DO YOU DRINK IT?

9-12

SUBJECTS:
Science (Physical Science, Ecology, Earth Science), Social Studies (Geography)
TIME:
2 class periods
MATERIALS:
3-liter soda bottles aquarium gravel sand (coarse) pump from liquid dispenser blue, yellow & Red food coloring paper cups straws student sheets droppers scissors or razor blades markers

OBJECTIVES

The student will do the following:

1. Create an aquifer model.

2. Locate major U.S. aquifers.

3. Explain how a well works.

4. Examine a well's relationship to the water table.

5. Apply principles of well placement.

6. Explain different ways that groundwater is contaminated.

BACKGROUND INFORMATION

An aquifer is an underground layer of rock or soil that holds the water called groundwater. The word “aquifer” is derived from the Latin “aqua” meaning “water ,”and “ferre” meaning “to bring” or “to yield.” The ability of a geological formation to yield water depends on two factors - porosity and permeability. Porosity is determined by how much water the soil or rock can hold in the spaces between its particles. Permeability means how interconnected the spaces are so that water can flow freely between them.

There are two types of aquifers. One is a confined aquifer, in which a water supply is sandwiched between two impermeable layers. These are sometimes called artesian aquifers because, when a well is drilled into this layer, the pressure may be so great that water will spurt to the surface without being pumped. This is an artesian well. The other type of aquifer is the unconfined aquifer, which has an impermeable layer under it but not above it. It is the most common type.

Aquifers may be categorized according to the kind of material of which they are made. A consolidated aquifer is composed of a porous or fractured rock formation. Most unconsolidated aquifers are composed of buried layers of sandy, gravelly, or soil-like material.

The top surface of the groundwater is called the water table. The water table depth varies from area to area and fluctuates due to seasonal changes and varying amounts of precipitation. Excessive pumping from the aquifer (wells) can also lower the water table.

Perhaps the largest aquifer in the world is the Ogallala aquifer located in the midwestern United States. This aquifer is named after a Sioux Indian tribe. It is estimated to be more than two million years old and to hold about 650 trillion gallons (2,500 trillion liters)! It underlies parts of eight states, stretching about 800 miles (1,288 km) from South Dakota to Texas. The Ogallala aquifer supplies vast amounts of water to irrigate the crops in this vitally important agricultural area.

Not only is groundwater used to irrigate crops, but it is also used for drinking water. About half of the U.S. population gets its drinking water from groundwater. Wells reach into the water table and bring water to the surface by being pumped by hand, windmill, or motor-driven devices. In ancient days, these wells were dug by hand and lined with stones or bricks to prevent the sides from collapsing. Today, most are formed by drilling a 2-4 inch (5-10 cm) hole and lining it with metal or plastic piping.

The biggest problem facing well water is contamination. Sources of groundwater pollution are leaking underground storage tanks, leaking septic tanks or septic tanks with inadequate drainfields, landfill seepage, animal waste, fertilizer, pesticides, industrial waste, road salt, and some natural contaminants. Another big problem causing groundwater contamination is abandoned wells that are not properly closed. These leave direct channels for contaminants to enter the aquifers. Some wells are even used to inject waste materials into the ground. When a groundwater source is contaminated, it is very difficult and expensive to clean up. The best way to protect well water is to prevent contamination from occurring.

Another type of well is an underground injection well. This type of well is used as a means of wastewater disposal, aquifer recharge, or solution mining of an economically significant mineral from a geologic formation. The most prevalent use of underground injection, however, is for wastewater disposal.

Underground injection wells have even been classified into categories by the U.S. EPA. They are as follows:

Class I	Municipal and hazardous/non-hazardous industrial waste
Class II	Oil and gas field wastes and enhanced recovery injection
Class III	Solution mining
Class IV	Shallow hazardous waste disposal (banned)
Class V	All other types of injection (floor drains, storm drains, etc.)

In most states, Class I hazardous and IV wells are prohibited. All states that have oil and natural gas production have Class II wells. Class III, or mining wells, inject water to solution mine a desired mineral (as salt). Injection wells not fitting any of these categories are Class V wells. Septic systems serving 20 or more people a day and floor drains found at service stations and car washes are examples of Class V wells.

Note: Two background information charts (A&B) should be supplied with this background narrative.

Subsurface disposal by wells depends on the capacity of the geologic formation to attenuate wastes that are properly injected into it.

Terms

aquifer:

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

aquifer recharge:
the addition of water by any means to an aquifer

artesian aquifer:
an aquifer that is sandwiched between two layers of impermeable materials and is under great pressure, forcing the water to rise without pumping. Springs often surface from artesian aquifers.

attenuation:
dilution or lessening in severity

confined aquifer:
an artesian aquifer

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

impermeable (substance):
a substance through which other substances are unable to pass

solution mining:
a type of mining wherein water is injected into a well to remove a desired mineral

unconfined aquifer:
an aquifer containing unpressurized groundwater, having an impermeable layer below but not above it

underground injection well:
a type of well used for wastewater disposal, aquifer recharge, or solution mining of minerals

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

ADVANCE PREPARATION

A. Collect materials for activities.

1. Each student can be asked to bring one 3-liter bottle and a pump from a liquid dispenser, or each group may prepare a group water pump model.

2. Fill three dropper bottles with water. Tint the water in each with a different color of food coloring. Set aside.

3. Make a transparency of U.S. Aquifer Map. Make enough copies for students.

C. Make a transparency of Well, Well, Well Map. Make enough copies for students.

D. Make copies of Background Information and sheets on Pathways To Groundwater Pollution for students.

E. Make a transparency of Model Example Sheet.

PROCEDURE

I. Setting the stage

A. Pass out Aquifer Map, Well, Well, Well Map, Background Information, and Pathways to Groundwater Pollution sheets.
B. Divide students into working groups of 3, 4, or 5.
C. Ask students to read Background Information, look at Pathways to Groundwater Pollution sheets, and discuss information in their groups.
D. Put terms on the board and have students copy on the Background Information sheet.

II. Activity

A. Show the students the transparency of the U.S. Aquifer Map.

1. Explain that the crosshatching on this map marks the places in the continental U.S. where abundant fresh water is available from aquifers. In these areas, large groundwater supplies are used by industries, communities, and agriculture. In the areas where there are no markings,

there is less likely to be plentiful groundwater available. These places will, however, have wells that supply individual households and livestock operations. Remind students that small aquifers exist almost everywhere, and that the map shows only major aquifers.

2. Ask the students to answer the following by naming states.

    a. Name several states where plentiful groundwater is available almost everywhere. (Florida, Mississippi, Louisiana, Iowa, Delaware, Nebraska, Michigan, New Jersey)
    b. Name several states that have the least groundwater in many places. (Montana, Washington, Oregon, Idaho, Pennsylvania, Kentucky, West Virginia, Vermont, New Hampshire)
    c. Where does your state rank with groundwater supplies? What is groundwater used for locally?
    d. Why does your group think that some states do not have very much groundwater?
    e. What is an advantage in an area where aquifers are small? (Contamination will not spread as easily.)

B. Show the students the transparency of the Well, Well, Well, Map.

1. Tell the students that one way to keep a well free of contaminants is to select a good site before it is drilled. Tell them that they are not considering the direction of groundwater flow in this activity, but that this would actually be a big consideration.
2. Tell students that they are to mark the place on their map where they think the well should be dug. They may illustrate this in any manner they choose.
3. Have students identify the possible groundwater contaminants on this map. Ask them if they can think of other possible contaminants.

C. Set out materials needed to make water pump and contamination models. Instruct students to follow directions.

1. Using the 3-liter bottle, cut off about ½ the top. Remove the black bottom and fill the remaining clear portion with approximately 2 inches (2.5 to 3.7 cm) of gravel and then 2 inches of sand. (Use transparency of model.)
2. Pour in 2 to 3 inches (5 to 7.5 cm) of water colored blue with food coloring and mark the location of the water table with a black or blue marker.
3. Place the pump into the gravel with the tube extending into the water.
4. Pump water out of the model, catching the water in the cup.

5. Discuss how contaminants like agricultural waste, sewage, road salt, and other surface contaminants can get into the groundwater. Demonstrate this by using the yellow food coloring on the surface of the sand and “rain” on your model. Pump more water out of the well. Observe results.
6. Place a straw into your model to represent an abandoned well. It should reach the same depth as your pumping well. Pour a contaminant (red food coloring) into abandoned well. Pump more water out of the pumping well. Compare this means of contamination with the surface contamination.

III. Follow-up

A. Have students list at least four possible sources of groundwater contamination.
B. Have students demonstrate knowledge of vocabulary by using the terms correctly in an explanation of groundwater, wells, and groundwater contamination.
C. Students should try simulating other types of contamination (leaking underground storage tanks) with their model.
D. Using the Background Information on underground injection wells, answer the following.

    1. Some states, such as Florida, use injection wells to recharge valuable aquifers used for drinking water. List the pluses and minuses of this practice as it relates to environment and public health. What Class well would this be? Why?
    2. Class II wells are used to re-inject salt water or liquid waste from oil and gas production. They are also used for further recovery of oil when reservoirs are depressurized but recoverable product remains. What is this called? How does it work?

IV. Extensions

A. Have students contact their local health department to obtain guidelines on digging new wells.

B. Share with students the following information about dowsing or “water witching” and divining rods. Some people will not have a well drilled without calling a water “witch”or “dowser” to locate the groundwater. Water witches or dowsers have been around for thousands of years. They use metal or wooden sticks (“divining rods”) to locate places where wells should be drilled. Some even predict the depth of the water table. Dowsers are not always successful in their efforts, but many people believe in their special ability to find water. Ask students to research the local use and efficacy of dowsing.

C. Write the American Groundwater Trust (6375 Riverside Drive, Dublin, Ohio 43017) for more information about wells and groundwater protection.

RESOURCES

Banks, M., British Calendar Customs, Volume 1, William Glaisher, Ltd., London, 1937.

Branley, F.M., Water for the World, T. Y. Crowell, New York, 1982.

"Groundwater Pollution Control," American Groundwater Trust, Dublin, Ohio, 1990.

"Ground Water: Issues and Answers," American Institute of Professional Geologists, Arvada, Colorado, 1984.

Grades 3-5 Water Sourcebook.

U.S. Department of the Interior, Water Dowsing, 1993, p. 15.