Comparing Aquifers
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Goal of Lesson:
Students will make models of different aquifers, pour water through them, and compare the rates at which water moves through three different model aquifers and the amount of water each aquifer holds. At the end of the activity, students will know how the materials of an aquifer affect the behavior of water in the aquifer.
E2.1B Analyze interactions between the major systems
E4.1A Groundwater is connected to the surface. The rate of infiltration and flow through the ground may be fast or slow depending on the type of material though which it flows.
E1.1C Conduct scientific investigations using appropriate tools and techniques.

Knowledge Needed:
- Ability to work in groups
- Understanding of the metric system and using it to make measurements
- How to operate a stopwatch
- How to compare and contrast
- Be able to fill out a chart
- Knowing how to infer
- What is a diameter
- Prerequisite vocabulary words: absorption, ground water, hydrosphere, variables, constants, hypothesis

Vocabulary:
- aquifer - any body of sediment or rock, that has sufficient size and sufficiently high porosity and permeability to provide an adequate supply of water for wells
- reservoir - a place in the Earth system that holds water
- porosity - a measure of the percentage of pores or open spaces in a material
- permeability - a measure of how easy it is to force water to flow through a porous material
- input - water that becomes part of the ground water
- output - discharge of water into another system (a good example for an aquifer would be a spring)
- infiltration - action of water entering the ground and becoming ground water

Materials:
- Clear 2-L plastic pop bottles (one per group) with the bottoms cut off.
- piece of cheesecloth
- scissors
- rubber band
- corrugated cardboard
- masking tape
- loam
- fine sand
- coarse sand
- clay

- pea gravel
- marbles
- 500-mL beaker
- measuring cup to hold 500 mL
- stopwatch
- science journals or lab journals
- pencils

Procedure/Instructions

Engage: Did you know that somewhere between 70 and 75 percent of the earth's surface is covered with water? And did you know that there is much more fresh water stored under the ground than on the earth's surface? Does anyone know what we call these underground areas of water? Wait for answers.

Explain: Define what an aquifer is before beginning.

On the board, write "How do materials of an aquifer affect the behavior of water in the aquifer?" and read this out loud before you begin.
1. Instruct the students to make a copy of the data table in their journals and set it to the side.

For the rest of the steps, I would suggest modeling a completed one or make one as they make one.
2. Place a piece of cheesecloth over the small opening at the neck and hold it in place with a rubber band.

3. Say, "Now you have to make a holder for the bottle top." Demonstrate or show that in the center of the cardboard, they need to mark a circle that is slightly less than the diameter of the plastic bottle. They are to cut this out and remove the circle from the cardboard.

4. The students will then place the cardboard over the beaker. Invert the bottle top and place the neck into the hole in the cardboard. Say "you will be placing material in the bottle top to make each model aquifer."

5. Students will now measure 5 cm down from the rim of the bottle top. Use a piece of masking tape to mark this height. Say "each model aquifer should be no higher than this mark."

6. Explain: As a group, decide how you want to test three aquifers. Each aquifer will consist of one or more layers of the ground materials available. Try to keep as many qualities constant as you can. For example, if you wish to compare an aquifer of a single material to an aquifer made of layers of different materials, then both model aquifers should have the same total volume. If you wish to compare many thin layers to two thick layers, then you should use the same materials in the same amounts for both model aquifers. ******You will probably need to explain this a few times with some models drawn on the board.***

Explore

7. Have the students walk around the different ground materials they will be using. Have them pay attention to the size of the particles.

8. After the students have checked out the ground materials have them get back into their groups and regain their attention. Have the students discuss at their groups what affect they think the size of the particles will have on the movement of water through their aquifers. How well will water flow through each material? How much water will each material hold?

After the students have completed the activity through step 8, have the students write a hypothesis to explain how water will behave in the three aquifers. Write this statement on the board for the students to use as a guideline
"If…., then……, because….."
9. Students will build one aquifer by putting material into the bottle top.

10. Draw your model aquifer in the table. Show the relative thickness of the layers with a measurement. Identify the content of each layer.

11. Estimate how long you think it will take for 500 mL of water to move through your aquifer. Record your estimate.

12. Measure 500 mL of water. Have someone have in charge of the stopwatch and someone else in charge of pouring water. Another person will hold the beaker under the aquifer to catch the water. Start the time as someone slowly pours all of the water into the open end of the bottle. Stop timing when the stream of water coming out of your aquifer is only a very slow drip. If the water does not stream out, stop timing when no more water drips out. Have students record time on their tables.

- **Explain that the pouring of water would be an input**
- **Explain that the water going into the aquifer would be infiltration**
- **Explain that the water coming out would be an output (such as a spring)**

13. Measure the volume of water in the beaker. Have students record this measurement on their tables.

14. Have students repeat steps 9-13 for their other two aquifers.

15. Students are to complete question sheet as a lab group when finished with the three aquifers and recording their data.

Elaborate:
Investigate further: Based on results, try to create an aquifer that holds as much of the water as possible and another that holds as little of the water as possible. What might be a confined aquifer be? What might be an unconfined aquifer?

For the Teacher
Sample hypothesis: If the particles of a material are large, then water will move through it more quickly and it will absorb less water.

Also: The rate of flow can vary a great deal, depending on the materials placed in the bottle. Times may be measured in seconds or minutes. Students should not try to hurry slow-moving water. They may use the time to make detailed observations through the sides of the bottle top.

Evaluate:
Use the rubric to grade the table and the responses to the questions. You can also evaluate during the activity to see if students are getting it.

Aquifer	Drawing	Description	Predicted Time	Actual Time	Water Collected (mL)	Notes
1						
2						
3						

Observe and Analyze

1. **Compare and Contrast** Through which model aquifer did the water flow the fastest? the slowest?

_____
_____

2. **Calculate** Which model aquifer held the most water? the least?

_____
_____

3. **Identify** What were the variables and constants in your experiment?

_____
_____

4. **Identify Limits** What possible limitations or sources of error did you find in this investigation?

_____
_____

Conclude

1. **Infer** How did the size of the particles affect the amount of water the model aquifer held?

_____
_____

2. **Infer** How did the size of the particles affect the rate at which the water flows through?

_____
_____

3. **Conclude** Compare your results with your hypothesis. Do your data support your hypothesis? _____
_____

4. **Apply** Based on your results, which type of soil is water most likely to run off, rather than seep into the ground? _____
_____

Investigate Further

Based on your results, try to create an aquifer that holds as much of the water as possible and another that holds as little of the water as possible.

Grading Rubric

	Excellent (A) 4	Good (B) 3	OK (C) 2	Poor (D) 1
Data	Very organized and clear data on table. All measurements complete and labeled correctly.	Data organized and clear. One or two measurements not labeled correctly.	Data organized but not clear. Measurements are not complete, labeled incorrect.	Data unorganized, unclear but is still present. Measurements incomplete/incorrect
Science Reasoning	Well thought out and clearly explained responses.	Responses make sense but need more clarification	Some responses make sense.	Responses not thought out-answers rushed only to get the assignment done
Group Work	Encourages others to participate, actively participates, helps others, cleans up after lab	Actively participates, sits with group, completes work, cleans up after lab	Sits with group, follows along, completes work, cleans up after lab	Uncooperative, refusing to sit with group, does not clean up after lab

Lesson is adapted from McDougal Littell Lab Generator