Groundwater Flow Concepts

Introduction/Information

Groundwater is not new water; it is "recycled" water that is related to all the other water on earth through a process called the hydrologic cycle. The hydrologic cycle describes the inter-relationship of groundwater, surface water such as lakes and streams, and atmospheric water such as clouds, snow, and rain.

When rain falls on the surface of the ground, some of it runs off the land into lakes and streams. This is called runoff. When water soaks into the ground, that process is called infiltration. The water soaking into the ground will first go through an unsaturated zone where some may be taken up by plants and returned to the atmosphere through a process called evapotranspiration. In a process called percolation, water passing through the unsaturated zone may reach the saturated zone and become groundwater. The top of the saturated zone is the water table.

Places where water enters the groundwater system are called recharge areas. Wherever water leaves the groundwater system is called a discharge area. Recharge areas are usually located in upland areas, such as mountains where more rainfall may occur. Discharge areas are usually low areas such as lakes, rivers, and wetlands. Groundwater often feeds lakes and streams. When groundwater bubbles up at the surface of the ground, that discharge area is called a spring.

There are two main water sources for surface water bodies such as lakes and rivers, runoff and water discharged from groundwater. When no runoff is present, baseflow, or water exclusively from groundwater provides all of the water in a river or lake. Baseflow is the reason that streams flow even during long periods of dry weather. The temperature of groundwater is about 50 degrees, year-round, so baseflow keeps streams a constant temperature which is important for organisms living in the rivers. It also helps to keep streams flowing in winter, even when the ground is frozen.
Your Task

You will explore the interrelationship of groundwater and surface water through use of a groundwater flow model. You will determine how water moves through the unsaturated and saturated zones and how water recharges and discharges from the groundwater system.

Materials

- Groundwater Flow Demonstration Model
- Recharge bottles (2)
- Discharge collection bucket
- Food coloring (red, blue, green, yellow)
- Grease pencil

Safety and Disposal

Water and diluted food coloring may be flushed down a drain with an excess of water.

Procedure

1. Before you begin, label each of the piezometers with a letter, A-G. Label the two pumping wells 1 & 2.

2. Fill two recharge bottles and invert one at the left end of the model. Leave the outlet at the bottom right open. Let water flow through the model.

   Notice that water entering the model at the left side saturates the sand and gravel and exits at the right. Groundwater is contained in spaces between sand grains and other soil particles, or in cracks and fractures in rocks. Water enters the groundwater system in areas called recharge areas. It then flows “downhill” until it reaches an area where it can come to the surface of the ground, called a discharge area. When either of the outlets is open, water can move through the model because the elevation of the outlet is lower than the inlet elevation. When the outlets to the model are closed, there is no flow through it.

3. Inject red dye into piezometer E. Inject yellow dye into piezometers D and F. Make sure you have injected enough dye to form about a 1” circle of color in the surrounding sediments.

4. Clamp both outlet hoses and invert the second bottle at the right end. Let the lake fill with water.
The **hydrologic cycle** describes the interrelationship of groundwater with surface water such as lakes and streams, and the water found in the atmosphere such as clouds, snow and rain. The lake in the model is an example of the interrelationship of groundwater and surface water.

**Q 1:** Where did the water that filled the lake come from?

___________________________________________________________________

Water in artesian aquifers is under pressure. This pressure causes the water level in wells penetrating the artesian aquifer to rise above the top of the aquifer. In this case, it discharges into the lake. Saturated soils surrounding the lake will also discharge water into the lake.

**Q 2:** What is happening to the yellow dye injected into the piezometers?

___________________________________________________________________

5. Remove the recharge bottles from the model. Open the outlet at the bottom right of the model.

**Q 3:** As water drains from the model, what happens to the water in the lake?

___________________________________________________________________

6. Replace the recharge bottle at the left of the model. Fill the wetlands depression with water and add yellow food coloring solution.

**Q 4:** What happens to the water from the wetlands?

___________________________________________________________________

Wetlands are an important part of the hydrologic cycle. When there is a lot of runoff, water collected in wetlands slowly seeps into the ground and acts as a recharge area. When the water table is high, wetlands can be a discharge area.

**Q 5:** Define a recharge area.

___________________________________________________________________

**Q 6:** Define a discharge area.

___________________________________________________________________
7. Using the grease pencil, mark the water levels in each of the observation wells in the upper aquifer (B, C, D, F, and G). Draw a line connecting the levels of those wells.

Q 7: What does this line represent?
_________________________________________________________________

8. Close the bottom right outlet and open the lake outlet. Make sure the lake outlet hose is emptying into a collection container. Observe the water levels.

Q 8: What happens to the water levels?
_________________________________________________________________

When the water levels have stopped changing, mark the new levels in each of the same observation wells with the grease pencils.

Q 9: What has happened to the water table?
_________________________________________________________________

9. Inject dye into all of the observation wells. Observe which direction the water flows.

Q10: Which direction does the water flow?
_________________________________________________________________

Q11: If this depression in the model represents a river, as it more closely does with the outlet open, where does the water in a river come from?
_________________________________________________________________

Rivers are natural discharge areas for groundwater. In the model, you will observe dye traces moving from all directions toward the river, and then entering into the river when the river outlet is open.

10. Close the lake outlet. As the lake fills, notice that the water collecting in the lake is not clear. It has been affected by the dye that has been injected at various points all over the model.

Q12: What could the dye possibly represent?
_________________________________________________________________
11. Squirt a little red dye across the surface of the model between the wetlands and the lake/stream depressions, keeping the solution close to the front panel, so it can easily be seen.

12. Using a recharge bottle, drizzle water across the surface of the model.

Q13: What might the dye represent?
__________________________________________________________________

Q14: What does the water represent?
__________________________________________________________________

As the water soaks in, watch the dye that was added earlier.

Q15: What happens to the dye that is already in the soil when water is applied to the surface of the model?
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Infiltration and percolation of water from precipitation helps push pollutants further into the soil and into the aquifer.

Q16: Where may the pollutants in the soil and the aquifer eventually go?
__________________________________________________________________

13. Using the hand pump, pump water out of well 1. Watch the dye that is in the sediments.

Q17: If this well is supplying drinking water to our homes, what else are we getting along with our drinking water?
__________________________________________________________________

Q18: If there is no new water on earth, where does the water for recharge come from?
__________________________________________________________________
Discussion and Conclusions

The Earth’s hydrologic cycle is comprised of the many paths that water takes through its various states, liquid, solid (ice), and gas (water vapor). Water continually moves through the ground, oceans, rivers, lakes, ice caps, and atmosphere of the earth, but it is always just changing form; it is neither created nor lost as it travels through the cycle. Groundwater flow describes the course of liquid water as it travels through the earth and the way it interacts with surface water, such as rivers or lakes. Water recharges, discharges, and picks up contaminants and pollutants as it goes. Substances added to the earth affect the water. Things buried deep in the earth can affect the quality of the water we drink. Any contaminants in the groundwater will eventually be discharged into surface water. Nutrients in the water can cause algae blooms, weed problems, and turbidity in surface water. Natural processes such as exposure to sunlight, aeration, and turbulence break down some pollutants. Other contaminants, such as nitrogen, can be tied up in plant growth. On average water is renewed in rivers once every 16 days. Water in the atmosphere is completely replaced once every 8 days. Slower rates of replacement occur in large lakes, glaciers, ocean bodies and groundwater. Replacement in these reservoirs can take from hundreds to thousands of years. Some of these resources (especially groundwater) are being used by humans at rates that far exceed their renewal times. Perhaps people need to stop and think: What will we do if we eventually make clean water a non-renewable resource?

This activity has been adapted from the Groundwater Flow Demonstration Model Activities for Grades 6 – 12, by Dr. Kitt Farrell-Poe, Extension Environmental Engineer, Utah State University Extension, October 1997, Utah State University Extension.