Properties of Soil

Objectives

- Students will learn about the makeup of soil and what it needs in order to be healthy and support plant life.

Skill Level: Middle School	**Class time:** 35 minutes for field study, 25 minutes for soil test

Materials

For soil test:

- 1 glass marking pencil
- 100-mL graduated cylinders
- 3 clear, 50-mL test tubes
- Potting soil and local soil samples from 2 locations
- 1 glass marking pencil
- Water
- 1 data sheet

For field study:

- 1 pencil
- 1 ruler
- 1 aluminum can
- 1 thermometer
- 1 yogurt container
- Water
- 1 data sheet (per group or student)

Next Generation Science Standards

Disciplinary Core Idea:
ESS2.C: The Roles of Water in Earth's Surface Processes

Performance Expectations:
MS-ESS-1 Develop a model to describe the cycling of Earth's material and the flow of energy that drives this process

Practices	**Crosscutting Concepts**
☐ Asking questions / defining problems	☐ Patterns
☒ Developing / using models	☐ Cause and effect: Mechanism / explanation
☒ Planning / carrying out investigations	☐ Scale, proportion, and quantity

☒ Analyzing / interpreting data	☒ Systems and system models
☐ Math / computational thinking	☐ Energy / matter: Flows, cycles, conservation
☐ Constructing explanations / design solutions	☒ Structure and function
☐ Engaging in argument from evidence	☐ Stability and change
☐ Obtaining / evaluate / communicate	

Background Information

Introduction:

The weathering of rock slowly produces soils. Constant exposure to wind and rain cause the rocky crust to slowly break down into smaller particles. It can take centuries to produce fertile topsoil. As rainwater seeps into cracks, temperature extremes cause the water to freeze. The rock expands, contracts, and fractures. These weathering actions are helped along by organisms that live on and in the soil.

Soil contains living and nonliving things including rocks, plants, and animals. Five to ten tons of animal life can live in an acre of soil. There are also bits of dead plants and animals in soil, which decompose and release nutrients into the soil. Earthworms digest organic matter, recycle nutrients, and make the surface soil richer. Plants use the nutrients of decomposed plants for another growth cycle in the soil.

Plants also absorb minerals from the soil, and many of these minerals come from rocks. Forest soil tends to be dark, damp, and to contain a lot of humus. Humus is a complex organic substance resulting from the breakdown of plant material in a process called humification. This process can occur naturally in soil, or in the production of compost. Humus is extremely important to the fertility of soils in both a physical and chemical sense. Humus-rich soil is able to hold plenty of water, and is also plentiful in nutrients. This allows the growth of a wide range of plants, and consequently supports different kinds of animals.

In contrast, sandy soil drains water. Sandy soil can be found in drier areas like deserts or in some areas near lakes or ponds. Sandy soil tends to be loose, dry, and light brown. There is less humus, and therefore fewer nutrients, in sandy soil than in forest soil. Clay soils usually contain a high percentage of mineral in the soil, often causing clay soil to be dark red in color. Clay soil also holds plenty of water and tends to be thick and heavy when wet. Certain kinds of plants, like certain species of grasses, sunflowers, and ironweed, can grow well in clay soil.

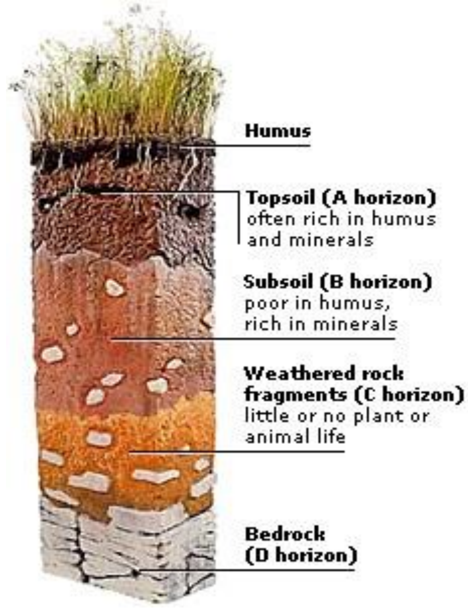

Figure 1. The composition of the different soil layers. Reference

The soil can be divided into three main layers: topsoil, subsoil, and bedrock. Topsoil contains the most humus, which is the dark part of the soil that is rich in nutrients. Under the topsoil are several layers that make up the subsoil. These layers tend to be sandier, and have less humus. Under the subsoil is bedrock, which is solid rock.

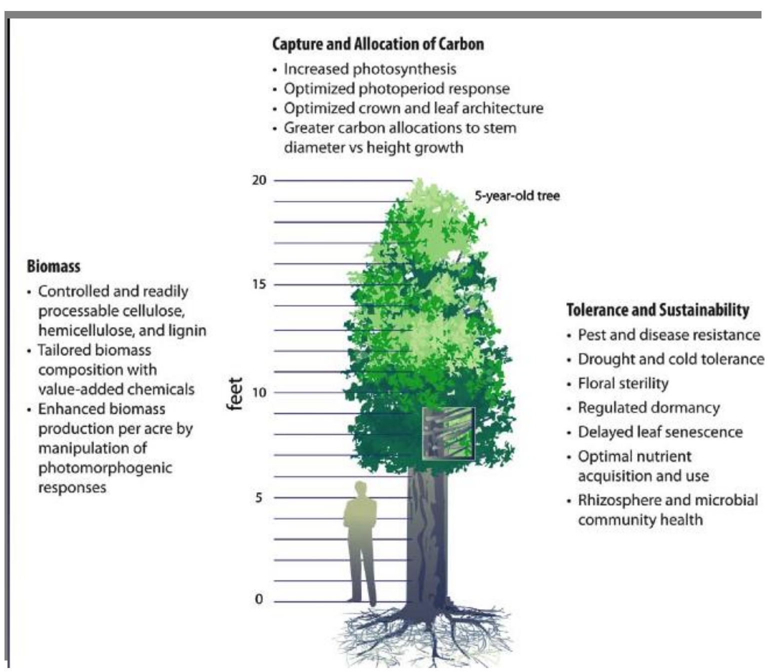

Figure 2. The many reasons that poplar trees make a good biofuel. Reference

Soils and soil conditions are a major point of interest for sustaining possible tree biofuels. Poplar trees are being tested to see if they are a practical renewable energy source. Popular trees can grow in most soil types and grow very fast. These trees are then converted into liquid energy for cars and planes. Poplars are also good biofuels because they require less water and chemical outputs when compared to corn. This is also beneficial because poplars do not have to compete with food crops for soil space. Having the right soil is essential to making this biofuel process possible.

Engage

Over time, the nutrients in a soil can become depleted if they are removed from the ecosystem in the harvest and not replenished. These nutrients must somehow be replenished if the soil is to regain its ability to support healthy crop growth. Plants growing in forests, wetlands and other non-agriculture ecosystems return their nutrients to the soil when they are recycled by soil organisms and reused by plants. In agricultural systems, soil nutrient retention may be promoted by planting cover crops (plants that enhance the soils by protecting, improving and providing nutrients but are not intended for harvest), utilizing no-till systems that return plant matter to the soil, or by applying fertilizers. Synthetic fertilizers add necessary nutrients to cropland, however, they fail to restore organic matter to the soil as manure does, and have been shown to adversely affect soil productivity. Regular use of synthetic fertilizers causes long-term depletion of organic matter, soil compaction and degradation of overall soil quality. Over-fertilization also causes important minerals such as calcium, magnesium and potassium to gradually leach out of the soil. When soil stops supporting crop plant growth, farmers will have to clear additional land to grow their crops. 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. An example of this is 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.

Explore

Experiment Questions:

- Which soil looks like it would best support life? Why?
- Which soil looks do you think has the most air? Which would hold the most water? How can you tell?

Procedure:

To start:

- Observe the 3 soil samples with a magnifying glass. What differences do you notice?

- Break the soil apart and look for organic and inorganic parts.

Soil Test

- Use the glass marking pencil to label three 100-milliliter (mL) test tubes "potting soil," "soil sample 1," and "soil sample 2."
- Place 20mL of the appropriate soil into each test tube. 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.
- Have students hypothesize which of the samples they expect the water to move through most quickly. Why?
- Slowly add 20mL of water to the tube containing the potting soil. Repeat, adding 20 mL of water to the tubes containing local soil samples. Note how long it takes water to move through the soil.
- Which of the soils you tested allowed for the fastest water movement? Which allowed water to reach the greatest depth? Record observations onto datasheet.

Field Study

Locate two sites where students will be able to investigate soil- preferably a "field" site and "forest" site. Have students use the following data sheet to record observations and conduct simple compaction and percolation tests. After all of the data has been collected have students discuss the soil differences between the two sites. Which site has healthier soil? Why? Which site would be better for plants to grow in?

Compaction

The compaction test measures how dense the soil is. When soil is very compact air and water cannot get into it. Ask students what can happen when soil gets too dry? It can erode. What can you learn by measuring the compaction of soil? You can learn about the soil's health and how much space is available for living things.

- Push the pointed end of a pencil into the soil as far as you can, using normal force.
- Mark the pencil at the soil level and pull it out of the soil.
- Using a ruler measure the distance from the marked spot to the pencil point and record.

Percolation

The percolation test also measures soil compaction by measuring the flow of water through the soil. Use a ruler to measure 3 cm from one end of the can, and then draw a line around the perimeter of the can using a permanent marker (this should already be done on existing cans).

- Push the can 3 cm into the soil, until it reaches the line encircling the can.
- Take a yogurt container filled with water and pour it into the can.
- Immediately start counting to measure how long it takes for the water to soak completely into the soil.

Explain

- How do you know if soil is healthy?
- Do all soils support the growth of plants equally well?
- Can you tell by visual inspection how well a soil will support plant growth? Why or why not?

Elaborate
• Can healthy soil support the growth of crop plants forever, or does it ever go 'bad'? • What happens to the environment when an agricultural soil loses its ability to support crops grown by farmers? • Why is it important for plant growth that soils contain air space? • What characteristics do you think the soil should have to support biofuel growth?

Resources

Additional Resources:

- Soil Science Society of America
- Hardwood Biofuels
- Soil Conditions for Poplar Trees

Resources Used:

- Underground Adventure
- Poplar for Biofuel