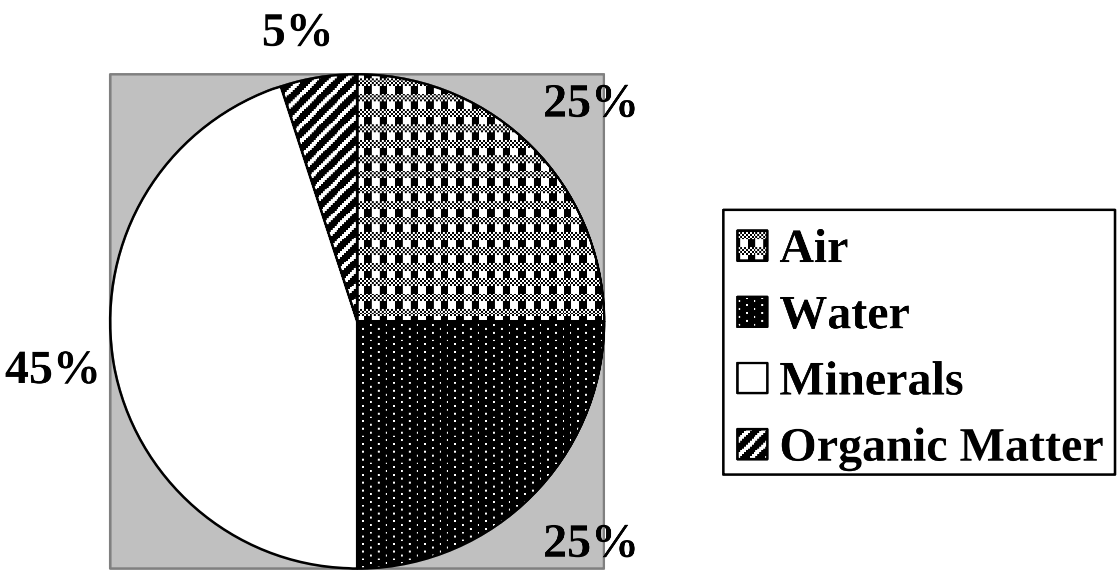
What is Soil?



Age: 8-10 years old (grades 3-4), but can be adapted for all youth 5-19 (grades K-12)

Objectives:

1. Members/students will be able to list the component of an average soil. They will be able to tell the difference between soil and dirt.
2. Members/students will predict whether a container with large rocks or small rocks can hold more water.
3. Members/students will generalize the relative size difference between sand, silt and clay particles by using objects such as a barrel, a plate and a coin.
4. Members/students will contrast the characteristics of soils with large particles with those with small particle sizes in terms of pore space availability and runoff potential.

Preparation:

Pore Spaces Activity
Materials Needed:

- Rocks, marbles, etc. – should be similar in shape and be grouped into two noticeably different sizes.
  - Ornamental rocks in different sizes can be purchased from large department or craft stores. See picture.

- Narrow straight-sided containers – 2
    - Narrow “bud vases” from department stores, craft stores, or florists are a good option. See picture.
- Graduated cylinder or other liquid measure instrument with small increments (a mark every 10 mL, approximately)
    - A baby bottle is a low-cost option. See picture.
- Water
- Eye dropper (optional)
- Note: Directions for the activity will follow in the “Content” portion of this lesson, but you may wish to test this experiment prior to teaching so you know what student results/responses you can expect.

Interest Approach:

Has your Mom or Dad ever scolded you for tracking dirt into the house? Have you ever planted flower, vegetables, or other plants outside in the soil? The dirt on your shoes and the soil in your garden are very much alike with one key difference. The garden soil is providing a place for roots to grow and contains necessary plant nutrients and holds water. The dirt on your shoes could do the same thing in larger quantities – it’s just out of place!

Today we learn what the term soil means and includes. We will discover that soil contains three different particle sizes and we will complete a simple science experiment to see the impact of soil particle size on soil composition.

Content:

- Soil has 4 main parts – minerals, air, water and organic matter. An "average" soil is approximately half (50%) solid material. The other half (50%) is air and water. A key reason soil should be called soil instead of dirt is the inclusion of air and water in the definition of soil. Soil without air and water won't allow plants to grow or any other organisms to live.
- Soil is alive! Roughly 5% of soil is organic matter (actually closer to 2.0-3% in Anderson County, KS). Organic matter includes things that are alive or recently were. Old plant material in which you can no longer tell exactly what it is (or was) is organic matter. Soil also contains earthworms, insects, fungi, bacteria and other organisms. In fact, 1 teaspoon of soil contains more bacteria than there are people on Earth. Remember, not all bacteria and fungi are bad. In fact most are good as they break down old plant material to provide nutrients to the soil.
- 45% of soil is minerals. Soil minerals are broken down into 3 size groupings – sand, silt and clay. Sand is the biggest and clay is the smallest. Surprised? All individual soil minerals are very small and they like to stick together, especially clay. You would have to have a very strong microscope to see an individual clay particle. To give you an idea of the size differences, consider this comparison example:

Barrel	Plate	Coin
"Sand"	"Silt"	"Clay"

- 50% of soil is air and water combined. An "ideal" soil is approximately 25% air and 25% water, but the actual percentage varies based on weather conditions, etc. The space in soil where water and air "fit" in soil is called pore spaces. This picture shows where they are.

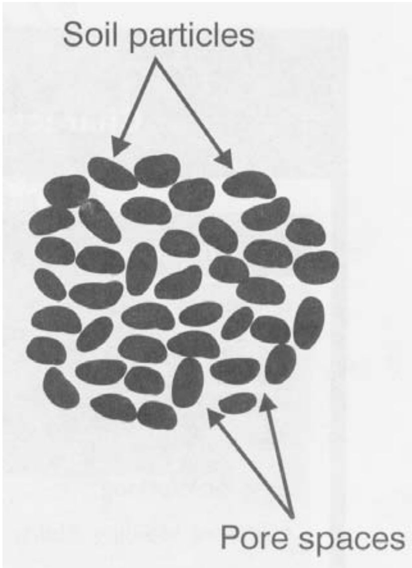


Figure (Biondo and Lee, 1997)

Pore Spaces Activity

1. Experience: Fill each container with the different sized rocks (marbles, etc). These rocks are like the minerals in a soil. One container is filled with large rocks to represent sand and one container is filled with small rocks to represent clay (or silt depending on size difference). Completely fill each container and try to level the surface. Note: You may want to select rocks that fit well together and pack reasonably tight for the large rocks. In real life the sides of the container wouldn't restrict the placement of soil particles. It would be possible to cut a soil particle in half when obtaining a volume of soil.
2. Share: Hypothesize (educated guess) which container will hold the most water when filled with rocks.
3. Accurately measure a volume of water. Start with 120 mL of water. Record this measurement. Carefully pour the water into one rock-filled container so not to spill. You will have to pour slowly into the small rock container. Keep filling until the water is at the container surface. You may even want to use an eye dropper to add the last amount of water. Replace any water left in the eye dropper (if used) in your measuring instrument. Accurately measure and record the volume of water remaining.
4. Refill your liquid measuring instrument to the same volume of water as before. Remember to do this as accurately as possible. Repeat procedure carefully pouring water into the other rock-filled container. Accurately measure and record the volume of water remaining.

5. Subtract the volume of water left from the start volume. For example, if the starting volume of water for the small rock container was 120 mL, and there is 30 mL of water remaining, I added 90 mL of water to the small rock container (120-30=90). Do this calculation for both the small and large rock containers.
6. Process: Compare your experimental results with your hypothesis. Do your results support your hypothesis or were you incorrect?
7. If your results indicate that the small rock container holds more water that would also be desirable. Soils with greater amounts of clay particles can sometimes hold more water if it has time to enter the soil instead of runoff.
8. If your results indicate that the large rock container holds more water this is O.K, it just means that the larger particles couldn't fit nicely in the solid-sided container. This is an opportunity to discuss experimental design or experimental error.
9. Generalize: Write 2-3 sentences that explain what your experimental results mean in regards to pore space available. Example: Both my rock-filled containers held 90 mL of water. Therefore, the pore space available with either the small particle size or the big particle size is the same.
10. Apply: Write 2-3 sentences about (or discuss) which rock-filled container required you to pour water more slowly to avoid spilling. Why? Example: I had to pour the water more slowly into the small rock-filled container to avoid spilling. With small pore sizes, it takes more time for the water to flow. The same effect occurs if you let water pour out of cups with either small or large holes (sieve, strainer, or colander effect).
11. With older students, I recommend talking about experimental error. For example using a baby bottle is not going to be as accurate as a graduated cylinder. Also, any

time you pour or move water there is a chance for spills. Errors could even occur with the most careful of human eye measurements.

Summary:

- Soil is made up of four parts – minerals, organic matter, air and water.
- Soil contains a mixture of three different particle sizes – sand, silt and clay. Sand is the biggest and clay is the smallest.
- Although pores are bigger with large (sand) soil particles, the total volume of pore space available in not necessarily larger.

Assessment:

1. Which of your rock-filled containers had more pore space? What does this mean for plants growing in soils with a lot of sand-sized particles? What does this mean for plants growing in soils with a lot of clay-sized particles?
   Answer: Neither, both my large rock and small rock container held the same amount of water so they had the same amount of pore space. This means that plants growing in soils with either sand-sized or clay-sized particles can have the same amount of water and air space.
2. Which rock-filled container had larger individual pores? What does this mean for water entering soils containing a lot of sand-sized particles? Which rock-filled container had smaller pores? What happens when water is applied too quickly to a soil containing a lot of clay-sized particles?
   Answer: The large rock-filled container had larger individual pores. Water can enter soils quickly that contain a lot of sand-sized particles. The small rock-filled container had smaller pores. When water is applied too quickly to soils with a lot of clay-sized particles, it spills or runs off the surface.

References:

Biondo, Ronald J. and Jasper S. Lee. Introduction to Plant and Soil Science and Technology. Danville, IL: Interstate Publishers, Inc., 1997.

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