WATER MASTER

Beneath The Surface

Water Science: Groundwater

This activity satisfies one of the required JNMN lessons needed to complete the Junior Water Science Master Badge.

Appropriate Ages 8-12

Expected Time: 45 min

Learning Objectives:

Students will be able to describe the importance of the Ogallala Aquifer to Nebraska's agriculture industry and recognize the threat that pesticides and fertilizers pose to groundwater quality.

NE Science Standards

Grades 3-6

SC.3.7.2.E

SC.4.13.4.C

SC.5.13.4.A

SC.5.13.4.C

SC.5.13.4.D

SC.6.13.5

Did You Know...

The massive Ogallala Aquifer located beneath part of Nebraska is the largest aquifer in the entire United States. Nebraska's careful monitoring of groundwater depletion and recharge has proven successful in managing this rare resource.

BEFORE YOU TEACH

BACKGROUND KNOWLEDGE

If completely drained, it is believed that 6,000 years would have to pass to refill the Ogallala Aquifer. It is hard to visualize just how much water is contained underground in Nebraska, but if we were to pump all of our state's groundwater to the surface, we would be covered in roughly 43 feet of water! Compare that to California, who would have less than a foot of depth.

VOCABULARY

Aquifer: a body of permeable rock that can contain or transmit groundwater.

Groundwater: the water found underground in the cracks and spaces in soil, sand and rock.

Saturation: The limit of absorption of water in soil.

Groundwater Depletion: Water-level declines due to sustained groundwater pumping.

Groundwater Recharge: The replenishing of groundwater resources through absorption.

Materials And Prep:

2 Laminated pictures of a well from aboveground

Large Tabletop Groundwater Model (for Educator use only)

2 Nebraska Water Maps - subsection Ogallala Aquifer

1 Principal Aquifer Map

2 Groundwater Vulnerability Maps

2 Water Level and Changes in Saturation Thickness Maps

Video Instructions for Model Interpretation:

https://go.unl.edu/8tyh

JUNIOR NEBRASKA MASTER NATURALIST

Engage: 10 min

Have students view at the Nebraska Water map (red bordered map), and identify all of the water sources they can see. They might point out lakes, the Platte River, the Missouri River, or other streams and rivers they might see. Ask them how they think farmers in Nebraska water their crops. Is the water in our rivers and the rain enough to water all of the crops in Nebraska? Explain that much of the food that we eat depends on groundwater, specifically from the Ogallala Aquifer.

Explore: 10 min

Display the laminated pictures of a Nebraska groundwater well. Refer to the Principal Aquifers Map for a national perspective. Then, using the Saturation Thickness Maps, determine which states use the Ogallala Aquifer.

Explain: 15 min

Demonstrate and interpret the Large Beneath the Surface Groundwater Model. Representing common examples of groundwater pollutants, fertilizer and pesticides, is food coloring. Recharge water is added into the model and combines with the pollutants. The mixture then diffuses across the model finding groundwater wells in its path.
Follow this link for interpreting the model: https://go.unl.edu/8tyh or scan QR code on page 1.

Extend: 5 min

Introduce students to the Groundwater Vulnerability to Contamination Map. Ask for their interpretations. (map with black background). The color key is embedded in the 3rd paragraph from the left.

Evaluate: 5 min

You and your family can help protect groundwater. Have students write down one solution on a sticky note and stick it to the whiteboard.

Hands On Extension

The interpretation of the Large Groundwater Model parallels the student's aquifer kit. Completing the following programs will reiterate the groundwater concepts.

Depending on the size of your class/group, you can plan for the student ratio per kit (Make Your Own Aquifer Kit) to be 2:1 or 3:1, with students working in pairs or trios. Separate into two programs due to time restraints or finish every experiment in one day.

Available as separate programs:
30 minutes, Experiments 1-3
30 minutes, Experiments 4-5
50 minutes, Experiments 1-5

In depth, time saving instructions with pictures are included in this curriculum guide. The Junior Nebraska Master Naturalist Coordinator, upon availability, will assist during the program, or ahead of the program date work through the experiments with the teacher/leader.

Contact the Jr. Nebraska Master Naturalist Coordinator for specifics.
www.nemasternaturalist.org

Aquifer Kits

Helpful Hints with Pictures for Make Your Own Aquifer Kits

Version I: less clean up, less time, 30 minutes, 3 experiments
In **Version I**, the sand should never be used, so during setup have every baggie of sand remain in the cardboard box that holds the aquifer kit. Also since the charcoal and dye will not be used in these experiments, they too should remain in the kit's cardboard box. Spray bottles completely filled at each station are recommended, more as a storage vessel than a rain maker, but the opportunity is there for both. Refer to pictures when reviewing instructions. The gravel in the kits, placed on paper plates, can take 24 hours to dry.

Version II: The magic starts here, 55 minutes, 5 experiments, same clean up as Version I.
The charcoal should remain in its baggie until the last activity.

Version III: Experiments 1-3 one day, then Experiments 4-5 another day. Use the Aquifer kits over 2 different days, 30 minutes for each day.

Experiment 1: *The charcoal & sand should remain in its baggie until the last activity.*

Groundwater well is pumping, rain is recharging and the water table is adjusting. Observe how the water table moves up or down.

1. The gravel represents the land that is underneath grass, leaves and soil. Begin by placing the aquarium gravel into the tank, shake until level.
2. From your spray bottle water, slowly measure 2.5 cups, (use the cup that resembles the medicine cup) and pour it into the corner of the tank. Ask students to tilt their heads and follow the path where the water entered the tank, until they see a faint horizontal line of water, this is the water table. Students should now find that the water table is halfway between the surface and the bottom.
3. Scoop gravel with your hand to make a depression. This will be the lake. Using water from the spray bottle, measure another ½ cup, and pour it directly into the lake.

4. With one of the pieces of nylon hosiery, fold it over and wrap the nylon around the bottom of the pump and secure it with the rubber band. This creates a well screen so that the gravel will not be drawn up into the pump.

5. If this is a brand new kit, prime the pump provided in the kit by turning it to the left several times until the stem pushes up.

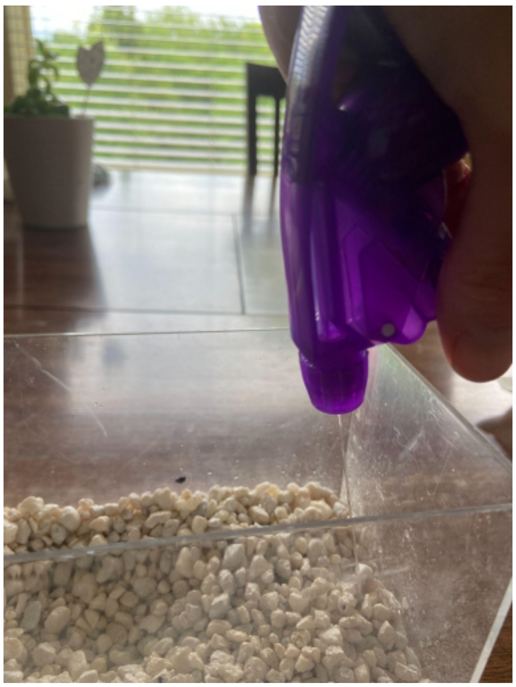
6. If the short tube was drying and left unattached to the hand pump, attach the short tube into the base near the spring.

Aquifer Kits

Experiment 1 continued: Observe how groundwater moves up or down in our aquifers.

7. On one side of the tank, position the 8 ounce cup to capture the water that is pumped from the tank. Before pumping, place the pump in the corner of the tank, press a very small strip of clay around the pump's tube, and onto the side of the tank, stabilizing the tube.

8. One student uses the hand pump to extract the groundwater, and another watches the groundwater by assessing the water table line. Now is a good time to introduce the term Depletion.



9. An additional student will now add 'rain' from the spray bottle into the corner of the tank. It percolates down into the soil, then travels through the gravel and across the length of the tank and enters the groundwater. Since the lake's depth is near groundwater level, also known as the water table, the lake eventually mixes with the newly saturated groundwater and the water level in the lake increases.

10. Next, remove most of the water out of the tank using the hand pump, transfer the extracted water to the small cup. Using the small cup, pour the rain directly into the lake, watch the groundwater rise up across the length of the tank. Are surface water and groundwater connected?

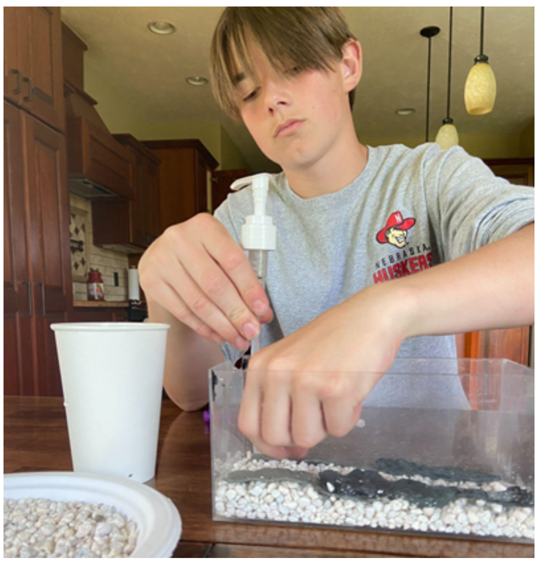
Lakes, rivers and marshes are examples of surface water and their water levels are affected by groundwater.

Aquifer Kits

Experiment 2: Ogallala Aquifer Well with a Confining Layer

By tipping the tank and pumping, empty the tank for Experiment 2, removing any residual water by absorbing with a paper towel.

1. Pour half of the gravel out of the tank onto a paper plate.
2. Craft the clay layer, usually three 1 inch strips, placed end to end horizontally and placed along the length of the tank. Replace the paper plate gravel into the tank, over the horizontally placed strips of clay.
3. Position the pump above the clay and pump 20 times.



4.Compare the water amount that was pumped this time with the amount of water pumped without the clay layer. A potential scenario for the students to think about could be… Imagine you are the water user, and that you have to place the groundwater pump through the clay, will you decide that you still want a groundwater pump? If so, what must you do to break through the layer?

Version II: Includes the previous 2 experiments, plus 2 more.
Time: 50 minutes

Sand should never be placed inside the tank, keep sand inside the baggie and use only in the cup and in the syringe.

Aquifer Kits

Experiment 3: Discover Permeability

The charcoal should remain in its baggie until experiment 5

Prepare for the next experiment by taking apart the syringe, and filling the syringe with gravel. Permeability is the length of time it takes for water to move through rock, soil or sand.

1. Track the time by counting in seconds until the cup of water is empty.
2. Position the syringe above the cup or tank, and add one ounce of water into the syringe, (ounces are marked on the other side of the small cup) and observe the speed of the water as it travels through the syringe.
3. Empty the syringe and dry. Now continue the demonstration by replacing the gravel with the sand.
4. Pour the sand from the baggie into the syringe.
5. Prepare the students to track the time by counting in seconds until the cup is empty.
6. Pour one ounce of water from the small cup into the syringe, and observe the water's speed through the sand.

- Decide which material has the greater permeability.

- What materials other than sand or gravel might be underground? Shale, granite and clay material take the most time to transmit water, and have the lowest percentages of permeability. Explain that the Ogallala aquifer is so large, spanning several states that its water moves underneath acres and acres of land, some of it moves even in between and through rock, and that surprisingly groundwater may move just inches per year.

Aquifer Kits

Experiment 3 continued: Porosity with sand, gravel and water.

Students learn that when groundwater percolates into the ground, it doesn't create underground lakes or streams. In fact, in some instances groundwater can only move inches per year. Groundwater wells are placed in areas where it is more easily pumped through rock, soil or sand. Porosity is the capacity of rock, sand or other sediment to hold water. Certain materials have greater porosity than others. Students will measure, record and formulate percentages that allows them to conclude which material has the greater porosity.

Which material holds more water?

Begin with the spray bottle as the source of water, small medicine cup, syringe and a pen and paper.

1. Fill the syringe with water to 30cc/mL

2. Expel the water in the syringe into the small cup, when filled to the top, record the quantity of water the cup holds, it's found on the outside of the cup. (Should be 30cc/ML.)

3. Using a paper towel, dry and fill the cup to 30cc/ML with gravel. Again add water using the syringe until it is filled to the 30cc/ML mark. Check the measurement on the side of the syringe to see how many cc/ML's of water were used and record the total.

4. Repeat by drying the cup again, this time filling it with sand. It may be best to have students keep the cup in the baggie of sand instead of pouring it too quickly. Again, add water to the brim of the cup, 30cc/ML, recording the measurement from the side of the syringe. How much was needed to fill the cup that held the sand?

5. To arrive at a conclusion of which material held more water, calculate the percentages, divide the volume of water that you were able to add to the material by the total volume of material. This is the porosity percentage. For example, if 15cc/ML of water were added to a cup filled with 30cc/ML of gravel, divide 15 by 30 and multiply by 100 to get a percent. In this example the porosity of the gravel would be 50%.

Aquifer Kits

Experiment 4: The next experiment demonstrates the physical movement of contaminants underground, and identifies danger zones.

The charcoal should remain in its baggie until the last activity.

1. Remove the clay layer, pat dry any additional water in the tank and spread out the gravel again. From the spray bottle, measure out 2.5 small cups of water to a corner, enough water so that the water table depth is half full. (Half of the gravel is dry and half is wet.)

2. An additional pump is built now. Beginning with the pliable tubing, similar to the hand pump, secure a well screen to the bottom of the pliable tubing with a rubber band. Connect the tip of the syringe into the new tubing to create a new groundwater pump.

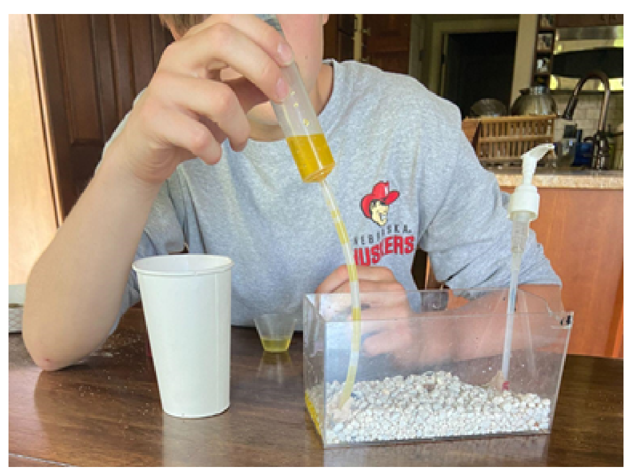
3. Place this new pump in one corner of the tank and the hand pump into the opposite end of the tank.
4. Fill the medicine cup completely full of water, add 2 drops of dye
5. Locate your new pump, and into the corner that is the closest, slowly add the pollutant mixture. ***See Images***

6. Empty the large cup. Position the large cup under the pump to collect the water. At the end of the tank, opposite from where the pollutant was poured, pump the original hand pump 20 times.

7. Observe where is the pollutant inside the tank. There is a horizontal plume of pollutant moving towards the hand pumped groundwater well.

8. With the syringe tip directly inserted into the tubing, extract as much water as possible into the new pump.
9. Pour the water that was in the large cup into the small cup and compare the concentration or color of the pollutant. Which pump's water contained the most pollution? and why?

Set the syringe with the colored water aside for the final experiment.



10. Tip tank to suction most of the water out, then use paper towels to absorb any remaining water from the tank.

Aquifer Kits

Experiment 5: Clean Contaminated Groundwater.

1. Dry the small cup. Using the charcoal provided, fill the small cup ½ full.

2. Be precise here... Add colored water until it reaches the ¾ full mark, or 25cc./mL. Use the colored water from the syringe that your students set aside.

3. Add a 4x4 inch piece of cling wrap to the top of the cup, secure it with a rubber band and shake vigorously for 60 full seconds, no stopping for the entire 60 seconds.

4. Remove the cling wrap and replace with a coffee filter, again securing the filter with a rubber band.

5. Where the gravel has no residual color, pour the liquid back into the tank. The water should now be 'remediated' or clear, the charcoal cleansed the affected groundwater.

Aquifer Kits

Clean up

Version I: Locate each kits carrier -cardboard box.

1. Pump all water out of the tank, use a paper towel to absorb what's left or have an adult tip the tank while holding the gravel back with a paper bowl.
2. On the 3 paper plates, divide the tank gravel equally and pour it out of the tank to dry.
3. Dry the inside of the tank.
4. Remove any residual gravel from clay.
5. Set clay out to dry.
6. Take apart the syringe, rinse and allow to air dry.
7. Rinse and dry the cup.
8. Twist the tube off the spring of the hand pump.
9. Rinse and open the two syringe pieces so they dry.
10. Lay all pieces out to dry near each kit's tank, rinse and wring out the nylon material, (the well screens) and lay flat.
11. Take the gravel from the cup and the syringe and add to the gravel that is drying on the paper plates.
12. Dump the wet sand onto a paper towel or directly in the trash.
13. Place the dye in a baggie and place it directly into the kit's cardboard box.
14. Place charcoal on a paper plate to dry and place in a baggie when completely dry
15. After the gravel has dried completely, this can take 24 hours, pour it back into the tank. Then take the open syringe, pump, and other items and place them on top of the gravel. Secure the tank lid to the tank with the large rubber band. Set upright in the box with the top of the cardboard box ajar.
16. Call JMNP Coordinator, 402-885-0990, for pick up.