NATIONAL GEOGRAPHIC

Activity*apply*

Using Groundwater Wisely

How can we use water sustainably?

Overview

Students use interactive computational models to explore the relationship between infiltration and recharge in natural and urbanized areas. They investigate how human development has changed the natural flow of water. Students explore the transfer of water from one aquifer to another and propose solutions to allow for water extracted from wells to recharge the aquifers from which they came.

For the complete activity with media resources, visit:
http://education.nationalgeographic.org/activity/using-groundwater-wisely/

Directions

1. Engage students in thinking about how water cycles through the ground.

Tell students that much of their water comes from groundwater and that water moves from the ground to the surface. Show the **Urban Water Cycle** diagram. Ask:

- *When precipitation falls, how does it move into and through the ground?* (When precipitation falls on the ground, it can run down the surface (runoff) or it can move into the ground. Water moves through the ground because sediments are permeable. If the sediments are very permeable, the water can penetrate deep into the ground, but if they are less permeable, the water will not be able to flow very deep into the ground.)
- *What effects have humans had on the natural movement of water?* (Humans have made a lot of the surface impermeable with buildings and pavement. The water cannot easily enter the ground through paved surfaces because they are impermeable.)

2. Discuss the role of uncertainty in the scientific process.

Tell students that science is a process of learning how the world works and that scientists do not know the “right” answers when they start to investigate a question. We can see examples of scientists' uncertainty in the forecasting of precipitation amounts. Have students go to the **NOAA National Weather Service**. Ask them to input their zip codes, hit “Go”, scroll down to the bottom of the page, and click on the “Hourly Weather Graph”. This page shows the hourly weather forecast for your area. The first box shows the predicted temperature and dew point (along with wind chill or heat index, when applicable). The second box shows the predicted wind speed and direction. The third box shows the predicted sky cover (i.e. cloud cover), relative humidity, and chance for precipitation.

The boxes below that line show whether the precipitation is likely to be rain, snow, freezing rain, or sleet. Point out the line for precipitation potential (the brown line). Ask:

- *Why is the precipitation shown as a "%"?* (Precipitation is dependent on other factors, such as relative humidity and temperature. It is more likely to precipitate when the temperature is the same as or lower than the dew point.)
- *If there is a likelihood of precipitation, why is the amount of rain/snow shown as ranges?* (The amount of precipitation that will fall is dependent on the amount of moisture in the atmosphere. The atmosphere is continually changing, so the amounts are guidelines for what could happen rather than perfect predictions.)

  **If there is no or low likelihood of precipitation in your area, you may want to find a different location (in the United States) that has a higher likelihood of precipitation. You can look at a current weather map (radar) to find where in the United States precipitation is happening currently. Your students will then be able to see scientists' forecasts of precipitation amounts represented as a range overlaid on the bar graphs.*

Tell students they will be asked questions about the certainty of their predictions and that they should think about what scientific data are available as they assess their certainty with their answers. Encourage students to discuss the scientific evidence with each other to better assess their level of certainty with their predictions.

3. Introduce the concept of systems in Earth's water resources.

Tell students that forecasting what will happen to Earth's fresh water supplies is a complicated process because there are many different interacting parts. Tell students that scientists think about how one part of the system can affect other parts of the system. Give students a simple example of a system, as described in the scenario below.

On an island, there is a population of foxes and a population of rabbits. The foxes prey on the rabbits. Ask:

- *When there are a lot of rabbits, what will happen to the fox population? (It will increase because there is an ample food supply.)*
- *What happens to the fox population when they've eaten most of the rabbits? (The foxes will die of starvation as their food supply decreases.)*
- *What happens to the amount of grass when the fox population is high? (The amount of grass will*

increase because there are fewer rabbits to eat the grass.)

- *If there is a drought and the grass doesn't grow well, what will happen to the populations of foxes and rabbits?* (The rabbit population will decrease because they have a lesser food supply. The fox population should also decrease as their food supply decreases.)

Humans introduce dogs to the island. The dogs compete with the foxes over the rabbit food supply. Ask: *What will happen to the populations of foxes, rabbits, and grass after the dogs are introduced?* (The foxes will decrease because they are sharing their food supply, the rabbits will decrease because they have more predators, and the grass will do well because of the lowered impact of the smaller rabbit population.)

Tell students that simple cause-effect relationships can expand into more complex system relationships. Let students know that they will be exploring the relationship between how sediments and rock types affects groundwater movement. Encourage students to think about how human actions play a role in changes in the flow of water and in freshwater availability.

4. Introduce and discuss the use of computational models.

Introduce the concept of computational models, and give students an example of a computational model that they may have seen, such as forecasting the weather. The weather forecast provides a good example of how model input is used to predict future conditions. Go to the **NOAA Weather Forecast Model**. Tell students that scientists used current information about the energy and moisture in the atmosphere as an input to the model, and that what they see on the weather map is the output of the model's calculations.

5. Have students launch the Using Groundwater Wisely interactive.

Provide students with the link to the Using Groundwater Wisely interactive. Divide students into groups of two or three, with two being the ideal grouping for sharing computer workstations. Inform students they will be working through a series of pages of models with questions related to the models. Ask students to work through the activity in their groups, discussing and responding to questions as they go.

Let students know that this is Activity 5 of the **Will There Be Enough Fresh Water?** lesson.

6. **Discuss the issues.**

After students have completed the activity, bring the groups back together and lead a discussion focusing on these questions:

- *What happens to rainwater when it rains in a city?* (The rain runs off impermeable surfaces into basins or rivers.)
- *How does that differ from when it rains in a non-urban area?* (In a non-urban area, the water can penetrate the ground because it is not covered by impermeable surfaces. The water in non-urban areas can recharge aquifers.)
- *How can humans better manage their use of limited water supplies?* (Humans can use water sparingly for necessary purposes. They can use the wastewater to recharge aquifers so that the wells don't run dry.)

Tip

To save students' data for grading online, register your class for free at the High-Adventure Science portal page.

Tip

This activity is part of a sequence of activities in the lesson Will There Be Enough Fresh Water?. The activities work best if used **in sequence**.

Modification

This activity may be used individually or in groups of two or three students. It may also be modified for a whole-class format. If using as a whole-class activity, use an LCD projector or interactive whiteboard to project the activity. Turn embedded questions into class discussions. Uncertainty items allow for classroom debates over the evidence.

Informal Assessment

1. Check students' comprehension by asking them to respond to the following question.

- Which area's aquifer is more likely to be recharged by precipitation: an urban area or a rural area? Explain your answer.

2. Use the answer key to check students' answers on embedded assessments.

Objectives

Subjects & Disciplines

Science

- Earth science
- General science

Learning Objectives

Students will:

- describe how human developments have changed the natural water cycle
- describe how wastewater can be used to recharge an aquifer

Teaching Approach

- Learning-for-use

Teaching Methods

- Discussions
- Multimedia instruction
- Self-directed learning
- Visual instruction
- Writing

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Information, Media, and Technology Skills
    - Information, Communications, and Technology Literacy
  - Learning and Innovation Skills
    - Critical Thinking and Problem Solving
- Critical Thinking Skills
  - Analyzing
  - Applying
  - Evaluating
  - Understanding

National Standards, Principles, and Practices

National Science Education Standards

• **(5-8) Standard A-1:**
Abilities necessary to do scientific inquiry
• **(5-8) Standard A-2:**
Understandings about scientific inquiry
• **(5-8) Standard B-1:**
Properties and changes of properties in matter
• **(5-8) Standard G-2:**
Nature of science
• **(9-12) Standard A-1:**
Abilities necessary to do scientific inquiry
• **(9-12) Standard A-2:**
Understandings about scientific inquiry
• **(9-12) Standard B-6:**
Interactions of energy and matter
• **(9-12) Standard F-6:**

Science and technology in local, national, and global challenges
• **(9-12) Standard G-2:**
Nature of scientific knowledge

Common Core State Standards for English Language Arts & Literacy

• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.9-10.1
• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.6-8.1
• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.6-8.3
• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Craft and Structure, RST.6-8.4
• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.9-10.3
• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Craft and Structure, RST.9-10.4
• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.11-12.1
• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Key Ideas and Details, RST.11-12.3
• **Reading Standards for Literacy in Science and Technical Subjects 6-12:**
Craft and Structure, RST.11-12.4

Next Generation Science Standards

• **Science and Engineering Practice 1:**
Asking questions and defining problems
• **Science and Engineering Practice 2:**
Developing and using models
• **Science and Engineering Practice 3:**
Planning and carrying out investigations
• **Science and Engineering Practice 4:**
Analyzing and interpreting data
• **Science and Engineering Practice 6:**
Constructing explanations and designing solutions
• **Science and Engineering Practice 7:**
Engaging in argument from evidence
• **Science and Engineering Practice 8:**
Obtaining, evaluating, and communicating information

Preparation

What You’ll Need

Required Technology

- Internet Access: Required
- Tech Setup: 1 computer per learner, 1 computer per pair, Interactive whiteboard, Projector

Physical Space

- Classroom
- Computer lab
- Media Center/Library

Grouping

- Heterogeneous grouping
- Homogeneous grouping
- Large-group instruction
- Small-group instruction

Resources Provided: Websites

- NOAA National Weather Service
- NOAA Weather Forecast Model

Resources Provided: Handouts & Worksheets

- Answer Key - Using Groundwater Wisely

Resources Provided: Interactives

- Using Groundwater Wisely Interactive

Resources Provided: Images

- Urban Water Cycle

Background & Vocabulary

Background Information

Human development has affected the natural water cycle in many ways. One way is in the urbanization of the landscape with more impermeable surfaces that do not allow water to infiltrate the groundwater. Another way is in extracting water from aquifers at a rate greater than the natural recharge rate.

Increasingly, water has been transferred from one aquifer to another as water is piped into urban areas from rural areas. This can deplete the aquifers in two regions, as water that falls into the urban area is unable to penetrate the impermeable surfaces.

Septic systems allow for local recharge of the aquifers. Water that is removed from local wells is returned as it leaches out of the septic system's leaching fields. By contrast, urban wastewater treatment plants often dump the treated water into streams, rivers, or the ocean. This water does not recharge the local aquifer or the aquifer from which it came. The wastewater can be discharged into holding pools where it can percolate through the soil and eventually reach a local aquifer.

Prior Knowledge

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Recommended Prior Activities

- Availability of Fresh Water
- Groundwater and Surface Water
- Groundwater Movement
- Using Fresh Water

Vocabulary

Term	Part of Speech	Definition
aquifer	*noun*	an underground layer of rock or earth which holds groundwater.
confined aquifer	*noun*	layer of water-bearing rock between two layers of less permeable rock.
conservation	*noun*	management of a natural resource to prevent exploitation, destruction, or neglect.
freshwater	*noun*	water that is not salty.
groundwater	*noun*	water found in an aquifer.
model, computational	*noun*	a mathematical model that requires extensive computational resources to study the behavior of a complex system by computer simulation.
permeable	*adjective*	allowing liquid and gases to pass through.
porosity	*noun*	the ratio of the volume of all the pores, or holes, in an object and the object's total mass.
porous	*adjective*	full of tiny holes, or able to be permeated by water.
precipitation	*noun*	all forms in which water falls to Earth from the atmosphere.
recharge	*verb*	to renew or restore to a previous condition.
runoff	*noun*	overflow of fluid from a farm or industrial factory.
stream	*noun*	body of flowing water.
sustainability	*noun*	use of resources in such a manner that they will never be exhausted.

Term	Part of Speech	Definition
system	*noun*	collection of items or organisms that are linked and related, functioning as a whole.
topography	*noun*	the shape of the surface features of an area.
unconfined aquifer	*noun*	layer of water-bearing rock covered by permeable rock.
urbanization	*noun*	process in which there is an increase in the number of people living and working in a city or metropolitan area.
water cycle	*noun*	movement of water between atmosphere, land, and ocean.
water infiltration	*noun*	process by which water on the ground surface or atmosphere enters the soil.
water table	*noun*	underground area where the Earth's surface is saturated with water. Also called water level.

For Further Exploration

Reference

- National Geographic: Encyclopedic Entry: aquifer
- National Geographic: Encyclopedic Entry: watershed
- National Geographic: Encyclopedic Entry: basin
- National Geographic: Encyclopedic Entry: wetland
- National Geographic: Encyclopedic Entry: reservoir
- National Geographic: Encyclopedic Entry: river
- National Geographic: Encyclopedic Entry: lake
- National Geographic: Encyclopedic Entry: water table

Partner

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This material is based upon work supported by the National Science Foundation under Grant No. DRL-1220756. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National

Science Foundation.