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# K-12 Partnership Lesson Plan

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# *Does Size Matter?*

# *Investigating the physical properties of soil and their effects on plants*

## Overview

Soil properties can often dictate the types of plants that can live in a particular habitat. The composition of soil affects everything from the amount of water available, to the types of nutrients and minerals present, to a plant’s root structure and growth. This lesson will focus its investigation on the particle sizes of various soil types. During this lesson, participants will look at sand, silt, and clay particles under a microscope and use this information to estimate the proportion of these components within various soil samples they have collected. They will also test the permeability of their soil and relate this to its makeup and particle size. Finally, plant adaptations to live in various soil types will be discussed, and a case study will incorporate data interpretation from a plant species that is adapted to live on a unique soil type. This lesson not only addresses both Earth Science and Natural Science curricula, but it also incorporates inquiry based learning, microscope work, and data interpretation.

**Objectives**

At the conclusion of the lesson, students will be able to:

* Use a microscope
* Understand basic differences between sand, silt, and clay in soil samples they collect
* Understand how physical properties of soil affect its permeability
* Brainstorm adaptations that plants need to live in different soil environments

**Length of Lesson**

2 hours

**Grade Levels**

6-12

**Standards covered (NGSS)**

Disciplinary Core Ideas:

*Middle School*

* **MS-LS2-4**: construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations
* **MS-LS1-5**: construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms

High School

* **HS-ESS2-2:** analyze geosciences data to make the claim that one change to Earth’s surface can create feedbacks that cause changes to other Earth’s systems.

Cross Cutting Concepts:

* Patterns
* Scale, proportion, and quantity
* Structure and function

Science and Engineering Practices

* Asking questions and defining problems
* Planning and carrying out investigations
* Analyzing and interpreting data
* Using mathematics and computational thinking
* Engaging in argument from evidence

***Previous Michigan Standards Met:***

* **B1.1**: scientific inquiry
* **B2**.**L2.p3D**: explain how the roots of specific plants grow
* **B3**.**L3.p3**: factors influencing ecosystems
* **E2**.**E2.1**: Earth systems overview
* **E3.1**: advanced rock cycle

**Materials**

* Samples of sand, silt, and clay
* Microscopes
* Cups and shovels for collecting outside or soil samples the students bring from home
* Test tubes and test tube racks
* Beakers
* Funnels
* Coffee filters or filter paper
* 50 mL graduated cylinders

**Background**

Geological processes can contribute to biodiversity through their effects on the abiotic environment that species are exposed to. One of these effects is through soil type. Soils are created through the weathering of rocks and different rocks as well as different weathering processes (water, heat, chemical) can affect the size of soil particles.

All soils are made up of different combinations of sand, silt, and clay; and each has very different sized particles. The relative amounts of each of these components in a soil will affect how quickly water flows through it as well as the growth of plant roots within the substrate.

Plants exhibit a variety of adaptations to deal with different soil substrates. For example, soils with large particle sizes such as sand drain water faster than soils with small particle sizes. Therefore, plants that live in these environments must often be able to deal with drought conditions- either by having long root systems, or the ability to store water after a rainfall (cacti). Some sandy environments such as beaches are very prone to erosion because large particle sizes prevent soil compaction. Some plants, such as American Beachgrass have long root systems that help to hold onto the sand and prevent erosion.

Although soils that have very small particles sizes such as those high in clay do not allow water to drain as quickly, they present their own challenges. For example, these small particles can be compacted very easily, making it difficult for root growth. Some plants have adapted to these conditions by being able to grow very strong taproots.

In addition to particle size, the type of minerals present in the rocks also affects plant growth. Serpentine soil is a soil type that is common on the West coast of the U.S. It has a low water holding capacity relative to other soils and is also low in calcium and high in magnesium, both of which are detrimental to plant growth. Some plants have specialized to deal with these conditions, however. For my PhD dissertation, I study adaptation to serpentine soil by a plant that lives both on and off serpentine soil. I present data showing the relative water content from serpentine soil and sandstone soil (from areas located only ~100 m. away from each other) as well as data from a study I performed to test whether individuals growing on the different soil types are locally adapted to that soil type. It turns out, they are! Therefore, not only do geological processes contribute to differences in species found in different areas, they can even contribute to differences within a species between adjacent populations.

### Activities of the session

1. Before the lesson set out all supplies around the classroom
2. Introduce sand, silt and clay- their relative sizes and how they are formed
3. Discuss how soil is made up of these components as well as air, water and organic matter. Ask students how the relative amounts of these components affect how plants grow?
4. Allow students to observe these particles under a microscope and sketch what they see
5. Discuss what students observed under the microscopes
6. Have students go outside and collect soil samples of their own (or students can bring in soil samples they collected previously).
7. Students will look at their soil samples under a microscope and sketch what they see. Ask students if they can classify their soil type based on the estimated percentages of sand, silt, and clay using the classification triangle diagram
8. Students will then test the composition of their samples by putting a small amount of their soil in a test tube. They will add water, shake to homogenize, and then allow it to settle out. Students can go back and look at it at the end of class (or the following day) to see the relative amounts of each layer.
9. Students will conduct a soil permeability lab on their samples. Follow the instructions in the attached worksheet.
10. As a class, compile the permeabilities of each soil type and where each soil type was collected. Discuss why permeabilities are different and how that may have affected the plants that grow there.
11. Allow students to answer the questions on the attached worksheet and/or discuss as a class
12. Discuss various adaptations that plants have for living in different soil types (see attached PowerPoint for examples).
13. An optional case study can be discussed- plant adaptation to serpentine soil. Information is included in the PowerPoint. A research project was conducted to investigate adaptation to this soil type in the species *Leptosiphon parviflorus* (variable linanthus).
14. Students can work through the attached data nugget and interpret the graphs depicting the results
15. At the end of lesson (or the following day) look at test tubes. Measure the height of each layer (sand, silt, clay, and organic matter will all settle out at different layers due to their different densities). Have students compare the relative amounts of these components to their estimation in step 6. Would they change their classification of their soil type?

**Resources**

* “Soil Properties” powerpoint
* “Soil Properties” worksheet
* Data Nugget extension (all available on the “Does Size Matter?” lesson page on the KBS GK-12 website)

**Extensions and Modifications**

1. Have students bring their own samples from their backyard to test
2. Students can design an experiment to test the ideal amounts of sand, silt, and clay for growing a particular plant
3. An experiment can be set up for growing roots in different substrates
   1. Carrots will look different depending on the particle size of the soil they are grown in
   2. A clear container such as a fish tank can be angled to force roots to grow against the window. The roots of any plant can then be observed as they grow through different substrates

**Assessment**

Students can be assessed by their ability to answer the questions provided in the attached worksheet and data nugget