Drinking Water: From the Globe to Your Glass

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INTRODUCTION

The ability to walk in your kitchen, turn on a faucet, and fill a glass with fresh, clean water is so commonplace in our society that most give no thought to where that water came from. Even for myself, every morning I drink a glass or two of water from a glass I fill in my kitchen with the confidence that it is not only safe to drink but also a necessary ingredient for my health. I shower, brush my teeth, and use water another hundred ways while rarely giving a thought of the processes that brought water into my house.

As abundant as water seems flowing from my faucet, I know as a teacher of world geography that while water seems plentiful, water sources are often unusable as-is for safe drinking or for agriculture. Benjamin Franklin, the famous American inventor, stated that a person only learns the true value of water when the well runs dry. For many citizens of the world this lack of safe water sources is a daily occurrence. Throughout history the presence of drinking water has played a role in determining where and how people live. The development of culture can be greatly determined by access to water sources.

The United States is blessed with an abundant amount of water, but the pressures of economic development and population growth strain the quality and quantity of fresh water available for drinking. Our students will be part of a generation that will have to make decisions on protecting safe water sources for future generations to come. This curriculum unit will allow students to acquire information about water issues and prepare them to make informed decisions on these issues for the future.

UNIT OVERVIEW

This unit will study drinking water from the global to local perspective. The following questions will guide the students:

a. Where does water come from?
b. How much water does our society use and how much do we need?
c. What are the sources for drinking water?
d. How is water made safe to drink?
e. What endangers our water sources?
f. What can the individual do to help protect water sources?

Where Does Water Come From?

Earth is a water-covered planet with over 70 percent of the Earth's surface immersed by water. This fraction of surface area, when multiplied by the average depth of water on the Earth's surface, adds up to more than 1.3 billion cubic kilometers of water on Earth. This volume of water, multiplied by its density to obtain mass, when compared to the mass of all materials in the first kilometer of the Earth's surface makes water the most abundant substance by mass on Earth. With such an abundance, it may be difficult to understand how there could be any crisis in the availability of water. The problem is highlighted by looking at the amount of water not available for use of many living things. Around 97% of water sources consist of seawater, which is too salty to drink or use for agriculture. Processes are available to convert seawater into fresh water but the cost is currently too high for large-scale use. The remaining three percent would seem adequate but two of the three percent is frozen in glaciers and polar ice sheets. That leaves the one percent that is left for our use. This is the first step for students to learn about the scarcity of fresh water. The first activity in the curriculum unit will use jugs of water to represent water on earth and the students will perform an activity that will demonstrate how limited freshwater is. In presenting this activity the student will be able to visualize the scarcity of our earth's fresh water.

To further answer the question of where water comes from is to examine the hydrologic cycle in which the Earth's water supply is renewed and made fresh. The process involves the cycle of water moving from the air to the land and back again. This cycle is powered by the sun and begins with the evaporation of water from the oceans and other water sources like rivers and lakes. The ocean provides the largest amount of evaporated water with over 80 percent of total water evaporation source for the hydrologic cycle.

The sun provides the energy that keeps the cycle in motion by heating the bodies of water and beginning the process of evaporation which places water in vapor form into the atmosphere. An equal amount of this water vapor is redistributed onto the earth in the form of rain, sleet, or snow. This action of water vapor condensing into clouds and falling to the earth is called precipitation. Unfortunately much of the rain falls back into the ocean or around coastlines where the rains may wash back into the oceans without being of use to civilization.

Some of the precipitation that falls on land runs off into rivers, lakes, and other surface waters, replenishing them. Rain may be absorbed from the ground by trees and other plants, which in turn give back some moisture to the air in a process called transpiration. Some water sinks down into the soil, finding its way into the mass of water and is stored in porous rock. This water-rock structure is called an aquifer. The top of an aquifer is called the water table. Some of this underground water is pumped to the surface through wells, and some flows into surface water where the water table meets lakes and rivers.

Although the hydrologic cycle brings a renewable source of fresh water that source of fresh water is finite. Location is a key indicator of water scarcity. The hydrologic cycle tends to bring only a certain amount of fresh water to any given location. Precipitation levels tend to stay the same for a geographic area over a number of years. In any location in the United States weather forecasters can predict how many inches of precipitation an area will receive. There may be differences over short time periods but overall the average amounts of precipitation generally stay the same. Many people live in areas with low levels of precipitation and need water for home, industrial, and agricultural use. It is very expensive to move large amounts of water great distances, so while some places have plenty of water, other places may have water shortages and not have the resources to acquire sufficient water.

How Much Water Does Our Society Use and How Much Do We Need?

Life on earth is determined by the presence of water because it is the one necessity for all living things. There are life forms such as anaerobic bacteria that do well without oxygen and there are creatures in the sea that live without light. There is no known living creature that can live without water. Water is the basic material for all living cells.

The question of how much water our society uses is generally easy to determine but the question of how much we need is not. The human body is made up of 60 to 70 percent water. It is possible for humans to live several weeks without food but a human could not live more than a few days without water. A loss of only 5 to 10 percent of the body's water will cause a person to suffer from dehydration. Severe dehydration (15% loss) is likely to be fatal.

Much of the water in humans circulates throughout the body and is used over and over again. However, some fresh water has to be brought in and some water has to be removed each day. The human body uses water to digest food, maintain body temperature, remove wastes and toxins, cleanse the eyes, lubricate joints, and more. The kidneys use water to cleanse the body of wastes in the bloodstream.

To start with the basics, the minimum recommended amount for human consumption is around two quarts of water a day. This water can be consumed by drinking water and by eating food, which consists mainly of water. Beverages such as milk and fruit juice are about 85 to 90 percent water. Other foods high in water content include tomatoes (94 percent), watermelon (93 percent), yogurt (89 percent), and apples (84 percent). Even dryer foods, like meat, are about 50 to 70 percent water, and even bread is about 35 percent water. But the water an individual drinks and the water in an individual's food is only a small portion of the water they use. The following table lists typical ways water is used in the household and the amount of water used:

Place of Use	Amount of Water Used
Standard toilet	average 5 gallons per flush
Water-saving toilet	1.6 gallons per flush
Bathtub	30 to 40 gallons
Shower	6 to 10 gallons per minute
Washing machine	20 to 30 gallons per load of clothes
Kitchen sink	Washing dishes by hand, prepare food – 10 to 20 gallons
Bathroom sink	Washing hands, shaving, brushing teeth – 10 to 20 gallons

Besides the personal use of water in the household there is water used outdoors. This includes watering lawns, flowerbeds, and vegetable gardens, as well as washing cars and filling swimming pools. Outdoor use varies from region to region in the United States. In Wisconsin, an average of two gallons per day is used outside the house. This figure may seem low but that is because heavy use occurs only during the three summer months. In hot, dry places like California and Arizona, some households may use over 100 gallons per day year round just for outside use. The United States uses approximately 150 gallons per person for ordinary household use. In comparison citizens in Europe use about 50 gallons per person while the citizens of other countries use much less.

One of the world's enduring problems is famine. Famine highlights one of the problems of water needs. In most areas in which people are starving the problem is not lack of food as much as the lack of water to grow the food. To grow an adequate supply of food for a person for a year requires around 300 cubic meters of water. This quantity amounts to almost a ton of water a day to grow food for one person's diet per year. Water is the one essential ingredient for all forms of food production, but food production is just one aspect of how water is used. It takes at least ten gallons to produce one 12-ounce can of vegetables. To produce one newspaper around 350 gallons of water is used and to produce a ton of steel a ton of water is used in the process. In the United States only eight percent of water is used for domestic purposes like drinking, washing, and other home uses. Other water use in the United States is as follows:

- 10% for business/industry
- 33% for irrigation
- 49% for electric power plants

In trying to answer the question of how much water our society needs the students must be able to track water use and ask questions about how our society uses water. One possible activity would involve students surveying individuals from other countries on water use and analyze the data to develop ideas on why Europeans use one-third less water than citizens of the United States.

Another activity will focus on surveying water use in the family so students can make their own estimates of water use at home, in their neighborhood, and the city in which they live. This activity will help the student become more aware of their water use and the need for water conservation measures in the home.

What Are the Sources for Drinking Water?

It is important for students to know the source of their water supply. Most towns and cities obtain their drinking water from nearby rivers, lakes, or reservoirs. These sources are called surface waters. The quality of surface water is influenced by the quality of the streams that flow into them and the land uses and activities that are conducted near them. Contaminants can easily be introduced into surface water and these sources must be protected.

The other possible source is groundwater. If the source is pumped from a well, then the water is being pumped from an aquifer. Just like surface waters aquifers must be protected from contaminants. Chemicals spilled or applied to the ground can move down and eventually contaminate an aquifer. This action can make groundwater unsafe to drink unless treated. It is especially important to protect the areas around wells because these areas are can be more easily affected by chemicals.

Drinking water is relatively inexpensive in the United States. But the price paid by consumers does not reflect the true cost of delivering water to the home and cleaning it up after using it. The cost of the water we use includes the cost of digging wells and pumping water, laying water pipes and sewage pipes, and building water-treatment plants. When Americans turn on a faucet, a billion-dollar water infrastructure works behind the scenes.

In most cities, public water systems deliver water to all households. There are public water systems owned by private investors, but most are owned and operated by local governments. Some people get their water from their own well, in which case they do not pay for water but for the cost of pumping it into their home. Federal and state regulations set standards for public water systems. People who have private wells must monitor their own water supply.

Whether the source is ground or surface, finding the source for any community water system is not difficult. Large cities tend to rely on surface water for their water systems. Smaller communities more often rely on groundwater. Contacting the local water division in your city or county will give the teacher or student information on community water sources.

How Is Surface and Groundwater Made Safe to Drink?

The most likely avenue for safe water to the home is through a water treatment facility. The purpose of the water treatment facility is to bring raw water up to drinking water standards set by the Safe Drinking Water Act (SDWA). The SDWA has different requirements for different sized communities. Research into these requirements may be assigned for students to determine the standards for the community they live in. The process of bringing raw water up to standards is dependent on the water source. Surface waters tend to need more filtration for microbial contamination while groundwater may have objectionable dissolved gases that need to be removed. Wastewater from households and industries are treated by wastewater treatment facilities before being introduced into surface waters that feed into many water treatment systems.

A typical water treatment plant for surface water might include the following steps:

- Screening to remove large debris.
- Mixing the water with chemicals that encourage smaller particles to clump together for easier removal with filters or screens.
- Sedimentation is the process that slows flow of water so gravity causes clumps of particles to settle and then filtered.
- Sludge processing takes what settles into a tank, dewatering, and disposing of the remains.
- Disinfection of the processed water to ensure that the water is free of pathogens.
- Distribution to customers.

What Endangers Our Water Sources?

Human life depends on an adequate supply of clean water. The World Health Organization estimates that 80 percent of all illnesses are related to water. In March 1990, the United States Centers for Disease Control reported that 26,000 cases of illness known to have been caused by contaminated drinking water occurred between 1986 and 1988. Thousands more were suspected but could not be proved. Over 700 different chemicals have been found in drinking water across the United States. Testing has shown some of these chemicals as being carcinogenic (capable of causing cancer) while others are known to be harmful, though not necessarily carcinogenic. Health officials have set standards for the upper limit of some of the chemicals known to be highly dangerous. It is important to set standards because water suppliers are required to monitor levels only of chemicals for which standards have been set.

There are three general types of contaminants that are being released into the earth's fresh and salt water. The three types are sewage, solid wastes, and chemical pollutants. Sewage can be domestic or industrial. Domestic sewage includes human wastes, food wastes, and other materials typically put down a toilet and/or a household's drain. The total amount of sewage introduced into water systems is difficult to imagine. It is estimated that every American flushes a toilet an average of ten times a day. This amounts to over a billion flushes every day. Industrial sewage is similar to domestic sewage, but involves larger quantities and often has specific chemicals not found in the home. Sewage that flows into the water is categorized as treated and untreated. Treated water has been processed through a treatment plant that works to break down the solid contents and reduce its chemical content. In all, the treatment plants are meant to purify the sewage as much as possible so that when it is emptied into the ocean or a river, the water will continue to be safe.

Untreated sewage is raw sewage. The danger for humans is great for those that may drink the water into which it flows. Diseases such as dysentery and hepatitis can be caused by water contaminated by sewage. The dangers are greatest in underdeveloped countries where any water treatment facilities may be antiquated or nonexistent. United States citizens are fortunate because, in general, U.S. sewage and water systems are modern and well maintained. Though the U.S. ranks with the best in water systems vigilance is important because plants do break down and bacteria, viruses, and other toxic substances have been known to enter water systems causing people to get sick and in some cases die.

Solid wastes are another source of contamination to water supplies. Garbage is one of the general types of solid waste. Solid wastes can enter the water a number of different ways. Soda cans left at the beach, plastic bags washed down a storm drain, and cigarette butts tossed out a window are just a few examples of solid waste items that make there way into water systems. Disposed plastics are a particular waste that is dangerous to wildlife.

The third general class of pollutants in water systems is chemical pollutants. Chemical compounds are classified as organic or inorganic. Organic compounds are carbon-based which means they contain the element carbon (C). Virtually all plant and animals are carbon-based. Inorganic compounds do not contain carbon. Minerals such as iron and lead are inorganic compounds.

Most naturally occurring inorganic compounds are minerals found in soil that dissolve in water, though some of these are harmful other minerals, such as calcium, magnesium, and potassium may be beneficial in small quantities. A problem can occur when the minerals found in water accumulate in large quantities. An example of how excess minerals accumulate into something harmful is the phenomenon of acid rain. Acid rain is precipitation that is contaminated with acidic substances, such as sulfuric and nitric acids, resulting from the burning of fossil fuels. When it falls on land, acid rain can release toxic minerals from the soil. These minerals find their way into surface water supplies, harming fish and plant life.

The inorganic minerals of greatest concern include lead and mercury. Lead is one of the most worrisome contaminants found in water. This mineral cannot be detected by look, smell, or taste, but even a tiny bit can cause devastating health problems. It is most dangerous to unborn babies, infants, and small children. High-level exposure to lead can cause brain damage and death. But even low and moderate levels of exposure, over long periods of time can cause nervous system damage in children. The Environmental Protection Agency (EPA) estimated in 1986 that some 40 million Americans had potentially dangerous levels in their drinking water from the pipes in their drinking water systems and various natural factors.

In drinking water and food, mercury can lead to nerve and muscular disorders and death. Even an extremely small amount of mercury can be harmful, and many surface water systems have been polluted with mercury from industrial wastewater. Nitrate is an inorganic chemical found in fertilizers. High nitrate levels cause problems primarily for infants. In a baby's body, nitrate is converted to nitrite, which keeps the blood from transporting oxygen and can lead to brain damage. High nitrate levels in surface and groundwater are usually the result of agricultural practices. Chemical fertilizers and animal wastes are high in nitrogen, which is converted to nitrate in the soil. This nitrate works its way down through soil to groundwater sources. Rainfall runoff washes nitrate into surface waters.

Organic compounds that contaminate drinking water are also both naturally occurring and synthetic. The amounts of synthetic organic compounds have greatly increased since the 1940s. The synthetic compounds often are produced by subjecting petroleum and petroleum byproducts to various chemical processes. Many do not readily break down when disposed of, and they can be dangerous to plants, animals, and people. These carbon-based chemicals range from weedkillers to polystyrene (as in Styrofoam cups), from life-saving medicines to refrigerator coolant.

Organic chemicals found in drinking water include trichloroethylene (a solvent), tetrachloroethylene (a solvent), vinyl chloride (a plastic), carbon tetrachloride (a solvent used to clean clothes), chloroform (an anesthetic), and aldicarb (a pesticide). Benzene, from which numerous other solvents, plastics, and insecticides are made, is known to cause leukemia after long exposure.

Students may question how these contaminants get into water. The vast majority of contaminants are a result of the things people do. The two basic categories for describing the sources of water pollution are point and nonpoint sources. Point sources of pollution are specific sites where contamination is known to occur. A factory that discharges wastewater into a river is a point source of pollution. Nonpoint sources are more widespread and general. For example, farmland rainwater runoff, contaminated with fertilizers and pesticides, seeps into groundwater and flows into surface waters. It would be very difficult if not impossible to trace the contaminant in the surface water to one specific farm as the source of the contaminant.

What Can the Individual Do to Help Protect Water Sources?

The United States federal government has passed a number of laws to try to control and clean up water pollution. In 1972 Congress passed a group of amendments to the Federal Water Pollution Control Act of 1956. These amendments became known as the Clean Water Act. The goal of the act was to restore and then maintain the purity of our nation's waterways. This act in turn has been amended several times as Congress calls for stricter regulations on polluters. The Safe Drinking Water Act of 1974 established policies for protecting drinking-water sources.

Many of the global problems linked to water scarcity and pollution are so numerous that that it may be difficult for an individual to make a great effect. The most important step is the student becoming aware of the issues and working at the family level to do their part. One of the activities that will be undertaken by the students will be looking for ways the student can help protect our water sources. The first area that the class will explore will be conservation. By using less, water resources can be saved for times when droughts reduce the short-term availability of water. Simple things like turning the faucet off while brushing your teeth can help save water.

The second area is in preventing litter from getting into the water systems. Many students go to recreational areas along the coast or near rivers or lakes. The individual student can take the lead in finding a trash receptacle to put their trash in. Even on the streets trash that washes down the gutter may wind up in water sources.

The third area in which students can become involved is in chemicals around the home. If you change the oil in your car, you do not pour it down the drain or into a storm drain. In both cases you are putting a chemical pollutant into the hydrologic cycle. This impact is true for old paint or other chemicals found in many garages or under the kitchen sink. Each student should realize by the end of the unit the importance of protecting our water sources.

STUDENT ACTIVITY SUGGESTIONS

The following are suggested activities that may be added as experiments or additional enrichment. More detailed examples of lesson plans may be found in the lesson plan section.

1) One activity allows the teacher to demonstrate how limited freshwater is. The materials needed are five one-gallon jugs, two glass jars, and a measuring cup. Fill the five one-gallon jugs with water. Tell the class to imagine that the five jugs of water represent all of the world's water. Ask students to guess how much of the five jugs represent the earth's fresh water. After a short discussion measure out two ½ cups into the first jar. This represents all of the fresh water in the world. From this jar, measure ¾ of a cup and put into the second jar. What's left in jar

one is all of the fresh water unavailable to us because it is frozen in polar ice caps. The ¾ cup in jar two represents all of the fresh water available to us for drinking and other uses. The visual of the comparison between the second jar and the five jugs of water creates a good reminder of how little of earth's water is available to us.

2) Another activity involves surveying water use. The teacher would first have each student come up with an estimate of how much water the family uses in a day and in a week. Next, the teacher would give each student a work sheet that helps him or her create a water use log for the home. When all students have completed this activity it is interesting to see the comparison for their estimate and the actual home use of water. This helps create awareness of how much water is used in the home and can lead to better ideas on how to conserve water.

3) An interesting demonstration of how surface waters can be cleaned is simple to set up and a nice visual for students. Take an empty two-liter plastic soft drink bottle and cut off the bottom. Next, use a rubber band to fasten a coffee filter to seal the space where the cap is removed. Turn the bottle upside down and pour in a layer of pebbles into the bottle. The coffee filter will keep the pebbles from falling out. Next, pour a layer of coarse sand over the pebbles followed by a layer of fine sand. Mix some dirt and water (or food coloring) together in another container to show the class as a sample of water that needs to be cleaned. Pour this sample slowly over the top layer of sand in the bottle. The bottle should be held above some type of clear container so the students can see the cleaned water after filtering through the layers of sand, pebbles, and the coffee filter. The teacher should practice a few times to adjust the amount of pebbles and sand to make the filtering effect go relatively quickly.

4) Create a simulation in which groups are formed to discuss water shortages for a medium sized city. Roles of mayor, city councilman, housing developers, industry and agricultural experts work together to find solutions to a water crisis. All solutions must fall in the categories of increasing the supply of water and/or decreasing the demand for water. Some solutions may lead to more research opportunities for students.

5) Ask representatives from water treatment, real estate developers, and agricultural agents to speak to the class about water issues. Many cities encourage tours for student groups to water treatment plants.

6) Put together a report or bulletin board on water use. Include articles and pictures from magazines, newspapers, and Internet sources.

7) Have the class adopt a waterway and study it. Any stream, creek, pond, or river in the vicinity of the school may be used.

8) Ask the students to find organizations that are working to save our resources. For example, the National Wildlife Federation is very concerned about water pollution. Have the students write letters or e-mail these organizations for ideas for class or individual projects in relation to water.

LESSON PLAN ONE

A Global View of the Wet Earth

This first lesson will introduce the physical view of water on the earth. An expectation for students is to analyze how the physical features of the earth influence the distribution of population on earth. Also, with distribution of population there must be an ability of civilizations to adapt to their environment. Water is abundant in some areas while scarce in others. A student should have the ability to view physical maps of the Earth and understand the relationships between water availability and culture development.

Objectives

The students will be able to:

1. Locate and label the major bodies of water and the major rivers of Earth;
2. Locate and label the major centers of population in the world;
3. Locate and label countries that are "water scarce" at the present time and those projected to be in future years;
4. Differentiate among various types of water resources; and
5. Know the impacts and stresses large centers of population exert on water resources.

Materials Needed

1. Outline maps
2. Lists of water sources
3. Population centers
4. Pencils (or colored pencils)
5. Globe(s)
6. Almanac(s)
7. World map(s)
8. Worksheets

Advance Preparation

A. Prepare copies of world maps and lists for each student or group of students who will work together.
B. Gather sufficient atlases, reference materials, maps, and globes.
C. Copy lists of waterways and population centers from an almanac.

Procedure

I. Setting the Stage
   A. Invite discussion about the uses and misuses of water, types of bodies of water, and problems from water shortages.
   B. Distribute copies of maps and lists to students.
   C. Explain the use of globes, almanacs, and other resources that have been provided.

II. Activity
   A. Identify types of surface water sources and locate examples on the maps provided.
   B. Locate water-scarce countries with large population centers on the maps provided.
   C. Relate water scarcity to:
      1. Topography (runoff),
      2. Climate (little natural precipitation),
      3. Economic development (the cost of wells, water treatment), and
      4. Population size or population growth rate (amount of water available per person).

III. Follow-Up
   A. Watch for current events stories about world water supplies. Keep a current bulletin board of these items.
   B. Have a geography bee to reinforce knowledge of types of surface waters and/or names of surface waters.
   C. Discuss the relationship between population centers and fresh water sources.

IV. Extensions
   A. Convert the amounts of water shown to gallons per person. Compare your own usage to that of an African nation.
   B. Locate large industries, agricultural areas, economic areas, and deserts. Note areas that have had recent water shortages.
   C. Do a current events search for these bodies of waters.
   D. Assign each student a current event on which to do further research.
   E. Add your state map with its rivers, lakes, bays, and dams to the assignment.
   F. List some possible solutions in terms of expense, time delay, and cultural acceptability.

LESSON PLAN TWO

Water You Doing About This?

This next lesson is designed to increase awareness of how much water individuals and families use. An objective in the area of geography is for students to acquire and analyze data. This plan is designed for students to survey their family’s water use, make comparisons with other students, and to extrapolate the numbers to infer water use by their neighborhoods and communities.

Objectives

The student will be able to:

1. Demonstrate quantities of water that an average family uses on a daily basis;
2. Explain how water resources can be managed to meet human needs; and
3. Explain how water can be conserved.

Materials Needed

1. Data sheet
2. Writing materials
3. Calculator

Advanced Preparation

Copy Water Use Student Sheets for each student.

Procedure

I. Setting the stage.
   A. Have the students list various ways that water is used in the home. Before students record how much water they use in a day and a week, have students record on their Data Sheet how much they *think* they use.
   B. Remind students that they will need to time showers and check for low flow equipment in their homes.

II. Activity
   A. Ask students to keep a Data Sheet of water use in their homes for two/three days. Students should record results on data table. They can add any appropriate activities that are not listed.
   B. Ask students to review the Student Sheet of average water volumes required for typical activities and then answer the following using the data from their two/three days.
      1. Estimate the total amount of water your family uses in a week. Give your answer in gallons and liters. (Approximately 4.2 liters equal a gallon)
      2. On average how much water did each family member use in a week? Give your answer in gallons and liters per person per week.
      3. On average how much water was used per family member each day? Give your answer in gallons and liters per person per day.

4. Compare the daily volume of water used per person in your family to the average daily water volume used per person in the United States (100 gallons).
5. What reasons can you offer to explain any differences?
6. Compare daily volume of water used per person in your family to the average daily volume used per person in several other countries. (Show a variety of water uses.)

III. Follow-up

A. Have students list some other ways they could conserve water at home (turning off the hose when not in use, taking shorter showers, fixing leaky faucets, installing water conservative toilets and shower heads).
B. Landscape with plants and grasses that are native to the area and thus require less watering.
C. Have students find out what is done locally with wastewater. Is it discharged to a surface water body, injected underground, or sprayed onto land surfaces (e.g. dedicated spray-fields, agricultural areas, or public access areas, such as golf courses)? Have students determine additional “uses” for treated wastewater (e.g. aquifer recharge) and determine the level of treatment needed for each use and associated costs.
D. Present any viable options as determined in C. above as recommendations to the community.

IV. Extensions

A. Have students find out the cost of installing different water saving devices in the home.
B. Have students estimate how long it would take for each item to pay for itself.

LESSON PLAN THREE

Water: More Priceless Than Gold

This lesson takes students from identifying a community’s source of water to discovering the rights of ownership of water and appreciating the importance and value of water. In many ways the study of water is not only geographical and cultural but also involve political and economic issues.

Objectives

The student will be able to:

1. Identify the source of the community’s water that is used for residential housing,
2. Describe an actual case study of a water-rights issue in the western part of the United States,

3. Write water rights laws that are free of ambiguities,
4. Demonstrate skill of solving water-rights issues,
5. Outline the water rights laws of his/her state,
6. Compute the monetary value of the water piped into homes in the community, and
7. Demonstrate an appreciation for the importance of water.

Materials Needed

A copy of the background material for each student.

Background Material

Water is indispensable! The possession of water rights with the ownership of real estate in the western half of the United States is prized as gold. Following this introductory paragraph is a summary of an actual water-rights dispute in a western state. Help settle the dispute as a class. In actuality, this has not yet been done. Role-play the end of the story to get an understanding of the emotions of the people who are battling for their water.

For 75 years, Jack Wilson and his family have owned hundreds of acres of land backing up to a national forest. In 1955, the Wilson family formed a real estate agency and began the development of several canyons in the area. Gravel roads were graded and dug out of the side of the canyon hills to provide access to one-acre lots. Triple Canyon Real Estate then began the sale of these individual lots. The agency even provided the construction of a cabin shell on each purchased lot if the buyer did not want to construct his or her own. Triple Canyon Real Estate continued to sell lots and cabins in this area until 1991.

Water pipelines were laid connecting the cabins to a storage tank that was supplied with water from three different springs. Water usage and its misuse have been a problem there in dry years when less water flowed into the springs. Sometimes cabin owners had undetected leaks in their pipes when they were away from the area for long periods of time. These leaks often nearly drained the storage tank, thereby depleting the available water and also decreasing the water pressure. This pressure was necessary to carry the water to all the homes, especially during holidays when the area became alive with people on vacations.

Mountain winter freezes and thaws are destructive to underground pipelines laid close to the surface. Extreme water pressure during times that the storage tank was full also caused a fast deterioration of the water system's pipes. Jack Wilson was inundated with complaints about the system. The State Engineer's office sent a letter to Triple Canyon Real Estate advising them of the improvements that had to be made to the water system.

Concerned citizens of the area decided to form a water board and did so with the encouragement of Jack Wilson. Dues were charged, and the money collected helped to pay for some of the improvements. Because all of the improvements suggested by the State Engineer's office were not carried out, this office sent another letter to Triple Canyon Real Estate. This time the recommendations were more stringent, and a deadline was given for their completion.

Jack Wilson was also advised to draw up a deed that would establish the springs of the area to be for residential usage, not agricultural. Wilson neglected to do so. One of the water laws of this state said that if the water from a spring had not been used as designated in a deed for the previous four consecutive years, the water may be used in another way. The water from the Meandering Slough Spring, which was the one in contention, had been used only for residential use since 1921.

In 1982 the newly formed water board elected a president (Harry Harrison) and a secretary (Nelda Ball). Their services were voluntary as were the services of the men who worked on the pipelines of Triple Canyon Estates. These men were retired petroleum engineers, oil-field workers, and plumbers.

In 1988 Nelda Ball and her husband Drew contracted to buy 15 acres of the Wilson Ranch to farm trees. The designated 15 acres were not part of the Triple Canyon Estates development but did contain one of the springs that was used to supply water to the residential area. Jack Wilson's lawyer, in drawing up the bill-of-sale, failed to include a retention of the water rig5hts for the area. This meant that Triple Canyon Real Estate's usage of water from Meandering Slough Spring was no longer legal.

Nelda and Drew Ball rerouted Meandering Slough Spring's water from the storage tank to another storage tank on their property. The property owners had approximately 1/3 less water to use for their subsistence. Jack Wilson convinced residential property owners that there was ample time for an appeal on the ruling. The board members, in their naivety and trust of Jack Wilson, let time pass without bringing suit against the Ball family.

The board from Triple Canyon Estates Water Association finally filed suit against Nelda and Drew Ball in 1989. The judge in the case, Martha Gregory, ruled in favor of Nelda and Drew Ball because of the water board's silence for a year after the legal decision. The Ball family did offer to sell water to the residents' Water Association at $99/acre-foot per annum. They would only agree to sell 15 acre-feet, however. The association turned this down, feeling that the law was on their side because of the state's water laws. Six years later, the homeowners had not regained the rights for usage of Meandering Slough Spring. There are over 400 homes and cabins using the water. They have had three lawyers at this and have been to court twice. All the lawyers had told the homeowners' Water Association that it was certain to win the case.

The homeowners have been trying to find another source of water for their residential area. They have received permission from the Forest Service to drill on the land in the National Forest or to pipe in water from a nearby spring. They have not, however, been able to find a suitable source.

Advanced Preparation

I. Answer the following by researching each topic:
   A. Determine how many gallons a family of four typically requires for subsistence each day.
   B. How many gallons of water must your water utility be able to supply daily in order to meet your community's demand? Yearly?

II. Call your community's water supplier and investigate the source of your water supply. Ask them the price of your water when it comes into your treatment plant. Compare this to the amount that the Ball family was going to charge Triple Canyon Estates owners.

III. Carefully read the Background Information and become familiar with the main players in the drama.

IV. Prepare copies of the Background Information for your students to read. Begin with the second paragraph.

V. Obtain the name and address of your district's state congressperson.

Procedure

I. Setting the Stage
   A. Ask the students these questions:
      1. How would you feel if every time you wanted to flush your commode, you would have to pour two gallons of water into the tank before it would flush? This water would have to be water that you had hauled into your home from an outside source or would be "graywater" from other uses in your home.
      2. How would you feel if you were limited to two 15-gallon baths a week? You dare not use any more water than this because if you did, you might not be able to take any baths the following week.
      3. How would you feel if you turned on the tap, only a few drops of water flowed, and you were expecting company the following day?
   B. Divide the class into two groups.
      1. One group is in favor of the Ball family retaining the water rights.
      2. The second group is in favor of the homeowners regaining their lost usage for Meandering Slough Spring.
      3. Collectively have each group prepare a list of arguments favoring its side.

C. Ask a willing teacher or an outside resource person to listen to the arguments presented in class and choose the group which best presents its arguments. Two students, perhaps absent the day before, can help the resource person make the decision.
D. Have each group choose a person to present its arguments and then let him/her do so. Have the Ball family presentation first. After both sides have had a turn, let each side ask questions of the other, or let any student speak who feels he or she has something extra to say.

III. Follow-Up (as a homework assignment)
A. Have the students summarize the two class-period activities by having them write what they believe to be the two best arguments, both pro and con, and the judge's decision.
B. Have the students write state water rights laws that may have prevented this situation from occurring.

IV. Extensions
A. Have student(s) write the state congressperson from their district requesting to send the class the water-rights laws of their state.
B. Review these laws and see if you can find any gray areas that might be sources of future conflict.
C. Review federal water laws in fact sheet to see if the current laws can solve the problem.

ANNOTATED BIBLIOGRAPHY

Teacher Resources

Arms, Karen. *Environmental Science*. Austin, Tex.: Holt, Rinehart, and Winston, Inc., 1996.
A textbook that was very helpful for a non-science teacher in learning the basics of water as taught in high school.

Clarke, Robin. *Water: The International Crisis*. Boston, Mass.: MIT Press, 1993.
This book is a very good resource on global water scarcity issues. I found the book very readable for teachers and/or students doing research on water scarcity around the globe.

DeVilliers, Marq. *Water: The Fate of Our Most Precious Resource*. Boston, Mass.: Houghton Mifflin, 2000.
I believe that this book is an excellent resource on water quantity and quality. Different areas of the world are researched and the book is easy to understand for teachers that teach in non-science areas.

Dolan, Edward. *Our Poisoned Waters*. New York: Cobblehill Books, 1997.
The author writes very effectively on water pollution issues. Some may feel that it is alarmist but the information on pollution hazards for water was very informative.

Postel, Sandra. *Last Oasis: Facing Water Scarcity*. New York: Norton & Co., 1992.
For researching various areas of the world for water scarcity issues this is a must read. Some may feel that the author is biased but the issues are put forth in a very objective way.

Symons, James. *Plain Talk About Drinking Water*. American Water Works Association. 2001.
The required text for the seminar is easy to read for teachers and students and answers most any question on the topic of water.

Student Resources

Donnely, Andrew. *Water Pollution.* New York: The Child's World Inc., 1999.
A book written for young readers on the subject of water pollution. The book is easy and interesting to read for fun or for research in writing reports on water pollution.

Leggett, Dennis and Jeremy Leggett. *Operation Earth: Troubled Waters*. New York: Marshall Cavendish Co., 1991.
This book contains more global information on water issues. The book contains excellent visuals and interesting projects for students.

Litvinoff, Miles. *The Young Gaia Atlas of Earthcare*. New York: Facts on File Inc., 1997.
This is a great book for any science or geography teacher. There are many stimulating maps and fun projects for students.

National Wildlife Federation. *Pollution Problems and Solutions*. Philadelphia, Pa.: Chelsea House, 1999.
A short and concise book from the National Wildlife Federation that is a great resource for practical solutions for pollution problems in the community.

Internet Resources

http://www.groundwater.org/KidsCorner/kidscorner.htm
Groundwater Organization
This website contains information on groundwater and has fun activities for young people.

http://www.globe.gov.fsl/welcome.html
The Globe Program
A website in which students can participate in science projects with scientists.

http://www.agiweb.org/education
American Geological Institute: Advancing Earth Science Education
This website gives teachers ideas on teaching earth science. I found several lessons on water issues.

http://www.capp.water.usgs.gov/gwa
Groundwater Atlas of the United States
One of many areas of the U.S. Geological Survey that provide excellent tools for teachers. This site maps groundwater for the United States.

http://www.sr6capp.er.usgs.gov/aquiferBasics/index
Aquifer Basics
A U.S. Geological Survey site that gives the teacher excellent information on aquifers.

http://www.nesen.unl.edu/lessons/water/waterlesson.asp
Water Related Lessons
A site for finding lesson plans specific to water issues.