ALL THE WATER IN THE WORLD

Adapted from Project WILD, "How Wet Is Our Planet" and the Nevada Science Project, "Water Everywhere"

Overview

Using a one liter sample to represent the total amount of water on earth, students will learn that although three quarters of our planet is water, there is very little available as fresh water. This demonstration will help students understand how fragile the water resource is.

Subjects: Science, Math, Social Studies, Comprehensive Health
Group Size: Entire class for demonstration; small teams, optional
Estimated Teaching Time: 45 minutes
Curriculum Framework: IA, ID, VIB
Environmental Education Framework: Goals IA, IVB, VA
Vocabulary: atmospheric water, groundwater, potable, salinity, surface water, water cycle, water vapor

Objectives

Students will:

- describe the amount and distribution of water on the earth in oceans, rivers, lakes, groundwater, icecaps, and the atmosphere.
- make inferences about the importance of responsible use of water, especially for desert dwellers.

Background

The earth has been called the water planet. Nearly three-fourths of its surface is water. The earth's water is in rivers, ponds, lakes, oceans, locked in the northern and southern icecaps, and drifting through the air as clouds. In other words, we can see the three states of matter in which water occurs. Water that has seeped into the earth's crust (groundwater) is more difficult to see, yet all these forms of water are part of a dynamic interrelated flow that we call the water cycle. Each part of the water cycle shares the total amount of water on the planet.

Classified by locations at which it is available on the earth, water exists as:

1. surface water, including oceans, icecaps, glaciers, lakes, wetlands, rivers, and streams;
2. groundwater, which is found below the earth's surface in cracks and pores in rocks and soil; and
3. atmospheric water, including water vapor and clouds.

The Phoenix area receives between seven and ten inches of rain in an average year. Potential annual evaporation rates in American

deserts range from seventy to 160 inches per year (p. 29 Audubon DESERTS). Note: Evaporation rates are generally calculated based on the amount of water that would evaporate from a completely exposed surface during one year. The disparity between precipitation and evaporation is one reason this area is called a desert.

Students think of the water on the planet as limitless, and yet an analysis of the percentages of water distribution shows that the amount of available water is limited. Scientists believe all the water we will ever have is on the earth right now. (The total amount is estimated to be 326 million cubic miles [326×10^6 cubic miles]. One cubic mile of water equals more than one trillion [10^{12} gallons or 3.785 trillion liters], making the total amount of water available about 326 quintillion gallons or 1233.91 quintillion liters. A quintillion is written 10^{18}, a number followed by 18 zeros, or five groups of three zeros after 1000!)

Although the total amount of water available to humans and the organisms with which we share the earth is unchanging, the quantity and quality at a specific location are greatly affected by people's actions. Human beings have a responsibility to conserve water, use it wisely, and protect its quality.

The major purpose of this demonstration is for students to understand how fragile our water resource is. The activity can be adapted for teams of four students by allowing the students to measure each volume from one or two liter containers.

Materials and Preparation

1. A globe (one showing the ocean bottom is best) or a world physical map
2. Determine the volume to be used. In the procedure, one liter represents all the water on earth. The chart on page 3 details substitute volumes for two liter or five gallons representations.

For demonstration using liter containers, or each team of students:

3. two one-liter soda containers: one empty, the other filled with colored soda or water with a few drops of blue food coloring
4. two graduated cylinders: one 100 ml; one 10 to 25 ml
5. four (at least 25 ml) clear containers, one nearly full of sand
6. 34 grams of salt for 1-liter container; 68 for 2-liter
7. funnel
8. one eye dropper
9. labels (provided) and tape
10. litter/pollution - 3 tiny pieces of paper, drop of oil, etc.

For demonstration using "kitchen equipment", replace items 3-6 with: five gallon containers; three quart containers; three measuring cups: 1 cup, 1/2 cup, 1/4 cup; 1/4 teaspoon; and 1 1/2 pounds of salt (instead of ruining that much salt, have students imagine that weight included in the ocean)

Procedure for Demonstration

1. Holding a globe or map of the earth, begin a discussion of how much water is present on our planet. *"Why is earth called the water planet?"* Have students estimate what portion of the earth's surface is covered with water (nearly three-fourths.) Ask *"Besides oceans, where else is water found?"* On the board, generate a list of students' responses. Probe for where water is found in all three of its forms: liquid, solid, and gas. Then ask, *"If this list represents all the water on the earth, or 100% of all the earth's water, estimate the percentage of water that is available as freshwater for humans to drink?"* Record the range of estimated percentages on the board.

DEMONSTRATION VOLUMES

Note: These are not equivalent measures

Water Source	1 Liter	2 Liters	5 Gallons
Oceans	972 ml	1944 ml	622 ozs. or 4 gal, 3 qt, 1 3/4 c.
Icecaps/glaciers	21.5 ml	43 ml	13.76 oz. or 1 1/2 cups
Inland Seas/ Salt Lakes	.08 ml	.16 ml	.0512 oz. or 1/4 teaspoon
Groundwater	6.25 ml	12.5 ml	4 oz. or 1/2 cup
Freshwater Lakes	.09 ml	.18 ml	.0576 oz. or 1/4 teaspoon
Atmosphere	.01 ml	.02 ml	.0064 oz. or 1/24 teaspoon
Rivers	.001 ml	.002 ml	.00064 oz. or 1/240 teaspoon!

2. Begin the demonstration. Ask students to imagine the container of colored water represents all the water on the earth and in our atmosphere. Begin pouring the amount of water that represents the oceans. Encourage students to tell when the ocean has been poured from the container. Nearly all, 97.2%, of the water on earth is ocean water. Remove 972 ml from the original container to the other one-liter container. Use the funnel to add 34 grams of salt to represent the salinity of the ocean (3.5%). Label this sample ***OCEAN.***

3. Take 21.5 ml from the original container to represent the water frozen in ***ICECAPS AND GLACIERS***, or 2.15% of all the water on earth. Place this sample and its label in a far corner of the classroom because we currently have no access to this source of water.

4. Place *.08 ml* in another container to represent the ***INLAND SEAS AND SALT LAKES*** that we are also unable to use. Sprinkle a tiny bit of salt into this sample, and label.

5. Pour *6.25 ml* from the original container into the container of sand. This represents **GROUNDWATER**, .625% of all the water on earth. Some of this water can be retrieved through wells.

6. In the remainder of the original container there should be .101 ml of liquid, representing .0101% of the total water on earth. This is the water in ***RIVERS*** *(.001 ml)*, ***FRESHWATER LAKES*** *(.09 ml)*, and ***ATMOSPHERIC WATER VAPOR*** *(.01 ml)*. Throw .01 ml of water into the air to represent the atmospheric water vapor. Pour the remainder into the final small container. Use an eyedropper to remove as small a volume as possible from the container to represent all the surface water that remains. Add tiny pieces of litter and a squirt of "pollution" to the small container, which now contains water that is not potable or suitable for drinking. Hold up the eyedropper and state, *"This tiny amount of liquid represents all the freshwater on earth that is available for human consumption."*

7. Not all the freshwater is equally distributed. To illustrate this, place two drops of water on the table. *"We get between seven and ten inches of rain a year in Phoenix. The rest of the United States averages 33 inches."* Point to one drop saying, *"Of course in Phoenix, if this water is exposed to the sun, it will evaporate. More water evaporates in the Sonoran Desert than we receive as freshwater."*

   Then push the second drop onto the floor, stating: *"This represents all the water we waste by taking half hour showers and letting the water run when we brush our teeth! That leaves none for the people who live in the Phoenix area. What are we going to do?"* Allow students time to share their ideas.

8. Return to the students' estimates of the total amount of water available as freshwater. Discuss the relative percentages. Work with the students to calculate the estimated amount of fresh water potentially available for human use:

groundwater	0.625%
freshwater lakes	.009%
rivers	.0001%
including ice caps/ glaciers	2.0%
TOTAL FRESHWATER	2.6341% OF ALL THE WATER ON EARTH

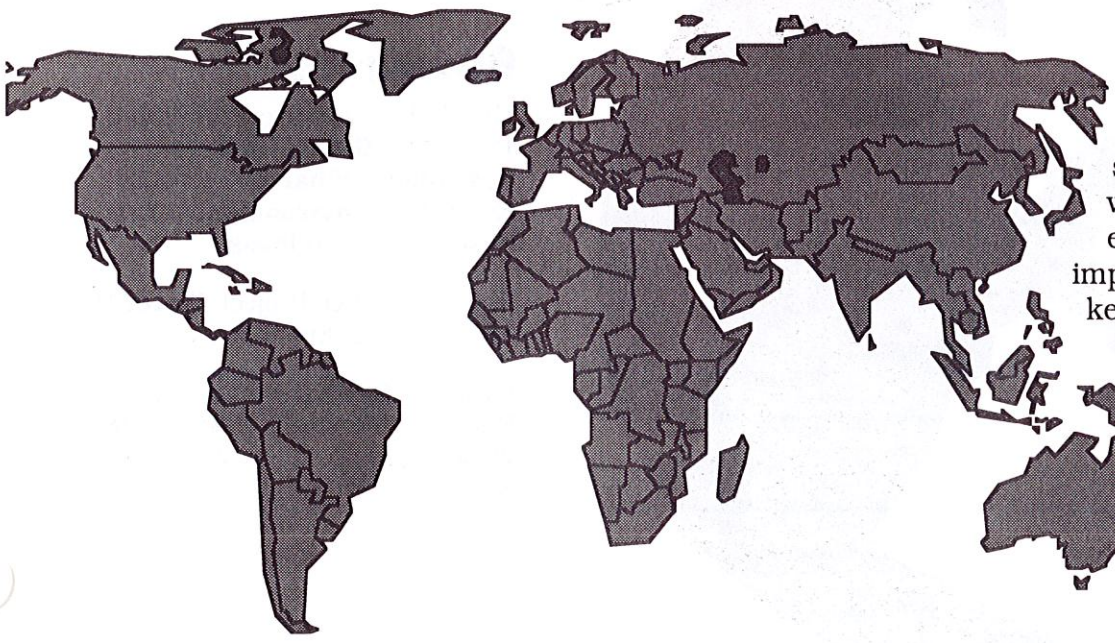
9. Have students examine four samples more closely. Place the groundwater, ocean, inland seas/salt lakes, and polluted samples in front of students and ask if the "water" is suitable for human consumption, *"Would you drink this?"* In discussing these figures, emphasize that the usable percentage of existing freshwater is reduced by access, pollution, contamination, and waste. Our water is used for food, transportation, trash disposal, energy, recreation, and making our landscaping look pretty. Each of these uses can cause damage to

our water sources. Students contribute to our water problems primarily through waste.

Discuss the needs of humans for usable fresh water. With considerable expense, good quality, fresh water is available to most people in this country. Many contaminants in surface water are removed through water treatment. Groundwater is pumped from the ground and is often potable. However, groundwater sometimes contains salts, other minerals, and contaminants that must be removed through treatment. Phoenix is lucky because most groundwater needs only to be chlorinated before it is used. Not all groundwater is available, however.

Groundwater too far below the surface is too expensive to extract. Desalinization plants have been built, but that is an extremely expensive way of getting freshwater. Some people have even talked about towing icebergs, although that method of getting freshwater has not yet proved economically viable.

10. Ask students where most drinkable water in their homes is used. In many Valley cities, more than half the water delivered to residential customers is used outdoors watering plants, washing cars, rinsing driveways. Inside homes, toilets use a great deal of water. Toilets can use as much as 7 gallons of water per flush (although all new construction requires low flow toilets of less than 2 gallons per flush.) Using toilets as waste baskets wastes water. *"In what other ways does water get wasted in your homes, school and city?"*



11. Help students identify other life forms that need fresh and saline (salt) water. Close by emphasizing the importance of keeping the earth's waters clean and healthy and - when we do use waters - using them wisely and responsibly.

Extensions

1. If your students need practice with scientific notation, have them calculate estimated water volumes in each category using the given percentages. Scientists believe that all the water that we will ever have is on the earth right now. The total amount is estimated to be 326 million cubic miles (326×10^6 cubic miles). One cubic mile of water equals more than one trillion (10^{12}) gallons or 3.785 trillion liters, making the total amount of water available about 326 quintillion gallons or 1233.91 quintillion liters. A quintillion is written 10^{18}, a number followed by 18 zeros, or five groups of three zeros after 1000!

2. Calculate the size of a model of the earth that would hold the water used in the demonstration, where 1 liter equals all the water on earth.

3. Show that sea ice is primarily fresh water. Into ice cube trays, pour the saline solution labeled OCEAN for this activity. Freeze. Have students taste the top and the bottom of the ice and record their observations. Ask for conclusions, or allow the students to design their own experiments "proving" their theories.

Evaluation

1. Estimate the percentage of water distributed in each of the following areas of our planet: oceans, rivers, freshwater lakes, inland seas and saltwater lakes, groundwater, icecaps and glaciers, and the atmosphere.

2. Why is it important that humans use water responsibly?

Resources

The Global Tomorrow Coalition, 1990, **The Global Ecology Handbook: What You Can Do About the Environmental Crisis,** Boston: Beacon Press.

Nevada Science Project, **Water Unit 1991**, *"Water Everywhere."*

Western Regional Environmental Education Council. 1986. **Project WILD Aquatic**, *"How Wet is Our Planet?"*

ALL THE WATER IN THE WORLD

LABELS

OCEANS 97.2%	FRESHWATER LAKES .009%
ALL SEA ICE, ICECAPS, GLACIERS 2.15%	INLAND SEAS & SALTWATER LAKES .008%
GROUNDWATER .625%	ALL RIVERS .0001%
ATMOSPHERE .001%	Data from "The Water of the World," Raymond Nace, U.S. Government Pamphlet 1977-0-240-966/44