Permeability and Porosity

Strand Geology

Topic Investigating Soil Porosity and Permeability

Primary SOL ES.8 The student will investigate and understand how freshwater resources are influenced by geologic processes and the activities of humans. Key concepts include

c) relationships between groundwater zones, including saturated and unsaturated zones, and the water table.

Related SOL ES.1 The student will plan and conduct investigations in which

a) volume, area, mass, elapsed time, direction, temperature, pressure, distance, density, and changes in elevation/depth are calculated utilizing the most appropriate tools;

c) scales, diagrams, charts, graphs, tables, imagery, models, and profiles are constructed and interpreted;

e) variables are manipulated with repeated trials.

Background Information

Permeability and porosity play a large role in many processes that shape the Earth and contribute to our daily lives. For many of us, these two factors contribute to the amount of available ground water and if there is standing water in our yards after a storm. Permeability is the ability of a fluid to move through the soil or other formation. Porosity is the availability of pore space to hold and transmit fluids. Porosity is represented by the ratio or percent of pore space that is represented in a material.

Depending on the nature of the subsurface material and the flow of groundwater, the amounts of water that can be stored in the ground vary greatly. The quantity of stored groundwater depends on the porosity of the material and the way the pores are connected. Sometimes rock or sediment may be porous and still prohibit water from moving through it.

Materials

For each group:

- 100 ml beaker filled with each of the following: gravel, sand, potting soil, and clay soil
- Four 16-20-ounce empty water bottles
- Nylon stocking
- Scissors
- Four rubber bands
- Four stands
- Four metal rings
- 800 ml of water
- Four 250-ml beakers
- Four 600-ml beakers
- Graduated cylinder

- Experiment Data Table (attached)

Vocabulary

bedrock, chemical weathering, erosion, humus, inorganic, mature soil, organic, oxidation, oxisols, parent rock, physical weathering, residual, soil, soil composition, soil hierarchy, soil maturation, soil profile, subsoil texture, transported, unweathered rock, weathered rock, weathering, well developed soil, young soil, zone of accumulation, zone of leaching

Student/Teacher Actions (what students and teachers should be doing to facilitate learning)

1. Have the students complete the prelesson activity (Going up and Going Down) and the questions that follow before breaking up into their groups for the lab activity.
2. Have each group of students prepare for the activity by cutting the bottoms off of four empty water bottles. Also, have them cut nylon stockings into squares to cover the mouths of the bottles.
3. Have each group place a nylon square over each bottle mouth and secure with a rubber band.
4. Have each group fill the bottles with a 100 ml beaker of the following materials: gravel, sand, potting soil, or clay soil. Each group should have a bottle with gravel, one with sand, one with potting soil, and one with clay.
5. Instruct groups to place each bottle in a ring clamp and attach it to a stand.
6. Have groups place an empty 600-ml beaker on each stand below the attached bottle.
7. Direct groups to simultaneously pour 200 ml of water into each of their four bottles containing the representations of four soil types. Have each group record the time it takes for the water to filter through each soil type.
8. Have groups compare the appearances of the filtered water in the beakers. Also, have them measure the amount of water in each beaker.
9. Instruct groups to empty the bottles and compare the appearances of the four types of soil.
10. Have each group record their observations in a copy of the attached Experiment Data Table.
11. Have groups repeat trials as needed.

Assessment

- **Questions**
  - How does the particle shape (rounded or flat angular) affect pore space or porosity?
  - Based on the flow of water through the soil, which soil types are permeable? Which are impermeable?
- **Other**
  - Have students graph the percentage of water absorbed by each type of soil.

Extensions and Connections (for all students)

- Discuss the flow of groundwater.

- Have students draw and label the parts of a groundwater system: aquifer, aquitards, zone of accretion, water table, and zone of saturation.
- For a connection to a future/past lesson it would be good to include the key features of a well and how they operate. Be sure to go over cone of depression and its effects on the groundwater system.
- Have students identify soil types that are permeable and soil types that are impermeable.

Strategies for Differentiation

- Group the students together in two main groups. Assign one group "municipal water source" and the other "well water source." Have them come up with a list of the pros and cons for the use of each water type. Once they have completed their lists, have them present their findings to the rest of the class. Facilitate an open discussion between the groups.
- At the end of the lesson and activity, have the students make a list depicting how permeability and porosity directly impact their daily lives. Have them draw a timeline from the time they wake up to when they go to bed regarding their encounters with porosity and permeability.

Experiment Data Table

Name: _____ **Date:** _____

Pre-Lesson Activity

Going up!
It is easy to ask the question, "Who cares about fluid movement through the ground"; however, there are numerous fluids and gases that we extract from the ground. We are only able to extract these items efficiently if we know about the porosity and permeability of the rocks they are located in.

1. What are some key natural resources that are extracted from the ground that would need to flow through a pore space?

2. Why is it important to be able to extract these resources in an economical manner?

3. List an example of a liquid that moves up through a solid that you have encountered or know about.

Going Down!
While we rely on many important materials to be extracted from the ground, it is also important to realize that materials need to move down through the ground/soil as well. One of the largest examples of this is water in the form of rain. For areas in the world that rely on groundwater, without rain there would be no water to extract.

1. If your home relies on a groundwater well that is fed from surface run-off, what type of rain-storm do you want to have and why? (mist, slow steady drizzle, or hard short downpour)

After living on your property for 20 years, you decide that you want to sell half of the land. It just so happens that this half of the land is the area that recharges your wells that supply your drinking water. Now that you have sold your land, the new owner decides that it is best to cover his new property with concrete to more closely resemble his old home in an urban environment.

2. What problems will you have now since your neighbor has created a concrete area over your well's recharge zone?

3. What characteristics of concrete caused the problem?

4. What could your neighbor have covered his land with to allow the rain to pass through the ground and recharge the wells?

Experiment Data Table

Observation	Gravel	Sand	Potting Soil	Clay Soil
Initial amount of water				
Final amount of water				
Amount of water absorbed				
Appearance of filtered water				
Comparison of appearances of the different types of soil				