



A Drop in the Bucket

What is abundant and rare at the same time?

■ Grade Level

Middle School

■ Subject Areas

Earth Science, Math, Geography

■ Duration

Preparation time: 30 minutes

Activity time: 30 minutes

■ Setting

Classroom

■ Skills

Gathering information (observing, calculating); Organizing; Interpreting (drawing conclusions)

■ Charting the Course

Prior to this lesson, students should review percentages. Participating in the “Blue Planet,” students will recognize the portion of Earth’s surface covered with water. “A Drop in the Bucket” illustrates the amount of salt and fresh water available on Earth. Students simulate the water cycle in “The Incredible Journey.” “The Life Box” illustrates the necessity of water for life.

■ Vocabulary

salt water, fresh water, potable, glacier, renewable resource, North Pole, South Pole, instream use

Project Summary
By estimating and calculating the percentage of available fresh water on Earth, students understand that this resource must be used and managed carefully.

Objectives

Students will:

- calculate the percentage of fresh water available for human use.
- explain why fresh water is a renewable resource.

Materials

- Two colors of construction paper
- Sheets of white paper
- Markers

The Activity

- Water
- Globe or world map
- 1,000-ml beaker
- 100-ml graduated cylinders
- Small dish
- Salt
- Freezer or an ice bucket
- Eyedropper or glass stirring rod
- Small metal bucket
- Copies of *What’s in a Drop?* ©

Making Connections

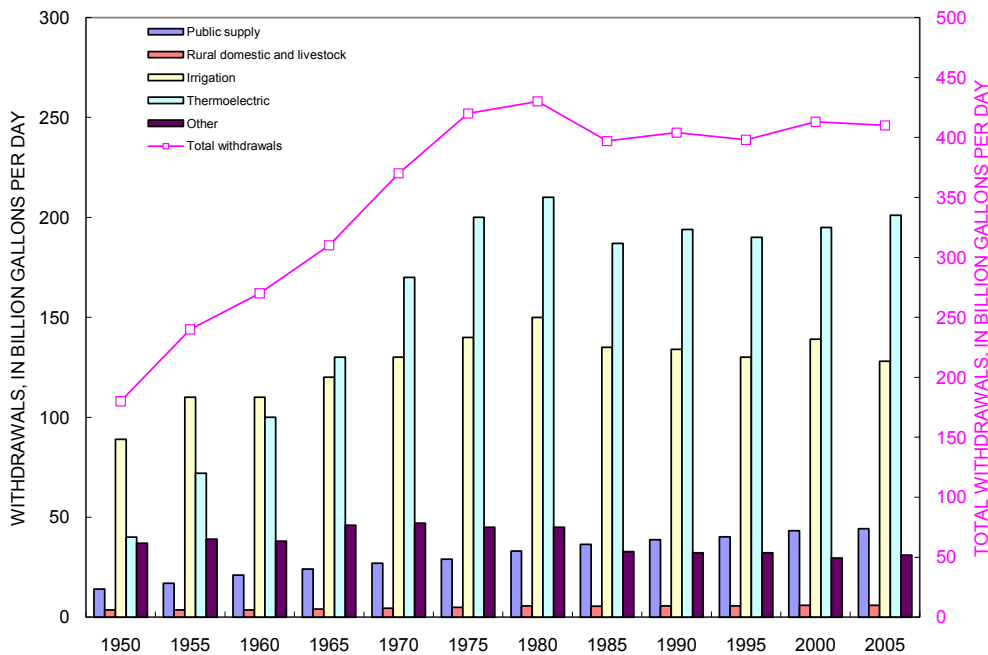
Students may know Earth is covered mainly by water, but they may not realize that only a small amount is available for human consumption. Learning that water is a renewable, yet limited, resource helps students appreciate the need to use water resources wisely.

Background

Ironically, on a planet extensively (71 percent) covered with water, this resource is one of the main limiting factors for life on Earth. The **Water Availability Table** summarizes the major factors affecting the amount of available water on Earth. If all the clean, fresh water were distributed equally among people, there would be about 1.6 million gallons (six million liters) per person. This is only about .003 percent of the total water on Earth. The good news is .003 is constantly being refreshed through the water cycle and this amount of fresh water is always available.

On a global scale, only a small percentage of water is available, but this percentage represents a large amount per individual. The paradox is that, for some people, water is plentiful, but for others it is scarce. Rainforests are places of plentiful water, whereas deserts have little water. In both places, people have learned to live and thrive with the available fresh water.

A Drop in the Bucket



Very large volumes of water are needed for cooling thermoelectric power plants. For more information about thermoelectric power and water use, refer to the full USGS “Summary of Estimated Water Use in the United States in 2005,” report (<http://pubs.usgs.gov/fs/2009/3098/>).

Trend in total water withdrawals by water-use category, 1950-2005.

Graph courtesy of the U.S. Geological Survey, Department of the Interior/USGS

Procedure

▼ Warm Up

- Tell students they are going to estimate the proportion of potable water on Earth and compare it to the rest of the water on the planet. Have students work in small groups.
- Instruct them to draw a large circle with a marker on a white sheet of paper. Offer them two sheets of different-colored construction paper. One color represents available fresh water; the other represents the rest of the water on the planet.
- Tell students that they will be tearing the two sheets of paper into a total of 100 small pieces. Ask them to estimate how many pieces will represent potable water and how many pieces will indicate the rest of the water on the planet.
- Instruct each group to arrange the 100 pieces within the circle so that these pieces reflect their estimates.
- Have groups record the number of pieces representing “potable” and “remaining” water.

ANSWER KEY:

Water Availability Table

Total water (100%) on Earth divided among all people (based on a world population of 6.9 billion people)	=	202.9 billion liters/person
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Minus the 97% of each share (196.813 billion liters) that contains salt (oceans, seas, some lakes and rivers)	=	6.087 billion liters/person
202.9 billion liters minus 196.813 billion liters		

Minus the 80% of this 6.087 billion liters that is frozen at the poles (4.869 billion liters)	=	1.218 billion liters/person
6.087 billion liters minus 4.869 billion liters		

Minus the 99.5% of the 1.218 billion that is unavailable (too far underground, polluted, trapped in soil, etc.) (1.212 billion)	=	6.0 million liters/person
1.218 billion liters minus 1.212 billion liters		

Most recent estimates indicate that there are approximately 370 quintillion gallons (3.7×10^{20}) of water on Earth.

▼ **The Activity**

NOTE: For simplicity, measurements have been retained in metric. To convert to standard measurements, refer to the *Metric Conversion Table* in the Appendix or use an Internet conversion site.

1. **Show the class a liter (1,000 ml) of water and tell them it represents all the water on Earth.**
2. **Ask where students believe most of the water on Earth is located. (Refer to a globe or map.)**
3. **Ask students to estimate how many milliliters of water they think would represent all of the fresh water on Earth. Pour 30 ml of the water into a 100-ml graduated cylinder.** This represents Earth's fresh water, about three percent of the total. Put salt into the remaining 970 ml to simulate salt water found in oceans, unsuitable for human consumption.

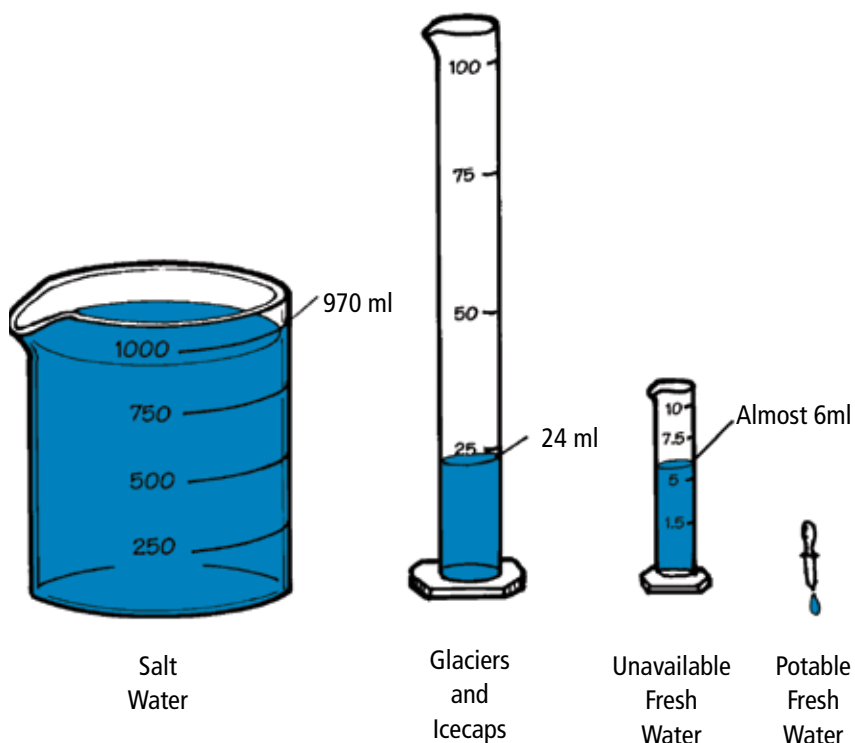
4. **Ask students what is at Earth's poles. Have students estimate what percentage of Earth's fresh water is stored in its frozen state.** Almost 80 percent of Earth's fresh water is frozen in ice caps and glaciers. Remind students that the North Pole is frozen sea ice while the South Pole is Antarctica (a continent) covered in an ice sheet. Pour 6 ml of fresh water into a small dish or cylinder and place the rest (24 ml) in a nearby freezer or ice bucket. The water in the dish (around 0.6 percent of the total) represents non-frozen fresh water. Only about 1.5 ml of this water is surface water; the rest is underground.
5. **Use an eyedropper or a glass stirring rod to remove a single drop of water (0.03 ml). Release this one drop into a small metal bucket.** Make sure the students are very quiet so they can hear the sound of the drop hitting the

bottom of the bucket. This represents clean, fresh water that is not polluted or otherwise unavailable for use, about .003 percent of the total! This precious drop must be managed properly.

6. **Discuss the results of the demonstration.** At this point many students will conclude that a very small amount of water is available to humans. However, this single drop is actually a large volume of water on a global scale. Have students use the **Water Availability Table** to calculate the actual amounts.

▼ **Wrap Up**

- Referring to the **Warm Up**, remind students of their earlier guesses at how much water on Earth is available to humans and compare the actual percentage of Earth's water available. Have students explain their reasoning for their initial estimates. How would they adjust their proportions? (One-half of one of the pieces of paper represents potentially available water [0.5 percent]. Only one small corner of this half [.003 percent] is actually potable water.)
- Discuss with students the complexity of what the single "drop" of available fresh water on Earth represents. Ask them who uses this water and for what. For example, thermoelectric power has accounted for the largest percentage of U.S. water withdrawals since the U.S. Geological Survey's 1965 water use summary.



- Distribute the **Student Copy Page—What’s in a Drop?** and discuss with students the large volume of water that “drop” represents and the diversity of water users that are dependent upon it. Ask students: Understanding that this “drop” represents a large volume of water, why is it critical that we carefully use, manage, protect and conserve water? (Water users require large volumes of quality water daily. In addition, other water users, including plants and wildlife, require clean water to thrive.)
- Ask students if water is a renewable resource (defined as a resource that can be replaced over a relatively short time). Water is replenished naturally through the water cycle and through human efforts to manage and protect water. Have students design a creative presentation (e.g., TV commercial, interview) to explain to others that water is a renewable and limited resource.
- While the mathematical calculations show that there are six million liters of water per person available on Earth, distribution is not equitable. Why does more than one-third of the world’s population not have easy access to clean water? Discuss with the class the main factors affecting water distribution on Earth (e.g., land forms, vegetation, proximity to large bodies of water, location, geology, geography, weather and climate). Other environmental influences affect availability of potable water (drought, contamination, flooding). Students can also consider that other organisms use water, not just humans.

▼ Project WET Reading Corner

Bowden, Rob. 2003. *Water Supply: Our Impact on the Planet*. Chicago, IL: Heinemann Library.

Filled with interesting facts about the scarcity of usable water on a planet practically covered with it.

Dorros, Arthur. 1993. *Follow the Water from Brook to Ocean*. Madison, WI: Demco Media.*

Two young children follow rain water to a brook and on to the ocean.

Hollyer, Beatrice. 2009. *Our World of Water*. New York, NY: Henry Holt and Company.

Meet six families on four continents and learn the ways these families and their communities use and share water.

Project WET Foundation. 2008. *Water Is Life*. Bozeman, MT: Project WET Foundation.

Colorful illustrations show the water cycle and how water is so important to humans and animals alike on the African continent.

Sussman, Art. 2000. *Dr. Art’s Guide to Planet Earth: For Earthlings Ages 12 to 120*. White River Junction, VT: Chelsea Green.

Highly acclaimed book examines matter cycles, energy flows and life webs, and how all are connected on planet Earth.

*National Governors Association Center for Best Practices and Council of Chief State School Officers. “Texts Illustrating the Complexity, Quality, and Range of Student Reading K-5.” And “Texts Illustrating the Complexity, Quality, and Range of Student Reading 6-12.” *Common Core State Standards Initiative*. www.corestandards.org (June 2009).



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A drop of water represents the potable fresh water currently available on Earth.

Assessment

Have students:

- determine the proportion of Earth's available fresh water (**Warm Up** and **Wrap Up**).
- calculate the volume of water available for human use (step 5).
- develop a television commercial or other presentation outlining reasons why water is a limited and also renewable resource (**Wrap Up**).

Extensions

Students can identify areas of the globe where water is limited, plentiful or in excess and discuss the geographical and climatic qualities contributing to these conditions. For example, large variations in precipitation occur within states. (Death Valley receives as little as two to five inches [5 to 12.5 cm] per year; only 100 miles [160 km] away, mountain ranges receive more than 30 inches [76 cm] per year.) These variations dramatically impact plants, people and other animals.

The amount of potable water per person in the **Warm Up** is based upon a world population of 6.9 billion people. Have students do an Internet search to determine the world population projections for 2025 and 2050. Based on these projected population increases, have students discuss the impact that this growth will cause and possible solutions.

Teacher Resources

Books

Gleick, Peter, et al. 2009. *The World's Water: The Biennial Report on Freshwater Resources, 2008-2009*. Washington, DC: The Island Press.

Journals

Dickerson, Daniel L., John E. Penick, Karen R. Dawkins, and Meta Van Sickle. 2007. "Groundwater in Science Education." *Journal of Science Teacher Education*, 18 (1), 45-61.

Heinhorst, Sabine and Gordon Cannon. 2004. "Nature: Water, Water, Everywhere, nor Any Drop to Drink." *Journal of Chemical Education*, 81 (2), 170-171.

Kenny, J.F., N. L. Barber, S. S. Hutson, K. S. Linsey, J. K. Lovelace, and M. A. Maupin. 2009. "Estimated use of water in the United States in 2005." *U.S. Geological Survey Circular 1344*, 52 p.

McDuffie, Thomas. 2007. "Precipitation Matters." *Science and Children*, 44 (9), 38-42.

Shoring, Nola. 2003. "Investigating Fresh Water—Some Ideas That Have Been Used Successfully in Primary Schools in the ACT." *Investigating*, 19 (2), 28-30.

Stokes, Nina Christiane and Mary Margaret Hull. 2002. "Every Drop Counts: Students Develop Public Service Announcements on the Importance of Water Conservation." *Science Teacher*, 69 (5) 40-41.

Websites

U.S. Geological Survey. Summary of Estimated Water Use in the United States in 2005. This website gives a summary of information on water use in the United States for 2005. <http://pubs.usgs.gov/fs/2009/3098/>. Accessed May 19, 2011.

U.S. Geological Survey. Estimated Use of Water in the United States in 2005. This website provides water use data down to the county level for the United States in 2005. <http://pubs.usgs.gov/circ/1344/>. Accessed May 19, 2011.

USGS
science for a changing world

Summary of Estimated Water Use in the United States in 2005

Public supply (31)
Domestic (11)
Livestock (Less than 1)
Aquaculture (2)
Industrial (4)
Mining (1)
Thermoelectric power (68)

2005 withdrawals by category, in percent.

Self-supplied industrial withdrawals were an estimated 18,200 Mgal/d, about 4 percent of total withdrawals. Industrial water use includes water used in manufacturing and producing commodities, such as food, paper, chemicals, refined petroleum, wood products, and primary metals. Although some water for industrial uses was delivered by public suppliers, this amount was not estimated for 2005. Surface water was the source for 83 percent of self-supplied industrial withdrawals. Less than 7 percent of total industrial withdrawals were saline water, and 97 percent of the saline water used was surface water.

Estimated Use of Water in the United States in 2005

Circular 1344
U.S. Department of the Interior
U.S. Geological Survey



Name: _____

Date: _____

Water Availability Table Quantity to be divided among people on Earth	Amount Available liters/person	% of total water
All the water on Earth	202.9 billion	100%
Only the fresh water (calculate 3% of the amount available)		3%
Only the non-frozen fresh water (calculate 20% of the remaining amount available)		0.6%
Available fresh water that is not polluted, trapped in soil, too far below ground, etc. (calculate 0.5% of the remaining amount available)		.003%

Every five years, the United States Geological Survey (USGS) compiles data to understand how much water was used by diverse water users in the United States. This information assists water managers in planning for present and future water needs by understanding how water resources are used throughout the nation.

In 2005, the USGS estimated the following:

- Total withdrawals were 410,000 million gallons per day
- Fresh water withdrawals were 85 percent of the total
- Surface water supplied 80 percent of all withdrawal

DIRECTIONS: On a separate sheet of paper, use the information in the chart below to represent water use in the United States in 2005 in a way that is graphically interesting. For example, create a pie chart, bar graph or other graphic. To see how the USGS represented this information, follow this link <http://pubs.usgs.gov/fs/2009/3098/pdf/2009-3098.pdf> and review their bulletin, "Summary of Estimated Water Use in the United States in 2005."

Water User	% of Water Use	Number of gallons used (million gallons per day or Mgal/day)
Public Supply	11	44,200
Domestic	1	25,600
Irrigation	31	128,000
Livestock	1	2,140
Aquaculture	2	8,780
Industrial	4	18,200
Mining	1	2,020
Thermoelectric Power*	49	201,000

*Very large volumes of water are needed for cooling thermoelectric power plants. For more information about thermoelectric power and water use, refer to the full USGS "Summary of Estimated Water Use in the United States in 2005" report cited above.

