Overview

This file includes lesson plans for three hands-on soil inquiries, written by Special Education teacher Taylah Hawks to better serve high school students with learning challenges. Ms. Hawks has framed the lessons according to the Next Generation 5-Es of Science Model. Because of their hands-on nature, the lessons can be adapted to other student populations. Teachers are free to further adapt the lessons and student handouts for the students.

Included:

- Soil Components: Hands on Healthy Soil
- Soil Components: It's Not Just Dirt
- Soil Percolation

Overview

While providing hands-on inquiry into soil composition and structure, this lesson initiates the consideration of the importance of soil in society and its relation to water quality. Students work in small groups to observe and record characteristics and components of soil samples. They share their findings through class discussion. A follow-up video (or Score Four PowerPoint) provides the scientific definitions and explanations for soil components, after which students match the terms to their class's observations. The Engagement and Exploration can be done outside or inside.

Next Generation Science Standards:

HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

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

HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.*

Learning Levels: Special Education, grades 9-12.

Lesson Time: 90 minutes

Student Objectives

- Consider how soil is used in society and its environmental roles.
- Observe the composition and structure of healthy soil.
- Learn scientific terms for what is observed:
  - Pores: spaces between soil particles
  - Aggregates: lumps of soil
  - Organic matter: bits of decaying and live plant material, worms and other organisms
  - Stones: inorganic matter.

Materials

- 1 shovel of healthy soil for each group (3-4 students)
  - Not all soil is "healthy." Samples of healthy soil can be dug from an area where plants (especially native ones) are well established, the ground has good drainage, and the soil has not been tilled or compacted. Places to obtain such samples include meadows, woods, and flower gardens. (See box at the end of the lesson for more tips on soil samples).
- Aluminum pans or newspaper for each group
- Magnifying glasses for each group
- Ruler (optional)
- Forks or other tools to break up the soil samples
- Notepaper

Engagement (5-10 minutes)

The teacher prompts students to take 5-10 minutes to address the two questions below (present and read aloud):

1. Write down four places that have any type of soil (clay, sand, silt, loam).
   Possible answers: beach, forest, farm, desert, park, garden
2. Explain on notepaper why the soil at each place is important.
   Possible answers: habitat, support for animals, support for trees, infiltration of water, nutrition and medium for growing plants

The class discusses answers briefly.

Exploration (40 minutes)

In small groups the students observe a healthy soil sample. As a team, they list what they observe about the structure, composition (including living organisms), color, smell, and texture on notepaper.

Alternative Approach

Teacher may prompt students with questions shown on the board and said verbally.

1. What is in the soil?
2. What do you notice about the soil structure? Is it loose particles or in clumps?
3. How does it feel?
4. Is it dry or wet?
5. Is there a smell?
6. What color is the soil?

Allocate time to clean up: put soil samples in one large container, gather forks and aluminum pans, and wash hands.

Explanation (20 minutes)

List the findings on the board and discuss them as a class:

- Possible answers: living organisms (insects, worms), worm tunnels, holes (pores) in the soil, white "threads" (fungus), plant roots, decaying leaves or wood, small pebbles, clumps of soil, as well as loose grains, fresh or woodsy smell, moist or dry, color.

The teacher puts on a video, *Composition of Soil- https://www.youtube.com/watch?v=QOU_h_OEf4E* or delivers the Score Four Soil Basics presentation (slides 1-6). Both media discuss these terms and concepts:

- Space: pores
- Lumps: aggregates
- Bits of decaying and live plant material (organic matter)
- Worms and other organisms (organic matter)
- Inorganic matter (something that has not been or is not living).

During the video/presentation, teachers encourage students to write definitions of targeted terms and concepts on note paper. Briefly discuss the definitions to make sure the students have a good understanding.

Elaboration (10 minutes)

The teacher has students categorize their initial list of observations in one of following categories: Decaying Organic Matter, Non-decaying Organic Matter, and Inorganic Matter. The students will write their responses on notepaper. (If better suited for your students, the class can attach category labels to a class list of observations on the board.) Possible answers are listed below:

Decaying Organic Matter	*Non-decaying Organic Matter*	*Inorganic Matter*
Bits of leaves	Insects	Pebbles
Wood	Roots	Sand Particles

Evaluation (10 minutes)

The teacher instructs the students to answer two of the following questions (presented and said verbally):

1. How could removing trees and vegetation from land change the soil?
2. How could running trucks or other equipment over ground change the soil characteristics?
3. How could a person improve soil to be healthy?
4. How do you think your school soil would compare to theses samples of "healthy soil?" Why?

Collecting Samples of Healthy Soil

Healthy soil has components that include and support life. For purposes of illustration, the class samples should have many of the following characteristics:

- Contain worms, worm tunnels, & arthropods
- Have an earthy, not offensive, smell
- Be easy to dig into (not compacted or hard)
- Have good permeability (Water seeps into and through it, rather than stagnating.)
- Include lumps of soil (aggregates)
- Include white threads of soil fungus
- Include decaying organic matter, such as leaf particles
- Include inorganic matter, such as small stones.

How & Where to Obtain:

- The samples should include the top four inches of soil from an area with plant roots.
- They should not be sifted or broken up intentionally.
- Moist soil samples work better than dry or wet soil for this initial observation. One could have samples of varying degrees of moisture for observation sake.
- Possible locations for good soil samples:
  - Gardens where the ground is not tilled and is protected by natural mulch
  - Woods or meadows
  - Under compost piles.

Overview

This lesson, designed to follow the "Hands On Healthy Soil" inquiry, allows students to investigate the characteristics of different soil types. Students gain a greater understanding of soil composition and structure through hands-on observations of soil samples and class discussions. Students will use their new knowledge to make predictions on the uses of different soil types and how they play a role in plant growth and water infiltration. They will work in small groups either outside or inside.

Objectives

- Define the following terms: *mineral, particle, textures, infiltration.*
- Investigate the characteristics of sand, silt, and clay to determine the composition of the school soil sample.
- Predict how these characteristics improve or limit plant growth and reduce stormwater runoff.

Materials

— Soil samples: sand, silt, clay, school soil
— Container(s) of soil samples for each team, containing enough soil to fill each student's palm
— Paper Towels
— Spray bottle or dropper for each team
— Spoons for each team
— Notepaper or Score Four Student Handout

Lesson Time: 155 minutes. As written, it occurs over two 90-minute classes.

Next Generation Science Standards:

HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

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

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

HS-ESS3-4.

Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

Learning Levels: Special Education Recommendations for grades 9-12.

CLASS 1

Engagement (10-15 minutes)

The teacher prompts students to take 10-15 minutes to define and draw examples of the following terms: *infiltration, mineral, particle of sand, silt, clay, and texture* as they relate to soil. (Teacher presents and reads aloud.)

- Infiltration – process of a liquid filtering or soaking into something.
- Mineral - a solid inorganic substance of natural occurrence.
- Particle - a small localized object to which can be ascribed several physical or chemical properties.
- Texture - the feel, appearance, or consistency of a surface or a substance.

Exploration (40 minutes):

The teacher directs this activity. In small groups of 3 or 4 (one soil sample per station), each student observes a soil sample of either sand, silt, clay, or school soil, using the procedure on the Student Handout: It's Not Just Dirt. Allocate 8 minutes for the groups to complete the investigation for one sample; then students rotate to stations with the other soil types until each mineral has been observed.

Post a timer for students to keep track of their time. The observations are to be recorded on the student worksheet.

Alternative Approach: Students with higher organizational skills can complete the investigation for all minerals at one station using the student handout.

Allocate time to clean up: put soil samples in one large container, gather spoons and containers, and wash hands.

Explanation (20 minutes)

Discuss the possible answers as a class. Some minerals feel different to the touch when they are dry versus wet. Below is an example answer sheet for teachers, but it is recommended that teachers do the feel test for the different samples prior to the class.

TEXTURE INVESTIGATION answer sheet				
Using soil samples, answer the following questions by writing yes or no.	Sand	Clay	Silt	School Soil
Can you form a ball?	Y	Y	Y	Y
Does it stay a ball when squeezed?	N	Y	N	Y
Can you for a ball and then roll the ball into a snake?	N	Y	N	Y
Can you form a ring with the snake shape?	N	Y	N	N
Does you sample feel gritty?	Y	N	N	Y
Does your sample feel like flour or powder?	N	N	Y	N
Does your sample feel sticky?	N	Y	N	N
What color is the sample?	Beige	Red	Gray	Brown

Elaboration and Evaluation (10 minutes)

The teacher instructs the students to answer the questions below (presented and said verbally):

1. Explain two key characteristics for each: sand, clay, and silt.
2. What would you classify your school soil as? Explain 3 characteristics that support your thinking.

Note to teachers: the soil likely will be a mixture, such as clayey sand.

CLASS TWO

Engagement: Think-Pair-Share (10-15 minutes)

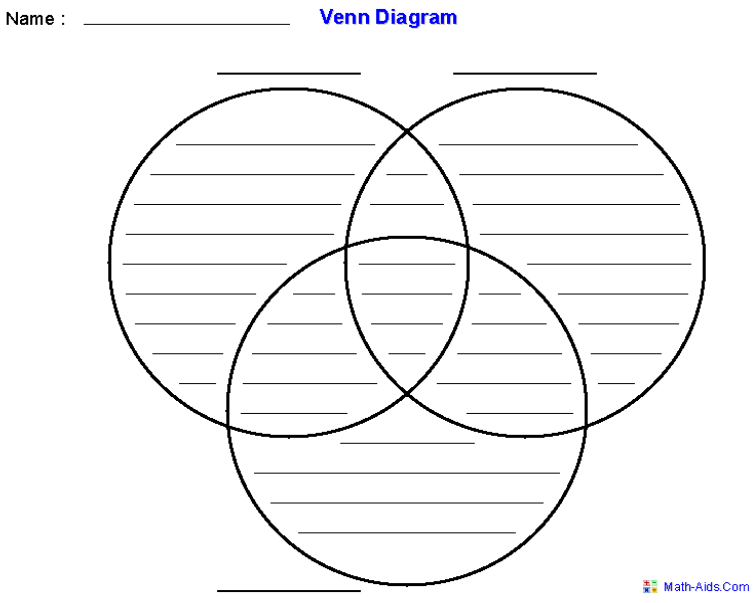
The teacher prompts each student to write down 3 observations and 3 inferences about the following picture.

Photo credit: https://www.montclareschool.org/wp-content/uploads/2017/04/seed-growing.jpg

After the students write their observations and inferences, they form pairs and write down two of their partner's notes that are different from their own. At the end of the activity, each student will have 8 notes to be shared in a brief class discussion.

Explanation (20 minutes)

Using the data from the Texture Investigation, the teacher directs and assists students to create a three-part Venn diagram comparing and contrasting the characteristics of the types of soil-clay, sand, silt.



Elaboration (30 minutes)

The teacher prompts students to make eight predictions on which characteristics in the Venn diagram would or would not lead to plant growth or water infiltration. The student's predictions should include explanations for each soil type. The teacher may provide sentence starters for students to model their thinking. "The capacity of (_____select soil type___) to (___select characteristic___) shows that it can support plant growth by…"

Show students the following example:

The capacity of clay to be formed into a ball and ring shows that it may support plant growth by holding plant roots in the ground.

Possible answers:

- The capacity of clay to be formed into a ball and ring shows that it may have poor water infiltration by having a close to solid form with tiny pores.
- The capacity of sand to not stay in a ball shape shows that it may have good water infiltration by having large pores and a loose form.
- The capacity of silt to be formed into a ball but not a ring shows that it may have good water infiltration by having loose form with large pores.

Evaluation

Teacher provides feedback to the students' predictions.

Overview

In this lesson students work in small groups to investigate the percolation properties of different soils. For best results, this lesson should follow the Score Four "Hands on Healthy Soil," and It's Not Just Dirt" inquiries.

Through observation, a lab, and class discussions, students will gain a greater understanding of mineral shapes and sizes and how these factors affect the movement of water through the soil. In addition, the students analyze how different soils may influence erosion, flooding, high percolation, and pollutant removal. Using their understanding of soils, they consider solutions to such issues as erosion, flooding, and water and air pollution.

Objectives

- Observe the difference in particle size in soil types.
- Investigate the percolation properties of soil types.
- Learn scientific terms to develop solutions for problems of erosion, flooding, and infiltration based on soil type.

Materials (each group of students)

- Water
- 1 timer
- 1 clear 2-liter bottle top for each soil sample
- 1 clear 2-liter bottom for each soil sample
- 1 piece of window screen for each soil sample
- Soil samples: sand, clay, school soil, silt, and loam.
- Notepaper

Lesson Time: 110 minutes

Preparation

- Prepare and practice the Engagement Demonstration.
- Prepare the lab materials and practice the setup and procedure before class.
- Review and print (or adapt) the student handout containing the lab procedure.

Teachers have found it helpful to show students a complete demonstration set of percolation bottles (clay, sand, silt, loam, school soil) prior to the lab, so that students can more easily emulate the inquiry.

Next Generation Science Standards:

HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

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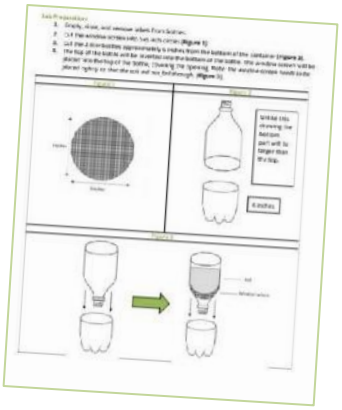
Learning Levels: Special Education Recommendations for grades 9-12.



Lab directions are on the last page.

Engagement (15-20 minutes)

The teacher gives a demonstration to help students envision how the shape and size of soil particles relate to pore space. The teacher sets up three beakers (at least 200 mL) containing one of the following: medium round rocks; small round rocks; and raw, flat, shelled sunflower seeds. These represent sand, silt, and clay, respectively. Water is added to each beaker until it reaches the top of the contents. Each beaker is filled to the same level. Afterwards, students are asked (presented and said verbally):

1. Describe the shape and size of the representation for sand, silt, and clay.
2. What representation (or soil) has the largest pore space?
3. Which one has the smallest pore space?

Discuss the answers to questions 1-3 briefly before to moving to question 4.

4. The students will be instructed to predict the how water will flow through (percolate) in actual soil samples. The teacher first familiarizes them with the *Percolation Test Chart*, found in the Score Four Soil Percolation Student Handout. Students will answer the prediction questions on the Percolation Test Chart.

   Notes:

   - The Percolation Test Chart includes some new terms, such as loam, which are defined in the handouts.
   - It could be helpful to show the students a completed percolation set-up at this point.

Exploration: Percolation Lab (30-40 minutes)

The teacher puts the students into groups of four or five. Each student has a role in their group: reader, timer, measurer, pourer, and data recorder.

Options, dependent upon the organizational levels of the students:

- It can be beneficial to model the lab or lead the class through the directions the first time. Otherwise, students should follow procedure on the student handout.
- Each group can perform the lab for all soil types, or each group can complete the test for one soil type one or two times.
- Kool-Aid can be added to the water before the percolation test to represent pollution Students will see if the Kool-Aid is removed from the water as it infiltrates through the soil.

Allocate time to clean up: put soil samples in one large container, gather forks and aluminum pans, and wash hands.

Explanation (25 minutes)

The groups will share their data with the class. If possible, the data will be averaged. Class discussions include any problems with their procedure. Teachers give students time to answer the post-lab questions.

1. Which soil had the most water percolate?
2. Which had the least?
3. Which soil had the fastest percolation rate?
4. Which had the slowest?
5. Optional: Which soil held the most kool-aid dye?
6. Optional: Which held the least?

The teacher plays the video, *Water Movement in Soil-* *https://www.youtube.com/watch?v=vmo0FRAVgkM*. Students takes notes on the lesson's terms and concepts.

Elaboration (15 minutes)

The teacher asks students to create solutions to environmental problems that are impacted by soil type. Each student will read and answer the questions in detail. Student responses should be at least a paragraph long for each question.

1. An area on the school campus has flooded due to poor water infiltration due to the clayey soil there. Describe how this problem can be improved.

   Possible Answer: The flooding can be improved by planting species of native plants or trees that grow well in clay. The plants would use/absorb the water, and their roots would add pore space to the soil, enabling infiltration and percolation. The addition of organic matter in the soil could introduce more pore space and absorb more water. Some people suggest adding large amounts of sand to the clay to introduce more pore space. Some students might suggest a rain garden, but when an area is mostly clay, a rain garden would not be able to drain properly without replaced soil and piping.

2. The ground at the edge of the park has no grass on it, because people walk over the area. When it rains, the soil gets washed away. This is an example of erosion. Explain what soil and plants could improve this problem. What would happen if the problem does not get fixed?

   Possible Answer: Large shrubs could be planted in a way that blocks people from walking over the area. Adding compost to the soil would add organic matter, which absorbs water and provides nutrients for the plants. The area could be further protected with mulch, plants, grass, or a different ground cover. If these or other preventative measures are not taken, then the erosion will continue, and deep holes (rills) could form. The erosion adds sediment to the stormwater, which pollutes waterways.

3. A family lives by a recreational lake. They are concerned that their well water could become contaminated from an old septic tank that has not been maintained, particularly because the soil is mainly sand with some silt. There are a few plants growing in this area and mainly large trees. Describe how the family can prevent their well from possible contamination and why these steps are beneficial.

   Possible Answer: This challenging situation does not have a clear-cut answer. As leaky septic systems pose both health and pollution problems, the family could contact experts or the public health department if they suspect a failing septic system. The placement of the tank and the depth of their well are factors to consider. Planting trees might or might not improve the situation -- although tree roots absorb nutrients, they also can perforate the pipes in a septic field. Planting a wide buffer of large trees and native plants near the lake could reduce the nitrogen and bacteria entering the lake, but, most likely would not remove all the contaminants if a septic were to fail.

Lab Preparation

1. Empty, rinse, and remove labels from bottles.
2. Cut the window screen into 5x5 inch circles (**Figure 1**).
3. Cut the 2-liter bottles approximately 6 inches from the bottom of the container (**Figure 2**).
4. The top of the bottle will be inverted into the bottom of the bottle. The window screen will be placed into the top of the bottle, covering the opening. *Note: the window screen needs to be placed tightly so that the soil will not fall through.* (**Figure 3**).

Figure 1

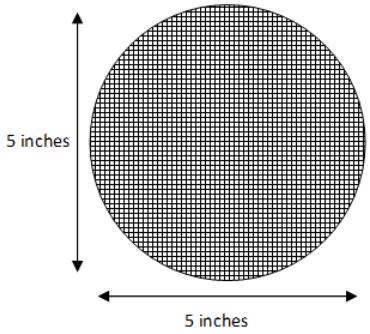
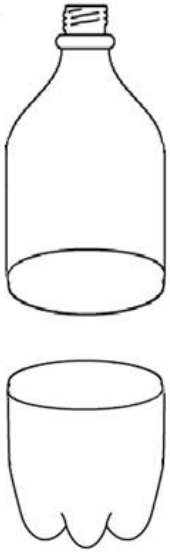


Figure 2



Unlike this drawing the bottom part will be larger than the top.

6 inches

Figure 3