

Soaking, Sopping, Wet! Porosity and Permeability

Skill: Science, Math, Language Arts

Objectives

Students will:

- Observe and measure the porosity and permeability of some materials.

Background

Part I - Porosity

"Groundwater" is the water underneath the earth's surface. Understanding water tables is the first step in understanding groundwater.

In a water table there are two zones, the "saturated" zone and the "unsaturated" zone. The "saturated zone" is the zone at the bottom of the water table where the gravel is completely covered with water. All of the spaces between the soil or gravel chunks are full of water. The gravel is saturated.

The "unsaturated zone" is the upper layer of the water table where the spaces between the chunks of soil or gravel are full of air, not water. Water passes through the unsaturated zone but doesn't stay there.

The water table is at the top of the saturated line and separates the saturated zone from the unsaturated zone. A well is a hole dug through the unsaturated zone into the saturated zone.

If water is pumped out of the saturated zone, nearby groundwater will move in to take its place. Wells take groundwater out of the earth ("discharge"). Unless more water is put into the ground ("recharge") the water table will eventually fall below the level of the well and water won't be available to pump out. Pumping too much of the water out of the well is overwithdrawal. When more water enters the groundwater system it is called "recharge." If the water table is going to remain the same, the water going into the ground (recharge) must equal the water coming out of the ground (discharge). A spring bubbling out of a hillside is also groundwater coming out. Ponds and lakes also can be fed by groundwater.

Any time the surface of the ground dips below the water table groundwater seeps out. Sometimes it seeps into lakes, ponds, rivers, streams or even the ocean. It is then surface water because it is no longer below the ground but on the surface instead.

It isn't just a matter of how much recharge an area gets (rainfall, melting snow, etc.), but also a question of how quickly the water can move into and through the ground. All of that depends upon the type of soil and rock the water is moving through.

Water moves at different rates through different types of materials. It moves quickly through sand, slowly through garden soil, and slowest through clay.

Water moves through rocks the same way. Rocks with large pores are called "porous." That means they can hold a lot of water. How easily water travels

P.A.S.S.

4th Grade

- Read 1.1, 3.1b
- Write 1.2

Science

- Process 1.1,2, 3.1,3, 4.4, 5.4

Math

- Process 1.2, 4.4
- Content 1.2b, 4.4b

5th Grade

- Read 1.1a, 3.1b
- Write 1.2

Science

- Process 1.1,2, 3.1,3, 4.4, 5.4
- Physical 1.1

Math

- Process 1.2, 4.4
- Content 4.4

6th Grade

- Read 1.1a, 3.1b
- Write 2.7

Science

- Process 1.1, 3.1,5, 4.5, 5.4
- Physical 1.1
- Earth 5.2

Math

- Process 1.1,3, 2.2, 4.1
- Content 2.3, 4.3



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Vocabulary

- porosity
- permeability
- groundwater
- water table
- saturated zone
- unsaturated zone
- well
- discharge
- recharge
- overwithdrawal
- porous
- sedimentary
- fractures
- faults
- impermeable
- aquifer

Materials

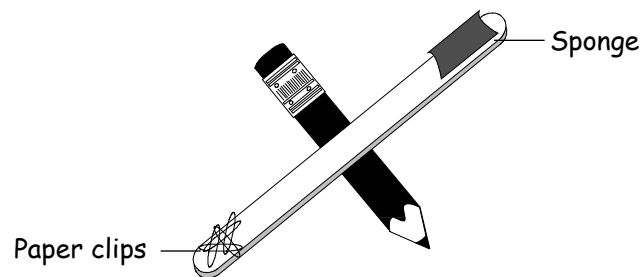
- Each team needs the following materials to complete experiments A and B for Part I
- Part I
- Homemade balance (Place a tongue depressor or popsicle stick across a Dowell rod. Tape the Dowell rod to a flat surface so it doesn't roll.)
- Small piece of sponge
- Paper clips
- pipette
- Water
- Paper cup
- Sand

through rock depends on whether the pores are connected to one another. Imagine a rock with bubbles trapped inside it. The bubbles might be unconnected. The water wouldn't move. Or, the bubbles might be connected to bubbles could be full of water, but if the bubbles aren't connected the one another. If the bubbles contained water, the water could flow from one bubble to another, in one side of the rock and out through the other, as water might move through a sponge

Procedure - Part I Porosity

Experiment A

- Construct the homemade balance as shown in illustration No. 1.



No. 1 Homemade balance

Experiment A con't

- Take a piece of dry sponge and weigh it by balancing it with paper clips.
 - a. Dry sponge = _____ paper clips (number)
- Soak the sponge in a container of water until it can hold no more water. Place it on the balance and reweigh it.
 - b. Wet sponge = _____ paper clips (number)
- Determine which sponge weighed the most by subtracting the dry weight from the wet weight.

How many more paper clips were required for the wet sponge than the dry one?



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Discussion and Evaluation

Why did the wet sponge weigh more?

Where is the water stored in the sponge?

Do you think the sponge can take in and store a lot of water for its size? When a substance can take in and hold a lot of the liquid in small spaces like a sponge does, we call it "porous" or the substance has "porosity." A sponge is porous. Do you think that soil, sand, and sand and rock mixes are porous? The next series of experiments will help you decide to what extent they are porous.

Experiment B

- Take a small cup of sand and weigh it by balancing it with paper clips.
 - a. Dry sand and cup = _____ paper clips
- Remove the cup from the balance and use the pipette to soak it with water until it can hold no more water (just before it looks muddy). Reweigh it by balancing it with paper clips.
 - b. Wet sand and cup = _____ paper clips
- Determine which cup of sand weighed the most by subtracting the dry weight from the wet weight.

How many more paper clips were required for the wet sand than the dry sand?

Discussion and Evaluation

Why did it weight more?

Where is the water stored in the sand?

Do you think that millions of gallons of water could be stored in sand?

Where is the water which you drink in Oklahoma stored?

How do we get this water out of the sand?



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Background

Part II - Permeability

Rock that water can move through is "permeable." A rock that water can't move through is "impermeable."

Water can move easily through the grains of sand in sandstone. Sandstone is sedimentary rock because it is formed of compressed sediment (sand). Sedimentary rocks tend to be good places to look for groundwater.

Other rocks, like granite, don't have pore spaces. They can't soak up liquid. However, they can transport water if there are cracks called "fractures" in the rock. Water can move from one place to another if the fractures meet. The more fractures the more water the rock can hold and transport.

Some fractures are called "faults." A fault is a large gap where a rock has split and the two parts move apart from one another. One part moves upward and the other part moves downward leaving a gap where the rock broke apart. The gap is called a fault. Water can flow easily through a fault.

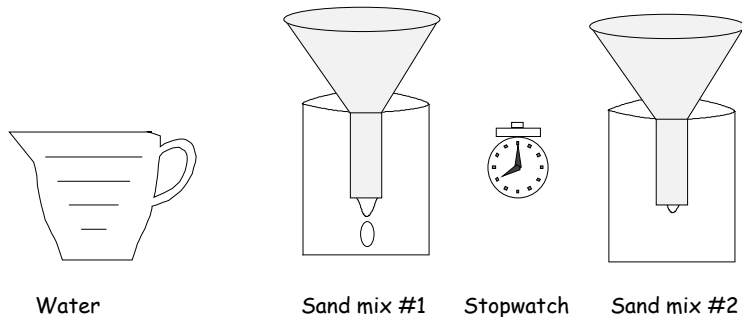
Groundwater in permeable soils and rock layers will move where gravity tells it. However, if the water reaches an impermeable layer of soil or rock it may just collect on top of that layer. If this water on the impermeable layer is above the water table it is called a "perched water table". The water on a perched water table is usually not too great an amount, and perched water tables aren't always good places for wells. However, if the water collects above an impermeable substance below the water table it is an "aquifer." An aquifer sandwiched between two impermeable layers is a confined aquifer.

Procedure - Part II Permeability

Do you think that all types of sand, rock and soil mixes store and transmit water equally? We suggest that this be done as a demonstration for the whole class. See illustration



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No. 2 Sand mix demonstration

- Place the window screen circle inside the plastic funnel, then set the funnel over a paper cup. Pour sand mix #1 on top of the screen until the funnel is about 2/3 full. Tap lightly.
- Pour a cup of water on top of the sand mix and count the seconds until the water comes through. If nothing comes through, keep adding water until it does. Be sure to keep the funnel over the paper cup to collect the water.
- Repeat the procedure with sand mix #2 and compare the results

Discussion and Evaluation

Did both mixes allow water to pass through at equal rates?

Which one allowed water to pass through faster? Were both clear? Which drained through?

Did the one which drained through first also drain the most total water?

Did the one that passed through faster have bigger grains of rock?

Does permeability depend upon the size of the particles in the mix?

When it rains, some water runs off into drains but some soaks down into the ground. What we put into the ground affects what the water will be like. Our reservoir of water is the sand beds below the surface. Only part of our rain goes into the ground. This means we must keep it clean and not waste our water. Oklahoma's population and water use has increased. Please help by making your family a water saving one.

Adapted with permission from *WET: Water Education for Teachers*, Cooperative Extension Service, Kansas State University, Manhattan, KS.

Materials

- Part II
- 2 Sand Mixes
- Sand Mix #1 - sand and soil
- Sand Mix #2 - sand and gravel
- Funnel
- Small piece of window screen (Cut into a circle to fit inside funnel)
- Paper cups
- Measuring cup
- Water

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