**DO NOT WRITE ON THIS**

# Soil Analysis: Porosity and Permeability

## Soil Porosity

Porosity is the percentage of open spaces or pores in a given volume of rock or sediment. Porosity determines the total amount of water a rock will hold, and varies from one material to another. The greater the volume of pore spaces a rock or sediment contains, the higher its porosity, and the more water it can hold.

Porosity is largely influenced by factors of particle size, shape, and assortment. Sorting refers to the amount of uniformity in size and shape of the particles, or grains, composing rocks or sediment. A well-sorted sediment possesses particles which are all about the same size and shape. The overall size of the grains is unimportant. In fact, sediment characterized by large grain size can have the same porosity as one composed of much smaller particles.

A sand deposit composed of well-rounded quartz grains of fairly uniform size would possess a high porosity. In contrast, poorly sorted sediments contain particles of many sizes, and are often of low porosity. This is because the smaller particles fill up the pore spaces between the larger grains, making the sediment or rock less porous. For example, if we mixed a well-sorted sand deposit with finer, poorly sorted particles of silt and clay, the porosity of the sand deposit will be lowered.

Porosity is also influenced by the way materials are packed together. Loosely packed unconsolidated sediments of sand, gravel, silt, and clay may have relatively high porosities of 20% to 50%. However, when these materials are compacted, cemented, and consolidated to form sedimentary rocks, their porosity is greatly reduced. Overall porosities in various materials can vary greatly with the level of compaction, fracturing, and cementation. In general, though, a porosity of less than 5% is considered low, 5% to 15% reflects a medium porosity, and over 15% is thought to be high.

To determine the porosity of your soil

1. Fill a 250 mL beaker to the 200 mL mark with dried soil and tamp down gently.
2. Fill a graduated cylinder to the 100 mL mark with water. (If the graduated cylinder is smaller, you may have to fill it twice!)
3. Gently pour the water onto the surface of the soil until the soil is completely saturated and water just starts to pool up on the surface.
4. Measure the amount of water left in the graduated cylinder. The amount used is the amount of pore space in your sample.
   - **a.** Calculate porosity as the percent of pore space compared to the volume of dry soil. **Show your work.**

## Soil Permeability:

The permeability of a rock or sediment refers to its ability to transmit groundwater freely. The rate at which a material transmits water depends not only on its total porosity, but also on the size of the passageways between its openings. To be considered permeable, the open spaces in a rock must be connected. The size and sorting of the particles composing the rock or sediment will affect its permeability.

Generally, materials of larger particle size that are consistently sorted will be more permeable. A rock can have high porosity, but low permeability if the open spaces are not well connected. For example, while clay may display a higher porosity than sand, the clay particles are much finer and the spacing between them is very small. As a result, while the clay may hold more water, the water is transmitted more readily through the sand than through the more porous clay. This is principally due to the fact that the molecular attraction on the water is much stronger in the tiny openings between clay particles. The passageways between particles in the sand are relatively large, and the molecular attraction on the water is relatively low, allowing the water to move more freely in this material

Friction slows down the flow of water through rock. Well-sorted, large grained rocks and sediments have less surface area to cause friction during the water's passage than do finer grained materials. Rocks composed of coarse grained particles, like sandstone, are often the most permeable. However, even smaller grained rocks, like limestone, can be permeable due to the presence of interconnected cracks and enlarged fractures due to solution.

Regardless of how large the spacing is between particles in a rock or sediment, they must be interconnected for water to pass through. Materials through which water cannot flow are called impermeable. Clays, shale, and most metamorphic and crystalline igneous rocks are often impermeable or are poor aquifers. The most effective aquifers are typically unconsolidated sand and gravel, sandstone, and some limestone. Permeability, then, plays a critical role in determining the rate at which groundwater flows through an aquifer. Where permeability is high, the groundwater passes quickly through the ground; when permeability declines, the flow is reduced

So why would knowing those two things be important? Consider for a moment the following scenario: You are building a house on some land near a stream. While it rarely floods your lawn, the soil often becomes saturated with water after particularly raining spring seasons. What type of soil would you want lining the outside walls of your basement – a soil that allows water to easily pass through, or a soil that does not? The answer is simple and obvious.

**DRY PERMEABILITY TEST**

1. Obtain a bottle that has the bottom cut off and the top covered in cheesecloth.
2. Obtain approximately 100 mL of soil using a beaker. Then, in another beaker, obtain 200 mL of water.
3. Place the soil into the inverted pop bottle. Be sure to NOT pack the soil down.
4. With a beaker underneath the opening to catch the water that permeates through, quickly pour the 200 mL of water on top of the soil.
5. Allow the water to permeate through until it stops.
6. Using a graduated cylinder, measure and record the amount of water that permeated through.

**WET PERMEABILITY TEST**

1. Use the damp soil from the dry permeability test.
2. Obtain the same quantities to test as you did in the dry test – except this time collect 100 mL of damp soil instead of dry soil.
3. Follow the same procedure as you did above.
4. Record and repeat as necessary.

**<u>Conclusion:</u>**

1. What is the difference between porosity and permeability?
2. How do particle size and sorting affect porosity?
3. What is the relationship between porosity and permeability?
4. Looking at the Soil Texture Triangle, which soil type has the greatest:
    a. Water retention ability? Why?
    b. Water percolation (permeability) rate? Why?
5. Which of the soils would be most suitable for lining a landfill? Explain your answer.
6. Which of the soils would be most suitable for siting a septic tank and leaching field? Explain your answer.