WHAT GOES ON DOWN UNDER?

9-12

SUBJECTS:
Science (Ecology, Earth Science, Physical Science)
TIME:
2-3 class periods
MATERIALS:
Per group: One clear container (plastic sweater box) Gravel to fill container over 2 cm Two 500 ml cups 1 pump dispenser (from lotion or soap bottle) sod (about 1 square foot per container) 500 ml of water grease pencils scissors ice pick coffee filter soil samples

OBJECTIVES

The student will do the following:

1. Explain some sources for the recharge and discharge of groundwater.

2. Identify the connection between surface and groundwater.

3. Describe the relationship between soil grain size and water flow rate.

4. Identify a rock type and geological formation.

BACKGROUND INFORMATION

Many people depend on groundwater for their supply of drinking water. Groundwater is water in the ground, and it occurs everywhere beneath the land. This does not mean that any well will encounter a sufficient quantity of water that will flow at an acceptable rate. On the contrary, the rate at which wells will flow, or the rate at which water can be pumped from them, varies from a trickle to more than a million gallons a day.

Why is this? This variability results from the way that water occurs underground. Some people believe that groundwater comes from underground lakes and rivers. While it is true that many caves do contain a lot of water, nearly all groundwater is actually found in tiny cracks and holes in the rock. Some rocks contain many holes that are well connected to one another; these rocks contain substantial amounts of easily produced water and are called aquifers (from the Latin words aqua and ferre, meaning “water” and “bring”). Tight rocks, those with few and small holes that may be poorly connected, produce very little water and are called aquitards or aquicludes. Aquicludes block water flow almost completely, whereas aquitards permit some flow of water, albeit commonly at such a low rate that it is of little use. There are no true aquicludes; any rock will transmit some water. However, some rocks transmit water at such an infinitesimal rate that it might as well be none at all. Aquifers are rock units that have much open space (aquifers are porous). These open spaces are well connected so that fluids may flow easily through the rock (aquifers are permeable). A porous and permeable rock is like a sponge; it can hold a lot of water, and it can give up a lot of water quickly. Aquifers tend to be interlayered with aquitards and aquicludes so if a deep well is drilled, there might be several different aquifers that could be tapped to supply water. The water in different aquifers under the same piece of land can be very different; the aquifers may be, to all intents and purposes, separate.

Even where large rivers or lakes could provide abundant water, many people choose to drill wells for their drinking water. This is because groundwater is less likely to be polluted than surface water. Most of the potential sources of pollution (for instance, farms, paper mills, or septic tanks) are at the surface or very close to it (for example, underground storage tanks). Thus, most pollution occurs at or very near the surface, and nearly all surface waters show at least some signs of pollution. However groundwater is somewhat protected from this contamination. Water travels slowly in the subsurface with speeds of inches or feet per day. Thus, even if some unwanted substances enter the ground, they may take a long time to penetrate deeply enough to affect the groundwater supply. Also, deeper aquifers that underlie aquicludes may be isolated from surface-derived contamination. Groundwater is commonly treated with chlorine to kill bacteria if it is to be used for drinking, but most groundwater needs no other treatment. Groundwater is a priceless resource that we ought to conserve, protect, and use wisely.

Terms

aquiclude:
a low-permeability unit that forms either the upper or lower boundary of a groundwater flow system

aquifer:
porous, water-bearing layer of sand, gravel, and rock below the Earth's surface; reservoir for groundwater

aquitard:
a low-permeability layer of rock or clay that can store water but transmits it very slowly from one aquifer to another

artesian well:
a well that produces water without need for pumping due to pressure exerted by confining layers of soil

discharge:
the outflow of groundwater from a flowing artesian well, ditch, or spring

dowsing:
to search for a source of water or minerals with a divining rod

drawdown:
the lowering of the water table as water is removed from an aquifer

geologic map:
a map of the Earth's surface with surface geologic formations superimposed over existing features such as roads, streams, lakes, and other features

geological formation:
a body of rock identified by lithic characteristics and stratigraphic position; the fundamental unit in lithostratigraphic classification

groundwater:
water that infiltrates into the Earth and is stored in usable amounts in the soil and rock below the Earth's surface; water within the zone of saturation

hydraulic head:
the height of the free surface of a body of water above a given subsurface point**;** the

sum of elevation, pressure, and velocity components at a given point in an aquifer

igneous rock:
rock that solidified from a hot, liquid state

lithic:
of stone

lithostratigraphy:
the arrangement of rocks in layers or strata; the branch of geology dealing with the study of the nature, distribution, and relations of the stratified rocks of the Earth's crust

metamorphic rock:
rock made by heating and pressurizing preexisting rocks

outcrop:
the exposure of bedrock or strata projecting through the overlying cover of detritus and soil

permeability:
the capacity of a porous material to transmit fluids. Permeability is a function of the sizes, shapes, and degree of connection among pore spaces, the viscosity of the fluid, and the pressure driving the fluid.

porosity:
a description of the total volume of rock or soil not occupied by solid matter

recharge:
(1) to replenish a waterbody or an aquifer with water**;** (2) the replacement of any water that may have flowed out or been pumped out of the aquifer

road cut:
a hill, ridge, or mountain side excavated for a road right-of-way. Road cuts leave exposed strata, rock, and soil that can be viewed in their natural state if not covered or vegetated.

sedimentary rock:
a rock that consists chiefly either of small pieces of rock cemented together (sandstone) or of crystals that grew from water (rock salt, limestone)

sinkhole:

a hole caused by collapse of the land surface, commonly because underlying limestone rock has dissolved away

water table:
upper surface of the zone of saturation of groundwater

well:
a bored, drilled, or driven shaft or dug hole. Wells range from a few feet to more than 6 miles in depth, but most water wells are between 100 and 2,000 feet in depth**.**

ADVANCE PREPARATION

A. Copy Student Sheet and collect materials.

B. The teacher may wish to put 8-10 small holes, using an ice pick, into one cup for each group.

PROCEDURE

I. Setting the stage

A. Discuss Background Information with students.

B. Put terms with definitions on the board.

C. Divide students into groups of 3-4. Distribute materials.

II. Activity

A. Construct a model of an aquifer.
   1) Have students use gravel to construct subsoil aquifers in the plastic container. Cover the gravel with sod on each side of the container to represent hills with a valley between. The valley is only to contain gravel to a height of about 2 cm.
   2) Have one student in each group hold the cup with the holes over the model.

3) Then have another student pour 500 ml of water into the cup for a simulation of rain. Tell students to note how the water infiltrates the gravel to become groundwater. Also, have them note what happens to the water falling on the sod.
4) Have a third group member draw a line with a grease pencil at the water level in the container all the way around the container. Note: The pencil mark illustrates the water table. Explain that a pond is formed when the water table is higher than the land surface.
5) Have a student in each group insert the pump into one of the hills on the side of the valley, pushing the bottom down to the groundwater.
6) Allow students to press the pump several times after the water has begun to flow. Catch the water in the paper cup with no holes. Instruct students to observe what is happening to the water table. Where did the water go? What is happening to the pond?
7) Discuss the concept of discharge. Discuss the effect of groundwater pumping on natural streams and lakes.
8) Have students answer these questions:

   a. Where does groundwater come from? (snow, sleet, rain: precipitation) Water could move from a stream or lake to recharge a water table if the table is below the stream level.

   b. What would happen to a neighborhood if a well were drilled near a stream or pond and enough water pumped to lower the water table? (Some water from a stream or lake would be removed by the pump through the well. If enough water were removed, the stream or pond might go dry.)

B. Ask students to discover aquifer conductivity by doing the following:

1. Take samples of soil from various locations in the community.

2. Describe the samples' grain size, color, and any other observed physical characteristics.

3. Place a standard volume in a coffee filter holder or other suitable container.

4. Pour a known volume of water through the different samples.

5. Measure the time it takes for the water to pass through the various soil samples and record.

6. Analyze the relationship between soil grain size and the rate of time it takes for the water to pass through the sample. Write a brief statement about this.

C. Have students identify a rock-type, geological formation and determine the possibility of an aquifer by doing the following:

1. Stop at a road cut and pick up a rock that is indicative of the area.
2. Determine the location of the sample site on a road map.
3. Locate a geologic map of the area and determine the formations in the area.
4. Determine whether the rock is of metamorphic, igneous, or sedimentary origin.
5. While at the outcrop, look for groundwater seeps.
6. Draw a sketch of the outcrop.
7. Analyze the rock and the formation. Determine if it is an aquifer.

D. Pass out the puzzles and post or pass out the word list.

III. Extensions

A. Have students research different types of aquifers in different regions of the country and present findings to the class.

B. The Student Sheet Puzzle could be timed or done as a contest and a quiz given with the terms used in it.

C. Students could do library research on their local aquifer. The results of this research could be turned in as research papers, presented to the class, or presented in other places, such as a local meeting of conservation or environmental group or a city council.

RESOURCES

College or university libraries and Geology departments can also be very helpful. Many informative brochures about groundwater have been published by a variety of entities.

The environmental agency in each state. (See list in back of guide.)

The Geological Survey in each state. (See list in back of guide.)

The U. S. Geological Survey.