Learn About Soil

Introductory Soil Science

Hands-on Approach

MO DIRT – Missourians Doing Impact Research Together

MISSOURI EPSCoR

MISSOURI TRANSECT

MO DIRT Do Impact Research Together

DONALD DANFORTH PLANT SCIENCE CENTER
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Introductory Soil Science Hands-on Approach

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INTRODUCTION

The Missouri Transect project, funded by the National Science Foundation EPSCoR program, uses different scientific approaches to study and predict the impact of climate change on agricultural productivity in Missouri. It also examines how stakeholder communities are likely to be affected by and respond to the challenges of a changing climate. Important components of The Missouri Transect are public education and outreach efforts. MO DIRT - Missourians Doing Impact Research Together, is a citizen science initiative that will crowdsource the collection of data on soil health and reciprocal soil-climate interactions across Missouri. This project includes a soil science learning program for citizens, particularly K-12 students, to learn about soil science and to understand that healthy soils are living, breathing entities that need our stewardship.

This document provides curriculum support with lessons for elementary and early middle school students designed to promote the interest of children in soil science through hands-on activities. Its intent is to generate awareness about soil health, soil conservation, and the relationship of soils and climate. The document includes activities that cover the physical, biological, and chemical properties of soil, soil health, and soil-climate interactions. For each activity there is a Teacher Protocol, a Student Worksheet, and Educational Cards with supporting information. In addition to the instructions for conducting an activity, the manual includes a series of questions to evaluate and monitor the student's knowledge gain (Checking Your Knowledge), and recommendations for conducting additional activities (Expanding Your Knowledge). The activities can be conducted in different settings including the classroom, laboratory, and in the field with different instructional times (30 minutes to two hours).

MO DIRT offers training to implement, monitor, and evaluate this curriculum with education leaders. A web-based portal is available to access educational and training materials, to post experiences with MO DIRT, and to share scientific and science education data.

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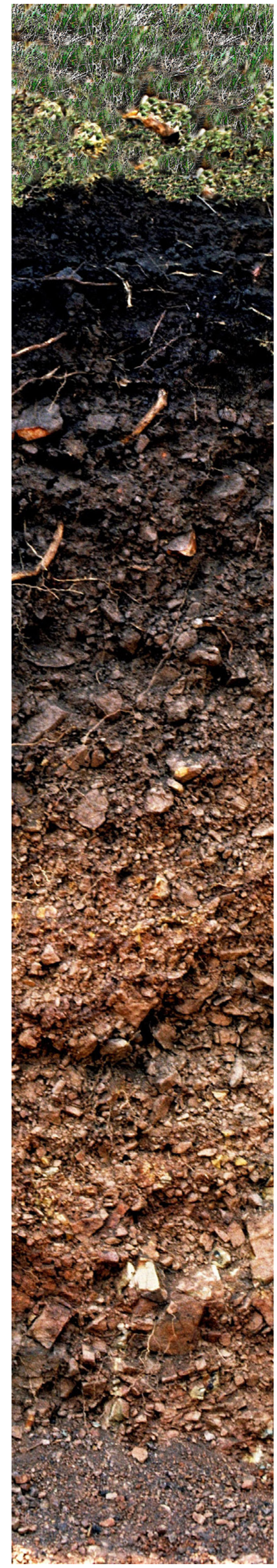
Background

BACKGROUND

Soil Functions



The soil is a complex mixture of minerals, air, water, organic matter and organisms at the surface of the Earth. Environmental factors, such as climate, as well as organisms influence the properties of the soil. On the other hand, the soil influences life and ecosystems functions in critical ways. Below are the main functions of the soil:

Biodiversity and habitat: Soil is the medium for the growth of plants, animals, fungi, and soil microorganisms by providing them with habitat, food, air, and water.

Recycling of nutrient and organic waste: Soil stores, controls the release, and cycles nutrients and other elements. Waste, dead organic matter, as well as contaminants, are transformed in the soil into forms available for use by plants and other organisms, and for release into the atmosphere or water.

Water relations: Soil regulates the infiltration, flow, and storage of water.

Filtering and buffering: Soil functions as a filter that helps to maintain the quality of water, air and other resources, and can help degrade or sequester toxic compounds.

Physical stability and support: Soil provides the anchoring support for plant roots and human structures.

Anthropogenic: Soil is an integral part of human culture, playing an essential role in agriculture, habitation, construction, health, art and other human endeavors.

The functions of the soil are made possible due to its properties. The next sections of this manual focus on the physical, biological, and chemical properties of the soil as well as on soil-climate interactions, soil health, and soil surveys.

Physical Properties of the Soil

Soil components

[Teacher Protocol page 15]

Soil is made of minerals, organic matter, water, and air. The proportions of these components vary greatly depending on soil type, water supply, and land management. However, in general, the composition of the **ideal soil** for plant growth is half solid (minerals and organic matter), one quarter gas (air), and one quarter liquid (water) (Figure 1). Air and water are mainly present in the porous portion of the soil. The pores are the spaces between the solid aggregates of the soil.

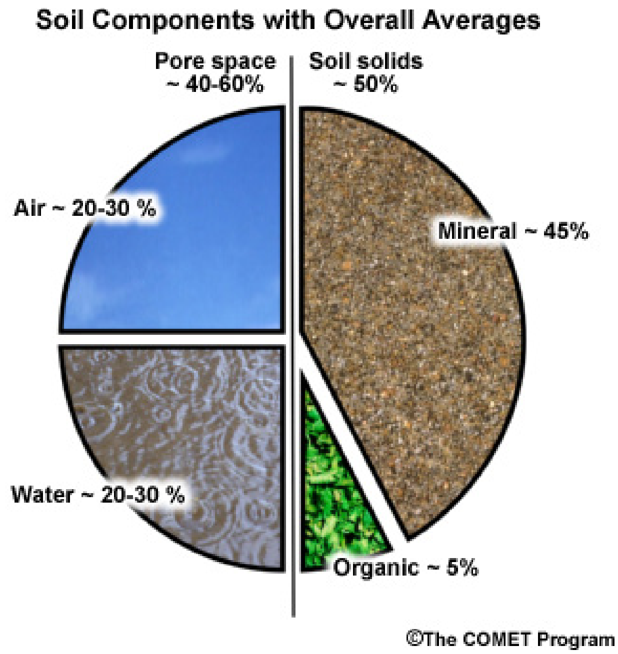


Figure 1. Components of the Ideal Soil and relative percentages of the solid, liquid and gas states.

The solid portion of the soil is mostly **mineral** particles (45%). These minerals are inorganic materials derived from rocks and are of three types based on the particle size (Figure 2). These particles are **sand**, **silt**, and **clay**. Sand and silt are rock fragments that provide the skeleton for the soil, while clay and organic matter are involved in most of the chemical reactions.

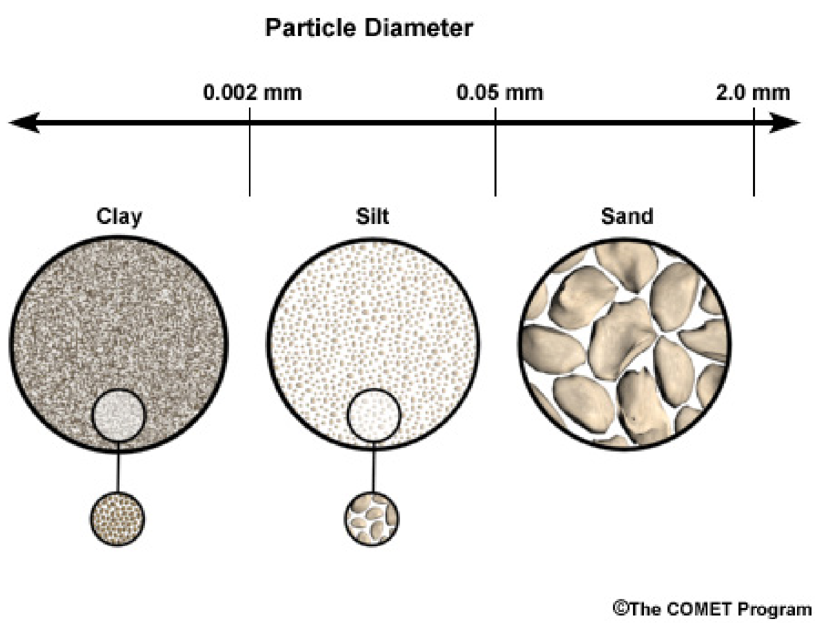


Figure 2. Types of soil particles determined by size.

The other 5% of the solid part of the ideal soil is **organic matter**. The soil organic matter is made of living organisms, remains and waste of soil organisms, and organic compounds produced by metabolism in the soil. The bodies and waste of soil organisms are progressively broken down by decomposers releasing nutrients into the soil. After several cycles of decomposition of organic matter, part of it turns into **humus**. This product of complex organic compounds increases the capacity of the soil to store water and sequester carbon for decades or centuries providing an optimal medium for plants to grow. Organic matter also binds mineral particles that result in aggregates that give the soil the structure of the ideal soil (see next sections). The stability of these aggregates is maintained with glue-like substances produced by organisms in the soil (roots, fungi).

Soil texture

[Teacher Protocol pages 18 and 22]

Soil **texture** is described by the presence and relative proportions of sand, silt and clay in the soil. Depending on their texture, soils will vary in their ability to retain water and nutrients. A simple way to examine soil texture is to physically handle dry and wet soil samples, using your fingers to work with small samples of the soil. **Sandy soils** feel rough (gritty) because sand particles have hard edges. These soils do not have many nutrients because they have large pores allowing gases and water to move through them rapidly. The sand particles do not hold on each other and cannot stay together. **Silty soils** are smooth and powdery and when wet make crumbles or ribbons but are not sticky. The silty soils have smaller pore spaces than sandy soils, therefore can hold more water. **Clayey soils** are smooth when dry and sticky when wet making balls or ribbons that stay together. Because their particles are so small, clayey soils can hold a lot of nutrients, water, and gases.

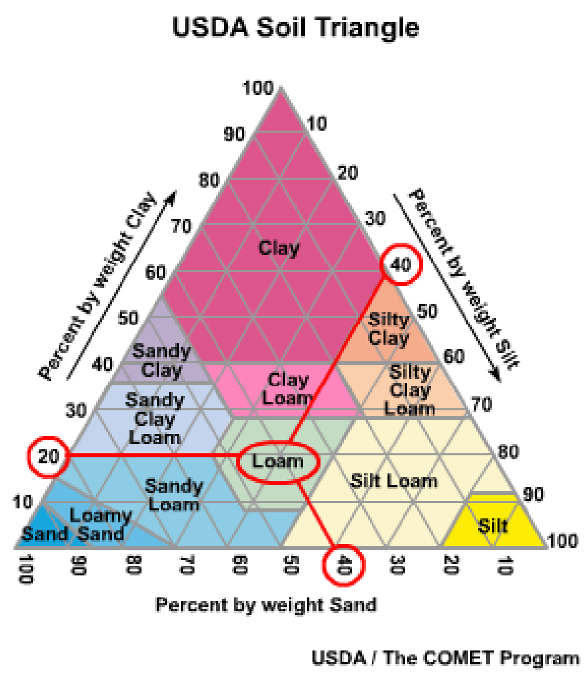


Figure 3. The USDA soil textural triangle helps determining the texture class of a soil sample based on the relative percentages of silt, sand and clay.

Most soils contain different combinations of sand, silt, and clay. The **Soil Textural Triangle** (Figure 3) shows the twelve possible soil classes based on the relative percentages of these combinations of textures. The most appropriate soil class for plant growth is **loam** that can absorb water very efficiently. Loam soil is composed of mostly sand and silt, with a smaller amount of clay. When the percentages of soil textures are known from a sample, the Soil Textural Triangle will tell the respective soil class using the following steps (Figure 3):

1 - Find the number that represents the percentage of sand along the bottom of the Soil Textural Triangle. At each number, two lines enter the triangle; at the selected number hold a ruler along the left line.

2 - Find the number that represents the percentage of silt along the right side of the texture triangle. Follow the diagonal line that emerges from the silt percentage number that intersects with your line along the ruler.

3 - Follow the line that emerges to the left of the intersection point back to the left side of the triangle, where it reaches the percentage of clay. Make sure that the percentage of clay on the chart is the same as the percentage calculated from the soil sample.

4 – Verify that the three percentages add to 100%. The soil class of the sample is at the intersection of the three lines.

Soil structure

[Teacher Protocol page 25]

Soil structure is the arrangement of soil particles (sand, silt, clay) and organic particles in soils. Different forces act on these particles forming groups at different scales call **aggregates** or **peds** (**pedon** for singular) (Figure 4). Particles bind together through attraction among them and through activities by soil organisms (burrowing, roots and fungi entanglement, and production of glues). The spaces among aggregates are called **pores** and can be filled with air, water, roots, or other organisms (Figure 4). A **healthy soil** will have similar number of small (< 0.06 mm) and large (> than 0.06 mm) pores. Large pores are good as aeration systems that allow the water to flow, while small pores hold water against gravity making the water available to plants.

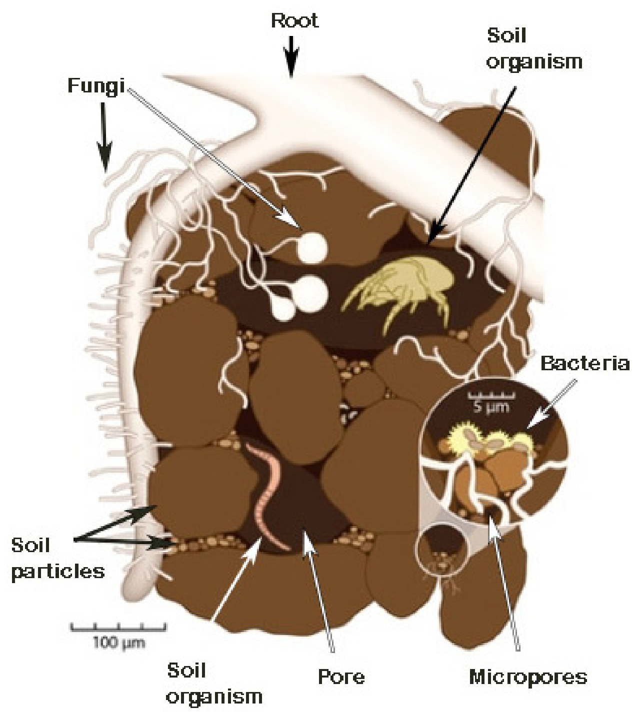


Figure 4. **Micropores and macropores are spaces of different sizes between the soil aggregates (peds) where air, water and living organisms are found. Modified from Nature Education.**

The peds have different shapes with rounded or sharp edges and have shapes of spheres, blocks, columns, or plates (Figure 5). Soil texture will determine the pore space within an aggregate, while the arrangement of aggregates with respect to each other determines the pore space between aggregates. The structure of the soil determines how easily air, water, and roots move through the soil. The most desire soil structure is the granular type that is arranged in small aggregates with rounded edges, and with both small and large pores.

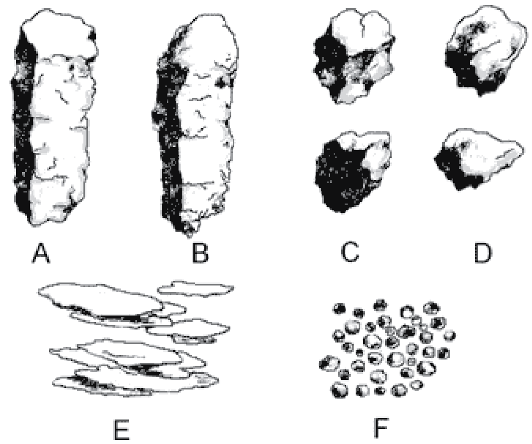


Figure 5. **Structure types (shapes) of mineral soils. A-prismatic, B-columnar, C-angular blocky, D-subangular blocky, E-platy, and F-granular Source: USDA.**

Soil profile

[Teacher Protocol page 28]

The soil is made of a series of layers or horizons that together form a **soil profile** (Figure 6). The most common horizons are named by the letters O, A, B, C, and R. They differ in color, texture, thickness, and structure. Depending on location, land management, and age of the soil these layers will vary in their thickness and occurrence. For example, agricultural and eroded soils are highly disturbed and may have lost the top layers, or young soils may have fewer layers.

O horizon (organic) is a thin dark layer of organic material (living organisms, remains of soil organisms, and organic compounds produced by metabolism in the soil) and humus (well-decomposed organic matter). This horizon is present in undisturbed habitats (wetlands, forest, prairies), while agricultural lands, and suburban and urban locations have lost this horizon.

A horizon (topsoil) is rich in nutrients (minerals) where most of the biological activity occurs. Here is where seeds germinate and roots grow, and animals, fungi, and bacteria are mainly concentrated. This activity makes to loosen and aerate the soil.

B horizon (subsoil) is mostly clay particles with high mineral contents that leached from horizons above, and some organic matter.

C horizon (parent material) is made of large rocks or broken bedrock from which the soil develops and without any organic matter.

R horizon (bedrock) is a mass of hard rock that forms the parent material.

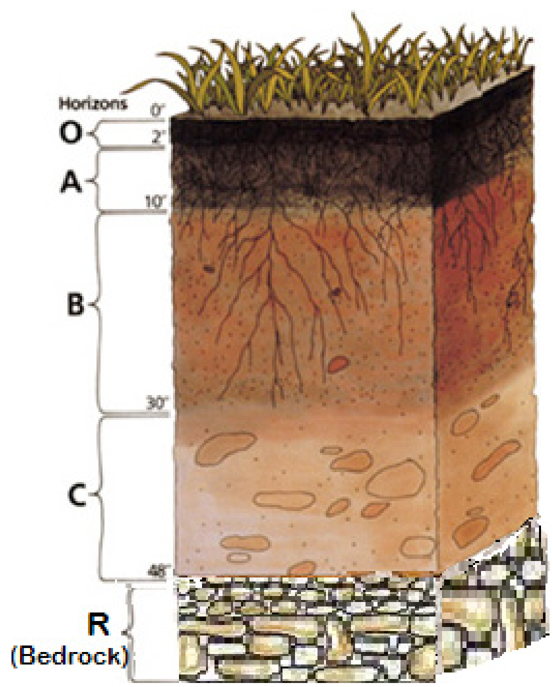


Figure 6. **Horizons of a soil profile. O-organic, A-topsoil, B-subsoil, C-parental material, and R-bedrock. Source: USDA.**

Soil and water relations

[Teacher Protocol page 25]

When water falls to Earth from rain or irrigation, plants intercept some water that could evaporate before it reaches the soil surface, and leaves and leaf litter cushion the impact of water droplets on the soil. Some water flows over the surface as runoff and some infiltrate into the soil (Figure 7). Depending on soil's properties water can be taken by plant roots, remain stored in pores, or move downward to become part of underground water stores.

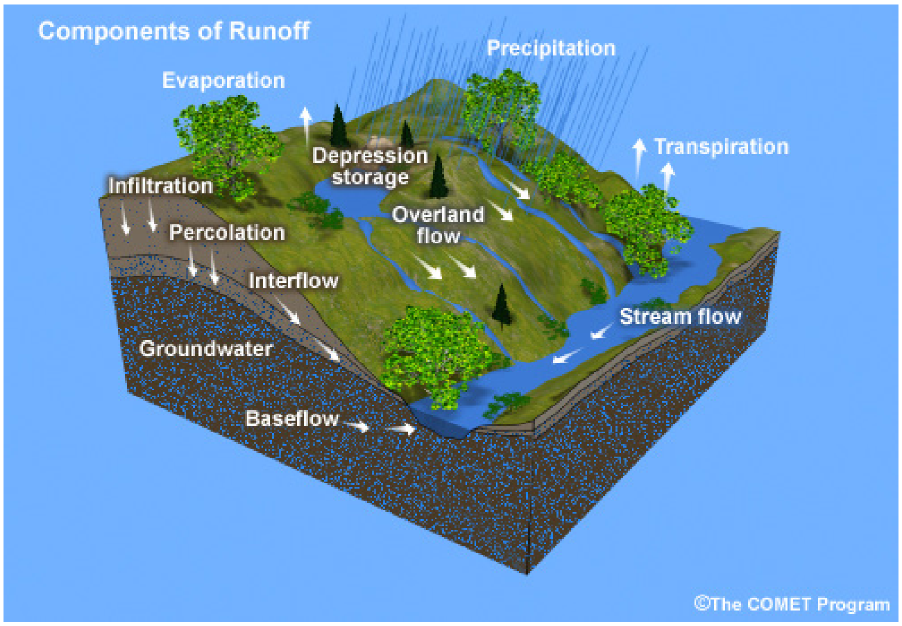


Figure 7. After precipitation part of the water evaporates while the rest flows as runoff or infiltrates into the soil.

The soil regulates the flow, storage and drainage of water. For plants to grow, the soil needs to have properties that allow the water to move slowly so plants can use it. Depending on soil structure and texture, water infiltrates faster into granular soil with numerous pores, than in massive compacted soil (Figure 8). The compacted soil forms crusts (prismatic or plate soil structures) sealing the soil and causing runoff of water over the surface. A coarse soil with large particles and large pores is a soil through which the water moves easily within hours (sandy soil), thus the water infiltration into the soil is fast. On the other hand, water moves very slowly (2-3 days) through soil with fine textures with small pores (clayey soil) holding the water so tightly that plants cannot get to it. When a soil has large pores filled

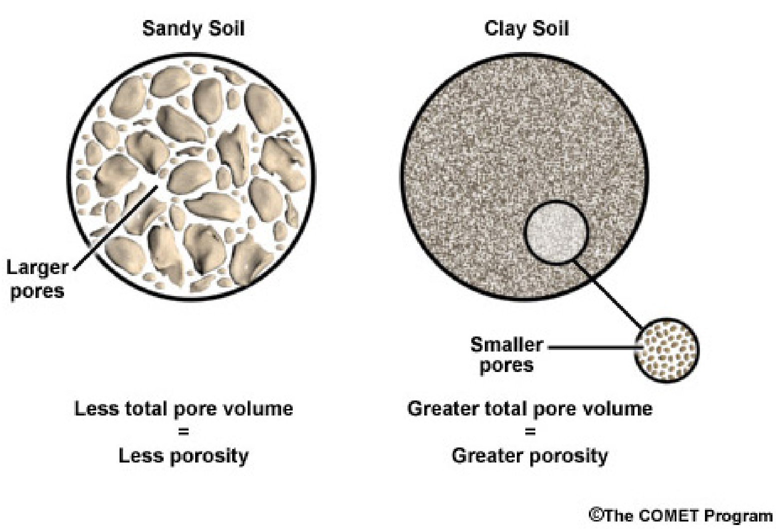


Figure 8. Soil pore space in sandy and clay soil. Modified from The COMET Program.

with both air and water, and small pores are filled with water, the soil is ideal for plant growth and is considered to be at **field capacity** (Figure 9).

Soil moisture also affects water movement through the soil (Figure 9). In dry soil, the water infiltrates faster through cracks resulting from the dryness, than when the soil is wet, because there is not enough room for water to move through the soil. When there is excess water due to heavy rains and floods, the soils become **saturated** because all of the pores are filled with water. Consequently, there is no air left to provide oxygen that is essential for the survival of most organisms. With time, the water in large pores moves downward (drainage or **percolation**). When the soil dries out, the water that remains in the soil is retained more tightly and is more difficult for roots to extract it. As less water is available, plants wilt and may die if water is not provided. At this stage, the water content of the soil is called the **permanent wilting point**. If the soil continues losing water through evaporation, the remaining molecules of water are tightly held in films of only 4 to 5 molecules, and the water is considered non liquid. At this point the content of moisture in the soil is termed the **hygroscopic coefficient**.

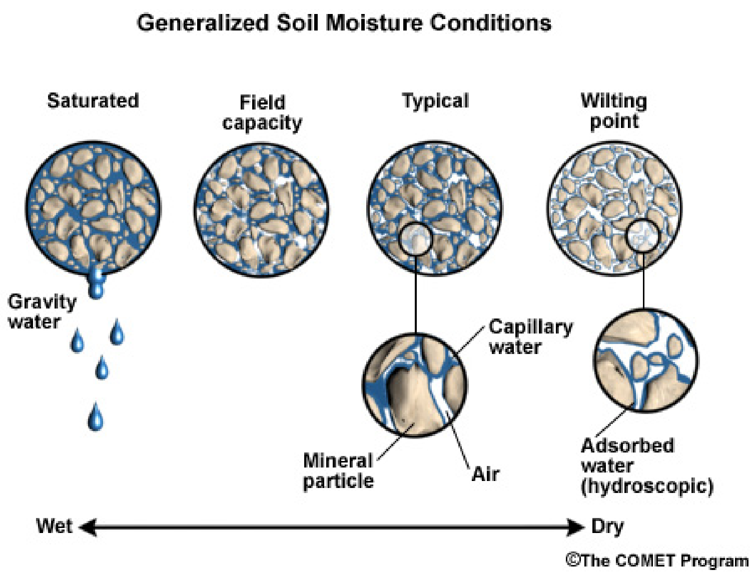


Figure 9. **Soil moisture conditions along a gradient from wet to dry environments.**

Water movement is also influenced by the soil profile. A soil that has an O horizon with high content of organic matter can slow down water flow by acting like a sponge that absorbs large amounts of water. In contrast, a soil that has lost this horizon will experience a high water runoff. For example, in an area where a thin sandy layer is at the top, water runoff will still occur under flooding conditions or heavy rains. The same problem may occur if there is an impermeable layer of rock under a thin layer of soil. The rock layer prevents water from infiltrating the soil.

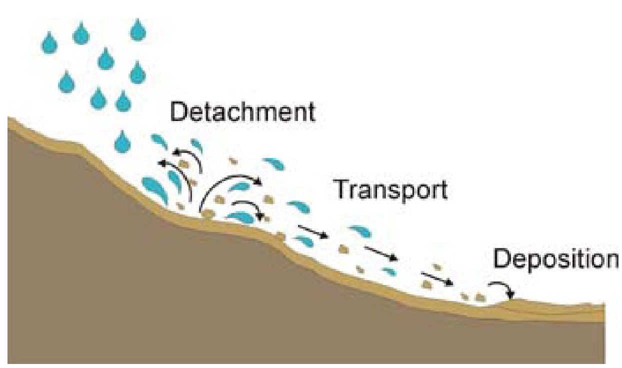


Figure 10. **After precipitation part of the water evaporates while the rest flows as runoff or infiltrates into the soil.**

Water is essential in soil dynamics and plant growth. However, water can detach and move soil particles from one place to another, causing

soil erosion (Figure 10). Water soil erosion is influenced by the topography of the land with soil on steeper slopes being more exposed to erosion than soil in a flat landscape.

Soil structure also influences the impact of erosion as light soils (large particles with relative large pores that loosely held together) are at the highest risk of water erosion. In addition, the impact of water erosion depends on the soil profile since a soil that lacks an organic layer will experience greater impact of water erosion than a soil with a vegetation layer protecting the soil. In general, runoff water causes erosion in higher intensity under larger and rapid flows. Water erosion does not act alone in generating soil disturbance. Wind erosion and anthropogenic activities such as cutting of trees, over-grazing of land by livestock, and poor agricultural practices also contribute to soil threats (Figure 11).

Figure 11. Erosion caused by running water on a recently disturbed and unprotected hillside in Georgia. Source: NRCS.

Figure 12. Weathering of the bedrock that contributes to soil formation. Source: Soil-Net.

Soil formation

[Teacher Protocol page 31]

There are five factors that influence soil formation: parent material, topography, climate, organisms, and time. Soils have properties derived from the combined effects of climate and biotic activities, modified by topography, and acting on parent material over periods of time. These factors do not act independently, but interact with each other to form soils. Consequently, soils vary locally due to differences in the interactions of the soil forming factors and to differences in the dominant factors.

Parent material. This is the material from which a soil develops and there are three types of it. **Residual parent materials** are soils that form in place due to **weathering** of the bedrock (breaking of rocks into smaller units) (Figure 12). **Transported parent materials** are sediments that originated a distance from where they currently occur transported through water, wind, or gravity. **Organic parent materials** form in place from the decomposition of organic remains (mostly plants and some animals). When the accumulation of organic matter is higher than the rate of its decomposition, organic deposits form. These deposits occur in areas with standing water with anaerobic conditions or areas cold enough for low biological decomposition.

Biological factors. Plants, animals, fungi, and microorganisms participate in soil formation by adding organic matter to the soil, contributing to the decomposition processes, and mixing and aerating the soil (Figure 13). In addition, decomposer organisms and plant roots release chemicals that facilitate weathering of the rocks. Depending on climatic factors different vegetation types develop in particular locations. Such differences in vegetation also influence soil formation. For example, in forests, leaves accumulate on the soil contributing to the formation of a layer of organic matter (O horizon), while in prairies very fibrous root systems mainly contribute to the formation of topsoil, a layer rich in organic matter (A horizon).

Figure 13. **Soil organisms participate in soil formation. Source: Image modified from the book *The Living Mantle***

Climate. Temperature and precipitation are the main drivers of climate, and these variables act on soil formation through mechanical and chemical weathering of the parent material (Figure 12 and 14). Mechanical weathering is the physical breaking of rocks cause by changes in temperatures and abrasion by wind, water, and ice. The process of chemical weathering involves the decomposition of material through chemical reactions. Depending on the temperature and moisture of a particular location, the rate of chemical weathering increases in hot-moist climates while in cool-dry climates it decreases. Climate also affects soil formation through its interaction with biological factors and topography (Figures 14 and 15).

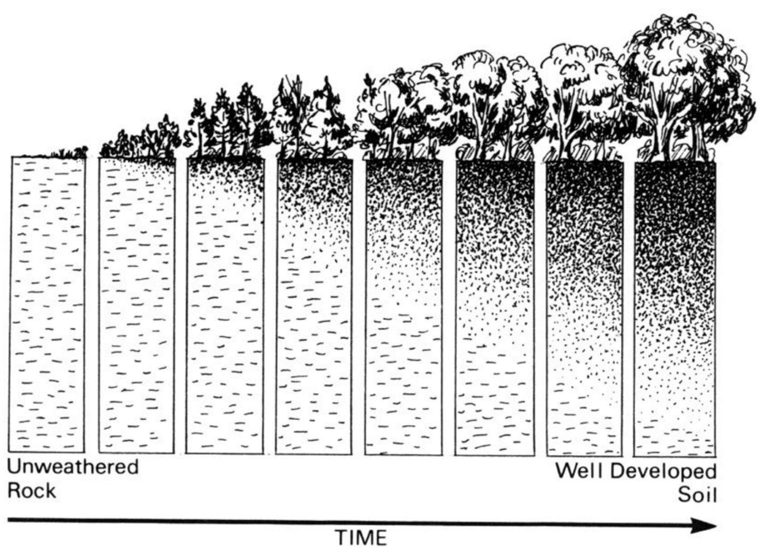


Figure 14. **Soil formation through the interaction of weathering, climate, time, and biological factors.**

Topography. This factor refers to the shape, slope, and elevation of the land. The topography influences the way water moves in the landscape and how vulnerable the soil is to water erosion (Figure 15). Steep slopes are dry and water moves fast making the soil more prone to water erosion generating a thin A horizon. In flat slopes, water moves slowly experiencing water-logging (fill with water) promoting the accumulation of an A horizon. Topography also interacts with climate to form soils through aspect, the direction the slope faces. North- and east-facing slopes have higher accumulations of organic matter than slopes facing south or west because they are cooler and moister. In addition, the topography of an area can enhance or mitigate the weathering of the parent material due to climate.

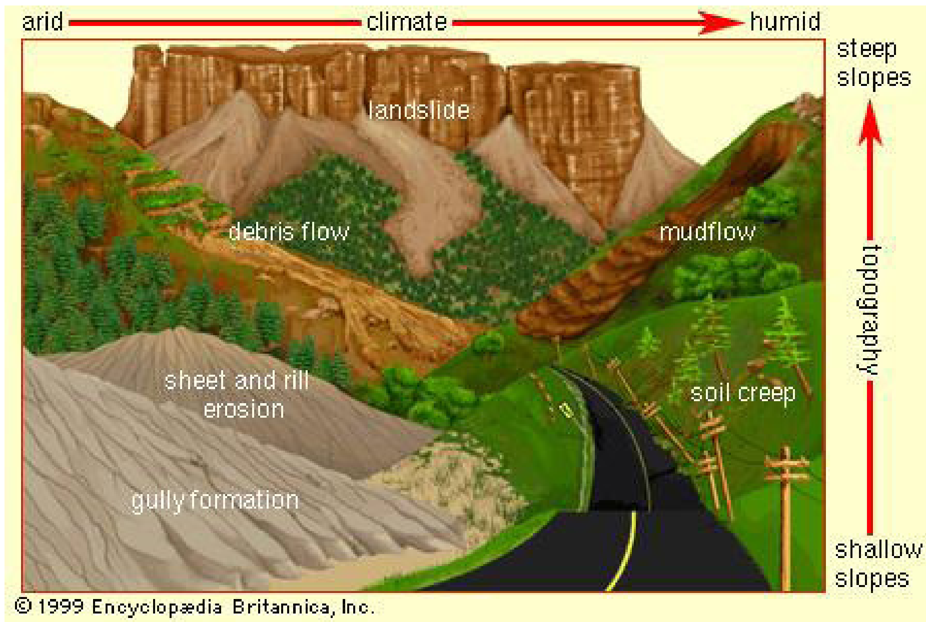


Figure 15. Soil formation is affected by the interaction of topography and climate.

Time. Soil formation is a continuous series of processes that occur over time due to the interaction of soil forming factors (Figure 14). Time influences soil formation depending on the rate of weathering and the profile development. As time goes by and soils age, layers (horizons) of soils develop and become thicker. For example, the formation of one centimeter of soil can take one thousand years.

Teacher Protocol

Introductory Activity

THE JOBS OF THE SOIL

Overview

Students receive an introduction to the soil functions (jobs) using images that they learn to interpret. The students are also introduced to the soil curriculum.

Objectives

The students should be able to

- define the term soil
- understand the functions (jobs) and the importance of soil in nature and for human benefits
- understand the general purpose of the soil curriculum

Background Summary

The **soil** is a mixture of minerals, air, water, organic matter, and organisms at the surface of the Earth. The main functions (jobs) of the soil include: 1) being the medium for the growth of a great variety of organisms; 2) storing, controlling the release, and cycling of nutrients and other elements; 3) regulating the infiltration, flow, and storage of water; 4) filtering that helps to maintain the quality of water, air and other resources; 5) anchoring support for plant roots and human structures; and 6) being an integral part of human culture (agriculture, habitation, construction, health, art, etc.).

Procedures

Step 1

Show the soil sample to the students and ask them if they know what that is. Discuss with the students their answers until it is clear that:

> The soil is a complex mixture of minerals, air, water, organic matter, and organisms at the surface of the Earth.

Step 2

Ask the students what are the jobs (functions) of the soil. Make a list of their answers on the blackboard/smart board.

Step 3

Show the plant in the pot and the pottery pieces and explain the jobs represented by these items. Relate these jobs to the answers of the students.

Step 4

Explain that the soil has more jobs and show the slide presentation explaining the images of the different jobs of the soil.

Time

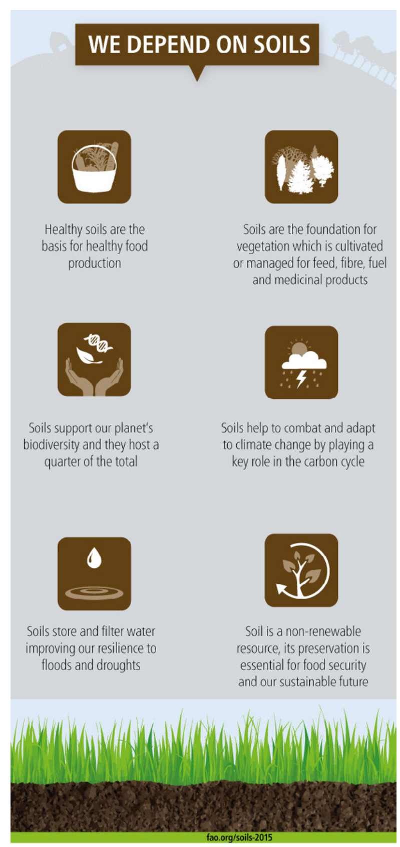
30 min

Materials Per Classroom

- ☐ Color pencils or crayons
- ☐ Piece of pottery (bowl, base, cups, etc.)
- ☐ Plant in a pot
- ☐ Power point presentation
- ☐ Soil samples. Two or more soil samples that show different colors and textures.
- ☐ White paper

Key Terms

Soil, functions, soil curriculum



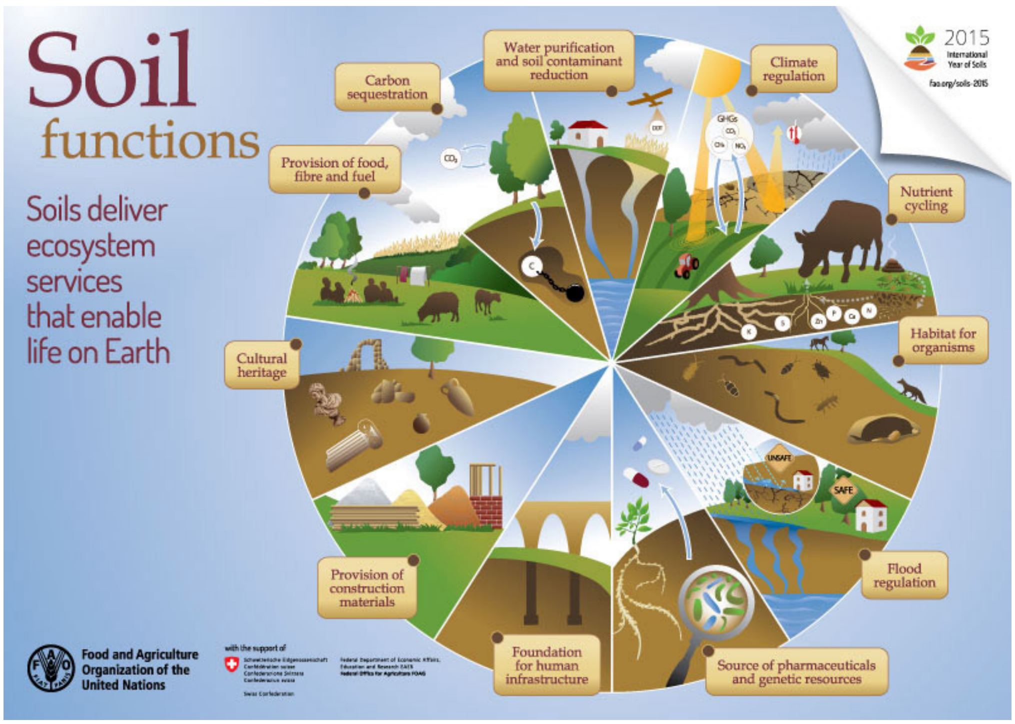
Food and Agriculture Organization of the United Nations

Step 5

Ask the students to make a drawing that illustrates one or more of the jobs the soil has.

Step 6

Present the soil curriculum to the students. Explain the objectives of the curriculum. Show the Teacher's Manual to the students and explain to them that during the academic year they will be working with you in learning about soils. The main subjects of the curriculum are: physical properties, biological properties, chemical properties, soil health, and soil survey. Tell the students that every week they will conduct a soil activity in groups of 3 to 5 students completing worksheets and using cards as guidelines. The worksheets include sections for procedures, results, and questions to evaluate their learning on the subject in place.



Activity 1.

WHAT ARE THE COMPONENTS OF THE SOIL?

Overview

Students examine soil samples to determine the components that make up an ideal soil for plant growth, and build their own soil model.

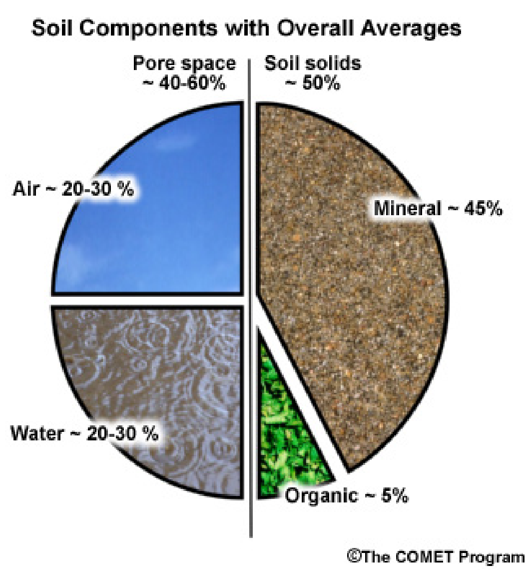
Objectives

The students should be able to

- identify the components of an ideal soil and the state (gas, liquid or soil) of those components
- give the percentages of the different components of an ideal soil. (Students in 4th and 5th grade should be able to understand percentages).
- understand that an ideal soil is a healthy soil for plants to grow
- identify the three types of soil particles based on their size (sand, silt, and clay)

Background Summary

The composition of an **ideal soil** for plant growth is half solid (minerals and organic matter), one quarter gas (air), and one quarter liquid (water). Air and water are mainly present in the pores, which are spaces between the solid aggregates of the soil. The solid portion of the soil is mostly **mineral** particles (45%). These particles are inorganic materials derived from rocks and are of three types based on their size. These particles are **sand** (> 0.05 - 2 mm), **silt** (0.002 – 0.05 mm), and **clay** (<0.002 mm). The other 5% of the solid part of an ideal soil is **organic matter** that is made of living organisms, remains of soil organisms, and organic compounds produced by metabolism.



Time

1 hour and a half

Materials Per Group

- Card: Soil Components
- Forceps or teasing needle
- Hand lens
- Materials for the model of soil composition: clear jar (~1000 ml), ping-pong balls, brown aquarium gravel, stuffing beads, plastic animals, roots (plastic lacing), water (~1/3 cup), and glitter (1/2 teaspoon).
- Samples of sand, silt, and clay (1/2 cup per sample)
- Sample of soil (~1/2 cup). Ask each group to bring a soil sample from their backyard or go with the students to collect soil samples at the school. Depending on the number of groups, collect at least three different soil samples from contrasting habitats (e.g. yard, playground, ornamental or vegetable garden, forest, prairie, road side, etc.)
- Tray
- Worksheet

Key Terms

Ideal soil, solid state, liquid state, gas state, organic matter, minerals, air, water, sand, silt, clay

Procedures

Step 1

Review the teacher's background on the components of the soil (page 3) and introduce the subject to the students. Explain to the students the objectives of the activity and why it is important.

Tell the students to think about the following questions:

- Do you know what soil is?
- What is in the soil?
- What are the components of the soil?

Step 2

Inform the students the order of the activity. The students will first examine a soil sample, second, will work with the soil particles, and third, will make their own soil model. Tell the students that all the materials to conduct the activity are in their workstations.

Step 3

Ask the students to put the soil sample in a tray and spread and smash the soil pieces using forceps or a teasing needle. Ask the students about what they see in the soil and what makes the soil. Ask the students what might be invisible to them in their soil samples and how do they know what is there?

Step 4

Have the students complete the first column of the Soil Components Table on their worksheets (section 1).

Step 5

Ask the students what is the state of the components that they observe in the soil sample (solid, liquid, or gas). Tell the students to complete the second column of the Soil Components Table in the worksheet (section 1). If the students are familiar with percentages, ask them to also complete the third column of the table.

Step 6

Use the Card on Soil Components to explain to the students the model of an Ideal Soil with its components and respective states, and their percentages. Make clear that the Ideal Soil is a healthy soil where plants can grow. Tell the students to compare their answers with the diagram of the Ideal Soil and complete the table in section 2 in the worksheet.

Step 7

Follow up with the student on their questions and answers on sections 1 and 2.

Step 8

Explain that the mineral portion of the soil is made of particles of three different sizes (sand, silt, and clay). Show the diagram of soil particles in the Card on Soil Components.

Step 9

Give each group a sample of sand, silt, and clay. Ask them to touch the samples and describe them in the Soil Particles Table of the worksheet (section 3).

Step 10

Tell the students that they are ready to make their own soil model. Explain what each of the items represents. Ask the students to fill the jar with the components in relatively similar percentages as in the Ideal Soil diagram in the Card on Soil Components. Explain that the mineral solid part could vary in the amount of sand, silt, and clay.

- Aquarium gravel: silt particles
- Bubbles: air
- Glitter: microorganisms
- Plastic animals: insects, millipedes, roly-polies, etc.
- Plastic lacing: roots
- Ping pong balls: sand particles
- Staffing beads: clay particles
- Water

Checking Your Knowledge

Ask the students to discuss the following questions about soil composition at the end of the worksheet. Discuss and clarify, or correct, the answers with the students.

- What components represent solid, liquid, and gas states in a soil? Include their relative percentages for an Ideal Soil.
- Which are the three types of particles in the mineral portion of the soil and how do you recognize them?
- What is the ideal soil good for?

Expanding Your Knowledge

Imagine the soil under a forest, a city, and a crop field. Do you think the composition of the soil in these three types of habitats would be the same? Discuss what you think their differences may be and what the consequences for plant growth might be.

Web Links

Physical properties of the soil: http://soils4teachers.org/physical-properties

Soil overview: https://www.soils.org/files/about-soils/soils-overview.pdf

Soils – Fundamental Concepts: http://urbanext.illinois.edu/soil/concepts/concepts.pdf

Activity 2.

WHAT IS THE TEXTURE OF YOUR SOIL? – QUALITATIVE METHODS

Time
1 hour

Materials Per Group

- ☐ Card: Soil Texture
- ☐ Ruler
- ☐ Soil samples (3). The samples should have different soil textures (sandy, silty, clayey) but should be unknown to the students. The samples should be labeled with numbers that only the teacher knows.
- ☐ Samples of sand, silt, and clay (1/2 cup per sample)
- ☐ Water
- ☐ Worksheet

Key Terms
Soil texture, silt, sand, clay, Soil Textural Triangle, soil texture qualitative test methods

Overview

Students use three qualitative test methods and the Soil Textural Triangle to determine the unknown texture of soil samples, and prepare soil samples based on known textures.

Objectives

The students should be able to

– understand what soil texture is

– determine the texture of a soil sample using three qualitative test methods

If the students know percentages they also should be able to

– use the Soil Textural Triangle to assign soil classes

– prepare a soil sample of a particular texture

Background Summary

Soil texture is described by the presence and relative percentages of sand (> 0.05-2 mm), silt (0.002 – 0.05 mm) and clay (< 0.002 mm) in the soil. Depending on their texture, soils will vary in their ability to retain water and nutrients. **Sandy soils** feel rough because sand particles have hard edges. These soils do not have many nutrients because they have large pores allowing gases and water to move through them rapidly. The sand particles do not hold on each other and cannot stay together. **Silty soils** are smooth and powdery and when wet make crumbles or ribbons but are not sticky. These silty soils have smaller pore space than sandy soils, therefore can hold more water. **Clayey soils** are smooth when dry and sticky when wet making balls or ribbons that stay together. Because their particles are so small, clayey soils can hold a lot of nutrients, water, and gases. Most soils contain different combinations of sand, silt, and clay. The most appropriate soil type for plant growth is **loam** that has a very good water infiltration and retention capacity. The loam soil is composed of mostly sand and silt, with a smaller amount of clay. The **Soil Textural Triangle** shows the twelve possible soil classes based on the relative percentages of sand, silt, and clay (see Soil Texture Card for explanation on how to use the Soil Textural Triangle).

Procedures

Step 1

Review the teacher's background on soil texture (page 5) and introduce the subject to the students. Explain to the students the objectives of the activity and why it is important.

Tell the students to think about the following questions:

- Are all soils made of the same particles (sand, silt, clay) and are these particles in the same amounts?
- How do you determine the texture of a soil sample?

Step 2

Remind the students of the three types of soil particles reviewed in the previous activity, and explain the concept of soil texture.

Step 3

Inform the students of the order of the activity. The students will first use three qualitative methods to determine the soil texture of a sample. Second, the students will use the Soil Textural Triangle to identify soil textures of samples. Third, the students will prepare a soil sample based on known textures. Tell the students that all the materials to conduct the activity are in their workstations.

Step 4

Explain the three qualitative test methods to determine the texture of a soil sample. Use the Soil Texture Card as a guideline.

Take a small sample of soil in your hand (1 tbsp.) and add 5-7 drops of water to make the soil moist. Use your fingers to "work" with the soil sample.

- Feel Test Method: Take the small soil sample in your hand and feel it. Does it feel gritty, smooth, or sticky? Sandy soils feel gritty, silty soils feel smooth, and clayey soils feel sticky.
- Ball Squeeze Test Method: Take the small soil sample in your hand and try to form a ball. In sandy soils the ball breaks with slight pressure and has a coarse texture. In silty soils the ball stays together but changes the shape easily. In clayey soils the ball does not break easily.
- Ribbon Test Method: Take the small soil sample and make a ball and squeeze it between your thumb and forefinger to try to make a ribbon. With sandy soils you cannot make a ribbon or the ribbon is less than 1 inch long. With silty soils you can make a short ribbon between 1-2 inches long. With clayey soils you can make a long ribbon greater than 2 inches long.

Step 5

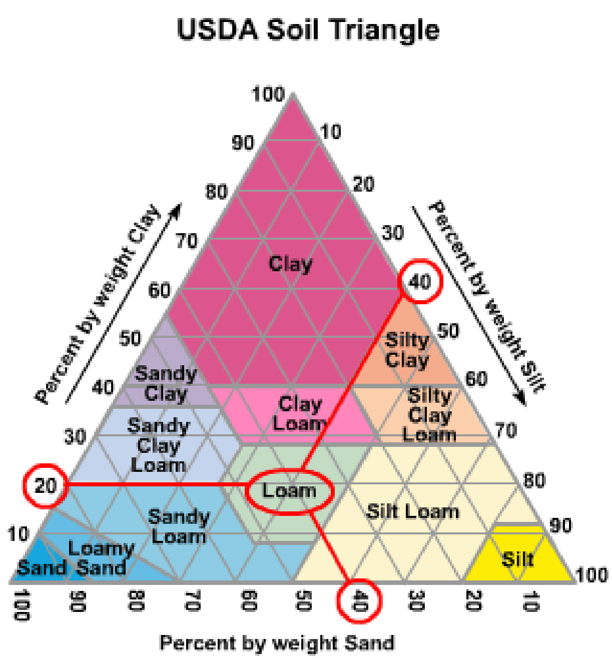
Ask the students to apply these methods to determine the texture of their unknown soil samples. Tell the students that the methods are explained in Soil Texture Card. The students should complete the table in the worksheet with their results (section 2).

Step 6

Discuss the results with the students and clarify questions.

Step 7

If the students know percentages they can continue conducting the following activities. Explain what the Soil Textural Triangle is and how it is used to determine the texture of a soil sample. Highlight the loam class as the best soil to grow plants. Below are the instructions on how to use a Soil Textural Triangle. You can use as an example the following percentages: 20% clay, 40% silt, 40% sand, and for soil class Loam.



USDA / The COMET Program

1 – Verify that the percentages of sand, silt and clay in your sample add to 100%.

2 – Locate the percentage of clay on the clay axis, and draw a line horizontally from left to right.

3 – Locate the percentage of silt on the silt axis, and draw a line going down diagonally to the left that goes parallel to the clay axis.

4 – Locate the percentage of sand on the sand axis, and draw a line going up diagonally to the left that goes parallel to the silt axis.

5 – The intersection point of the three lines is in the region of the soil class of the sample.

Step 8

Ask students to use the Soil Textural Triangle to determine the textural class of three hypothetical soil samples in their worksheet (section 3).

Step 9

Ask the students to choose one of the three hypothetical samples and prepare the corresponding soil class based on the percentages of sand, silt, and clay given in the Soil Textural Triangle for that class.

Checking Your Knowledge

Ask the students to answer the following questions about soil texture at the end of the worksheet. Discuss and clarify, or correct, the answers with the students.

- Explain one qualitative method to determine the soil texture of a sample.
- What is the best soil texture class that supports plant grow in general, and why?
- What is the use of the Soil Textural Triangle? (For students that know percentages)

Expanding Your Knowledge

- Grow the same type of plants in soils with different textures and compared how they grow.

Web Links

Physical properties of the soil: http://soils4teachers.org/physical-properties

Soil overview: https://www.soils.org/files/about-soils/soils-overview.pdf

Soils – Fundamental Concepts: http://urbanext.illinois.edu/soil/concepts/concepts.pdf

Activity 3.

WHAT IS THE TEXTURE OF YOUR SOIL? – QUANTITATIVE METHODS

Time

2-3 days. Preparation time: 25 minutes; waiting time: 2-3 days; observation and data collection time starts 30 minutes after beginning the experiment.

Materials Per Group

- ◻ Soil sample (1 cup). Ask each group to bring a dry soil sample from their backyard or go with the students to collect soil samples at the school. Depending on the number of groups, collect at least three different soil samples from contrasting habitats (e.g. yard, playground, ornamental or vegetable garden, forest, prairie, road side, etc.). Air dry soil samples overnight.
- ◻ Garden trowel
- ◻ Newspaper or cardboard
- ◻ Mallet or mortar
- ◻ Clear straight sided jar or canning jar (16-20 oz) with lid
- ◻ Funnel (optional)
- ◻ Non-foaming dishwater detergent (1/2 tsp)
- ◻ Ruler
- ◻ Erasable markers
- ◻ Water (1 cup)
- ◻ Card: Soil Texture
- ◻ Worksheet

Key Terms

Soil texture, silt, sand, clay, Soil Textural Triangle, soil texture measuring method

Overview

Students use the Measuring Method to determine quantitatively the texture of soil samples from different habitats. This activity is for students with an understanding of percentages.

Objectives

The students should be able to

– identify quantitatively the texture of a soil sample using the Measuring Method and the Soil Textural Triangle

– understand how and why the soil particles (sand, silt, and clay) settled down when using the Measuring Method

– recognize the differences in soil textures among soils from different habitats

Background Summary

Soil texture is described by the presence and relative percentages of sand (> 0.05-2 mm), silt (0.002 – 0.05 mm) and clay (< 0.002 mm) in the soil. Depending on their texture, soils will vary in their ability to retain water and nutrients. **Sandy soils** feel rough because sand particles have hard edges. These soils do not have many nutrients because they have large pores allowing gases and water to move through them rapidly. The sand particles do not hold on each other and cannot stay together. **Silty soils** are smooth and powdery and when wet make crumbles or ribbons but are not sticky. These silty soils have smaller pore space than sandy soils, therefore can hold more water. **Clayey soils** are smooth when dry and sticky when wet making balls or ribbons that stay together. Because their particles are so small, clayey soils can hold a lot of nutrients, water, and gases. Most soils contain different combinations of sand, silt, and clay. The **Soil Textural Triangle** shows the twelve possible soil classes based on the relative percentages of these textures (see Soil Texture Card for explanation on how to use the Soil Textural Triangle).

Procedures

Step 1

Review the teacher's background on soil texture (page 5) and introduce the subject to the students. Explain to the students the objectives of the activity and why it is important.

Tell the students to think about the following questions:

- If you put a sample of soil in water and shake it, what do you think will happen to the different size particles?
- Would they all fall to the bottom of the jar at the same time? Or might they settle out in some order?

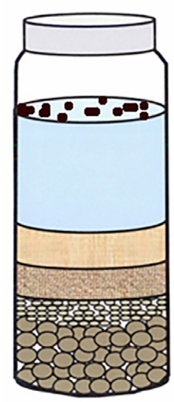
Step 3

Inform the students the order of the activity. First, the students will prepare a soil sample to apply the Measuring Method. Second, the students will collect results and make calculations to determine the percentages of each of the different particle types. Third, the students will use the Soil Textural Triangle to determine the soil class of the sample.

Step 4

Ask the students to prepare the soil sample following the instructions of the Measuring Method explained in the Soil Texture Card.

- Spread the soil sample on a newspaper or cardboard to dry overnight. Remove rocks, roots, and trash.
- Crush soil aggregates (lumps, clods) with a mallet or mortar until there is ½ a cup of soil pulverized.
- Fill the jar with ½ cup of soil and 1 cup of water.
- Add ½ teaspoon of detergent and close the jar tightly and shake hard for 2 minutes. This helps breaking the soil aggregates and separating the mineral particles.
- Put the jar where it will not be disturbed for 2-3 days. Observe the jar each day and note any changes.



Step 5

Explain that the soil particles will settle down according to size with sand settling down within 1 minute, silt within 2 hours, and clay within 2-3 days when the respective measures of the thickness of each soil layer should be taken. Thickness equals the distance between the upper and bottom margins of a particular layer. Make the measurements in centimeters. (For some soil samples, the clearing of the water may take weeks.)

Step 6

When the water clears, ask the students to follow the instructions in the Soil Texture Card to measure the thickness of each layer (sand, silt, clay) and the thickness of the total deposit (all soil layers). Tell the students to write these results in the table of their worksheet (section 2, first and second column). Since layers may not be even, pick a side of the jar to take the measurements where there is an average representation of the layers thickness. Tell the students to write these results in the table of their worksheet (section 2, first and second column).

Step 7

Explain to the students how to calculate the percentage of each soil layer and ask them to complete the table in their worksheets (section 2, third column). Advise the students to look at the Measuring Method in the Soil Texture Card for guidelines on how to make these calculations.

- Sand thickness (cm) / Total thickness (cm) x 100% = ___% sand
- Silt thickness (cm) / Total thickness (cm) x 100% = ___% silt
- Clay thickness (cm) / Total thickness (cm) x 100% = ___% clay
- Total thickness of all layers (cm) = 100%

Step 8

Tell the students to use the Soil Textural Triangle in the Soil Texture Card to determine the texture class of their sample and to include the result in their worksheets (section 3).

Step 9

Discuss with the students the results of each group and highlight differences in the relative percentages of sand, silt, and clay among soil samples that come from different habitats. Also, relate the different soil textures to their water holding capacity and the type of habitat from where the soil sample came from (section 4). For example, prairies may have clayey soils with a high water retention capacity, vegetable gardens may have loamy soils with optimal water retention capacity, and playgrounds may have sandy soils with very little water retention capacity.

Checking Your Knowledge

Ask the students to answer the following questions at the end of the worksheet. Discuss and clarify, or correct, the answers with the students.

Did you see a pattern in the order of layers among the soil samples? Describe it.

Why is there a consistent order in the type of layers among the samples?

Do samples from different habitats have similar amounts of each of the three soil particles? Why?

Expanding Your Knowledge

Is the soil texture the same within a habitat? Take 3-5 soil samples of the same habitat (farm, backyard, vegetable garden, prairie, forest) at least 50 m apart and compare the texture of the samples to see how they vary in their composition of clay, sand, and silt.

Web Links

Physical properties of the soil: http://soils4teachers.org/physical-properties

Soil overview: https://www.soils.org/files/about-soils/soils-overview.pdf

Soils – Fundamental Concepts: http://urbanext.illinois.edu/soil/concepts/concepts.pdf

Activity 4.

HOW DOES WATER MOVE THROUGH SOILS WITH DIFFERENT STRUCTURES?

Overview

Students explore soil structure and its interactions with soil texture to influence the movement of water through the soil.

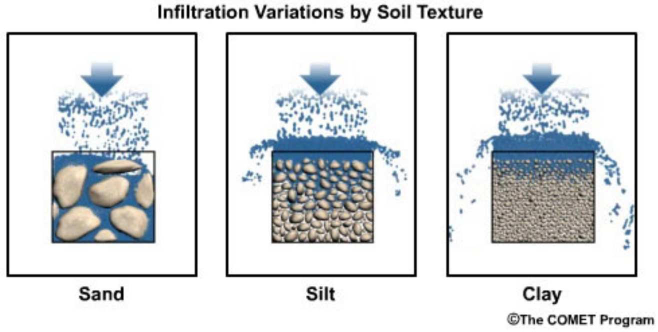
Objectives

The students should be able to

- understand the arrangement of soil particles into aggregates
- identify the space between particles and aggregates as pores that vary in size
- realize that depending on soil structure and soil texture, water flows differently through the soil

Background Summary

Soil texture is described by the presence and relative percentages of sand (> 0.05-2 mm), silt (0.002 – 0.05 mm) and clay (< 0.002 mm) in the soil. **Sandy soils** feel rough and do not have many nutrients because they have large pores allowing gases and water to move through them rapidly. **Silty soils** are smooth and have smaller pore spaces than sandy soils, therefore can hold more water. **Clayey soils** are smooth when dry and sticky when wet and their particles are so small that these soils can hold a lot of nutrients, water, and gases. Most soils contain different combinations of sand, silt, and clay. **Soil structure** is the arrangement of soil particles (sand, silt, clay) and organic particles in soils. These particles can be found in groups call **aggregates**. The spaces among aggregates are called **pores** and can be filled with air, water, roots, or other organisms. A **healthy soil** will have similar number of small (< 0.06 mm) and large (> than 0.06 mm) pores. Large pores are good as aeration systems that allow the water to flow, while small pores hold water against gravity making the water available to plants. The most desire soil structure is the granular type that is arranged in small aggregates with rounded edges, and with both small and large pores.



Time

1 hour

Materials Per Group

- ☐ 1 soil sample (1/2 cup). Ask each group to bring a soil sample from their backyard or go with the students to collect soil samples at the school. Make sure that the samples represent soils with contrasting soil structures and textures (sandy soils, loam, clay, etc.). Dry the soil samples overnight before using.
- ☐ 1 plastic bottle (2 litters). Cut in 2 making sure that the top (funnel) when upside down fits and holds into the bottom part of the bottle.
- ☐ 2 coffee filters
- ☐ Measuring cylinder (300 ml)
- ☐ 1 small watering can with shower head. The head of the watering can should be smaller than the opening of the cut bottle.
- ☐ 1 cups of water
- ☐ Cards: Soil Texture and Soil Structure and Soil-Water Relations
- ☐ Timer
- ☐ Worksheet

Key Terms

Soil structure, aggregates, pores, water flow

Procedures

Step 1

Review the teacher's background on soil texture, soil structure, and soil and water relations (pages 5, 6 and 8) and introduce the subject to the students. Explain the objectives of the activity and why it is important.

Tell the students to think about the following questions:

- Can the size of the particles in the soil determine the speed of water flow?
- Does the size of pores in the soil affect the flow of water through these spaces?
- How do soil texture and soil structure work together to let the water move fast or slow through the soil?

Step 2

Inform the students the order of the activity. The students will first setup an experiment to examine water flow through a soil sample. Second, the students will collect data on time and amount of water flowing. Third, the students will compare their results from different soil samples. Tell the students that all the materials to conduct the activity are in their workstations and that in the card of Soil Structure and Soil-Water Relations they will find the instructions for the experiment.

Step 3

Ask the students to remove from the soil sample rocks, twigs, and any other large objects; to place the top of the bottle (funnel) upside down inside the bottom part of the bottle; and to place a coffee filter into the funnel, add the soil sample, and cover the sample with another filter. Make sure the soil is evenly distributed in the filter. This will avoid "hollow" areas on the sides that will allow water to run freely instead of passing through the soil affecting the measurements.

Step 4

Each group should assign a student as time keeper who will record the time from the moment the water is poured into the funnel until water drops run 5 seconds apart. The time should be recorded in seconds to have standardized records.

Step 5

After measuring one cup of water and place it in the watering can, the students are ready to pour the water into the funnel and record the time. Ask to add the water evenly on top of the soil avoiding pouring water at the edges and on a particular spot. Also avoid moving the bottle or pulling the filter during the filtration of the water. Warn the students that depending on the type of sample the water may go very fast or very slow. Ask the students to record in the worksheet the time it took the water to pass through the soil (section 2).

Step 6

Tell the students that in order to measure the amount of filtered water they should lift the funnel with the soil and not pull the filters to avoid extra water to be collected. They should use the measuring cylinder to calculate the amount of water collected. Ask the students to record this amount in the worksheet (section 2).

Step 7

Tell the students to complete their tables with the results from the other groups.

Step 8

Ask the students to compare the results among groups by responding to the questions in section 3 of the worksheet. To help the students answering the questions, recommend them to use the information on the cards of Soil Texture and Soil Structure and Soil-Water Relations.

Checking Your Knowledge

Ask the students to answer the following questions about soil structure and water retention at the end of the worksheet. Recommend the use of the cards on Soil Texture and Soil Structure and Soil-Water Relations for information on the subject. Discuss and clarify, or correct, answers with the students.

- What type of soil aggregates and pores should a healthy soil have?
- Describe the soil structure of a soil that cannot retain water and of a soil that can retain water very effectively.

Expanding Your Knowledge

Examine soil particles, aggregates, and pores with a microscope and think in the kind of activities do you think happen in the pores of the soil.

Web Links

Soils – Fundamental Concepts: http://urbanext.illinois.edu/soil/concepts/concepts.pdf

Soil and water relationships: http://www.noble.org/ag/soils/soilwaterrelationships/

Soil and water: http://www.fao.org/docrep/R4082E/r4082e03.htm

Activity 5.

HOW DOES THE SOIL CHANGE VERTICALLY?

Time
1 hour

Materials Per Group
- ◻ Soil cores. At least 2 contrasting cores from different habitats, preferably one disturbed and one undisturbed habitat (e.g. forest, prairie, agricultural land, playground)
- ◻ Poster of soil profiles
- ◻ Puzzle of soil profiles. Five puzzles, each from a different habitat to compare among groups.
- ◻ Card: Soil Profile
- ◻ Worksheet

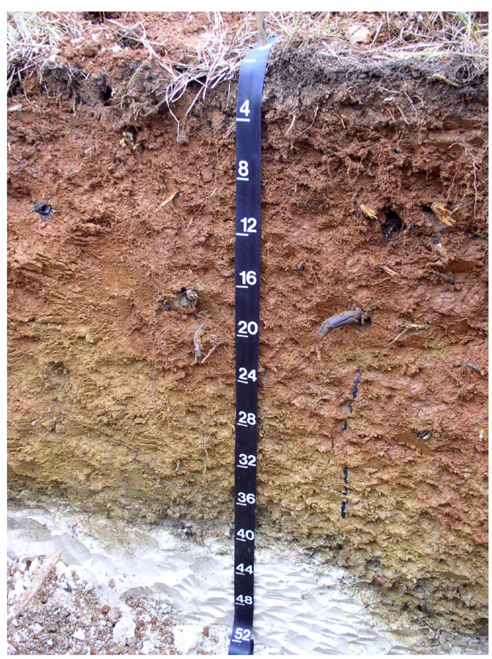
Key Terms
Soil profile, soil horizons, organic material, minerals, parent material, bedrock

Overview
Students observe soil profiles from different habitats and make a puzzle of the different layers in a soil profile.

Objectives
The students should be able to

- distinguish the most common soil horizons in a soil profile
- describe the general characteristics of each horizon
- recognize that different habitats have different soil profiles

Background Summary
The soil is made of a series of layers or horizons that together form a **soil profile**. From top to bottom the horizons are: **O horizon** (organic) is a thin dark layer of **organic material** and **humus** (well-decomposed matter) present in undisturbed habitats (wetlands, forest, prairies), while agricultural lands, and suburban and urban locations have lost this horizon. **A horizon** (topsoil) is rich in nutrients (minerals) where most of the biological activity occurs. **B horizon** (subsoil) is mostly clay particles with high mineral contents that leached from horizons above, and some organic matter. **C horizon** (parent material) is made of large rocks or broken bedrock from which the soil develops and without any organic matter. **R horizon** (bedrock) is a mass of rock that forms the parent material.



Procedures

Step 1

Review the teacher's background on soil profiles (page 7) and introduce the subject to the students. Explain the objectives of the activity and why it is important.

Tell the students to think about the following questions:

- Is the soil uniform (texture, color, absence of layers) as you look deeper into the ground?
- Is the soil profile the same among habitats (disturbed vs. undisturbed)?

Step 2

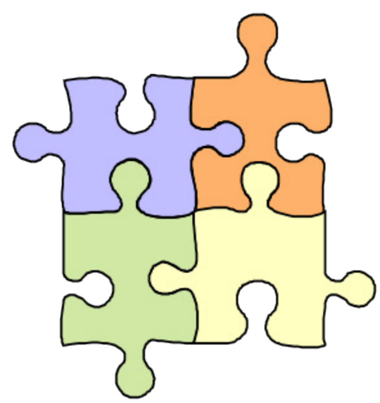
Inform the students the order of the activity. First, the students will observe soil cores. Second, the students will work on a puzzle of soil profiles. Third, the students will compare their soil profiles among groups. Tell the students that all the materials to conduct the activity are in their workstations.

Step 3

Use the poster of soil profiles and the soil cores to explain what a soil profile is, the different types of horizons, and the variations in soil profiles across habitats.

Step 4

Ask each group to make a puzzle of a soil profile using the Soil Profile Card as a guide:



- Show the students a puzzle and explain that the different pieces represent the letters of the horizons, the names of the horizons, and the components of the horizons.
- Tell the students to find the matching parts for each layer (horizon)
- Recommend the students to think in the components of the different horizons to help them put the pieces in the right order.
- Ask the students to complete the table in the worksheet with the information provided in the puzzle (section 3).

Step 5

Ask the groups to share their puzzles with the class, explaining what type of habitat corresponds to that profile and telling the main characteristics that identify that specific soil profile. Tell the students to complete the questions in the worksheet (section 4).

Checking Your Knowledge

Ask the students to answer the following questions on soil profile at the end of the worksheet. Recommend them to use the Soil Profile Card for

Web Links

From the surface down: http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_053238.pdf

Down and Dirt: http://school.discoveryeducation.com/schooladventures/soil/down_dirty.html

The soil profile: http://www.nerrs.noaa.gov/doc/siteprofile/acebasin/html/envicond/soil/slform.htm

information on the subject. Discuss and clarify, or correct, the answers with the students.

– Does the soil look the same as you go deeper into the ground? Explain your answer.

– Describe the main soil layers (horizons)? What is in each layer? How do they look different?

Expanding Your Knowledge

– Investigate how soil formation and land management contribute to the differences in the soil profile among habitats (forest, prairies, agricultural land, etc.).

Activity 6.

HOW DOES THE SOIL FORM?

Overview

Each student makes his/her own soil using food ingredients that represent the five factors involve in soil formation (parent material, topography, climate, biological factors, and time). A group will share the materials, but each member of the group does a soil model.

Objectives

The students should be able to

- identify the five factors involve in soil formation
- understand that these factors interact with each other to form soil
- understand that takes hundreds to thousands of years to form soil

Background Summary

There are five factors that participate in soil formation: parent material, topography, climate, organisms, and time. There are three types of parent materials. **Residual parent materials** are soils that form in place due to weathering processes of the bedrock. **Organic parent materials** are form from the decomposition of organic remains (mostly plants and some animals). **Transported parent materials** are sediments that originated a distance from where they currently occur transported through water, wind, or gravity. **Topography** refers to the shape, slope, and elevation of the land that influence water movement that can generate soil erosion. **Climate** is driven by temperature and precipitation, variables that act on soil formation through mechanical and chemical weathering. **Biological factors** include the formation of soil by adding organic matter to the soil, participating in decomposition processes, and mixing and aerating the soil. Soil formation is a continuous series of process that occur over **time**. As soils age, and depending on the rate of weathering, layers (horizons) of soils develop becoming thicker with time. The formation of one centimeter of soil can take one thousand years. The five factors of soil formation do not act independently since they interact with each other to form soil. Soil varies locally due to these interactions and to differences in the local dominant factor.

Time

1 hour

Materials Per Group

- ☐ 2 diagrams on the five factors of soil formation and their interactions
- ☐ 10 large pieces of graham crackers. Two pieces per student (bedrock-R horizon)
- ☐ 1 cup of cookie crumbs (parent material-C horizon)
- ☐ 1 can of chocolate frosting (16 oz.) (subsoil, topsoil, and topography)
- ☐ 1 package of rainbow mix sprinkles (1.75 oz.) (roots and animals)
- ☐ 1 package of red sugar crystals (2.25 oz.) (microorganisms)
- ☐ 1 package of chocolate sprinkles (1.75 oz) (leaf litter)
- ☐ 1 strip blue gel frosting (3.5 oz) (rain)
- ☐ Paper towels
- ☐ 5 small trays (one per participant)
- ☐ 5 wood or metal spatulas
- ☐ Coloring activity: paper, pencils, colors
- ☐ Card: Soil Formation
- ☐ Worksheet

Key Terms

Soil formation, parent material, topography, climate, biological factors, time, weathering

Procedures

Step 1

Review the teacher's background on soil formation (page 16) and introduce the subject to the students. Explain the objectives of the activity and why it is important.

Tell the students to think about the following questions:

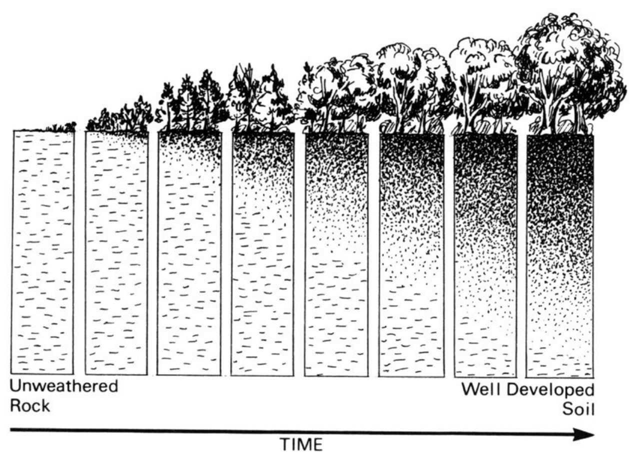
- What factors participate of soil formation?
- Do these factors act in the same way and at the same time to form soil?
- How long it takes to form soil?

Step 2

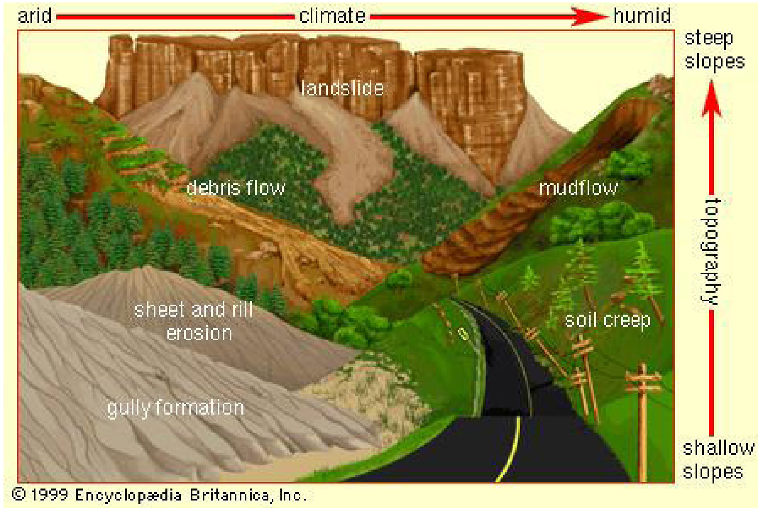
Inform the students the order of the activity. First, the students will examine diagrams on the five factors that participate of soil formation and their interactions. Second, the students make their own models of soil formation. Third, the students make a drawing representing one or more of the factors of soil formation. Tell the students that all the materials to conduct the activity are in their workstations.

Step 3

Show the students the diagrams below that illustrate how parent material, climate, topography, biological activity, and time participate of soil formation, as well as how some of these factors interact.



Interactions among parent material (weathering), climate, biological factors and time to form soil. Soil begins to form over time due to the action of climate (temperature and precipitation) on the parent material through weathering of the bedrock. Soil layers (horizon) began to develop as organic matter accumulates due to the establishment of plants and other organisms in the soil.



Interactions of climate and topography in soil formation. A gradient of climatic conditions from arid to humid interacts with a topography gradient from shallow slopes to steep slopes. Soils in arid climates in steep slopes are more unstable experiencing the impact of erosion and landslides that alter or prevent processes of soil formation. On the other extreme, soils in humid climates in shallow slopes are more stable allowing processes of soil formation to act.

Step 4

Explain to the students that they are going to make their own soil using food ingredients that represent the five factors that participate in soil formation. Students in groups of 3-5 students will share the ingredients but each student will do his/her own soil model. Confirm if students have food allergies before starting the project. Follow the instructions below and recommend the students to use the Soil Formation Card as a guide:

- Place in a tray two large pieces of graham crackers (bedrock).
- Sprinkle the cookie crumbs (parent material) on top of the crackers.
- Spread the chocolate frosting and create hills and valleys (topography).
- Add rainbow mix sprinkles (roots and animals) and the red crystals (microorganisms) on top of the frosting. You may mix them with the frosting or add more frosting on top.
- Add chocolate sprinkles (leaf litter-organic matter).
- Squeeze the blue gel frosting on top of the hills of the chocolate frosting. The gel moves down the hills into the valleys representing water running along rivers. Water and temperature are the main drivers of climate. As the gel moves, the hills or valleys of chocolate frosting may change in shapes. This represents the impact of water erosion on soil as soil particles are washed away. If the gel is too thick you can mix it with some water to make it more liquefy.
- This activity may take approximately 30 minutes. In real time an inch of soil takes from hundreds to thousands of years to form. Each minute may represent 100 to 100,000 years.

Web Links

From the Surface Down: http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_053238.pdf

Soil Formation and Classification: file:///U:/MO%20DIRT/Soil%20educational%20material/Soil%20formation%20and%20profiles/Soil%20Formation%20and%20Soil%20Classification%20-%20Scoop%20on%20Soil.html

Soil Formation and Classification (NRCS): http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/edu/?cid=nrcs142p2_054278

Step 5

Ask the students to work on their worksheet (section 1 and 2).

Checking your Knowledge

Ask the students to answer the following questions on soil formation at the end of the worksheet. Recommend them to use the Soil Formation Card for information on the subject. Discuss and clarify, or correct, the answers with the students.

- List the five factors that participate in soil formation.
- Do the factors of soil formation interact with each other? Give an example of an interaction between two factors of soil formation.
- How long it takes to form an inch of soil?

Expanding Your Knowledge

Explore making a living soil using earthworms to bring life to sterilize compost as the earthworms bring with them microorganisms that are good for the soil.

Students' Worksheets

Activity 1.

WHAT ARE THE COMPONENTS OF THE SOIL?

Group Name: ______________________ **Date:** ________

Group Members: ______________________

____

____

Overview
Students examine soil samples to determine the components that make up an ideal soil for plant growth, and build their own soil model.

Objectives
The students should be able to:

- identify the components of an ideal soil and the state (gas, liquid or soil) of those components
- give the percentages of the different components of an ideal soil. (Students in 4th and 5th grade should be able to understand percentages).
- understand that an ideal soil is a healthy soil for plants to grow
- identify the three types of soil particles based on their size (sand, silt, and clay)

Background Summary
The composition of an **ideal soil** for plant growth is half solid (minerals and organic matter), one quarter gas (air), and one quarter liquid (water). Air and water are mainly present in the pores, which are spaces between the solid aggregates of the soil. The solid portion of the soil is mostly **mineral** particles (45%). These particles are inorganic materials derived from rocks and are of three types based on their size. These particles are **sand** (> 0.05 - 2 mm), **silt** (0.002 – 0.05 mm), and **clay** (< 0.002 mm). The other 5% of the solid part of an ideal soil is **organic matter** that is made of living organisms, remains of soil organisms, and organic compounds produced by metabolism.

Note
This activity is designed to be developed within 1 hour. At your workstation you will find the materials to conduct this activity.

Time
1 hour and a half

Materials Per Group
- ☐ Card: Soil Components
- ☐ Forceps or teasing needle
- ☐ Hand lens
- ☐ Materials for the model of soil composition: clear jar (~1000 ml), ping-pong balls, brown aquarium gravel, stuffing beads, plastic animals, roots (plastic lacing), water (~1/3 cup), and glitter (1/2 teaspoon).
- ☐ Samples of sand, silt, and clay (1/2 cup per sample)
- ☐ Sample of soil (~1/2 cup). Ask each group to bring a soil sample from their backyard or go with the students to collect soil samples at the school. Depending on the number of groups, collect at least three different soil samples from contrasting habitats (e.g. yard, playground, ornamental or vegetable garden, forest, prairie, road side, etc.)
- ☐ Tray
- ☐ Worksheet

Key Terms
Ideal soil, solid state, liquid state, gas state, organic matter, minerals, air, water, sand, silt, clay

1. Complete the Table of Soil Components with the components you see in your soil sample and the state of these components (solid, liquid, and gas). Estimate the relative percentages for the liquid, solid, and gas portions of the soil.

Table of Soil Components

Components of soil	State of components	Approximate percentage (or amounts) for each component

2. Complete the Table of Soil Particles with the observed textures and particle sizes.

Table of Soil Particles

Type of soil particle	Texture feeling (sticky, soft, grainy)	Particles size

3. Build your own soil model following the instructions in the Card on Soil Composition.

Checking Your Knowledge

Respond to the following questions and discuss the answers with your teacher.

What components represent the solid, liquid, and gas states in soil? Include their relative percentages for an Ideal Soil.

Which are the three types of particles in the mineral portion of the soil and how do you recognize them?

What is the ideal soil good for?

Web Links

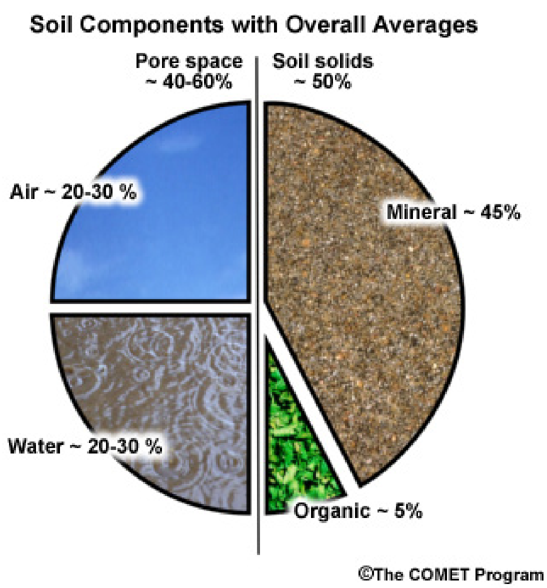
Physical properties of the soil: http://soils4teachers.org/physical-properties

Soil overview: https://www.soils.org/files/about-soils/soils-overview.pdf

Soils – Fundamental Concepts: http://urbanext.illinois.edu/soil/concepts/concepts.pdf

Expanding Your Knowledge

Imagine the soil under a forest, a city, and a crop field. Do you think the composition of the soil in these three types of habitats would be the same? Discuss what you think their differences may be and what the consequences for plant growth might be.



Activity 2.

WHAT IS THE TEXTURE OF YOUR SOIL? – QUALITATIVE METHODS

Time
1 hour

Materials Per Group
- ☐ Card: Soil Texture
- ☐ Ruler
- ☐ Soil samples (3). The samples should have different soil textures (sandy, silty, clayey) but should be unknown to the students. The samples should be labeled with numbers that only the teacher knows.
- ☐ Samples of sand, silt, and clay (1/2 cup per sample)
- ☐ Water
- ☐ Worksheet

Key Terms
Soil texture, silt, sand, clay, Soil Textural Triangle, soil texture qualitative test methods

Group Name: ______________________________ **Date:** ________

Group Members: ______________________________________

____

____

Overview
Students use three qualitative test methods and the Soil Textural Triangle to determine the unknown texture of soil samples, and prepare soil samples based on known textures.

Objectives
The students should be able to
- understand what soil texture is
- determine the texture of a soil sample using three qualitative test methods
- use the Soil Textural Triangle to assign soil classes
- prepare a soil sample of a particular texture

Background Summary
Soil texture is described by the presence and relative percentages of sand (> 0.05-2 mm), silt (0.002 – 0.05 mm) and clay (< 0.002 mm) in the soil. Depending on their texture, soils will vary in their ability to retain water and nutrients**. Sandy soils** feel rough because sand particles have hard edges. These soils do not have many nutrients because they have large pores allowing gases and water to move through them rapidly. The sand particles do not hold on each other and cannot stay together. **Silty soils** are smooth and powdery and when wet make crumbles or ribbons but are not sticky. These silty soils have smaller pore space than sandy soils, therefore can hold more water. **Clayey soils** are smooth when dry and sticky when wet making balls or ribbons that stay together. Because their particles are so small, clayey soils can hold a lot of nutrients, water, and gases. Most soils contain different combinations of sand, silt, and clay. The most appropriate soil class for plant growth is **loam** that has a very good water infiltration and retention capacity. The **Soil Textural Triangle** shows the twelve possible soil classes based on the relative percentages of sand, silt, and clay (see Soil Texture Card for explanation on how to use the Soil Textural Triangle).

Note

This activity is designed to be developed within 1 hour. At your workstation you will find the materials to conduct this activity.

1. Use the three qualitative test methods to determine the soil texture of your three soil samples with unknown textures. The methods are described in the Card of Soil Texture.

2. Fill the table with your observations after using the qualitative methods to determine the texture of a soil sample.

Soil sample #	Feel test: gritty, smooth, or sticky.	Ball squeeze test: ball breaks, stays for a short time, or resists breaking.	Ribbon test: no ribbon, short ribbon, solid-long ribbon	Resolve the mystery here! Soil texture: sandy, silty, or clayey
1				
2				
3				

3. Use the Soil Textural Triangle to identify the soil texture of the following three hypothetical samples. The Soil Textural Triangle is explained in the Soil Texture Card.

Sample 1: 40% sand, 40% silt, and 20% clay is ______________________________

Sample 2: 65% sand, 20% silt, and 15% clay is ______________________________

Sample 3: 34% sand, 33% silt, and 33% clay is ______________________________

4. Now you are ready to make your own soil! Pick one of the samples above (1, 2 or 3) and combine the sand, silt, and clay in the percentages assigned to the sample. Describe your soil class based on the three qualitative test methods.

____

____

____

Checking Your Knowledge

Respond to the following questions and discuss the answers with your teacher.

Explain one qualitative method to determine the soil texture of a sample?

___

___

___

What is the best soil texture class that supports plant grow in general, and why?

___

___

What is the use of the Soil Textural Triangle?

___

___

Web Links

Physical properties of the soil: http://soils4teachers.org/physical-properties

Soil overview: https://www.soils.org/files/about-soils/soils-overview.pdf

Soils – Fundamental Concepts: http://urbanext.illinois.edu/soil/concepts/concepts.pdf

Expanding Your Knowledge

Grow the same type of plants in soils with different textures and compared how they grow.

Activity 3.

WHAT IS THE TEXTURE OF YOUR SOIL? – QUANTITATIVE METHODS

Group Name: ______________________________ **Date:** ________

Group Members: ______________________________

____

____

Overview

Students use the Measuring Method to determine quantitatively the texture of soil samples from different habitats. This activity is for students with an understanding of percentages.

Objectives

The students should be able to

- identify quantitatively the texture of a soil sample using the Measuring Method and the Soil Textural Triangle
- understand how and why the soil particles (sand, silt, and clay) settled down when using the Measuring Method
- recognize the differences in soil textures among soils from different habitats

Background Summary

Soil texture is described by the presence and relative percentages of sand (> 0.05-2 mm), silt (0.002 – 0.05 mm) and clay (< 0.002 mm) in the soil. Depending on their texture, soils will vary in their ability to retain water and nutrients. **Sandy soils** feel rough (gritty) because sand particles have hard edges. These soils do not have many nutrients because they have large pores allowing gases and water to move through them rapidly. The sand particles do not hold on each other and cannot stay together. **Silty soils** are smooth and powdery and when wet make crumbles or ribbons but are not sticky. These silty soils have smaller pore space than sandy soils, therefore can hold more water. **Clayey soils** are smooth when dry and sticky when wet making balls or ribbons that stay together. Because their particles are so small, clayey soils can hold a lot of nutrients, water, and gases. Most soils contain different combinations of sand, silt, and clay. The **Soil Textural Triangle** shows the twelve possible soil classes based on the relative percentages of these textures (see Soil Texture Card for explanation on how to use the Soil Textural Triangle).

Time

2-3 days. Preparation time: 25 minutes; waiting time: 2-3 days; observation and data collection time starts 30 minutes after beginning the experiment.

Materials Per Group

- ☐ Soil sample (1 cup). Ask each group to bring a dry soil sample from their backyard or go with the students to collect soil samples at the school. Depending on the number of groups, collect at least three different soil samples from contrasting habitats (e.g. yard, playground, ornamental or vegetable garden, forest, prairie, road side, etc.). Air dry soil samples overnight.
- ☐ Garden trowel
- ☐ Newspaper or cardboard
- ☐ Mallet or mortar
- ☐ Clear straight sided jar or canning jar (16-20 oz) with lid
- ☐ Funnel (optional)
- ☐ Non-foaming dishwater detergent (1/2 tsp)
- ☐ Ruler
- ☐ Erasable markers
- ☐ Water (1 cup)
- ☐ Card: Soil Texture
- ☐ Worksheet

Key Terms

Soil texture, silt, sand, clay, Soil Textural Triangle, soil texture measuring method

Note

This activity is designed to be developed within 1 hour. At your workstation you will find the materials to conduct this activity.

1. Follow the instructions in the Soil Texture Card on the Measuring Method to determine the percentage of each texture in your soil sample.

2. Complete the table with the thickness (cm) of each layer of your soil sample and the calculation of the relative percentage for each layer. Include the land use from where your soil sample was taken.

Layers name	Layer Thickness (cm)	Relative percentage per layer Thickness of layer/ thickness of total deposit x 100%	Habitat of soil sample (e.g. yard, playground, parking lot)
Sand			
Silt			
Clay			
Total deposit		**100%**	

3. Use the Soil Texture Card to determine the soil texture class of your sample using the Textural Triangle.

Texture of your soil sample: ____________________

4. Interpret and compare your results with other groups, and answer the following questions.

How do you interpret the differences in the percentages among the textures in your sample with the habitat from where the sample came from?

How is your sample different from other samples (more clay, more sand, less silt)?

____

____

____

How is your sample different from others based on the habitat from where the samples were collected?

____

____

____

Checking Your Knowledge

Ask the students to answer the following questions at the end of the worksheet to interpret and compare their results with the ones from the other groups. Discuss and clarify or correct the answers with the students.

Did you see a pattern in the order of layers among the soil samples? Describe it.

____

____

____

Why is there a consistent order in the type of layers among samples?

____

____

____

Expanding Your Knowledge

Is the soil texture the same within a habitat? Take 3-5 soil samples of the same habitat (farm, backyard, vegetable garden, prairie, forest) at least 50 m apart and compare the texture of the samples to see how they vary in their composition of clay, sand, and silt.

Web Links

Physical properties of the soil: http://soils4teachers.org/physical-properties

Soil overview: https://www.soils.org/files/about-soils/soils-overview.pdf

Soils – Fundamental Concepts: http://urbanext.illinois.edu/soil/concepts/concepts.pdf

Activity 4.

HOW DOES WATER MOVE THROUGH SOILS WITH DIFFERENT STRUCTURES?

Group Name: ______________________________ **Date:** ________

Group Members: ______________________________

____

____

Overview

Students explore soil structure and its interactions with soil texture to influence the movement of water through the soil.

Objectives

The students should be able to

- understand the arrangement of soil particles into aggregates
- identify the space between particles and aggregates as pores that vary in size
- realize that depending on soil structure and soil texture, water flows differently through the soil

Background Summary

Soil texture is described by the presence and relative percentages of sand (> 0.05-2 mm), silt (0.002 – 0.05 mm) and clay (< 0.002 mm) in the soil. **Sandy soils** feel rough and do not have many nutrients because they have large pores allowing gases and water to move through them rapidly. **Silty soils** are smooth and have smaller pore spaces than sandy soils, therefore can hold more water. **Clayey soils** are smooth when dry and sticky when wet and their particles are so small that these soils can hold a lot of nutrients, water, and gases. Most soils contain different combinations of sand, silt, and clay. **Soil structure** is the arrangement of soil particles (sand, silt, clay) and organic particles in soils. These particles can be found in groups call **aggregates**. The spaces among aggregates are called **pores** and can be filled with air, water, roots, or other organisms. A **healthy soil** will have similar number of small (< 0.06 mm) and large (> than 0.06 mm) pores. Large pores are good as aeration systems that allow the water to flow, while small pores hold water against gravity making the water available to plants. The most desire soil structure is the granular type that is arranged in small aggregates with rounded edges, and with both small and large pores.

Time

1 hour

Materials Per Group

- ☐ 1 soil sample (1/2 cup). Ask each group to bring a soil sample from their backyard or go with the students to collect soil samples at the school. Make sure that the samples represent soils with contrasting soil structures and textures (sandy soils, loam, clay, etc.). Dry the soil samples overnight before using.
- ☐ 1 plastic bottle (2 litters). Cut in 2 making sure that the top (funnel) when upside down fits and holds into the bottom part of the bottle.
- ☐ 2 coffee filters
- ☐ Measuring cylinder (300 ml)
- ☐ 1 small watering can with shower head. The head of the watering can should be smaller than the opening of the cut bottle.
- ☐ 1 cups of water
- ☐ Cards: Soil Texture and Soil Structure and Soil-Water Relations
- ☐ Timer
- ☐ Worksheet

Key Terms

Soil structure, aggregates, pores, water flow

Note

This activity is designed to be developed within 1 hour. At your workstation you will find the materials to conduct this activity.

1. Follow the instructions in the card of Soil Structure and Soil – Water Relations to determine the time that it takes the water to move through the soil and the amount of water that passes through.

2. Complete the table with your results. Give the time elapsed for the water to move through the soil and the amount of water collected. Include in your table the results of the other groups.

Group Number	Soil Type	Particle and pore size description	Time elapsed for water to move through soil (seconds)	Amount of water collected (ml)
1 (our group)				
2				
3				
4				
5				

3. Answer the following questions based on the results you and other groups obtained.

In which type of soil did the water move the fastest through? Why?

In which type of soil did water take the longest time to move through? Why?

From which type of soil is more water collected? Explain your answer.

From which type of soil was less water collected? Explain your answer.

Checking Your Knowledge

Respond to the following questions and discuss the answers with your teacher.

What type of soil aggregates and pores should a healthy soil have?

Describe the soil structure of a soil that cannot retain water and of a soil that can retain water very effectively.

____

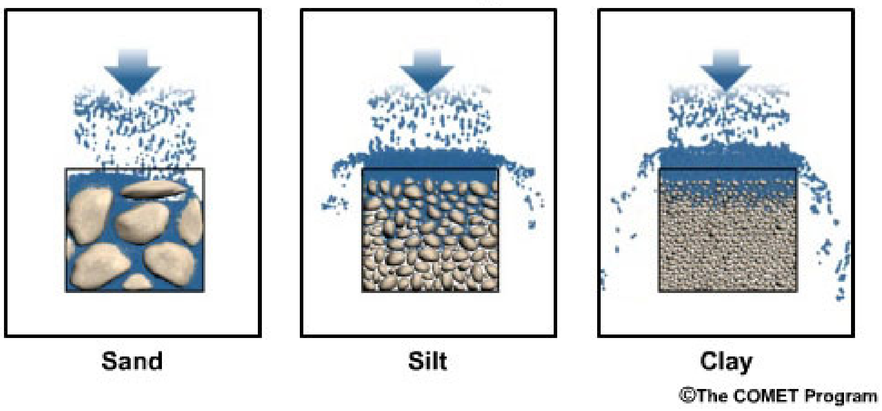
____

____

Expanding Your Knowledge

Examine soil particles, aggregates, and pores with a microscope and think in the kind of activities do you think happen in the pores of the soil.

Infiltration Variations by Soil Texture



Web Links

Soils – Fundamental Concepts: http://urbanext.illinois.edu/soil/concepts/concepts.pdf

Soil and water relationships: http://www.noble.org/ag/soils/soilwaterrelationships/

Soil and water: http://www.fao.org/docrep/R4082E/r4082e03.htm

Activity 5.

HOW DOES THE SOIL CHANGE VERTICALLY?

Time
1 hour

Materials Per Group

- ☐ Soil cores. At least 2 contrasting cores from different habitats, preferably one disturbed and one undisturbed habitat (e.g. forest, prairie, agricultural land, playground)
- ☐ Poster of soil profiles
- ☐ Puzzle of soil profiles. Five puzzles, each from a different habitat to compare among groups.
- ☐ Card: Soil Profile
- ☐ Worksheet

Key Terms
Soil profile, soil horizons, organic material, minerals, parent material, bedrock

Group Name: ______________________________ **Date:** __________

Group Members: ____

____

____

Overview

Students observe soil profiles from different habitats and make a puzzle of the different layers in a soil profile.

Objectives

The students should be able to

- distinguish the most common soil horizons in a soil profile
- describe the general characteristics of each horizon
- recognize that different habitats have different soil profiles

Background Summary

The soil is made of a series of layers or horizons that together form a **soil profile**. From top to bottom the horizons are: **O horizon** (organic) is a thin dark layer of **organic material** and **humus** (well-decomposed matter) present in undisturbed habitats (wetlands, forest, prairies), while agricultural lands, and suburban and urban locations have lost this horizon. **A horizon** (topsoil) is rich in nutrients (minerals) where most of the biological activity occurs. **B horizon** (subsoil) is mostly clay particles with high mineral contents that leached from horizons above, and some organic matter. **C horizon** (parent material) is made of large rocks or broken bedrock from which the soil develops and without any organic matter. **R horizon** (bedrock) is a mass of rock that forms the parent material.

Note

This activity is designed to be developed within 1 hour. At your workstation you will find the materials to conduct this activity.

1. Look at the Soil Profile Card to learn about soil horizons and their characteristics.

2. Make a soil profile puzzle and use the Soil Profile Card as your guide to put the pieces in the right order.

3. Complete the Soil Profile Table with the information on your puzzle.

Habitat: ______________________________

Horizon	Depth (cm)	Color	Relative abundance of Roots (none, few, some, many)	Main components
O				
A				
B				
C				
R				

4. Answer the following questions:

Is the soil profile in your puzzle showing the same characteristics as soil profiles from other groups? How is your profile different from others?

____

____

____

Why are these soil profiles different from each other?

____

____

____

Checking your Knowledge

Respond to the following questions and discuss the answers with your teacher.

Does the soil look the same as you go deeper into the ground? Explain your answer.

____

____

____

Describe the main soil layers (horizons)? What is in each layer? How do they look different?

____

____

____

Expanding Your Knowledge

Investigate how soil formation and land management contribute to the differences in the soil profile among habitats (forest, prairies, agricultural land, etc.).

Web Links

Physical properties of the soil: http://soils4teachers.org/physical-properties

Soil overview: https://www.soils.org/files/about-soils/soils-overview.pdf

Soils – Fundamental Concepts: http://urbanext.illinois.edu/soil/concepts/concepts.pdf

Activity 6.

HOW DOES THE SOIL FORM?

Group Name: ______________________________ **Date:** __________

Group Members: ____

____

____

Overview

Each student makes his/her own soil using food ingredients that represent the five factors involve in soil formation (parent material, topography, climate, biological factors, and time). A group will share the materials, but each member of the group does a soil model.

Objectives

The students should be able to

- identify the five factors involve in soil formation
- understand that these factors interact with each other to form soil
- understand that takes hundreds to thousands of years to form soil

Background Summary

There are five factors that participate in soil formation: parent material, topography, climate, organisms, and time. There are three types of parent materials. **Residual parent materials** are soils that form in place due to weathering processes of the bedrock. **Organic parent materials** are form from the decomposition of organic remains (mostly plants and some animals). **Transported parent materials** are sediments that originated a distance from where they currently occur transported through water, wind, or gravity. **Topography** refers to the shape, slope, and elevation of the land that influence water movement that can generate soil erosion. **Climate** is driven by temperature and precipitation, variables that act on soil formation through mechanical and chemical weathering. **Biological factors** include the formation of soil by adding organic matter to the soil, participating in decomposition processes, and mixing and aerating the soil. Soil formation is a continuous series of process that occur over **time**. As soils age, and depending on the rate of weathering, layers (horizons) of soils develop becoming thicker with time. The formation of one centimeter of soil can take one thousand years. The five factors of soil formation do not act independently since they interact with each other to form soil. Soil varies locally due to these interactions and to differences in the local dominant factor.

Time

1 hour

Materials Per Group

- ☐ 2 diagrams on the five factors of soil formation and their interactions
- ☐ 10 large pieces of graham crackers. Two pieces per student (bedrock-R horizon)
- ☐ 1 cup of cookie crumbs (parent material-C horizon)
- ☐ 1 can of chocolate frosting (16 oz.) (subsoil, topsoil, and topography)
- ☐ 1 package of rainbow mix sprinkles (1.75 oz.) (roots and animals)
- ☐ 1 package of red sugar crystals (2.25 oz.) (microorganisms)
- ☐ 1 package of chocolate sprinkles (1.75 oz) (leaf litter)
- ☐ 1 strip blue gel frosting (3.5 oz) (rain)
- ☐ Paper towels
- ☐ 5 small trays (one per participant)
- ☐ 5 wood or metal spatulas
- ☐ Coloring activity: paper, pencils, colors
- ☐ Card: Soil Formation
- ☐ Worksheet

Key Terms

Soil formation, parent material, topography, climate, biological factors, time, weathering

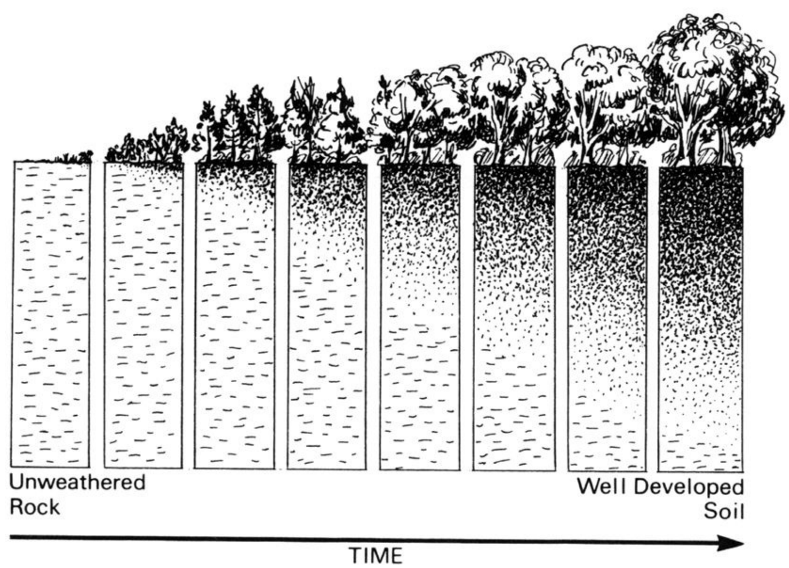
Note

This activity is designed to be developed within 1 hour. At your workstation you will find the materials to conduct this activity.

1. Use the Soil Formation Card to help you connect with a line the terms in the left column to the five factors of soil formation in the right column. More than one line can end on a term in the right column.

Temperature	Climate
Young and old	
Roots	Parent material
Valleys	
Organic matter	Biological factors
Big rocks	
Hills	Topography
Rain	
Aging	Time
Weathering	

2. Make a drawing representing one or more of the factors involve in soil formation. For example, you could include valleys, hills, and or cliffs to represent topography; rain, heat, or flow of water to represent climate; plants, roots, animals, leaf litter to represent biological activity; and or horizons of young and old soils to represent time and parent material.



Checking your Knowledge

List the five factors that participate in soil formation.

____

____

____

____

____

Do the factors of soil formation interact with each other? Give an example of an interaction between two factors of soil formation.

____

____

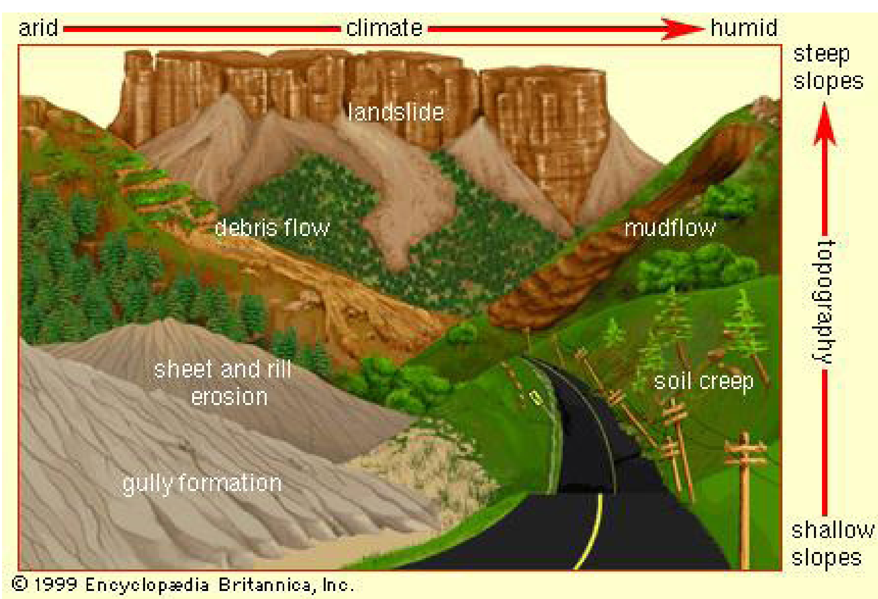
____

- How long it takes to form an inch of soil?

____

Expanding Your Knowledge

Explore making a living soil using earthworms to bring life to sterilize compost as the earthworms bring with them microorganisms that are good for the soil.



Web Links

From the Surface Down: http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_053238.pdf

Soil Formation and Classification: file:///U:/MO%20DIRT/Soil%20educational%20material/Soil%20formation%20and%20profiles/Soil%20Formation%20and%20Soil%20Classification%20-%20Scoop%20on%20Soil.html

Soil Formation and Classification (NCRS): http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/edu/?cid=nrcs142p2_054278