**Groundwater: Why it’s important, how it flows & what’s in your water?**

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Activity 2 - Inspired by and adapted from Awesome Aquifers activity produced by The Groundwater Foundation (<https://www.groundwater.org/kids/getinvolved/so/aa.html>) for the Science Olympiad.

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**Learning Objectives:**At the end of this lab, you will be able to:

* Describe the source(s) of your water and discuss the importance of groundwater as a resource.
* Develop an aquifer model that demonstrates the connection between groundwater and surface water (the water cycle).
* Classify geologic materials by porosity and permeability and use them to determine how different materials control groundwater transport in the subsurface.
* Access and analyze groundwater quality data to characterize and monitor contamination.

**Activity 1: Where Does Your Water Come From?**

When you turn on your kitchen faucet, the water comes out… and that’s probably the most thought many of us give to our water supply. People around the world can get their water resources from **fresh surface waters** (rivers, lakes, etc.), or they can access **groundwater** resources for their water supply.

Let’s begin by taking a pre-lab survey. Take about **3 minutes** to complete the questions below:

1. From where do most people **around the world** access their water? Do most use surface water or groundwater resources for their domestic (at home) water supply? Take your best guess at the source of domestic water supplies worldwide:

\_\_\_\_\_\_\_\_\_\_\_ % of people in the world get their water from **surface water**.

\_\_\_\_\_\_\_\_\_\_\_ % of people in the world get their water from **groundwater**.

1. From where do you think most people in the **United States** get their water?

\_\_\_\_\_\_\_\_\_\_\_ % of people in the **U.S.** get their water from **surface water**.

\_\_\_\_\_\_\_\_\_\_\_ % of people in the **U.S.** get their water from **groundwater**.

1. (a) Where do YOU (at your house/dorm) get your tap water from (circle one)?

(A) Municipal water supply (B) Private Well (C) Other (List below)

(b) Do you know the source of that water?

(A) Surface Water (B) Groundwater (C) No Idea

1. Do you treat your water at home in any way? (Filter [fridge, pitcher, under sink etc.]? Water softener?)
2. Household water use is a small fraction of total water use worldwide. List at least two additional ways societies use water as a resource. (For each list whether you think they are more likely to be supplied by surface waters or groundwater).
3. Water use: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Circle one: Surface Groundwater
4. Water use: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Circle one: Surface Groundwater

**Activity 2: What is an Aquifer & How Does One Work?**

Water at Earth’s surface is constantly being exchanged through the atmosphere, the surface, and the subsurface as part of the Hydrologic (Water) Cycle. In this portion of the lab, you will experiment with different materials to determine how each interacts with water. Then we will put that information to use to construct a model of the water cycle, complete with a surface water body, an aquifer, and a functioning water well. Let’s begin!

*Activity 2a) Material Discovery*

You and your group will test how water interacts with 5 different materials: Sand, gravel, clay, and 2 others (varied by group). Set up an experiment with the materials provided that allows you to describe their relevant properties.

1. For each material, list its properties: in the table below:

|  |  |
| --- | --- |
| **Material** | **Notes: Important Properties/Interaction with Water** |
| Sand |  |
| Gravel |  |
| Clay |  |
| Other 1 (coffee filter, cotton ball, activated charcoal, plastic film) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |  |
| Other 2 (coffee filter, cotton ball, activated charcoal, plastic film) \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |  |

1. (a) Which material has the greatest potential to hold (store) the most water? What properties of this material made it well-suited for this function?

(b) What is the term for a layer of rock or soil that is able to store AND transmit groundwater?

1. (a) Which material has the greatest potential to restrict or block water from flowing? What properties of this material made it well-suited for this function?

(b) What is the term for a layer of rock or soil that restricts, limits or prevents groundwater from flowing through it?

1. Which material you selected would be best to use if you were going to try to remove contaminants from water or prevent contaminated water from moving through the system? What properties of this material made it well-suited for this function?

*Activity 2b) Build an Aquifer!*

Next, you will use your clear plastic container to create a physical model to demonstrate groundwater flow and storage beneath Earth’s surface. Using the materials provided, you will demonstrate the following concepts (*Note: not all of these concepts need to be shown to the instructor at the same time*):

1. An unconfined aquifer
2. A body of surface water
3. An aquitard
4. A confined aquifer
5. A water well
6. The water table
7. How precipitation and infiltration recharge groundwater resources
8. How groundwater and surface water are connected

When you are finished, create two concept sketches (1) a side view (Cross-section) of your model, and (2) an overhead view (map view) in the boxes on the next page. Label your sketches with the items A through H listed above.

Write down three observations unique to your model that you believe will influence the behavior of water. For example, how does the thickness of your model’s confined aquifer compare to that of the confining layer (aquitard)? Predict how your observations will affect water in your model (Impact).

1. Observation 1:

Impact 1:

1. Observation 2:

Impact 2:

1. Observation 3:

Impact 3:



Show these concepts and sketches to your instructor so they can initial the space below. Once you’ve had your model checked, answer the questions below:

**Instructor Initial**: \_\_\_\_\_\_\_\_\_\_\_\_

1. When it rains, precipitation that reaches Earth’s surface has two options. Either it will collect and flow across the surface as **runoff** (potentially becoming part of surface water like streams or lakes), or it will seep through pores (small spaces or gaps) in the geologic materials at Earth’s surface as **infiltration**.

(a) Was infiltration or runoff more common in your model? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

(b) How could you change conditions in your model to alter the proportion of runoff vs. infiltration at the surface?

1. Near the surface, infiltrating water will migrate down (**percolation**) through the *unsaturated zone* (wet, but air is also present in spaces underground) until it accumulates and eventually completely fills the voids (pores, fractures) underground as part of the *saturated zone*. The **water table** is the boundary between unsaturated and saturated rock/soil. Locate the water table in your model and label it with your dry erase markers.

(a) In order to have your model’s well work, into which subsurface area did you need to penetrate?

(b) What happened to the water table in the model as you pumped water from your well?

(c) Did that have any impact on your surface water body? Explain.

1. If a contaminant (dyed water) was introduced as a spill at the surface of your model, what would happen to it? Describe the path you expect it to take and where it would ultimately end up. Draw that path on your sketch of the overhead view of the model.

At this point, decide upon a location in your model where you will introduce a spill of contaminant (dyed water). Predict how you expect the contaminant to behave. Make it “rain” in your model and observe the contaminant. Watch the actual path that the contamination follows, and try to pump the well again to see if contamination shows up in the well water.

1. Did the contamination behave the way that you expected it to? Was your well impacted? Explain your answer
2. If you were to repeat the contamination experiment, but with a different well location, where would you place it? Why?

**Activity 3: Who Ruined Your Water!?**

The map below shows an area with three groundwater **monitoring wells** (1-3) and three potential sources of groundwater contamination (A-C). Recent testing has identified contamination from benzene (a common component of gasoline) in Well #3. Use the information to complete the table.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Well** | **Surface Elevation** | **Depth to Water** | **Concentration of**  ***Benzene* Detected** | **Water Table Elevation** |
| 1 | 580 ft | 18 | None detected |  |
| 2 | 590 ft | 26 | None detected |  |
| 3 | 600 ft | 40 | 10 parts per billion (ppb) |  |



Answer the following questions using the well data and map above:

1. Briefly describe how you determined groundwater table elevation for each of the well samples:
2. What controls the direction that groundwater travels in the subsurface? In other words, how do hydrologists determine which direction groundwater is flowing in a region?
3. (a) In the example above, provide the general direction below that the groundwater is flowing in this area and indicate it with an arrow on the map.

The water flows from \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ to \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ in this area.

(b) Which specific site (A, B, or C) is the most likely source of the contamination found in Well #3? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

(c) Besides the site you listed in (b) above, do you think that any of the other sites (A, B, or C) are at risk of potentially having groundwater contaminated with benzene? Explain.

1. If you were going to fully characterize the extent of groundwater contamination in this area, use your pen/pencil to draw in and label at least 2 more well locations (Wells #4 and #5) that you would like to sample on the map above.

1. Many contaminants are only found in small volumes relative to the amount of groundwater or surface water to which they’ve been added. But that doesn’t mean that we can ignore those contaminants, because many are extremely toxic, even at small concentrations. It is common to see contaminant concentrations reported in “parts per billion” (ppb). But it is hard to imagine what ppb means in everyday terms. One common way to visualize it is that a 13,200 gallon swimming pool (like the one pictured) holds about a billion (109) drops of water. So in our example, 10 ppb of benzene contamination is equivalent to 10 drops of benzene in this swimming pool.

Obviously, nobody is drinking 13,200 gallons in a single day. The average person should drink eight (8) 8-ounce glasses of water a day, which adds up to about 2 liters or *0.5 gallons of water per day*.

1. If an average person was drinking from Well #3 that contained 10 ppb of benzene, how many **years** would it take them to ingest 10 drops of benzene (along with 13,200 gallons of water)? ***Show your work below!***

(b) The Environmental Protection Agency's maximum allowable level for benzene in drinking water supplies is 5 ppb. What does this suggest about the toxicity of this substance?

**Activity 4**: **What’s in Your Water?**

You’ve used the sample bottle provided by your instructor to collect a drinking water sample from your own water supply. Using the Drinking Water Test Kit, we’ll now test for a number of constituents within your water sample.

*Disclaimer: Please keep in mind that the test kit is an inexpensive, commercial product designed to be a preliminary screening of drinking water quality. A wide range of factors may contribute to detection of contaminant levels above the EPA maximum contaminant levels (MCLs). If your test returns elevated levels of a specific contaminant, it is your responsibility to determine whether additional testing of your water supply is warranted. There are many accredited labs that can accurately test your water if you have concerns.*

1. Please provide specific details about the collection of your water sample:

(a) Approximate date/time of collection: Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Time: \_\_\_\_\_\_\_\_\_\_\_\_ am / pm

(b) Water sample source: Municipal [enter city name] or private well?: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

(c) Water sample location & fixture: Please include the building and the specific fixture (kitchen sink, bathroom, water filter, refrigerator, etc.): Building collected: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Fixture Description: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

(d) Filtration/treatment: Was your water filtered or treated in **any/all ways** prior to being collected? If so, please describe (Ex: pitcher filter, refrigerator, water softener, under-sink filtration, etc.):

1. Below is a table of contaminants that our test kit samples. Within the right column of the table, use internet sources and/or the local municipal Water Quality Report to describe the source of unsafe levels/ranges of each of these contaminants in drinking water supplies. NOTE: “EPA MCLs” refers to the Maximum Contaminant Levels from the US Environmental Protection Agency. The US EPA is the federal regulatory agency that sets and enforces the allowable levels of chemical constituents in water supplies. State, county, or local agencies may have stricter guidelines, but they may NOT allow higher levels, as these are a matter of public health.

|  |  |  |  |
| --- | --- | --- | --- |
| **Contaminant** | **Test Results** | **EPA MCLs** | **Contaminant Source** |
| Lead | ­­­­­­  \_\_\_\_\_\_\_\_\_\_ | 15 ppb |  |
| Pesticides | \_\_\_\_\_\_\_\_\_\_ | 4 ppb |  |
| Bacteria | \_\_\_\_\_\_\_\_\_\_ | None |  |
| Total Nitrate | \_\_\_\_\_\_\_\_\_\_ | 10 ppm |  |
| Nitrite | \_\_\_\_\_\_\_\_\_\_ | 1 ppm |  |
| Total Chlorine | \_\_\_\_\_\_\_\_\_\_ | 4 ppm |  |
| pH | \_\_\_\_\_\_\_\_\_\_ | 6.5-8.5 | Look up how high/low pH levels occur in water: |
| Total Hardness | \_\_\_\_\_\_\_\_\_\_ | 50 ppm |  |
| Total Dissolved Solids (TDS)\*  \*from Lab Sampler |  |  |  |

1. Compare your results to your lab partner(s) (or to average data for the region provided by the instructor). Are there any noticable differences between the results? What factors may explain that difference?
2. (a) Are any of the levels in your drinking water above the EPA MCLs? If so, list them below:

(b) In the event that somebody did have levels above the EPA MCLs, what do you think would be the next appropriate steps to take? (In other words, what could you do at home to treat your water? What else should you do?)

1. If you had collected a second sample after running the water for 10-15 minutes for your morning shower, do you think any of your results might be different? If so, why?

***Something to Consider***...What is your responsibility as a good citizen and contributing member of society to protect water resources for your own health and well-being as well as that of your community? What agencies exist in your area that protect water resources either formally (regulatory, commercially) or informally (non-profits, community groups, etc.)?