Lesson 2 | Explore

Properties of Soils

At a Glance

Overview

Students examine different types of soil that have been mixed with water and allowed to settle. Next, they investigate soil components and how air space allows soils to hold and transmit water.

Major Concepts

- Soils vary in their compositions.
- Soils are a bank of nutrients.
- Soils contain both organic and inorganic matter.
- Soils contain differing amounts of air space.
- Soils differ in their abilities to hold and transmit water.

Objectives

After completing this lesson, students will be able to

- list aspects of soil composition,
- appreciate that soils are living and dynamic,
- recognize that soils vary in composition,
- describe where nutrients in soil come from,
- recognize that plants generally take up water and nutrients from the soil, and
- recognize that growing crops can deplete agricultural soils of nutrients.

Teacher Background

Consult the following section in Teacher Background:

3.0 Properties of Soils

In Advance

Photocopies

Activity 1	Master 2.1, *Dry Soil Investigation* (Make 4 copies per group of 4 students.) Master 2.2, *Graphic Organizer* (Make 2 copies per group of 4 students.) Master 2.3, *Soil and Air Space* (Make 4 copies per group of 4 students.) Master 2.4, *Soil and Water* (Make 4 copies per group of 4 students.)

Materials

Soil separation	For the class: 3 clear, 350 mL plastic bottles 300 mL each of potting soil, local soil, and sand Water
Dry soil investigation	For a group of 4 students: 2 hand lenses 1 tsp each of potting soil and local soil 2 pencils
Soil and air space	For a group of 4 students: 3 clear, 50-mL test tubes 30 mL each of potting soil, local soil, and sand 120 mL of water 1 ruler 1 glass marking pencil
Soil and water	For a group of 4 students: 3 clear or translucent, 100-mL graduated cylinders 120 mL each of potting soil, local soil, and sand 120 mL of water 1 glass marking pencil

Preparation

Teacher note

Try to obtain coarse sand such as that used for home improvement products. Clean, fine sand may not allow water to pass as readily as most sands found in soils. The preparations described in this section can be carried out by students if desired.

Soil separation. In Step 6, students are asked to observe three different soil types (potting soil, local soil, and sand) that have been mixed with water and allowed to settle. For this demonstration, clear plastic, 350-mL bottles work well. Fill each bottle about $^{2}/_{3}$ full of soil. Place potting soil, local soil, and sand in separate bottles. Add water to near the top of each bottle. Place caps on the bottles, shake the contents well, and place the bottles in a location where they will not be disturbed. Prepare at least one day before making observations.

Group 1: Dry Soil Investigation. Make available potting soil and local soil, enough to be contained in the centre circle of Master 2.1, *Dry Soil Investigation* (about 1 tsp for each group of 4 students). Also have hand lenses available.

Group 2: Soil and Air Space. Make available three clear test tubes that can hold 50 mL. If these are not available, you can use graduated cylinders. Make available at least 30 mL each of potting soil, local soil, and sand. Also have available a ruler and a container that holds at least 120 mL of water.

Group 3: Soil and Water. Make available three 100-mL graduated cylinders that are clear or translucent. Make available at least 120 mL each of potting soil, local soil, and sand. Also have available a container that holds at least 120 mL of water.

a

b

Figure 2.2.
a. Soil separation after sitting for one day
b. Organic material floats on the surface of the water

Procedure

Activity 1: Properties of Soils

Teacher note

Be careful when moving the three bottles with the soils settled in water (Step 6). Excessive movement will cause the soil layers to mix together. Try to keep the bottles undisturbed so that later classes can view them.

Tip from the field test

The activities in this lesson vary with regard to complexity. You may consider assigning students to groups based on their interests and abilities.

1. **Remind students that in the previous lesson they investigated essential plant nutrients that are found in soils. Ask, "Aside from essential elements, what else do you find in soils?" Write students' responses on the board or on an overhead transparency.**

   At this time, accept all answers. Student responses may include rocks, sand, clay, insects, worms, bacteria, bits of wood, and water. If necessary, point out that these materials contain many of the essential elements.

2. **Ask students, "How would you categorize the components of soil?"**

   Student responses will vary. Guide the discussion to bring out the fact that soil consists of nonliving inorganic material such as clay, silt, and sand as well as living and nonliving organic material such as dead plant material, bacteria, insects, and worms.

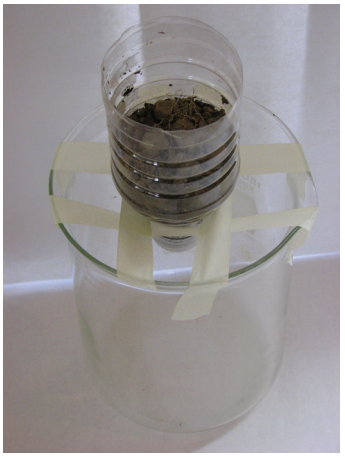


Figure 2.3.
Setup for the soil and charge investigation.

By the end of Grade 7, students will:

- describe the roles and interactions of producers, consumers, and decomposers within an ecosystem (*e.g., Plants are producers in ponds. They take energy from the sun and produce food, oxygen, and shelter for the other pond life. Black bears are consumers in forests. They eat fruits, berries, and other consumers. By eating other consumers, they help to keep a balance in the forest community. Bacteria and fungi are decomposers. They help to maintain healthy soil by breaking down organic materials such as manure, bone, spider silk, and bark. Earthworms then ingest the decaying matter, take needed nutrients from it, and return those nutrients to the soil through their castings.*).

3. **Ask students, "How does soil help plants to grow?" Write student responses on the board.**

   Student responses will vary. Guide the discussion to bring out the following:

   - Soils provide support for plants' root systems.
   - Soils provide essential nutrients.
   - Soils hold water and make it accessible to plants.

4. **Ask students, "Can healthy soil support the growth of crop plants forever, or does it ever go 'bad'?"**

   Student answers will vary. If not mentioned by a student, guide the discussion to bring out the fact that soils are like a "nutrient bank" and that crop plants growing in them make constant "withdrawals." Over time, the nutrients in a soil become depleted because the nutrients are removed from the ecosystem in the harvest. These nutrients must somehow be replenished (such as through the application of fertilizers) if the soil is to regain its ability to support healthy crop growth. Explain that plants growing in forests, wetlands and other non-agriculture ecosystems return their nutrients to the soil where they are recycled by soil organisms and reused by plants. In agricultural systems, soil nutrient retention may be promoted by planting cover crops or utilizing no-till systems that return plant matter to the soil.

5. **Explain that a healthy soil can take hundreds of years to form and it is a precious natural resource. Ask students, "What happens to the environment when an agricultural soil loses its ability to support crops grown by farmers?"**

   Student responses will vary. Students may respond that when a soil stops supporting crop plant growth, farmers will have to clear additional land to grow their crops. You may point out that this is happening in some agricultural soils that formerly supported rain forests. Here, farmers grow food on land until they deplete it of nutrients. They must then clear additional land for their crops. Lack of plant growth increases the rate at which erosion takes place. Over time, such erosion can produce desert areas. Students may have heard of the dust bowl that was created in the North American plains during the 1930s. Drought conditions killed the crops and, without either the crop plants or the natural prairie vegetation that farming replaced to hold the soil together, the topsoil was blown away by high winds.

By the end of Grade 7, students should:

- explain why an ecosystem is limited in the number of living things (*e.g., plants and animals, including humans*) that it can support.
- describe ways in which human activities and technologies alter balances and interactions in the environment (*e.g., clear-cutting a forest, overusing motorized water vehicles, managing wolf-killings in Yukon*).

6. **Show the class the bottles of potting soil, local soil, and sand that were previously mixed with water and allowed to settle. Explain how they were prepared. Ask students to gather around the bottles and make observations about the different soils.**

   Students will observe that the different soils separate differently. At this point, students will not know what is found in each layer. They should record their observations and refer back to them later in the lesson.

   - The potting soil will show a thick layer of dark material on the bottom, a thick layer of cloudy water, and a thinner layer of organic material on the top.

- Local soils may differ, but a typical soil will show layering similar to potting soil, though there may be less organic material floating on the surface.
- Most of the sand will form a very thick layer on the bottom of the container. There will be a thick layer of clear water and a very thin layer of material on the surface.

7. **Remind students that soils contain both organic and inorganic material. Ask, "Can you identify the organic material in each container?""**

   Responses will vary. If necessary, explain that the organic material is less dense than the inorganic material and floats on the surface of the water.

8. **Explain to students that the cloudiness in the water comes from inorganic particles called clay that are so small that they can remain suspended in the water. Point out that most of the nutrients in the soil are found in the organic material and the clay.**

9. **Ask students, "Do all soils support the growth of plants equally well?"**

   Most students will recognize that since soils differ in their amounts of organic material and clay, they will vary in their ability to support plant growth.

10. **Explain that they are now going to investigate some other properties of soils that affect plant growth. Divide the class into groups of 4 students and direct them to their work areas.**

    Student groups will explore three different aspects of soil. Depending on the size of your class, there will be two or three student groups assigned to each of the three different activities. Therefore, you will need to set up multiple lab stations:

    - Group 1: Dry soil investigation.
    - Group 2: Soil and air space.
    - Group 3: Soil and water.

11. **Pass out the appropriate masters to the groups as follows:**

    - **Group 1:** **Master 2.1, *Dry Soil Investigation* (1 copy per student in group)**
      Master 2.2, *Graphic Organizer* (2 copies per group)
    - **Group 2:** **Master 2.3, *Soil and Air Space* (1 copy per student in group)**
    - **Group 3:** **Master 2.4, *Soil and Water* (1 copy per student in group)**

12. **Instruct students to follow the directions on their handouts, record their observations, and answer any questions.**

    Give students approximately 15 minutes to complete their investigations.

    Collect students' answers to the questions posed on Masters 2.1, *Dry Soil Investigation*, 2.3, *Soil and Air Space*, and 2.4, *Soil and Water.*

Answers to discussion questions:

Group 1, Dry Soil Investigation

1. In what ways are the two soil types similar? How are they different?

   Potting soil and local soil are similar in that they both contain organic and inorganic materials. Organic materials come from plant and animal sources as well as from bacteria and other microorganisms too small to be seen without a microscope. Both soils also contain inorganic particles that vary in size. The two soils differ in the relative amounts of organic and inorganic materials. Often, the potting soil will have more organic material than the local soil. The local soil often contains small pebbles and rocks not found in the potting soil.

2. Can you tell by visual inspection how well a soil will support plant growth? Why or why not?

   Generally, we cannot tell how well a soil will support plant growth by visual inspection alone. Although we may be able to see organic material and clay that help support plant growth, it is not possible to see how many of the essential nutrients are present or in what concentration they are found.

Group 2, Soil and Air Space

1. Why did the final water level differ among the three types of soil?

   The different soil types contained varying amounts of air space within them. The potting soil has about 50 percent air space, while the sand has much less. The local soil most likely has less air space than the potting soil, but more than the sand. As water enters the soil, it occupies the spaces previously taken up by air. This means that the more air space in the soil, the more water is taken up, and the lower the observed water level.

2. Why is it important for plant growth that soils contain air space?

   The air space provides room for the soil to hold water and dissolved nutrients needed by the plant. The air also provides oxygen, which is needed by the roots of all plants and most (but not all!) microorganisms that live in the soil.

Group 3, Soil and Water

1. Infiltration refers to the ability of soil to accept water. Which of the soils you tested accepted the most water?

   The potting soil and sand likely accepted the most water, with the local soil accepting a lesser amount.

2. Percolation refers to the ability of soil to transmit water throughout its depth. Which of the soils you tested allowed for the fastest water movement? Which allowed water to reach the greatest depth?

   Water should have been transmitted most quickly through the potting soil. Sand is expected to transmit water most slowly, while the local soil transmits water at a rate between that of the potting soil and the sand.

13. After the groups complete their investigations, reconvene the class and ask each group to take turns reporting their results.

Student reports will vary. For each type of investigation, summarize the results on the board or an overhead transparency. As necessary, ask guided questions to bring out the following:

- **Group 1: Dry Soil Investigation:**

  o Soils differ in their composition.

  o Soils contain organic and inorganic particles of varying size.

  o Soils contain microorganisms that cannot be seen but are critical to plant growth. (Remind students about how plants use nitrogen—discussed in Lesson 1.)

  o Visual inspection cannot fully evaluate the nutrient content of soils.

- **Group 2: Soil and Air Space:** As water was slowly added to the soil samples, students should have noted that both the potting soil and the local soil produced air bubbles that rose to the surface. Few or no air bubbles would be seen when water was added to sand. After the water was allowed to percolate into the potting soil, students should have observed that the final water level was approximately halfway between the surface of the soil and the line drawn on the test tube. This means that the potting soil contained about 50 percent air space. The local soil also would contain a significant amount of air space, though it may be less than the potting soil. The sand would display only a small amount of air space, depending on the grain size. Make sure to bring out the following points**:**

  o Soils differ in the amounts of air space that they contain.

  o Average soils that support crops consist of nearly 50 percent air space. An astute student may recognize that wetland rice is an important exception to this general rule.

  o The air space in soil can be occupied by either air or water.

  o Soils need both air space and water to support a plant's root system.

  o Plant roots absorb nutrients from the soil water.

- **Group 3: Soil and Water:** As water was slowly added to the potting soil, students should have noted that water was immediately taken up by the soil and that some water reached the bottom of the graduated cylinder in less than 1 minute. The results with local soil would vary, depending on its composition. Most soils would accept the water less quickly than the potting soil, and the rate at which the water percolates through the soil would be somewhat slower. The sand will accept the water almost as potting soil. Make sure that students recognize that differences in soil texture mean that soils differ in their ability to accept water (infiltration) and transmit it (percolation).

14. **Conclude the lesson by asking students to list properties of soils that are important to support plant growth.**

    Write the list on the board or on an overhead transparency. Students should mention the following:

    - The soil is firm enough to support the plant's root system.
    - The soil contains the essential plant nutrients.
    - The soil contains adequate amounts of organic material and clay.
    - The soil contains about 50 percent air space.
    - The soil allows water to infiltrate and percolate through it.

15. **Explain that in the next lesson they will investigate how nutrients are absorbed and distributed throughout the plant.**

Optional Homework Assignment 1

Ask students to write a short paper that describes how scientists use the soil triangle to classify different types of soils.

Provide students with relevant information from the *Teacher Background* section.

Optional Homework Assignment 2

Instruct students to work with a parent or guardian to obtain a soil sample from near where they live. They can use the phone book or the Web to find an address for the provincial department of agriculture or local agricultural extension department that conducts soil testing.

Students should send in their soil samples for analysis to assess the quality and to see if any essential nutrients are lacking. You can collect the soil analyses obtained by different students and see if there are any differences according to location.

Private soil testing laboratories will usually be willing to provide discounts for soil analyses for use in projects by students for educational purposes. These types of results can be used effectively as a long-term and or science fair project.

M = Involves copying a master

Lesson 2 Organizer

Activity 1: *Properties of Soils*

What the Teacher Does	Procedure Reference
Remind students of their previous work on essential elements. Ask students: ■ "Aside from essential elements, what else do you find in soil?" ■ "How would you categorize the components of soil?" ■ "How does soil help plants grow?" ■ "Can fertile soil support the growth of crop plants forever, or does it ever go 'bad'?"	Page 69-70 Step 1-4
Explain that healthy soil is a precious natural resource. ■ Ask, "What happens to the environment when soil loses its ability to support crops grown by farmers?"	Page 70 Steps 5
Show the class the bottles of different soils that were mixed with water and allowed to settle. ■ Explain how they were prepared. ■ Have students gather around the bottles and make observations.	Page 70 Step 6
Remind students that soil contains both organic and inorganic material. ■ Ask, "Can you identify the organic material in each container?"	Page 71 Step 7
Explain that the water is cloudy due to tiny particles of clay suspended in it. Point out that most of the nutrients in soil are found in the organic material and attached to the clay particles.	Page 71 Step 8
Ask students, "Do all soils support the growth of plants equally well?"	Page 71 Step 9
Explain that they will investigate some other properties of soils that affect plant growth. Divide the class into groups of 4 and direct them to their work areas.	Page 71 Step 10
Pass out masters to groups as follows: ■ Group 1: Master 2.1, *Dry Soil Investigation* and Master 2.2, *Graphic Organizer* ■ Group 2: Master 2.3, *Soil and Air Space* ■ Group 3: Master 2.4, *Soil and Water*	Page 71 Step 11 M
Instruct students to follow the directions on their handouts. They should record their observations and answer any questions.	Page 71 Step 12
After students complete their investigations, reconvene the class and ask each group to report their results.	Page 72-73 Step 13
Conclude the lesson by asking students to list properties of soils that are important to support plant growth.	Page 73 Step 14
Explain that in the next lesson, they will investigate how nutrients are absorbed and distributed throughout the plant.	Page 73 Step 15

Master 2.1, *Dry Soil Investigation*

Name _____

Date _____

Procedure

Step 1. Place 1 teaspoon (tsp) of potting soil in the centre circle of one copy of the graphic organizer and 1 tsp of local soil in the centre circle of the other copy of the graphic organizer.

Step 2. Use a hand lens and a pencil to sort the soil components into the categories listed on the graphic organizer.

Step 3. Once both soil samples have been separated into their components, compare the results for the two types of soils.

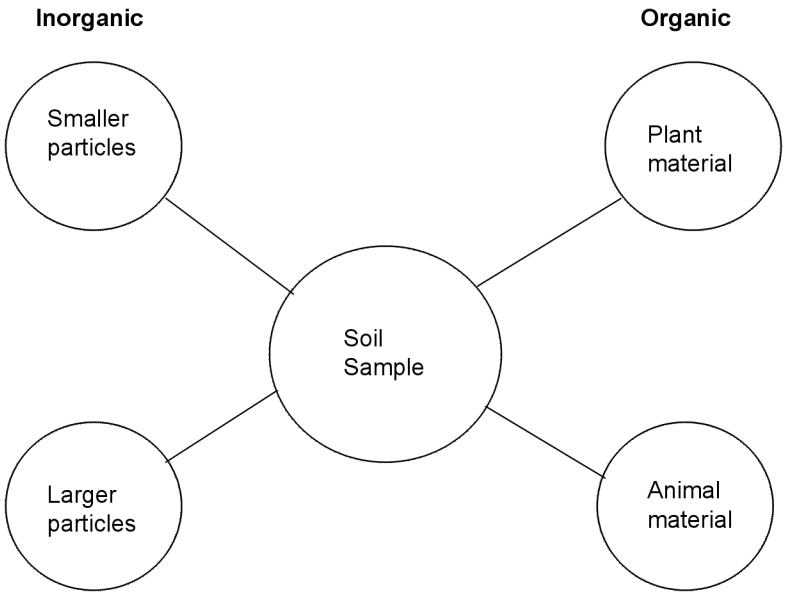
Discussion Questions

1. In what ways are the two soil types similar? How are they different?

2. Can you tell by visual inspection how well a soil will support plant growth? Why or why not?

Name _____

Date _____


Inorganic
Organic
Smaller particles
Plant material
Soil Sample
Larger particles
Animal material

Name
Date

Procedure

Step 1. Use the glass marking pencil to label three 50-mL test tubes "potting soil," "local soil," and "sand."

Step 2. Place 20 mL of the appropriate soil into each test tube.

Step 3. Use a ruler to measure the height of the soil in the test tube. Make a mark near the top of the test tube at a position twice the height of the soil.

Step 4. Slowly add 20 mL of water to the tube containing the potting soil. Record your observations in the following table. Repeat, adding 20 mL of water to the tubes containing local soil and sand.

Soil Type	Observations
Potting soil	
Local soil	
Sand	

Discussion questions

1. Why did the final water level differ among the three types of soil?

2. Why is it important for plant growth that soils contain air space?

Name _____

Date _____

Procedure

Step 1. Label three 100-mL graduated cylinders "potting soil," "local soil," and "sand."

Step 2. Place 80 mL of the appropriate soil into each graduated cylinder.

Step 3. Slowly add 20 mL of water to the graduated cylinder containing the potting soil. Record your observations in the following table. Note how long it takes water to move through the soil. Repeat, adding 20 mL of water to the cylinders containing local soil and sand.

Soil Type	Observations
Potting soil	
Local soil	
Sand	

Discussion questions

1. Infiltration refers to the ability of soil to accept water. Which of the soils you tested accepted the most water?

2. Percolation refers to the ability of soil to transmit water throughout its depth. Which of the soils you tested allowed for the fastest water movement? Which allowed water to reach the greatest depth?