Soil Profile:

11. Repeat the process with two other manufactured profiles with at least 2 different layers.
12. Remember the aim is to get the purest water possible!

Profile composition	Water color before filtration	Water color after filtration
Sandy Profile1: Sand		
Sandy Profile 2: Sand		
Profile B1:		
Profile B2:		
Profile C1:		
Profile C2:		

Questions

1. How long does it take for water to go through your manufactured soil profile into the cup?

2. What were the various layers in your manufactured soil profile? List the order of the various components?

3. What happens to the floaties in the water?

4. Is the same water mixture in the bottom cup the same clarity for all soil profiles?

5. Was your purified water sample clear enough to let light through so it is visible at varying distances?

6. What can you do to improve the clarity of your water sample if you redo this experiment?

Activity 5: *Soil core sampling and delineation*

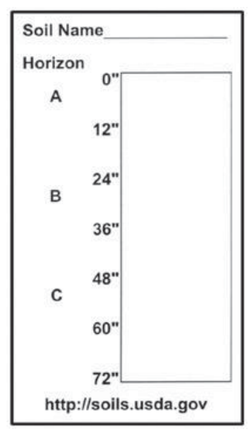
If you look in a soil pit or on a roadside cut, you will see various layers in the soil. These layers are called soil horizons. The arrangement of these horizons in a soil is known as a soil profile. Soil scientists, who are also called pedologists, observe and describe soil profiles and soil horizons to classify and interpret the soil for various uses.

Soil horizons differ in a number of easily seen soil properties such as: **color**, **texture**, **structure**, and **thickness**. Other properties are less visible. Properties, such as **chemical** and **mineral** content, **consistence**, and **reaction** require special laboratory tests. All these properties are used to define types of soil horizons.

Soil scientists use the capital letters **O**, **A**, **B**, **C**, and **E** to identify the master horizons, and lowercase letters for distinctions of these horizons. Most soils have three major horizons -- the surface horizon (**A**), the subsoil (**B**), and the substratum (**C**). Some soils have an organic horizon (**O**) on the surface, but this horizon can also be buried. The master horizon, **E**, is used for subsurface horizons that have a significant loss of minerals (eluviation). Hard bedrock, which is not soil, uses the letter **R**.

Horizon	Description
O	Thin organic horizon on the surface, comprised mainly of decomposed organic matter
A	Surface horizon or topsoil; dark in color (because it also has a lot of organic matter)
E	Subsurface horizon in which the minerals have been leeched out; distinguished by a gray/white color
B	Subsoil (not as dark since there isn't as much organic matter)
C	Parent material (what the soil formed from). Just like their parents – where they came from.
R	Hard bedrock

In this activity we are going to build a soil profile showing the exact nature of individual horizons at respective depths of the soil profile.

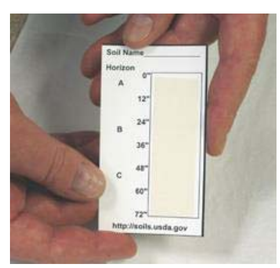


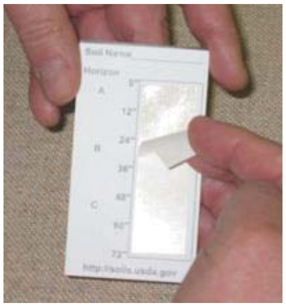
Materials

Soil Profile drawn on cardstock paper
Rolls of double-sided carpet tape (One inch tape is adequate)
Shovel
Meter tape or ruler for depth measurement
6 containers to collect samples at six depths

Procedure:

1. Go out into the field and collect soil samples at the six depths listed on your cardstock paper.
2. Preserve these containers making sure you label each container with the appropriate depth the sample was collected.
3. Print the soil profile cards onto cardstock paper or draw your own design on a 3" x 5" note card.
4. Attach a short strip of carpet tape to the card.
5. Pull back the tape at the top to expose some of the sticky tape and place soil from the surface horizon to represent the depth of this soil.





6. Pull back the tape for each additional layer one at a time following the same procedure.

7. Properly dispose of the remaining tape piece.

8. The card can now be placed in an envelope to protect it.
9. You might also collect a little surface vegetation to keep with your soil type for learning about plant-soil relations.

Activity 6: *Soil Profile Horizon Identification Challenge*

In this activity we will test your ability to identify soil profile Horizons. Different soil profiles will be presented to each group for you to delineate the various horizons on each profile using sticky strip page markers.

Remember, soil horizons differ in a number of easily seen soil properties such as observable: **color**, **texture**, **structure**, and **thickness**. Other properties are less visible. Properties, such as **chemical** and **mineral** content, **consistence**, and **reaction** require special laboratory tests. All these properties are used to define types of soil horizons.

Materials:

Soil profiles in color printed on large format paper
Sticky note paper markers
Video on how to identify soil horizon at:
https://www.youtube.com/watch?v=I-QTjbBTUbY and https://www.youtube.com/watch?v=Zigo6T7fZ88

Procedure:

1. Each group will review basic characteristics of profiles presented so far and watch the video
2. Then each group will work together to identify the various horizons in each profile in the templates presented
3. Submit your sheets of paper after you have identified the various horizons in each profile.

Wrap Up Activity: *Soil Properties of Importance in Nature*

The textural and water content abilities of soils have huge implications that determine how successful plants and natural processes function in the ecosystem.

Based on our understanding of the soil properties and characteristics of soils we have studied, rate how important each of the soil components listed are for each natural function listed. Place a check mark in a box for each component that will affect an activity.

Human Activity	Soil texture	Deep soil profile	Soil as a purifier	Bulk density	Particle density	Soil water content
Nutrient availability for plant growth						
Root penetration for support						
Resistance to drought						
Clean water in aquifers						
Habitat for other animals						