Playing in the Dirt: Discovering Soil

Grades 9-12

Science

Objectives

Through classroom experiences, students will compare different types of soil found around their school and home to identify three basic soil components. They will plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

Vocabulary

Horizon— a distinct layer of soil or its underlying material in a vertical section of land
Microflora—microscopic plants of a specific region or time
Organic Material— the layer of soil made up mostly of leaves and insects, which have died
Subsoil— the layer of soil under the topsoil, which has a much lower percentage of organic matter and humus
Substrate— the base on which an organism lives, soil is a substrate for plants
Topsoil— surface soil, usually including the organic layer, in which plants have most of their roots and which the farmer turns over for plowing

Background

When you dig into the ground under the grass in your yard, you will find soil. But what happens if you keep on digging? If you dug far enough, would you run out of soil? How far would you have to dig before you ran out? And what would you find there?

"The nation that destroys its soil destroys itself."
- Franklin D. Roosevelt

If you dug far enough, you would hit solid rock. This is called bedrock. But before you got there you would have to dig through three different layers of soil. The layers are known as **horizons**, and all the layers together make up the soil profile. The first layer would be nothing but dark-colored **organic materials.** That is the layer formed by plants and insects that have died and dead leaves that have fallen. Just under that is the **topsoil**. The topsoil is the best place for plants to take root and grow. It is a mixture of air, water, organic material (matter from dead plants and animals) and minerals (sand, clay, silt).

In most places the topsoil is between six and 20 inches thick. The **subsoil** is the layer below the topsoil. It is made mostly of clay or sand and has very little organic material. Plants have a hard time growing in subsoil. Between the subsoil and the bedrock are a layer of small rocks that have started to break off the bedrock. This layer is the parent material of the soil. That's because most of what makes up the soil was once part of the rock.

Soil covers much of the land on Earth. It provides a **substrate** for plants (roots anchor in soil), a source

of food for plants, and a home for many animals (insects, spiders, centipedes, worms, burrowing animals, bacteria, and many others). Soils are home to two or more tons of living things per acre. **Microflora**, insects, worms and animals, as well as other organisms, produce acids that, in turn, help break down soil minerals. Organic matter is beneficial to soils. It increases water-holding capacity, serves as a reservoir for plant nutrients such as nitrogen, and provides food for the living things in the soil.

Minerals have several different ways of getting into the soil. Sometimes they come from the ashes of volcanoes that have erupted. Usually the minerals come from rocks that have been broken apart. Water from rain flows into the cracks of rocks. When the water freezes, it expands and causes the cracks in the rocks to get bigger and little bits of rock break off. Sometimes the roots of trees and deep-rooted plants grow into the rocks and draw the minerals up through the roots and into the plant. The minerals become part of the leaves that later fall to the ground. Many rocks are broken apart by lichens — tiny plants that live on rocks. Sometimes water just keeps running over the rock until tiny particles start to wash away. We call all these processes "weathering." Water and wind carry the tiny bits of rock along until they get trapped by the soil. It can take hundreds of years for rocks to break into pieces that are small enough to form soil. It takes between 200 and 500 years for just one inch of topsoil to form.

Additional Resources

- Soil and Soil Dynamics video: https://youtu.be/mg7XSjcnZQM
- Soil Texture by Feel video: https://www.youtube.com/watch?v=GWZwbVJCNec

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Teacher Resources

Activity 1: What is Soil, (Science) 1 50 minute class periods

Materials

- Pen or Pencil
- **Activity 1 Worksheet 1"What is Soil?" worksheets**
- Computer access to show "Soil and Soil Dynamics" video

Procedures

Engage:

1. To determine what students already know about soil, have each student develop an answer to the following question… "What is Soil?"
2. Ask the question, then through "Think. Pair. Share." have students work with a partner to answer the question on the **"What is Soil?"** worksheets.

Explore

1. Show video https://youtu.be/mg7XSjcnZQM or Pass out the included reading page for reference.
2. Have students develop statements/questions about the importance of soil based on the information in the video or reading page.
3. Have students develop a model to describe the cycling of Earth's materials and the flow of energy that drives the process.
4. Explain how one change to Earth's surface can cause changes to other Earth systems. How have changes in the availability of soil influenced human activity?

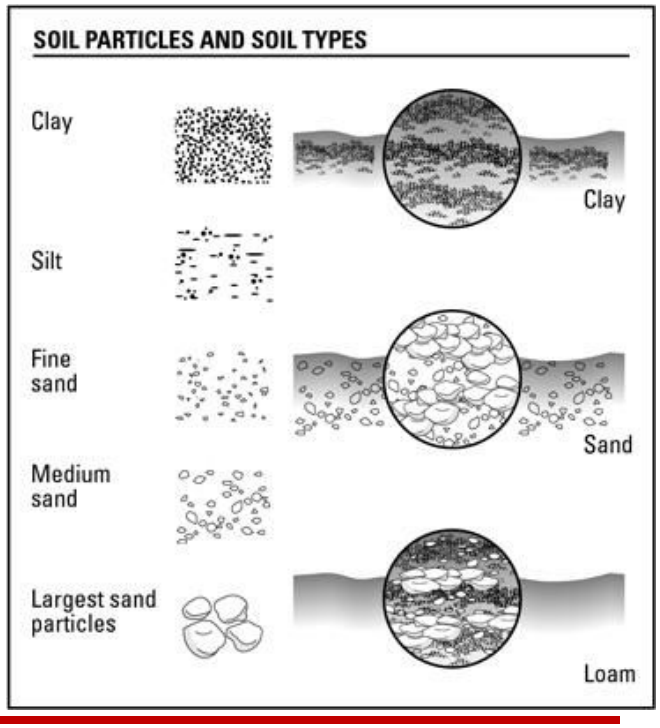
Explain

1. Discuss the three basic soil components and the qualities that each add to the soil.

   SAND - Sand particles are the largest of the three types. They can be angular or rounded.

   SILT - Silt particles are more angular and larger than clay but still microscopic.

   CLAY - Clay particles are microscopic and flat.



Activity 2: Ribbon Test to Determine Soil Type (Science) 1 50 minute class period

EXPERT TIP: Test each of the soil samples beforehand to make sure they work for this activity!

Materials

- Soil samples from three different areas, as follows:
    1. topsoil from a flower bed.
    2. soil from a building excavation site.
    3. subsoil from an eroded road bank.
- Small tray or plate for students to work over
- Spray Bottle
- Large bucket or container for students to dump materials
- Large bucket or container filled with water for students to wash large particles off (you don't want all that soil to go into your sink)
- "Soil Texture by Feel" video: **https://www.youtube.com/watch?v=GWZwbVJCNec**
- **Activity 2 Worksheet 1 "Ribbon Test to Determine Soil Type"** worksheets

Procedures

THIS ACTIVITY IS MESSY.

Extend or Elaborate

1. Provide each student with a small handful of soil. *Note: Distribute samples of different soil types to students at random so that not everyone has the same soil type.*
2. Students will determine soil type by feel.
3. Students will gradually add water to their soil samples using spray bottles until they can make balls of moist soil.
4. Students will gently stretch the soil between their thumbs and forefingers and try to make a ribbon. (Some samples will not form into a ribbon, depending on the soil texture).
5. Students will note the feel of the soil as they are working it.
6. Students will use the descriptions below to assign soils to different textural classes.

SAND	Loose and single-grained with a gritty feeling when moistened. Not sticky and will not form a ribbon when pressed between thumb and index finger.
SANDY LOAM	Contains sufficient silt and clay to give coherence to the moistened soil. Feels gritty and also slightly sticky. Will not form a ribbon.
CLAY LOAM	Forms short ribbons of less than 3 cm long.
CLAY	Extremely sticky and plastic when moist. Easily forms a ribbon longer than 3 cm.

Activity 3: Discovering Soil Profile (Science) 1-3 50 minute class periods

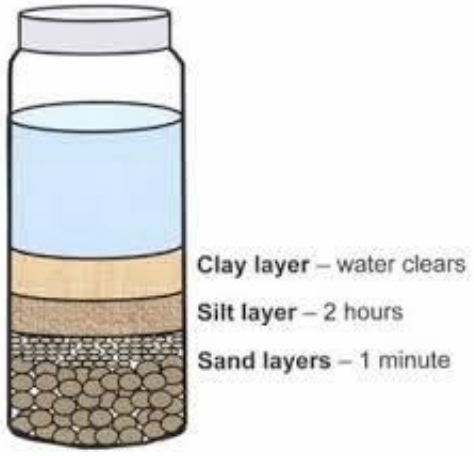
EXPERT TIP: Test each of the soil samples beforehand to make sure they work for this activity!

Materials

- Soil samples from three different areas, as follows:
    1. topsoil from a flower bed.
    2. soil from a building excavation site.
    3. subsoil from an eroded road bank.
- Masking tape
- Marker
- 3 straight-sided jars and lids, equal in size and shape (Large glass pickle jars work well.)
- Rulers
- **Activity 3 Worksheet 1 "Soil Make-Up"** worksheets

Procedures

1. Each group will fill 3 jars ⅔ full of water.
2. Use masking tape, to label each jar with the soil type (A, B, C) and your group name.
3. Pour one soil sample into each jar being sure the sample matches the label. Fill each jar about 1/3 full with soil.
4. Finish filling each jar with water to about 5 cm from the top and tightly secure your lid.
5. Take turns shaking the jar until all of the soil is "dissolved" and the particles are suspended in the water (about 2 minutes).
6. Find a spot in the classroom to place your jar where it won't be disturbed.
7. Allow the jar to settle for the next 24-48 hours.



After the "settling period" you should be able to see distinct layers.

1. Observe the layers of sediment. (floating material is organic matter)
2. Using your ruler, measure in cm the total depth of sediment in the jar and record your findings in the table.
3. Next, measure the depth of each layer and record it on the table.
4. Calculate the percentage of each soil component using the "Soil Calculations" area and then record the percentages on the "Soil Layers Chart" worksheet.
5. After recording the percentages on the "Soil Layers Chart," classify the soil sample by comparing the percentages to those on the "Soil Texture Chart."
6. Record your results on the last line of the "Soil Layers Chart."
7. Complete the discussion questions and turn in your assignment.

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Standards

Oklahoma Academic Standards

Activity 1: What is Soil (Science)

HS-ESS2-2 Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks and interactions that cause changes to other Earth's systems.

HS-ESS3-1 Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

Activity 2: Ribbon Test to Determine Soil Type (Science)

HS-ESS2-5 Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

HS-ESS3-5 Construct a scientific explanation from evidence for how geological processes lead to uneven distribution of natural resources.

Activity 3: Discovering Soil Profile (Science)

HS-ESS2-5 Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

HS-ESS3-5 Construct a scientific explanation from evidence for how geological processes lead to uneven distribution of natural resources.

Playing in the Dirt: Discovering Soil

Activity 1 Worksheet 1: What is Soil?

Name: _____Date: _____

Class/Hour/Teacher: _____

Work together to come up with a definition and description of soil.

What is Soil: _____

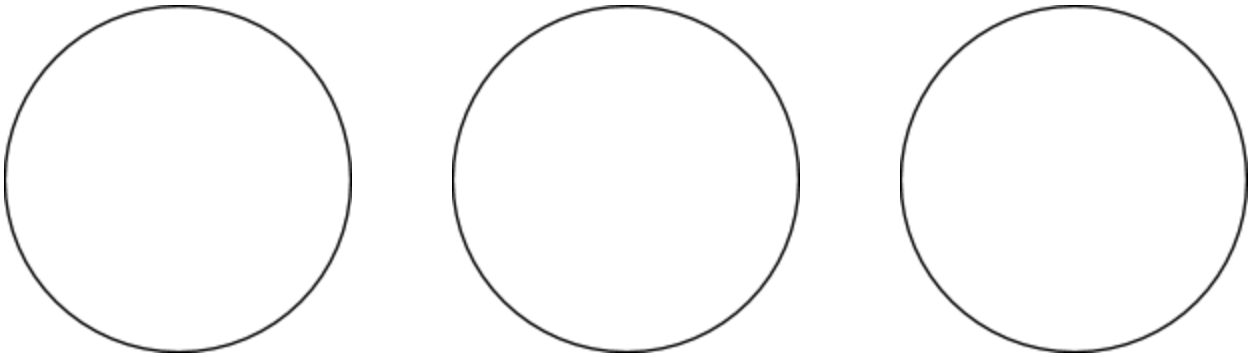
THINK	PAIR

SHARE

Three Components of Soil

Draw and label each of the three components of soil from LARGEST to SMALLEST

LARGEST **SMALLEST**



_____ _____ _____

Draw a model to describe the cycling of Earth's materials and the flow of energy that drives the process.

Explain how one change to Earth's surface can cause changes to other Earth systems. How have changes in the availability of soil influenced human activity?

Use the chart and information from the video to discuss the basic soil components and the qualities that each add to the soil.

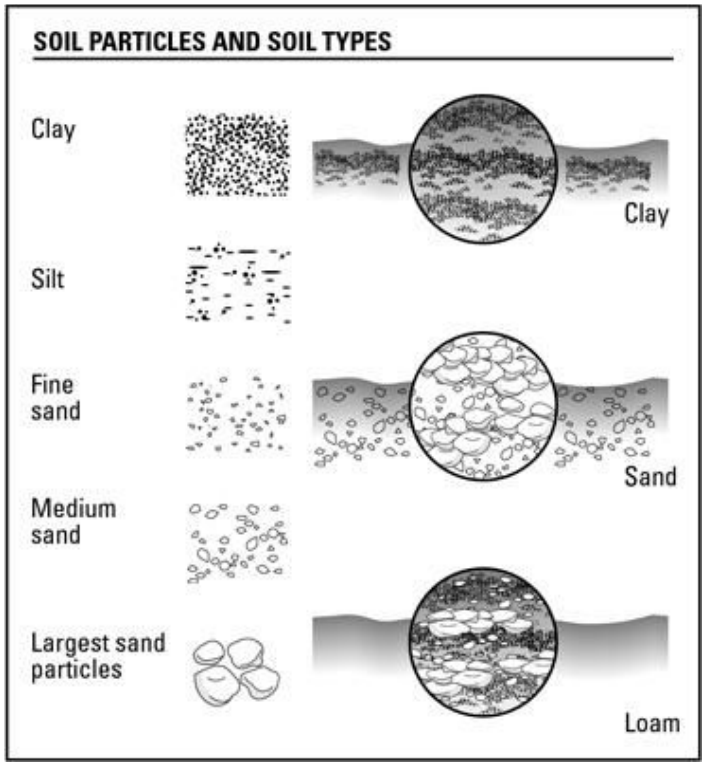
CLAY

SILT

FINE SAND

MEDIUM SAND

LARGEST SAND PARTICLES



OKLAHOMA SOILS

When you dig into the ground under the grass in your yard, you will find soil. But what happens if you keep on digging? If you dug far enough, would you run out of soil? How far would you have to dig before you ran out? And what would you find there?

If you dug far enough, you would hit solid rock. This is called bedrock. But before you got there you would have to dig through three different layers of soil. The layers are known as horizons, and all the layers together make up the soil profile. The first layer would be nothing but dark-colored organic materials. That is the layer formed by plants and insects that have died and dead leaves that have fallen. Just under that is the topsoil. The topsoil is the best place for plants to take root and grow. It is a mixture of air, water, organic material (matter from dead plants and animals) and minerals (sand, clay, silt).

In most places the topsoil is between six and 20 inches thick. The subsoil is the layer below the topsoil. It is made mostly of clay or sand and has very little organic material. Plants have a hard time growing in subsoil. Between the subsoil and the bedrock are a layer of small rocks that have started to break off the bedrock. This layer is the parent material of the soil. That's because most of what makes up the soil was once part of the rock.

Soil covers much of the land on Earth. It provides a substrate for plants (Roots anchor in soil.), a source of food for plants, and a home for many animals (insects, spiders, centipedes, worms, burrowing animals, bacteria, and many others). Soils are home to two or more tons of living things per acre. Microflora, insects, worms and animals, as well as other organisms, produce acids that, in turn, help break down soil minerals. Organic matter is beneficial to soils. It increases water-holding capacity, serves as a reservoir for plant nutrients such as nitrogen, and provides food for the living things in the soil.

Minerals have several different ways of getting into the soil. Sometimes they come from the ashes of volcanoes that have erupted. Usually the minerals come from rocks that have been broken apart. Water from rain flows into the cracks of rocks. When the water freezes, it expands and causes the cracks in the rocks to get bigger and little bits of rock break off. Sometimes the roots of trees and deep-rooted plants grow into the rocks and draw the minerals up through the roots and into the plant. The minerals become part of the leaves that later fall to the ground. Many rocks are broken apart by lichens — tiny plants that live on rocks. Sometimes water just keeps running over the rock until tiny particles start to wash away. We call all these processes "weathering." Water and wind carry the tiny bits of rock along until they get trapped by the soil. It can take hundreds of years for rocks to break into pieces that are small enough to form soil. It takes between 200 and 500 years for just one inch of topsoil to form.

CLAY, SILT, SAND

There are three basic categories of particles that exist in soils. Clay is the smallest, feels sticky and often stains the fingers. Silt feels smooth and soft and is somewhat slick. Clay and silt particles cannot be seen with the naked eye. Sand particles can be seen with the naked eye. They are the largest and feel gritty.

Soils are distinguished by observing the percentage of each of the three types of particles. These mixtures are called loams. If soil has more sand it is a "sandy loam," more silt, a "silty loam," or more clay, a "clay loam." Soils vary in their ability to be cultivated. The combination of particle types dictates how the soil will handle, drain and hold water.

Clay loams hold water tightly, but they drain poorly. Clayish soils are sticky. Plants growing in clay may suffer from a lack of air around the roots because the tiny clay particles absorb so much water. Clay soils drain poorly and prevent plants from getting the needed water around their roots.

Sandy loams provide enough air to the roots because the particles are large; however, sand does not hold water well, and it drains quickly. The water becomes unavailable to thirsty plants. Plants in sand soils need to be watered frequently.

Silty loam can be found around water sources. It is generally the soil that is carried in by flooding and then left in the drying process. This soil can collect organic materials and nutrients and store them in the existing soil. The best growing soils combine the airiness and drainage of sand with the water-holding capacity of clay. Loam soils that contain approximately 40% sand, 40% silt and 20% clay are considered the best cultivating soils.

SOIL FORMATION

Soil formation is influenced by five factors: geology (parent material), topography, climate, plants and animals (organic material), and time. These factors give soil profiles their distinctive character. Color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, pH, and other features are used to characterize soils. After a soil is described and its properties are determined, soil scientists assign the soil to one of 12 taxonomic orders and/or one of many suborders.

The Natural Resources Conservation Service (NRCS) has identified and mapped over 20,000 different kinds of soil in the United States. They come in a wonderful range of hues, from black to yellow to deep red.

In Oklahoma, there are over 2,500 different kinds of soil—more different varieties than just about any area this size on earth. We have a variable climate and many different kinds of geologic materials across the state. These factors influence the formation of different kinds of soil. Our state is well known for our red soil, caused by the large amount of iron in the soil, but no one individual soil occurs throughout every region of the state. Port silt loam, our state soil, is the most common soil in Oklahoma and is present in at least 33 counties. It is very productive and is used to grow a wide range of crops—cotton, wheat, sorghums, oats and others. Port silt loam is dark brown to dark reddish brown and is derived from upland soil materials weathered from reddish sandstones, siltstones and shales. The natural soil supports a native, undisturbed vegetation of tall prairie grasses and native trees, including pecan, walnut, bur oak and cottonwood.

SOIL EROSION

Soil erosion is what happens when soil is washed or blown away. The slope of the land, the climate and the texture of the soil all play a part. In places where the land is covered with plants such as grass or trees, erosion takes place so gradually that the new soil is formed before erosion has time to occur.

That is not the case in places where the soil has little or no plant cover. The Grand Canyon is a very familiar example of erosion by water. Most of the erosion there was the work of nature rather than man. In that part of the country the hot, dry climate makes it difficult for plants to grow. The soil is sandy. Sand particles don't stick together very well, so they wash away easily. The land around the Grand Canyon slopes into the Colorado river, and that also makes erosion more likely.

Heavy rains cause soils to erode away in many parts of Oklahoma where the land slopes and the soil is unprotected. One of the best examples of wind erosion in Oklahoma is the Little Sahara State Park in Major County. Windy conditions, sandy soils and sparse vegetation are the cause of the erosion there.

Keeping soil healthy is very important to farmers. For that reason, careful farmers do their best to protect their soil. The best way for farmers to do this is to keep their fields covered with vegetation at all times. Plant cover provides a cushion against the beating force of the rain and also slows the wind at the soil's surface.

Some farmers protect their soil by leaving stubble or residue in their fields after they have harvested their crops. Other farmers plant their fields with grass or cover crops during seasons when they are not growing their main crop. Alfalfa, clover and field peas send roots deep into the soil and help hold it in place. Those crops also fix nitrogen from the air and make it available to the soil. When it is time to plant, the farmer will turn the stubble or cover crops under to add extra organic matter to the soil. The organic matter, in turn, helps the soil hold together and soak up moisture rather than wash away.

Sources: "Port Silt Loam: Oklahoma's State Soil," Oklahoma Conservation Commission pamphlet; "Discovering Dirt," AIMS Education Foundation, 1987; Dirt: Secrets in the Soil, Utah Foundation for Agriculture in the Classroom

Playing in the Dirt: Discovering Soil

Activity 2 Worksheet 1: Ribbon Test to Determine Soil Type

Name: _____Date: _____

Class/Hour/Teacher: _____

RIBBON TEST

You are going to conduct a RIBBON TEST for the soil provided to you by your teacher. First, with a small amount of soil in your hand, *slowly* add water to your sample until you are able to form a moist ball of soil. Gently stretch the stretch the soil between your thumbs and forefingers and try to make a ribbon. To see this in action, go to the link:
https://www.youtube.com/watch?v=GWZwbVJCNec

1. As you work the soil, use the diagram to determine which type of soil you have:
    (1) When wet, does the soil form a ball?
        (a) Yes; go to #2
        (b) No: the soil you have is considered SAND
    (2) Does the soil Ribbon or does it crumble?
        (a) Yes the soil forms a ribbon; go to #3
        (b) No, it crumbles: the soil you have is considered LOAMY SAND
    (3) How long is your soil ribbon in cm?
        (a) The ribbon is less than 2.5 cm in length; Type of LOAM – go to #4 then 5
        (b) The ribbon is between 2.5 and 5 cm; Type of CLAY LOAM – go to #4 then 6
        (c) The ribbon is more than 5 cm; Type of CLAY – go to #4 then 7
    (4) Next, you will test if the soil is smooth or gritty. To do this, place a small amount of the soil in your hand and add water to excess (think soupy mud). Rub the soil with your finger to see if it is Gritty like sugar or smooth like flour?
    (5) For types of LOAM (ribbon less than 2.5 cm in length):
        (a) It feels VERY gritty – SANDY LOAM
        (b) It feels VERY smooth – SILT LOAM
        (c) It feels neither gritty nor smooth - LOAM
    (6) For types of CLAY LOAM (ribbon between 2.5 and 5 cm in length):
        (a) It feels VERY gritty – SANDY CLAY LOAM
        (b) It feels VERY smooth – SILTY CLAY LOAM
        (c) It feels neither gritty nor smooth – CLAY LOAM
    (7) For types of CLAY LOAM (ribbon more than 5 cm in length):
        (a) It feels VERY gritty – SANDY CLAY
        (b) It feels VERY smooth – SILTY CLAY
        (c) It feels neither gritty nor smooth – CLAY
    (8) Next, place the soil you used for the ribbon test into the container designated by your teacher. Wash your hands and return to your work station.

Use the descriptions below to assign soils to different textural classes.

SAND	**Loose and single-grained with a gritty feeling when moistened. Not sticky and will not form a ribbon when pressed between thumb and index finger.**
SANDY LOAM	**Contains sufficient silt and clay to give coherence to the moistened soil. Feels gritty and also slightly sticky. Will not form a ribbon.**
CLAY LOAM	**Forms short ribbons of less than 3 cm long.**
CLAY	**Extremely sticky and plastic when moist. Easily forms a ribbon longer than 3 cm.**

What type of soil do you think you have? Why?

Would this soil increase or decrease water runoff and soil erosion? Explain.

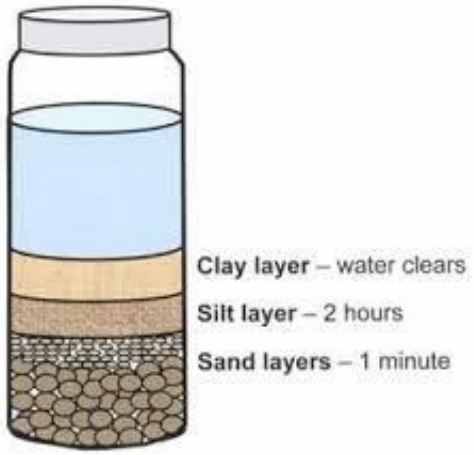
Playing in the Dirt: Discovering Soil

Activity 3 Worksheet 1: Discovering Soil Profile

Name: _____Date: _____

Class/Hour/Teacher: _____

1. **Each group will fill 3 jars ⅔ full of water.**
2. **Use masking tape, to label each jar with the soil type (A, B, C) and your group name.**
3. **Pour one soil sample into each jar being sure the sample matches the label. Fill each jar about 1/3 full with soil.**
4. **Finish filling each jar with water to about 5 cm from the top and tightly secure your lid.**
5. **Take turns shaking the jar until all of the soil is "dissolved" and the particles are suspended in the water (about 2 minutes).**
6. **Find a spot in the classroom to place your jar where it won't be disturbed.**
7. **Allow the jar to settle for the next 24-48 hours.**



After the "settling period" you should be able to see distinct layers.

1. **Observe the layers of sediment. (floating material is organic matter)**
2. **Using your ruler, measure in cm the total depth of sediment in the jar and record your findings in the table.**
3. **Next, measure the depth of each layer and record it in the "Soil Layers Chart."**
4. **Calculate the percentage of each soil component using the "Soil Calculations" area and then record the percentages in the "Soil Layers Chart".**
5. **After recording the percentages on the "Soil Layers Chart," classify the soil sample by comparing the percentages to those on the "Soil Texture Chart."**
6. **Record your results on the last line of the "Soil Layers Chart."**
7. **Complete the discussion questions and turn in your assignment.**

Soil Layers Chart

	SOIL A		SOIL B		SOIL C	
Measurements and percentages	**Depth (cm)**	**Percent (%)**	**Depth (cm)**	**Percent (%)**	**Depth (cm)**	**Percent (%)**
ALL soil particles						
SAND particles						
SILT particles						
CLAY particles						
Type of Soil						

Calculations:

Soil A

Percentage of **SAND** particles = $\frac{\text{Total height of SAND particles}}{\text{Total height ALL soil particles}}$ = _____ X100 = _____%

Percentage of **SILT** particles = $\frac{\text{Total height SILT particles}}{\text{Total height ALL soil particles}}$ = _____ X100 = _____%

Percentage of **CLAY** particles = $\frac{\text{Total height CLAY particles}}{\text{Total height ALL soil particles}}$ = _____ X100 = _____%

Soil B

Percentage of **SAND** particles = $\frac{\text{Total height of SAND particles}}{\text{Total height ALL soil particles}}$ = _____ X100 = _____%

Percentage of **SILT** particles = $\frac{\text{Total height SILT particles}}{\text{Total height ALL soil particles}}$ = _____ X100 = _____%

Percentage of **CLAY** particles = $\frac{\text{Total height CLAY particles}}{\text{Total height ALL soil particles}}$ = _____ X100 = _____%

Soil C

Percentage of **SAND** particles = $\frac{\text{Total height of SAND particles}}{\text{Total height ALL soil particles}}$ = _____ X100 = _____%

Percentage of **SILT** particles = $\frac{\text{Total height SILT particles}}{\text{Total height ALL soil particles}}$ = _____ X100 = _____%

Percentage of **CLAY** particles = $\frac{\text{Total height CLAY particles}}{\text{Total height ALL soil particles}}$ = _____ X100 = _____%

Soil Texture Chart

	% clay	% silt	% sand
loam	20	40	40
silt loam	15	60	25
silt	5	85	10
sandy loam	10	20	70
loamy sand	5	10	85
sand	2	3	95
clay loam	35	35	30
clay	60	20	20

NOTE: A more detailed description of soil textures can be found on the internet by using a search engine and typing in "Soil Texture Triangle."

Draw a picture of each jar in the spaces below. Include percentages of the soil levels and the soil textures you have identified for each sample.

Sample A **Sample B** **Sample C**

Soil texture _____ **Soil texture** _____ **Soil texture** _____

Discussion Questions:

1. **Does the soil from each sample have better, worse, or the same drainage as loam?**

2. **How would the samples compare to loam for water capacity, airiness and ease of handling?**