POROSITY & PERMEABILITY: "DOWN AND DIRTY"

OBJECTIVES

The student will do the following:

1. Discover that the more open space in rock or soil (porosity), the more water it can hold.
2. Determine that soil with the same size particles will hold more water (is more porous) than soil with different-sized particles.
3. Identify the characteristics that make certain soil types more permeable, or better able to transfer water, than others.

SUBJECTS:
Science, Language Arts

TIME:
60 minutes

MATERIALS:
3 large paper or plastic cups
3 plastic container lids
water
thumbtack
watch or clock
student sheets (included)
sand
topsoil
clay
pencil
four 250-mL beakers or measuring cups
scissors
chalkboard or large paper
blue crayons or markers
teacher sheet

BACKGROUND INFORMATION

According to many experts, there is over 40 times more water underground than found in all the lakes, rivers, and streams on earth. Groundwater is a vital part of the water cycle. As precipitation replenishes groundwater sources, the water is affected by the soil and rock layers through which it must filter. Soil and rock layers have two basic characteristics that determine its effect on water flow: porosity and permeability.

Porosity refers to how much space there is in a volume or formation of rock or soil. The more space between particles, the more water the formation is able to hold. For example, loosely packed soil can hold more water than soil that is tightly packed. Also, soil with the same sized particles can hold more water than soil with different sized particles because smaller particles fill the spaces between the larger particles, leaving less space for water to occupy.

How well soil or rock allows water to flow through it is called its permeability. Formations with large, interconnected pores usually transmit water more quickly. Rock formations with large cracks, like fractured limestone, also allow water to move through more quickly.

These two characteristics affect groundwater in important ways. For example, the rate at which an aquifer regains and retains water depends on both porosity and permeability. Movement of contaminants such as septic seepage or spilled or leaked gasoline also depend upon the porosity and permeability of soil and rock layers.

Terms

porosity: the property of being porous, having pores; the ratio of minute channels or open spaces (pores) to the volume of solid matter.

permeability: the property of a membrane or other material that permits a substance to pass through it.

ADVANCE PREPARATION

A. Gather needed materials.

B. Obtain the clay, topsoil, and sand for the "P VS. P Experiment." (NOTE: Avoid using commercial potting mix. Use topsoil.)

C. Copy the student sheets "P VS. P Puzzlers;" and "P VS. P Experiment."

D. Prepare the cups for the experiment in advance.

1. Using 3 cups, fill one with sand, one with clay, and one with topsoil. (Leave 1 inch [2.5 cm] of space at the top of the cups.)

2. Using a thumbtack, punch several small holes in the bottom of each cup. Be sure to punch the same number of holes in each cup.

3. Using scissors, cut a hole in each plastic container lid so that a cup can be inserted and lodged in the hole. Put the lids (with the cups stuck in them) on the beakers or measuring cups.

PROCEDURE

I. Setting the stage

A. Have the students brainstorm as many different and unusual words to describe "soil" as possible. Record these on the chalkboard or large paper.

B. Discuss some of the words given by students. Point out the useful words.

C. Explain that while soil has many uses, two often overlooked uses are filtering water (that becomes groundwater) and acting as a pipeline for our underground water supplies.

II. Activity

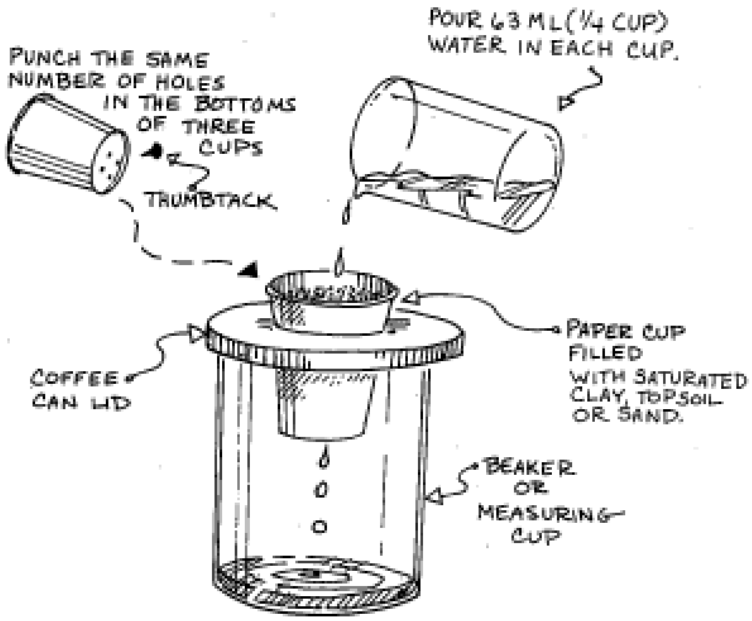
A. Explain that there are several types of soil. Some soil is mostly sand, some is mostly clay, and some is a mixture of sand, clay, rock, and other things, like dead plants. The composition of soil determines its ability to absorb water and to allow water to move through it.

B. Permeability Experiment (NOTE: May be performed as a classroom demonstration, as illustrated, or as a small team activity.)

1. Distribute the student sheet "P VS. P Experiment."

2. Have the students examine the samples and hypothesize which type of soil will allow water to pass through the most quickly. Point out that a soil type's ability to let water move is called permeability. Students should record their hypotheses on the handout.

PERMEABILITY EXPERIMENT



3. Pour 1/4 cup (63 mL) of water into the first cup. Have the students record the time when the water was poured.

4. Have the students record the time when the first water drips from each cup.

5. Repeat this procedure for the second cup, then for the third. Compare each time. Have students rank the times in order from fastest to slowest.

6. Ask the students to explain why each permeability rate was different and write their conclusions on the space on the worksheet.

7. Explain that soils with larger, interconnected spaces tend to allow water to move more quickly. (NOTE: Your results will depend somewhat on what kind of topsoil you use. You may, however, expect the sand to be most permeable and, probably, the clay to be least permeable.)

C. Porosity Test

1. Explain to the students that soil and rock also have differing abilities to hold water. This depends on how much of the sample is made of empty spaces between the particles and how large the spaces are. This is called porosity.

2. Have the students record a hypothesis about which soil type will hold the most water on their worksheet.

3. Allow water to drip for another 10-15 minutes. (NOTE: During this time, you may wish to proceed to follow-up or extension activities.)

4. Measure and record the amount of water in each beaker or measuring cup. Have the students record this on their sheets. Instruct them to subtract this amount from the starting amount to determine the total amount of water held for each soil type. Have them record this information. (NOTE: You will have to help them subtract the fractions. Milliliters will be easier for them to use.)

5. Using the total amount of water held, have students rank in order the porosity of the soil types and write a conclusion on the worksheet.

6. Ask the students to explain why the highest ranking soil held the most water. (NOTE: Again, your choice of topsoil will affect the results.)

III. Follow-Up

A. Have the students complete the student sheet "P VS. P Puzzlers."

B. Record the number of correct hypotheses made by students during the experiment and discuss the conclusions reached.

IV. Extensions

A. Contact your local cooperative agricultural extension office or Soil Conservation Service office for information about the soil in your area.

B. Have the students gather different samples around their home and perform the experiment, reporting on the results.

RESOURCES

Bernstein, L., et al., Concepts and Challenges in Earth Science, Globe Book Company, 1991.

Cedar Creek Learning Center, Groundwater: A Vital Resource (Student Activities), TVA Environmental & Energy Education Program, Knoxville, Tennessee, 1986.

Spangler, J. T., Focus on Earth Science, Teacher's Laboratory Manual, Charles E. Merrill Publishing, Columbus, Ohio, 1984, p. 103-104.

POROSITY & PERMEABILITY EXPERIMENT

Permeability of soil or rock: The ability of soil or rock to let water pass or move.

Hypothesis: Which soil type do you think will allow the water to pass through it most quickly: _____ Why? _____

_____

Soil Type	Clock Time of Water In	Clock Time of Water Out	Time (seconds)
Sand			
Topsoil			
Clay			

Conclusion: Which soil allowed the water to move through the most quickly? _____

Why? _____

_____

Porosity of soil or rock: The ability of soil or rock to hold water.

Hypothesis: Which soil type do you think will hold the most water? _____

Why? _____

Soil Type

Sand	1/4 cup (63 mL) poured in — ___ amount that passed through amount held in soil
Topsoil	1/4 cup (63 mL) poured in — ___ amount that passed through amount held in soil
Clay	1/4 cup (63 mL) poured in — ___ amount that passed through amount held in soil

Conclusion: Which soil held the most water? _____

Why? _____

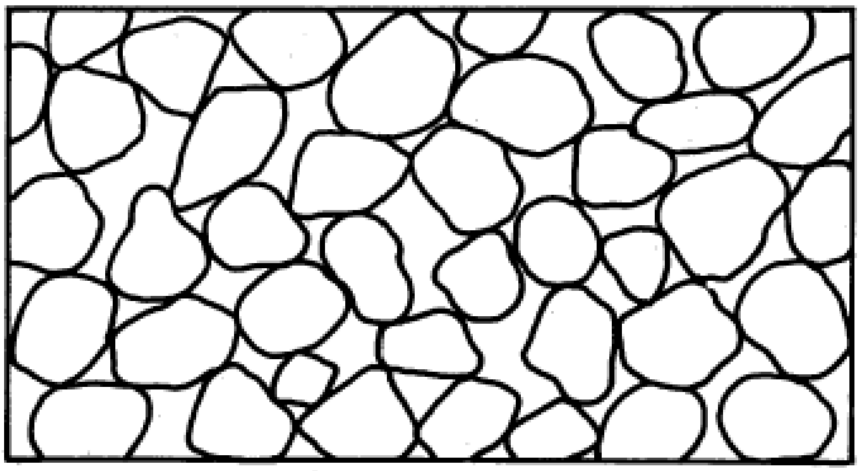
_____

POROSITY & PERMEABILITY PUZZLERS

Name _____ Date _____

Porosity: Color in the spaces between the particles to see which soil is more porous. Use a blue crayon or marker to represent water.

#1



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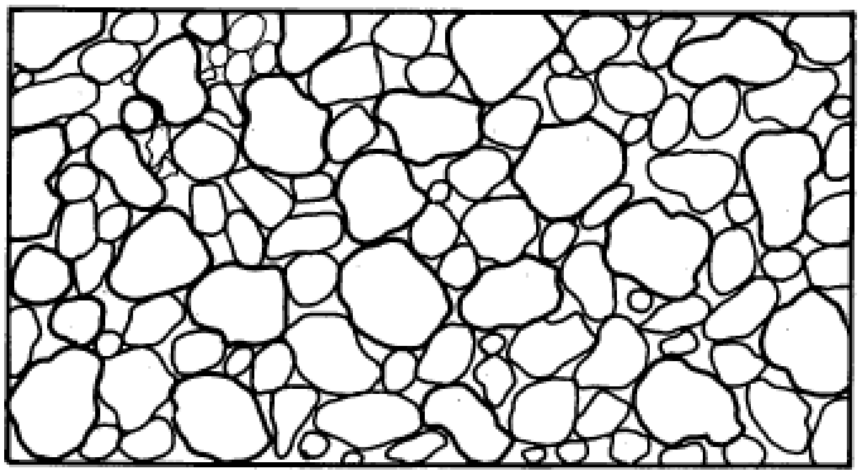


Which has the most open spaces? _____

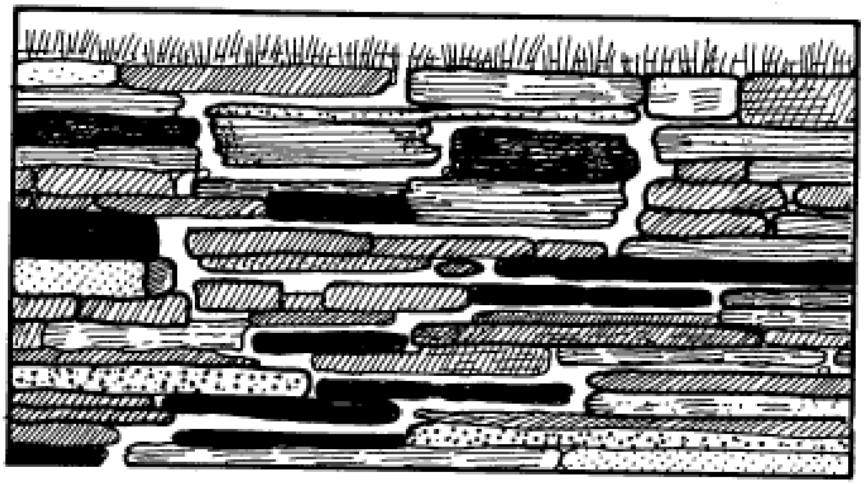
Which would hold the most water? _____

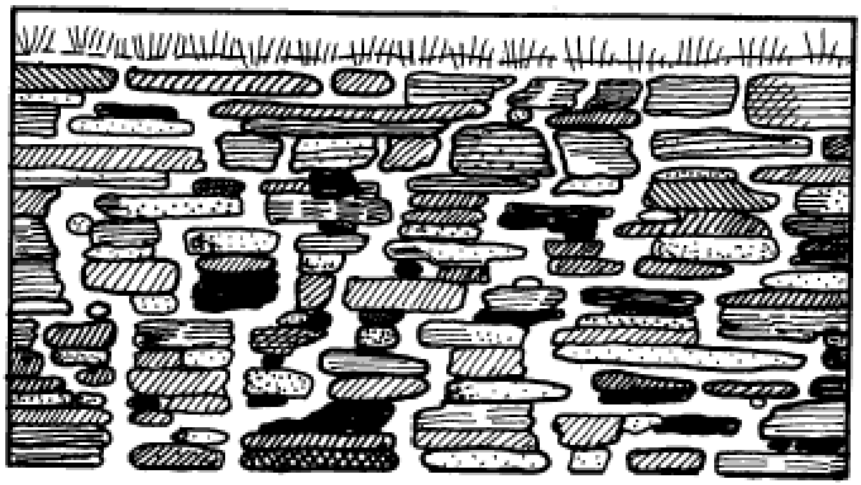
Why? _____

POROSITY & PERMEABILITY PUZZLERS - PART 2

Name _____ Date _____

Permeability: Do the two mazes below. Show the paths water can take between the particles by using a blue crayon or marker.





Which allows water to flow more freely? _____

POROSITY & PERMEABILITY PUZZLERS - PART 2
(ANSWER KEY)