Porosity and Permeability Lab

The terms porosity and permeability are related.

- **porosity** – the amount of empty space in a rock or other earth substance; this empty space is known as pore space. Porosity is how much water a substance can hold. Porosity is usually stated as a percentage of the material's total volume.

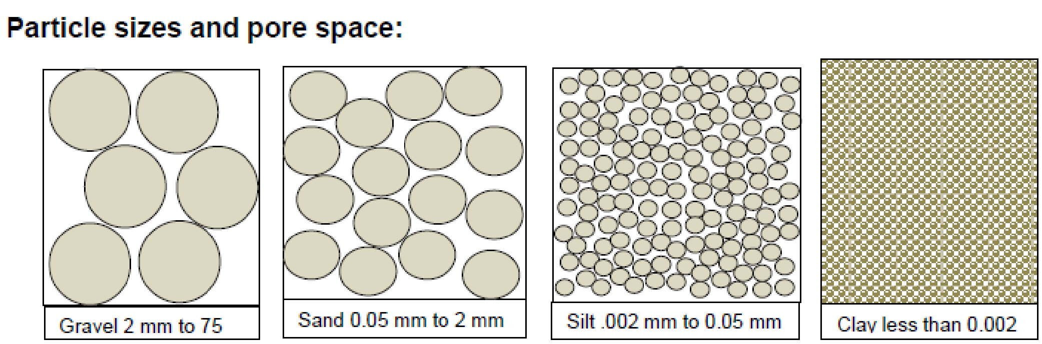
- **permeability** – is how well water flows through rock or other earth substance. Factors that affect permeability are how large the pores in the substance are and how well the particles fit together.

Water flows between the spaces in the material. If the spaces are close together such as in clay based soils, the water will tend to cling to the material and not pass through it easily or quickly. If the spaces are large, such as in the gravel, the water passes through quickly.

There are two other terms that are used with water: percolation and infiltration.

- **percolation** – the downward movement of water from the land surface into soil or porous rock.
- **infiltration** – when the water enters the soil surface after falling from the atmosphere.

In this lab, we will test the permeability and porosity of sand, gravel, and soil.



Hypothesis

Which material do you think will have the highest permeability (fastest time)? _______________
Which material do you think will have the lowest permeability (slowest time)? ______________
Which material do you think will have the highest porosity (largest spaces)? ________________
Which material do you think will have the lowest porosity (smallest spaces)? ________________

Materials

2 large cups (one with hole in bottom)
marker
timer
calculator
spoon or scraper
water
pea gravel
yard soil (not potting soil)
sand

Procedure for measuring porosity

1. Measure out 100 mL of water in the graduated cylinder.
2. Pour the 100 mL of water in one of the cups and use the marker to mark the level.
3. Pour the water back into the graduated cylinder.
4. Fill the same cup with sand up to the mark you drew.
5. Pour the 100 mL of water slowly into the sand. Stop when the water level just reaches the top of the sand.
6. Record the amount of water left in the graduated cylinder in the right column.
7. Calculate the pore space by subtracting the amount left in the graduated cylinder from the original 100mL.
8. Repeat steps 4-7 with the pea gravel and yard soil.
9. Calculate the %porosity and record in the table. Use this formula:

$$\text{porosity} = \frac{\text{pore space volume}}{\text{total volume}} \times 100$$

Procedure for measuring permeability

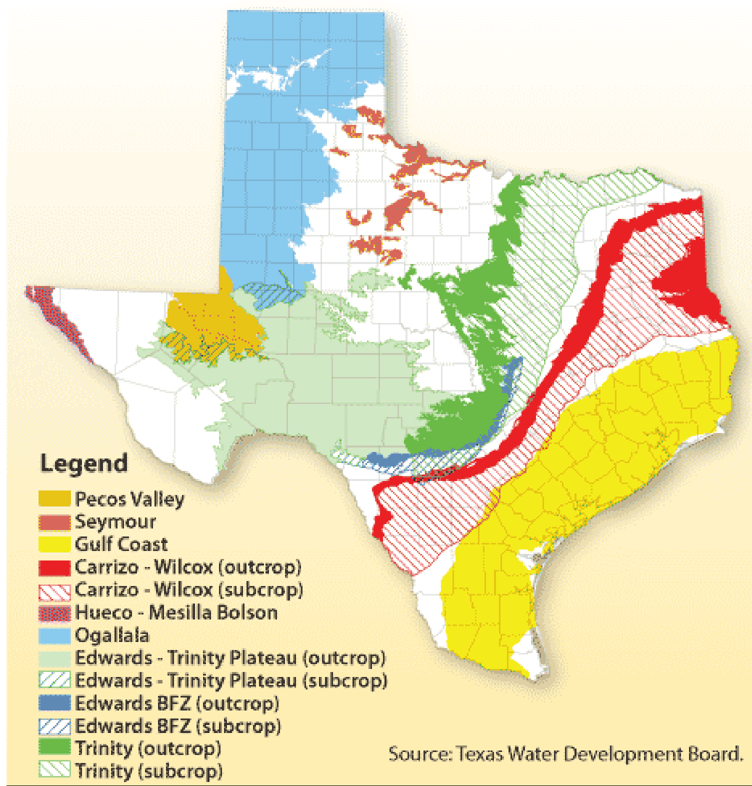
1. Place the same amount of sand in the cup with a hole in the bottom.
2. Get a timer ready. Hold the cup over a beaker to catch the water.
3. Pour the entire 100 mL of water quickly into the cup of sand. Start recording as soon as the water hits the sand.
4. Stop timing as soon as the first drop of water comes out of the hole in the bottom.
5. Record how many seconds it takes for the water to reach the bottom.
6. Repeat steps 1-5 with the pea gravel and soil.

Bottle Aquifer

An aquifer is a natural underground area where large quantities of ground water fill the spaces between rocks and sediments and creates and underwater “pool” of water. This water is frequently pumped up using water wells and used for humans and livestock.

The state of Texas has 23 aquifers that cover approximately 75% of the state. The Ogallala Aquifer accounts for about 90% of the water in all of Texas Aquifers. Groundwater from Texas aquifers is used for irrigation, city use, manufacturing, and livestock production. Pumping water from many aquifers in Texas has resulted in a significant lowering of the water table.

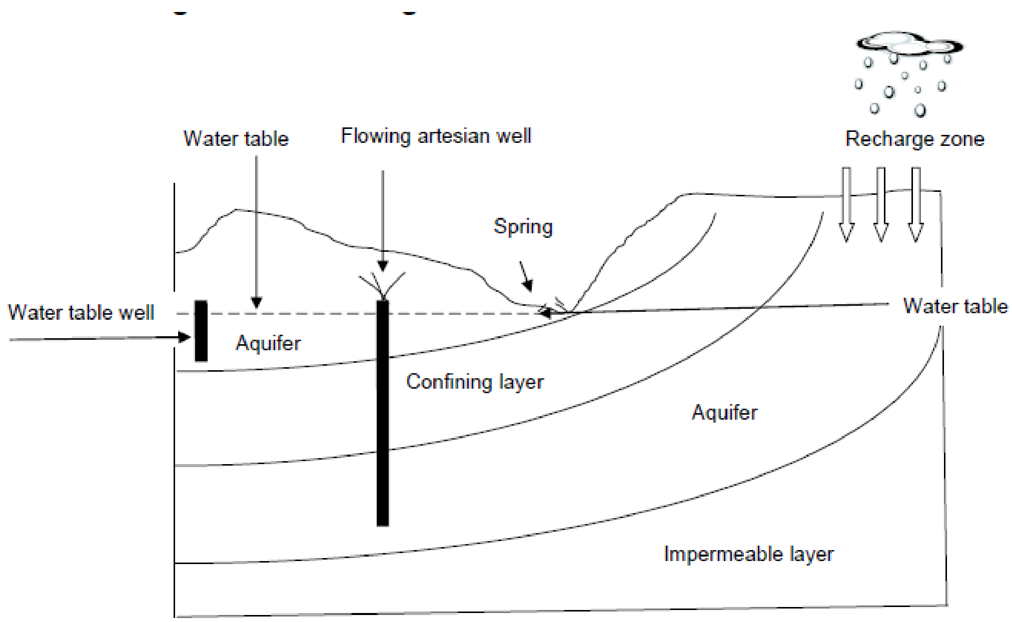
The water table is the upper surface of ground water below which the soil or rocks are permanently saturated with water and where the pressure of water in the soil equals the pressure of the atmosphere.



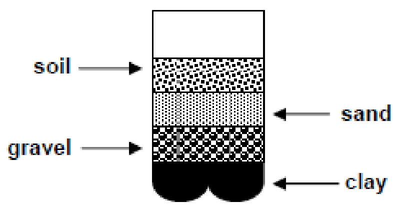
The water table fluctuates with the seasons and from one year to another based on how much precipitation has fallen, how much has been pumped out for human use and how much is used by plants and animals. Using a blue marker, trace the solid and dotted line labeled “water table” in the diagram below.

Less permeable rock below an aquifer that keeps groundwater from draining away is called a confining layer (color the confining layer with a yellow pencil). The water held within the pores of the sand, soil, and clay above the confining layer is called an aquifer (color the upper aquifer with a light blue pencil) .

Sometimes, deeper in the ground is an impermeable layer (color the impermeable layer with a dark brown pencil). When water is trapped between the confining layer and the impermeable layer, it forms an artesian aquifer (color the lower aquifer with a dark blue pencil). Water in an artesian aquifer is under a large amount of pressure and can bubble up out of the ground in some places. Rainwater cannot penetrate the confining layer to get to an artesian aquifer. Artesian aquifers are refilled in a recharge zone where there is no confining layer.



Materials



1 soda bottle
ruler
scissors
push pin
water
3 oz cup
1 cup gravel
1 inch of sand
1 cup non-potting soil
modeling clay
250 mL beaker

Procedure

1. Use the modeling clay to fill in the base of the soda bottle. Mold it into the dips so that there is a flat surface at the bottom of the soda bottle.
3. Pour about 1 inch of gravel over the clay and level the gravel out flat.
4. Pour in about 1 inch of sand and gently level the sand over the gravel.
5. Pour in 1 inch of soil over the sand and level it out.
6. Take the push pin and create many holes in the bottom of the small cup.
7. fill the 250 mL beaker with water.
8. One student will hold the cup with the holes over the aquifer while another slowly pours water into it the cup.
9. Observe the aquifer as water trickles into it.

Name___________________________________ period _____
date assigned_____________ date due ______________ date returned _____________

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Hypothesis

Which material do you think will have the highest permeability (fastest time)? ______________
Which material do you think will have the lowest permeability (slowest time)? _____________
Which material do you think will have the highest porosity (largest spaces)? _______________
Which material do you think will have the lowest porosity (smallest spaces)? _______________

Record you data for the experiement.
Calculate the percent porosity and record. Use this formula:

$$\% \text{ porosity} = \frac{\text{volume of pore space (amount of water)}}{\text{volume of material}} \times 100$$

sediment	Total Volume (mL)	Volume left in Cylinder (mL)	Pore Space Volume (total volume – volume left)	% porosity	Permeability (seconds for water to pass through)
Example	100 mL	65 mL	100 - 65 = 35 mL	35/100 x 100 = 35%	
sand	100 mL				
pea gravel	100 mL				
soil	100 mL				

Watch the power point…

Answer the following questions in complete sentences.

1. Which earth material had the highest porosity? Explain why.

____
____
____

2. Which earth material had the highest permeability (fastest time)? Explain why

____
____
____

3. Which earth material had the lowest porosity? Explain why.

____
____
____

4. Which earth material had the lowest permeability (slowest time)? Explain why.

____
____
____

5. Using your own words, define the following words:

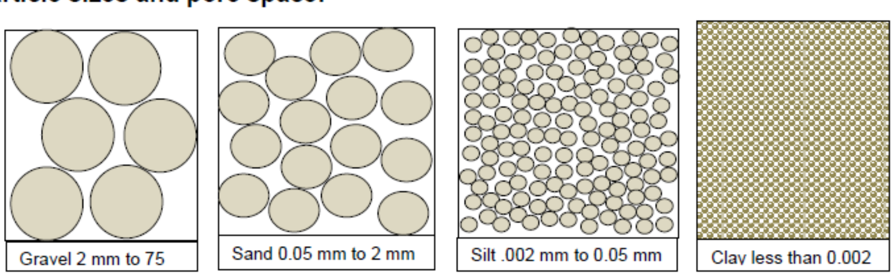
porosity - ____
____

permeability - ____
____

percolation - ____
____

infiltration - ____
____

Particle sizes and pore space:



6. What do you think causes the difference in time that it takes water to pass through the different materials? Use the terms porosity and permeability in your answer.

7. In what type of soil would you recommend locating a drinking water well? Explain why.

8. After doing the activity, try to define the following terms:

groundwater -

surface water -

Watch Power Point

9. Did any of the soil samples show groundwater? If so, which ones.

10. Did any of the models show surface water? If so, which ones?

Bottle Aquifer Lab

Watch the power point slides on watersheds, aquifers and groundwater

Answer the following questions in complete sentences.

11. After building the aquifer and looking at the power point slides, come up with definitions for the following terms:

groundwater - ______________________________

aquifer - ______________________________

watershed - ______________________________

12. Describe what you see in the demonstration.

____

13. Why did we use different types of earth material?

____

14. What did the cup with the holes represent in our model?

____

15. How does water get into an aquifer?

____

____

____

16. Why are aquifers and ground water important to life on earth?

____

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17. How can pollution effect aquifers and ground water?

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