Waste and Water Section

Waste and Water Introduction

Why is water so important?

Clean, abundant water is one of our state's greatest treasures, whether it comes from the ground or from lakes, streams, rivers or coastal waters. We use water for navigation, industry, agriculture, recreation, fisheries, power production, and household use - washing and drinking. Eighty percent of the water used in Washington State is supplied by surface waters such as lakes, rivers, and ponds. Ground water supplies the remaining 20 percent.

Water suitable for drinking is called potable water. It can come from surface water, but more than 60 percent of the state's residents rely on ground water for drinking.

Almost all the water in public systems is required to be disinfected and treated to meet standards set by the U.S. Environmental Protection Agency (EPA). The exceptions would be ground water from protected deep aquifers. In 1995, Americans bought 2,691,000,000 gallons of bottled water.

How safe is our ground water?

Ground water is stored under the surface of the earth in cracks and crevices of layers of stone, in spaces between pieces of gravel, and between grains of sand. As an experiment, take a small glass and fill it completely with sand, then slowly pour in fresh water. The water actually collects in spaces between grains of sand. The gravel and sandy or rocky layer that holds the ground water is called an aquifer. Aquifers are filled by precipitation seeping into the ground and by surface waters to which the aquifer is interconnected.

Water can become contaminated when wastes seep into the earth and then into the aquifer. Ground water pollution in Washington comes from five types of pollutants:

- Metals and trace elements from industrial, mining or agricultural activities;
- Nitrates resulting from overuse of fertilizers, density of septic systems, applications of municipal and industrial wastewaters, and storm water infiltration;
- Pesticides from both large and small scale agricultural activities, and from residential use;
- Petroleum from industrial spills and leaking underground storage tanks; and
- Synthetic organic chemical releases from industrial operations.

Chemicals don't readily break down or disperse in ground water - so their concentrations are often several hundred times greater than the level found in surface water.

Can septic systems pollute ground water?

People who don't live in town often have their own sewage disposal system, called a septic system. It consists of a collection tank and a drainfield which provides filtration and treatment by dispersing the household sewage into the ground. With one-third of the U.S. population on septic systems, over 1 trillion gallons of waste per year are disposed of below the ground's surface.

Inadequately treated sewage from failing septic systems is the most frequently reported cause of ground water contamination. It poses a significant threat to drinking water and human health because diseases and infections may be transferred to people through the well water they drink. Improperly treated sewage that contaminates nearby surface water, also increases the chance of swimmers contracting a variety of infectious diseases. People who eat shellfish from polluted beaches can get very sick - or even die.

The solution to the septic system problem is proper design of new systems and regular inspection and maintenance of existing ones. Having your septic tank inspected each year and pumped about every three years is good insurance against causing water pollution, and against having to replace a system that failed from neglect - a very expensive project.

Landfills and ground water - a dangerous duo

When rain falls on a landfill, the water percolates down through the refuse and forms new liquid chemical compounds called leachate, which may flow into fresh water sources on the surface or seep into aquifers and contaminate them.

Modern landfills such as the new section at Cedar Hills Landfill near Seattle have heavy plastic liners installed in the bottom which prevent the leachate from leaking into the ground water. Collection systems use pipes and pumps to draw the leachate out of the landfill and store it in ponds for primary treatment. Then the leachate is piped to the METRO wastewater treatment plant in Renton, Washington, for secondary treatment. Water-quality monitoring wells are drilled around the modern landfill and water samples are checked on a regular basis to ensure that leachate isn't escaping from the landfill site into the ground water aquifer. At Cedar Hills, the METRO discharge permit allows for an average of 961,000 gallons of leachate per day.

Many older landfills have no leachate collection system or protective plastic liner to prevent ground water contamination. The EPA compiled a National Priority List (NPL) which prioritizes hazardous waste sites for immediate action. The Superfund is the federally funded program to clean up hazardous waste sites. In 1996 in Washington State, 52 Superfund sites were on the National Priority List. Nine of these are landfills.

Nonpoint pollution - the growing problem

Pollution of surface or ground water can come from obvious, visible points such as discharges from sewage treatment plants or factories, or from many small "nonpoint sources" like street and highway runoff, poor logging practices, gardening chemicals, erosion, agriculture, septic systems that don't work right, and even pet waste.

In general, pollution from industry and sewage treatment plants is on the decline, while nonpoint pollution is increasing. Today just nine percent of stream pollution comes from industry, while 65 percent is nonpoint pollution, primarily from agriculture. In Washington, the primary causes of water quality problems in streams are high temperature and fecal coliform bacteria.

Watersheds - the basic unit of landscape

Surface water flows downhill, collecting in waterways and lakes, eventually returning to the ocean from whence it came. Evaporation rises and condenses into clouds which move over the earth, and rain on it. Rain seeps into the ground and washes across it, picking up anything in its path and draining the watershed toward a common outlet.

Everybody lives in a watershed. Mega-watersheds are oceans; huge watersheds are basins like the Columbia River or the Mississippi. Local watersheds may drain into a bay or a lake or even a stream. The idea of a watershed helps us understand how nonpoint sources can contribute even more pollution to a receiving waterbody than sewage treatment plants or industries.

The used oil problem

Used oil is the largest single source (over 40 percent) of pollution in our nation's waterways. Most is dumped down storm drains that empty into streams and lakes, poured on the ground, or sent off to a landfill in the garbage by do-it-yourselfers. One pint of oil can produce a slick of approximately one acre on surface water. One quart of oil will foul the taste of 250,000 gallons of water. More than 4.5 million gallons of used oil are discarded every year in Washington State.

A common source of oil in ground water is underground storage tanks for heating oil and gasoline. A leak of just a single gallon of gasoline per day is enough to render the ground water supply of a town of 50,000 people unfit for consumption.

Lakes on the line

Lakes in this state, often shallow because of their glacial origin, suffer from too much algae and aquatic plant growth. Summer algae blooms deplete oxygen vital to fish. The primary cause of these problems is excessive nutrients - phosphorus and nitrates from animal waste, detergents, industry, fertilizers, animal waste, and leaking septic systems.

Water use and the need for conservation

The average American uses 60-80 gallons of water each day inside the home:

- 27 gallons to flush the toilet
- 24 gallons for showers or baths
- 22 gallons for laundry
- 13 gallons in the lavatory
- 2 gallons for dishwashing.

(Can you think of ways to save water in your household?)

Outdoor residential use varies considerably with climate, type of landscaping and lot size and can range from 30 to well over 100 gallons per user per day.

When all water uses including domestic, business, industry, and agriculture are added together, approximately 339 billion gallons of water are used every day in America. That means that every day each of us in the United States uses about 1,400 gallons of freshwater - more than any other industrialized country and many times more than any developing nation. Here's the breakdown:

- Irrigation (crops and golf courses) - 40.4%
- Thermoelectric power (generation of electric power with fossil-fuel, geothermal or nuclear energy) - 38.5%
- Domestic (indoors and outside) - 7.5%
- Industrial (processing, washing and cooling for manufacturing) - 7.2%
- Commercial (motels, hotels, restaurants, office buildings, etc.) - 2.4%
- Livestock (includes feed lots, dairies and fish farms) - 1.3%
- Mining (extracting materials and petroleum, milling) - 1%

In Washington, 70 percent of water use is for irrigation, considerably more than the 40 percent nationwide. Nearly every county in the state has areas where there is not enough water to meet the demands of a growing population. About 40 percent of the state's watersheds have streams where flows are already too low some time during the year. Three million more people will need water by the year 2020. That's like adding a city of 100,000 every year. Demand for water increases with growing population. So does the potential for pollution.

Whose problem is it? Who has the solution?

Most nonpoint sources of pollution are caused by controllable human activities. But the people responsible for the problems are often unaware of the effects of their actions. To keep our water clean -and to make sure we have enough to go around - everyone needs to learn what they can do to protect water. Everyone needs to help.

Resources -

1. Butkus, Steve, 1996 Washington State Water Quality Assessment (305(b) Report) Washington State Department of Ecology

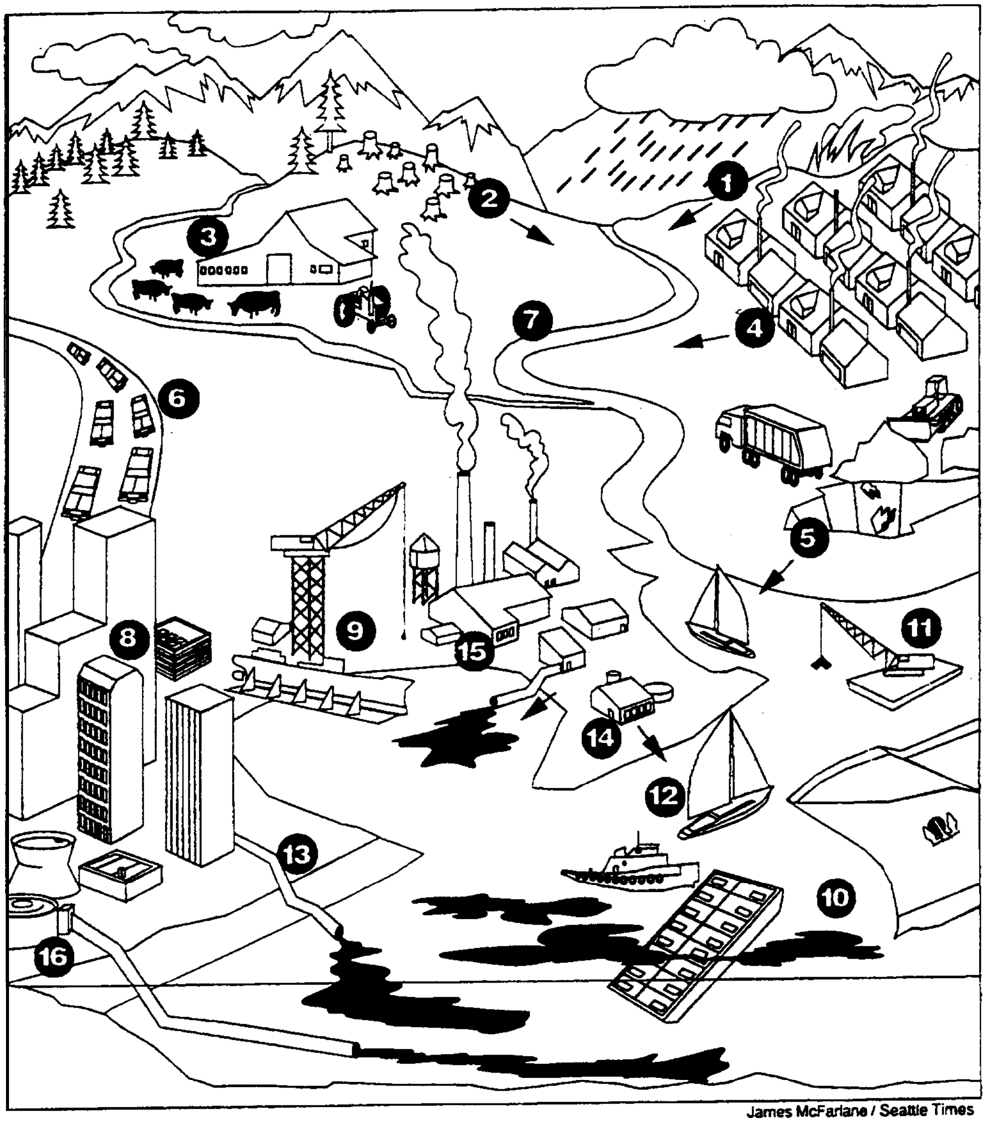
2. World Resources Institute, Houghton Mifflin Co., The 1994 Information Please Environmental Almanac, Boston, New York, 1994

3. American Water Works Association Water Industry Data Base

4. US Geological Survey Circular 1081

5. Ecology, publication # 90-BR10, "A Guide to the Used Oil Problem",

6. International Bottled Water Association



Almost every activity we do produces pollution that sooner or later is carried downhill by rainfall and rivers into Puget Sound

1. Air pollution from slash burning, automobiles, factory smokestacks, wood stoves and similar sources falls into Puget Sound or settles on the land, where rainfall carries it into the water.
2. Logging creates erosion and forestry contributes herbicides and insecticides.
3. Farms contribute manure, fertilizers and pesticides.
4. Rain runoff from neighborhoods carries waste oil, paint thinner, household chemicals and pesticides, fertilizers, pet manure and pollution from failing septic tanks.
5. Contaminants from garbage landfills leach into the water table and eventually make their way to streams and Puget Sound.
6. Auto-exhaust particles, oil and metals are washed off roadways into ditches and storm drains that lead to Puget Sound
7. Rivers are the highways that carry pollutants to salt water.
8. Cities contribute a variety of pollutants, including toxic metals, dirt and pet manure.
9. Shipyards deposit metal, chemicals, paint overspray, toxic bottom paints and contaminated sand from sandblasting.
10. Ships contribute fuel spills, oily bilge water, raw sewage, plastic garbage thrown overboard and loose cargo.
11. Harbor dredging stirs up polluted bottom mud, dispersing it more widely.
12. Pleasure boaters spill fuel, pump out sewage, sometimes use toxic bottom paints and drop garbage overboard.
13. During heavy rainstorms, overflowing stormwater with raw sewage is dumped directly into the Sound.
14. Industries discharge chemicals, toxic metals, waste-oil products, wood waste and other pollutants.
15. Pulp and paper mills and log yards discharge waste water into Puget Sound.
16. Sewage-treatment plants discharge waste water that still has in it bacteria, oils and grease, toxic chemicals, metals and sediment.

SOURCE: Puget Sound Water Quality Authority.

More Than Meets The Eye

Subject: Science
Grades: 3-8
Teaching Time: One Class Period
Focus: Aquifer, Water Quality, Ground Water Pollution, Contaminated Drinking Water

Rationale

Many Washington counties depend on ground water for their drinking water.

Even small quantities of certain substances can pollute large volumes of drinking water.

Learning Objective

Students will:

- Understand how water may be stored in the ground.
- Understand that, once contaminated, aquifers are difficult if not impossible to purify.

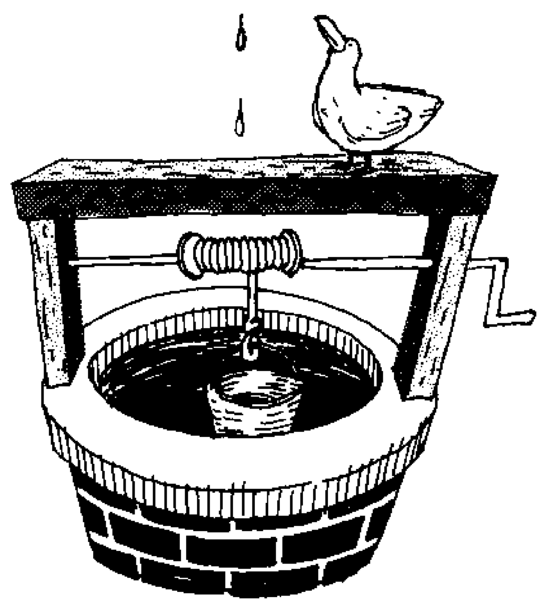
Materials

Teacher Demonstration

- One household sponge
- Red food coloring.
- Eyedropper
- Clear container to catch water
- Brochure - EPA
- "Water in Soil" overhead

Student Activity (optional)

- Several household sponges cut into quarters or halves (Enough pieces for each student in the class to carry out his or her own demonstration with small sponge pieces. Use different types of sponges and have students compare the number of times it takes to completely flush the dye from the different types. Sponges that only take one or two times can represent sandy soils, while sponges that take a lot of flushes can represent clay.)
- Containers to catch water (These can be cut-off milk cartons, cups, or other recycled containers that students bring from home.)



Pre & Post Test Questions

1. Where does rain go when it falls on the ground?

2. What is ground water?

3. Where does drinking water come from?

4. What does contaminate mean?

5. What are three products in your house that could contaminate ground water?

Learning Procedure

1 Tell students that the water they drink and cook their food in may come from underground. **Ask:** "Is the ground solid?" "If so, how can water be stored in the ground?"

2 Show students the large sponge. **Ask:** Is this sponge solid? Can it hold water?

3 Set the sponge over a clear container. Pour water over the sponge until it's saturated. This occurs when the water begins to drip into the container. Empty the container. **Ask:** "Is there water in the sponge?" "If so, where is it?"

4 Explain that the water is filling the "air spaces" in the sponges. Show the overhead "Water in Soil." Point out the "air spaces" available in the soil. Explain that this is how ground water is stored. This saturated sponge is like the ground.
Tell students that some soils are better than others at holding water. (Sandy soils don't hold water as well as clay soils.) Special underground areas that hold lots of water are called aquifers.
Ask: "How much of the sponge is air holes?" "How much is "solid?" In the ground, the aquifer area will have a porosity (water's holding capacity) of 5 to 50 percent.[1]

5 Stand the sponge on end. Add one or two drops of red dye onto the saturated sponge. Explain that the dye represents hazardous substances or poisons that, if improperly disposed of, can contaminate ground water. For example, weed and bug killers, gasoline, or oil from leaking tanks.
Note how the "contaminant" begins to disperse throughout the "aquifer."

6 Squeeze the water from the sponge into the clear container and note its color. Attempt to clean the "aquifer" by resaturating the sponge and resqueezing. Keep track of the number of times necessary to do this before the water becomes completely clear again.

7 **Ask:** "What have we learned about ground water?" (That contaminants are impossible or very hard to remove from aquifers; that it may take a long time to wash a contaminant from an aquifer.)
Ask: "What are some of the ways poisonous things might get into ground water?" (Runoff from pesticides used in farming; illegal dumping of hazardous waste; pouring household hazardous substances such as furniture polishes or paints down the drain, etc.)

8 **Ask:** "What can we do to keep poisons out of our drinking water?" (Make sure they are properly disposed of; find safer substitutes, etc.)

1 R. Allen Freeze and John A. Cherry, Groundwater Englewood Cliffs, N.J.: Prentice-Hall, 1979, p. 37.

Resources - *See page 233.*

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Buol, S.W. Soil Genesis and Classification. Ames, IA: Iowa State University Press, 1980.

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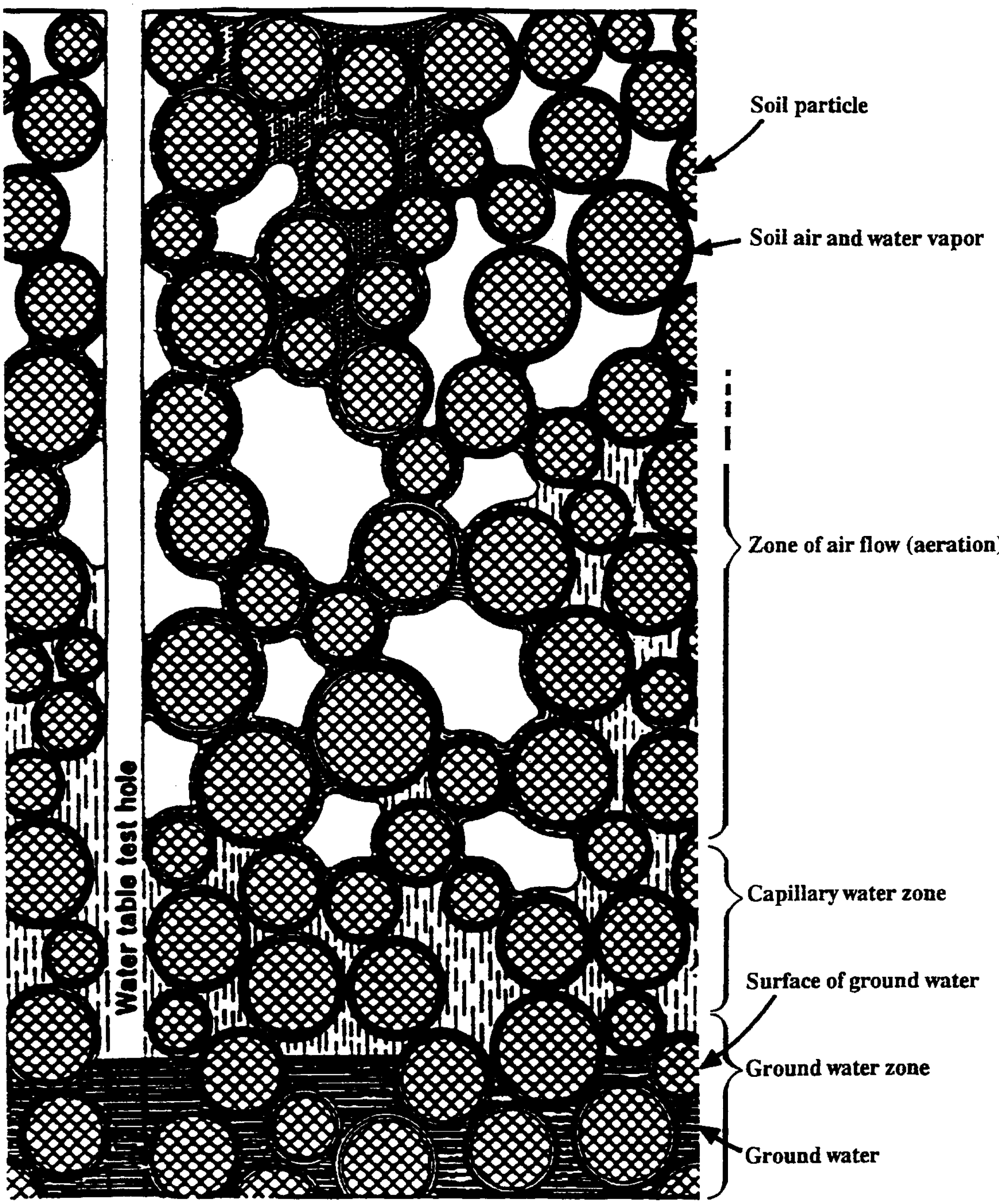
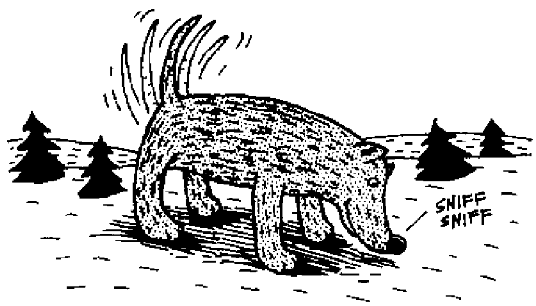
Golden, Augusta, Water: Too Much, Too Little, Too Polluted? New York, N.Y.: Harcourt Brace Jovanovich, 1983.

Water In Soil



Zunker's classification of soil moisture. (Redrawn from Zunker, 1930)

Where, Oh Where Has Our Water Gone?



Subjects: Science, Environmental Studies, Music, Geography

Grades: 4-8

Teaching Time: One Class Period

Focus: Waste and Water, Drinking Water Resources, Water Conservation and Protection

Rationale

Our planet has a vast, fixed supply of water. Only a small portion of this water, however, is readily available for human consumption.

Clean water is one of our most vital natural resources. Keeping it that way is an important responsibility.

Learning Objective

Students will:

- Understand the importance of conserving water and protecting it from contamination.

Teacher Background

Review information on "Distribution of World's Estimated Water Supply" chart, p. 210.

Materials

Demonstration Materials

- One ten-gallon container (or two five-gallon containers, etc.)
- Six one-cup measuring cups
- One eyedropper
- One plate
- One siphon
- Overhead or handout: "Where, Oh Where Has Our Water Gone?"
- Globe or large wall map of the earth

Optional Student Materials

Song lyrics, "Where, Oh Where Has Our Water Gone?"

Pre & Post Test Questions

1. What percentage of the world's water supply is in the oceans? In ice caps and glaciers?

2. What are three sources of fresh water?

3. What is ground water? What percentage of total fresh water is ground water?

Learning Procedure

1 Using a globe or a large map of the earth, ask students to guess how much of the water on the earth's surface is usable by human beings. Record students responses on the board. **Ask:** "What might make this water unusable?" (salt water, too hard to get to, polluted, tied up in icebergs, etc.)

2 Have one person from the class demonstrate the world's total water supply by filling the ten-gallon jug (many wastepaper cans are about ten gallons). **Say:** "This represents the total amount of water on our earth." **Ask:** "Where is our water on earth found?" (oceans, rivers, streams, underground, icebergs, etc.) Record student responses on the board and point out these locations on the map or globe.

3 **Ask:** "How much of our total water is ocean or salty water?" "How much is fresh or potentially drinkable?" Have another student demonstrate the total freshwater supply by either siphoning water from the jug to the five one-cup containers or, if the jug has a wide enough mouth, filling the cups by dipping them into the jug. Ask how much should be siphoned. Have a student label the large container "Salty Ocean Water." Ask students to locate oceans on the map or globe.

Say: "These five cups represent the total fresh water available." **Ask:** "Where is fresh water found?" (rivers, lakes, ground water, icebergs, etc.)

4 **Ask:** "How much of this total fresh water is not frozen in icebergs or snow or other impossible to reach places?" Get another volunteer to pour one-half of the five cups into a sixth cup. Have a student label the four and a half remaining cups as "Total Unusable Fresh Water." **Ask:** "Where is most of this impossible to reach water found?" (Arctic and Antarctic oceans and land, high mountains, Alaska, etc.) Point out these locations on the map.

5 Tell students that this half cup stands for the fresh water that is not completely inaccessible. **Ask:** "How much of this water is drinkable water?" Have a student draw nine drops of water from this cup and squeeze them one by one onto the plate. Have a student label the remaining water in the half cup "Fresh Water Available But Not Usable." **Say:** "This represents fresh water that is too expensive to get or too polluted to drink."

6 Tell students that the nine drops stand for the amount of water that is available for human consumption. **Ask:** "Where is most of this water?" (in the ground) Explain that about eight and a half of those drops represent the amount of the world's fresh water held in ground water. (Ground water holds 96 percent of the world's freshwater resources) Tell students that ground water is water that is stored in the ground in areas called "aquifers." Tell students that the other half a drop is in unpolluted lakes, reservoirs, etc. Show the overhead "Where , Oh Where Has Our Water Gone."

7 Reemphasize that a very small amount of the world's water is usable and available for human use. Even though the water cycle of rain coming from clouds (precipitation), evaporation of water from lakes and oceans, and condensation of moisture from the air (dew in the morning is a prime example) make it seem as if water is continually being added, stress that the amount of fresh water is fixed. (The places it is stored are essentially fixed.)

8 **Ask:** "How does rainwater and snow (precipitation) become ground water?" Have students list human activities which could affect the quality or quantity of ground water? (Allowing poisonous wastes to be disposed of in dumps; pouring used motor oil down a street drain; watering crops by pumping from aquifers.)

9 **Ask:** "How does waste affect the quality of our water?" To find out, do the activities "Waste and Water" p. 213, and "What Waste Went Where," p. 255.

10 Have students make a graph or pie chart of the data from the experiment.

11 Have the students make pie charts or bar graphs showing the distribution of the world's freshwater supply.

Extended Learning

Distribute the lyrics to the song "Where, Oh Where Has Our Water Gone?" p. 211. Have the class sing the song. (Lower-level grades)

Resources - *See page 233.*

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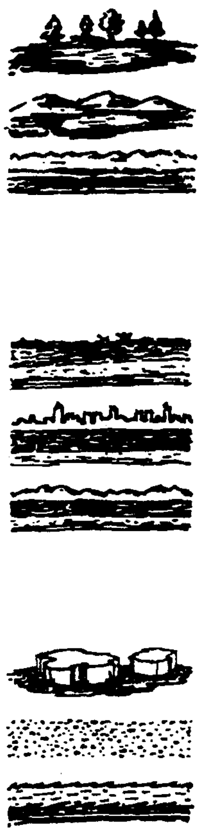
Distribution of the World's Estimated Water Supply



Location	*Percentage of Total Water*
Surface Water	
Freshwater lakes	.009
Saline lakes and inland seas	.008
Average in stream channels	.001
Subsurface Water	
Vadose Water (includes soil moisture)	.005
Ground water within depth of half a mile	.31
Ground water - deep lying	.31
Other Water Locations	
Icecaps and glaciers	2.15
Atmosphere (at sea level)	.001
World ocean	97.2
TOTAL (rounded)	100

U.S. Department of the Interior/Geological Survey

Of the world's water supply, only some .6341 percent is fresh and found in freshwater lakes, in streams and channels, in vadose form (just below the surface and in the soil), and under the ground to a depth of one mile. The water locked up in glaciers is not available.
(U.S. Department of the Interior/Geological Survey)

Song: "Where, Oh Where Has Our Water Gone"

D AND A CHORDS FOR GUITAR

To be sung to the tune "Where, Oh Where Has My Little Dog Gone"

1. Where, oh where has our water gone.
   Oh where, Oh where can it be!
   In the earth, the sky, and the ocean strong,
   That's just where it will be.

2. Where, Oh where has our water gone.
   Oh where, Oh where can it be.
   Some in the ocean too salty to drink.
   And that's not useful to me!

3. Where, Oh where has our water gone?
   Oh where, Oh where can it be?
   Deep underground and out of our reach.
   Still it's not useful to me.

4. Where, Oh where has our water gone?
   Oh where, Oh where can it be?
   Some in the atmosphere turning to rain.
   I hope it will rain down on me.

5. Where, Oh where has our water gone?
   Oh where, Oh where can it be?
   Some in the ice caps and glaciers you know.
   None of it useful to me.

6. Where, Oh where has our wastewater gone?
   Oh where, Oh where can it be?
   Polluted and dirty, so icky to see.
   None of it useful to me.

7. Where, Oh where has our water gone?
   Oh where, Oh where can it be?
   Industry uses it for manufacturing.
   Where is the water for me?

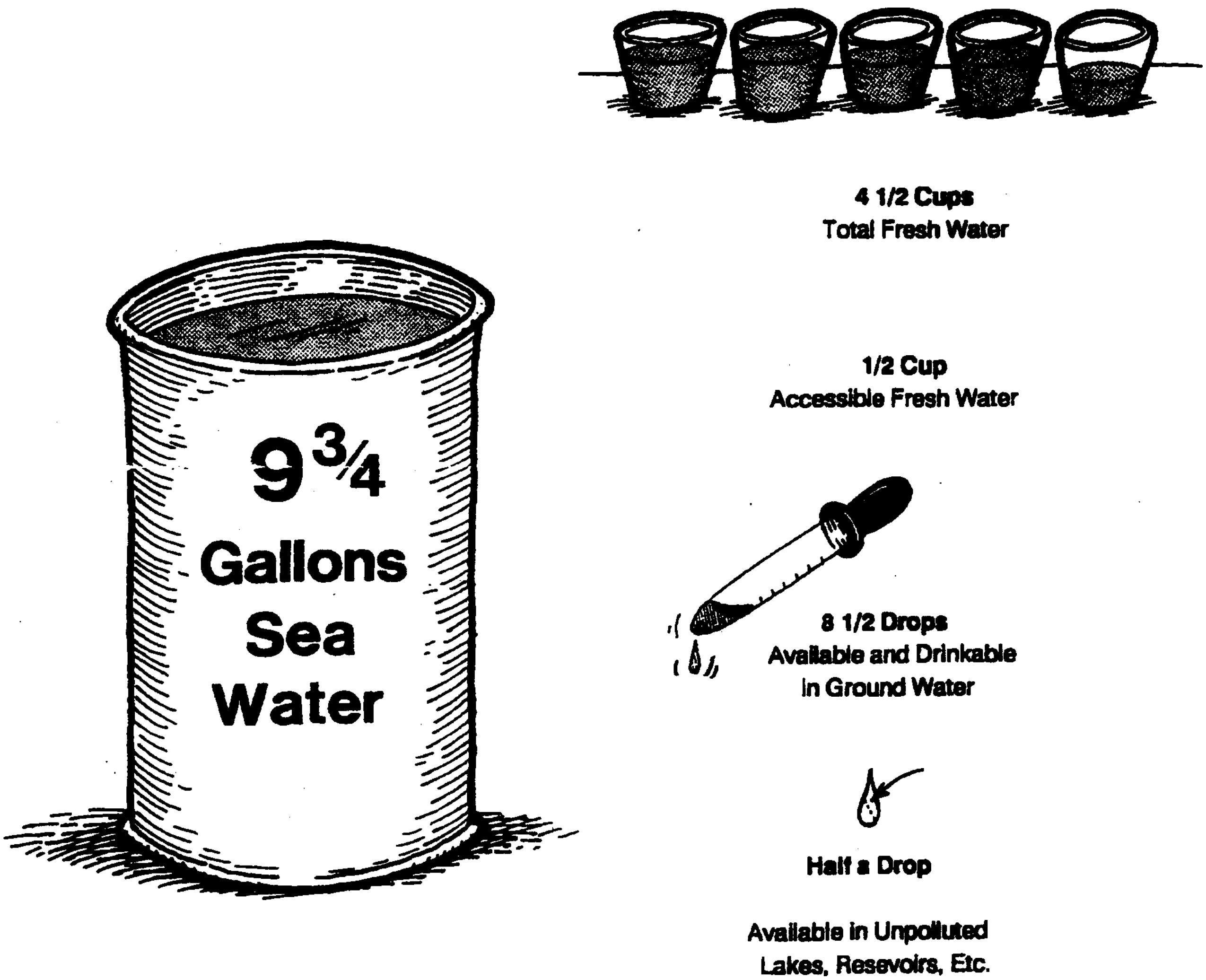
8. Where, Oh where has our water gone?
   Oh where, Oh where can it be?
   Some in the faucet, the sink, and the tub.
   That is the water for me.

9. If we recycle and clean the water we use,
   And throw just a little away,
   Then we'll have more for the things that we need,
   And enough water each day.

New words by Barb Russell

This song material borrowed from the Energy Food and You: An Interdisciplinary Curriculum Guide for Elementary Schools. Washington State Office of Environmental Education, Olympia, 1980, p. 62c.

Where Oh Where Has Our Water Gone?



The Earth's Water = 10 Gallons

Waste and Water

Subjects: Earth Science, Environmental Studies

Grades: 4-8

Teaching Time: One Class Period With Extended Observation

Focus: Water Pollution, Leachate, Ground Water

Rationale

Clean water is one of our most vital natural resources. Keeping it that way is an important responsibility.

Learning Objective

Students will:

- Demonstrate how waste in the form of landfill leachate can contaminate ground and surface water.

Teacher Background

"In Washington State, over 75 percent of drinking water comes from ground water in 21 counties. Another 12 counties derive over half of their drinking water from ground water."[1]

"The general quality of Washington's ground water is good; but on 500 known or suspected hazardous waste sites, 15 percent have shown ground water contamination. At 50 percent of these sites, there is a potential for contamination of drinking water. Contamination has been documented at 5 percent of the sites already." [2]

A number of Washington's landfills, such as the Colbert landfill in Spokane, are hazardous waste sites. And all landfills, because they are repositories for household hazardous wastes and other pollutants, have the potential to contaminate ground and surface water.

Materials

Demonstration Construction Materials

- Corrugated cardboard boxes
- Strips of paper
- Aluminum foil
- Shallow bowls or saucers
- Red and blue food coloring
- Plate glass or clear plastic
- Sand or wood chips
- Clay (either actual soil or modeling clay)

Pre & Post Test Questions

1. What is leachate?

2. Where do the majority of Washington citizens get their drinking water?

3. What kinds of soil are most common in Washington State?

4. What is ground water?

Learning Procedure

1 Tell students they are going to create a model of what can happen to wastes when they are disposed of in dumps or sanitary landfills. **Say:** "Until recently, there have been two ways to get rid of solid waste.

- Dumps were large holes in the ground where solid wastes of all kinds were thrown. Over time, the material could accumulate into piles high above the ground. Because of food wastes, these dumps could attract rats, birds,

1 Washington State Department of Ecology, "Ground Water Quality in Washington State," Citizen's Guide to Ground Water Quality In Washington State, Olympia, 1986, p.1.

2 Washington State Department of Ecology, "Ground Water Quality Management Strategy Summary," Citizen's Guide to Ground Water Quality In Washington State, Olympia, 1986, p. 1.

and other wildlife, some of which carried diseases.

- Sanitary landfills represent an improvement over dumps by providing a cover of dirt over each day's pile of refuse. The dirt compacts the waste and reduces the health hazard from disease-carrying wildlife.

2 Explain to students that neither of these disposal methods may solve the problem of leachate. Leachate is produced when rainwater, either directly or through runoff, soaks into a landfill. The water slowly moves downward through the landfill under the influence of gravity. As it trickles through, it can mix with toxic substances that have been deposited in the landfill. Depending on the size of the landfill, leachate can be generated in large volumes. For example, the Cedar Hill landfill near Seattle generates an average of 960,000 gallons of leachate a day.

3 Tell students that in the past, however, most Washington landfills have had no systems to collect leachate. As a result, the contaminants have moved down into the soil, in some cases contaminating ground water. Leachate moves most easily through porous sandy-gravelly soils. Clay inhibits the movement of leachate. Washington State regulations now require liners in the bottom of landfills, leachate collection systems, methane gas collection systems, and ground water quality monitoring wells. These innovations are designed to maintain a healthy environment. Show the overhead "Soil Types and Ground Water Pollution."

4 Display the overhead "A Model: Rainfall, Landfills, and Ground Water Pollution." Hand out copies to students and have students, working in teams, to construct a model of water contamination using the handout as a guide.

5 Study the model landfill drawing p. 217. Use the following steps to have groups of students construct a model landfill.

- Use a sturdy cardboard box as the landfill. Cut away one side of the box for observation.
- Put a plastic or clay liner in the bottom of the box to prevent leakage of water from the bottom of the box.
- Put in a glass plate or clear plastic film in the cut down side for viewing the experiment.
- Fill the landfill with sand or wood chips. (Sand may be too heavy for the cardboard box to be carried.)
- Place a clear glass bowl against the cutdown side of the box for easy viewing, then bury it in the bottom of the landfill and mound the sand up on the sides of the cardboard box.
- Pour clean water in the bowl until the bowl is about half full.
- Bury sheets of aluminum foil in the sand on two sides of the bowl. The foil beneath the surface should slope down toward the edge of the bowl, making a channel. The edge of the foil should be just over the lip of the bowl, but kept at as low a degree of visibility as possible.
- Take two strips of paper or paper towels ---- saturate one with red food coloring and the other with blue food coloring. Then place the paper on top of the submerged layers of foil in the landfill. (Refer to drawing.) The pieces of paper represent landfills and the food coloring represents leachate.

6 Regularly observe the clear water in the shallow bowl to determine if and when it becomes "contaminated" by the food dye from either of the two "landfills."

7 Add "rain" in the form of drops of water, to the two dye-soaked pieces of paper in the model "landfill." Record any changes in the migration of the "leachate."

8 **Ask:** "Where does the solid waste from your house go?" "Where is your county's landfill?" "What soil types predominate in your county?" "On what soil type is your county landfill probably built?"

(Your county Soil Conservation Service can help students with the answers to these questions.)

“Where does the leachate from your county landfill go?” “Does your county landfill have a leachate collection system and ground water monitoring?” For example, the Cedar Hills Landfill in King County has over 50 ground water monitoring wells to test for on- site ground water contamination. It also has a special leachate collection system and two wastewater treatment ponds. (Your county public works director, or county commissioner can help you answer these questions.)

Ask: “Where does your school get its drinking water?” “Where does the drinking water you use at home come from?”

Extended Learning

1 Obtain city or county geologic maps and have student teams determine where future landfills might be sited.

2 Obtain maps from your county that list the sources of drinking water. Locate your source of drinking water.

Acknowledgment

This activity is based on the materials from Groundwater: A Vital Resource, Tennessee Valley Authority, Office of Natural Resources and Economic Development, Environmental/Energy Education Program, Knoxville, Tennessee 37902.

Resources - *See page 233.*

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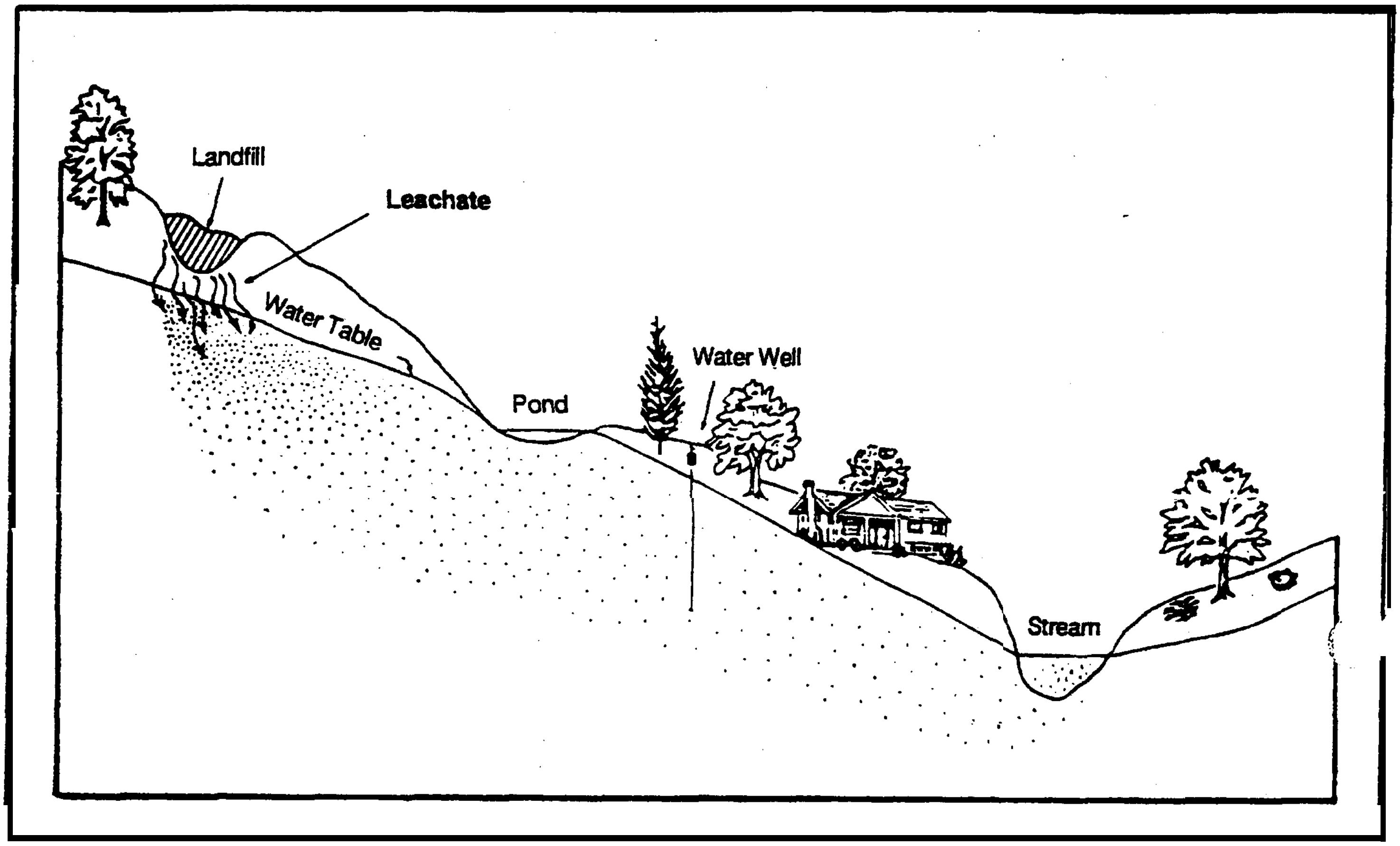
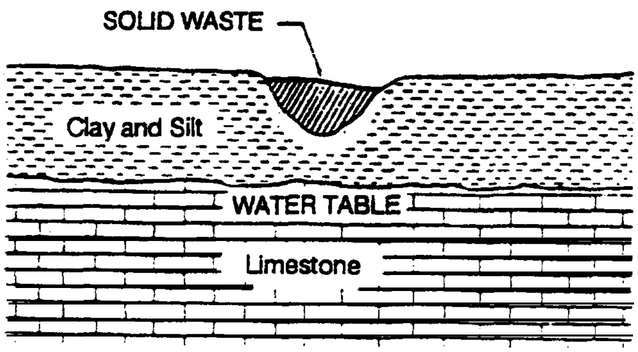
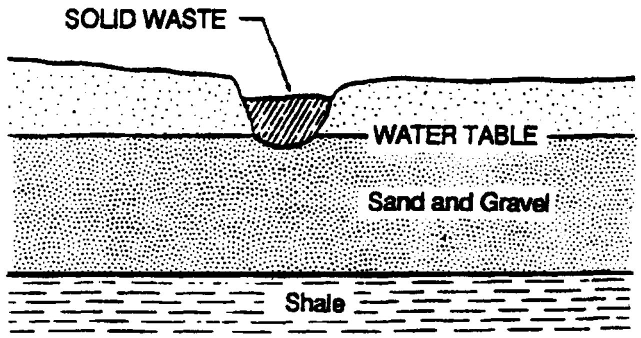
Soil Types and Ground Water Pollution

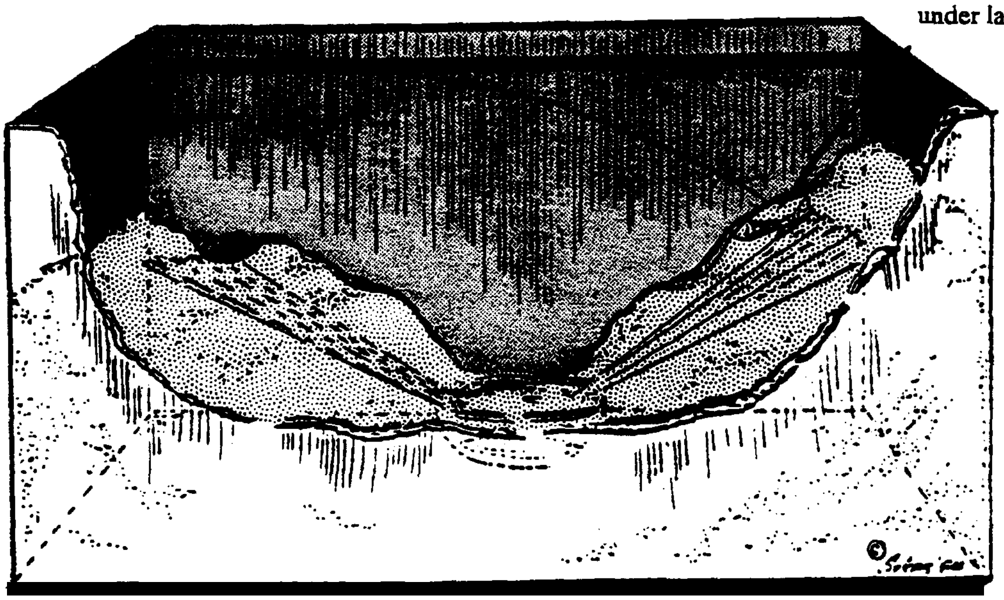




Relatively Safe



A Model: Rainfall, Landfills, and Ground Water Pollution



Materials

- Corregated cardboard box
- Strips of paper
- Aluminum foil
- Shallow bowl or saucer
- Red and blue food coloring
- Sand (available at many garden supply stores) or wood chips
- Clay (modeling clay or actual soil)

Oil and Water Don't Mix

Subjects: Science (Biology), Chemistry, Auto Shop

Grades: 4-12

Teaching Time: One Class Period

Focus: Waste and Water, Used Oil and Water Pollution, Aquifers, Ground Water, Plankton, Oil Recycling

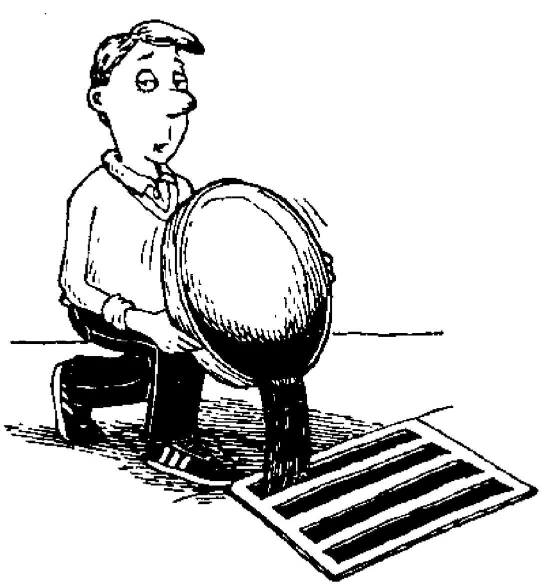
Rationale

Given its potential to harm public health and the environment, used oil should be recycled by re-refining it into lubricating oil or its energy recovered by reprocessing it into fuel oil.

Learning Objective

Students will:

- Learn how, where, and why we recycle used motor oil.



Teacher Background

Many of us are concerned with the damage done when a supertanker has an oil spill. Few of us however, realize the environmental impact of our own waste management practices. Unless otherwise footnoted, the following facts come from The Association of Government Oil Recycling Officials.

- Used automotive oil is the single largest source of oil pollution (over 40 percent) in our nation's waterways. Most is dumped by people who change their own oil.
- In 1960 service stations performed 90 percent of automotive oil changes. Today, do-it-yourselfers change about 60 percent of the automotive oil.
- Over five million gallons of used oil are dumped in Washington State each year. The used oil is usually dumped on the ground; in trash going to a landfill; or down a storm drain leading to streams, lakes, Puget Sound, or the ocean.
- During engine use, oil picks up toxic contaminants, carcinogens, and heavy metals (lead, zinc, arsenic, chromium, and cadmium). If used oil is not properly recycled, these toxics are carried into the environment.
- One pint of oil can produce a slick of approximately one acre on surface water.
- Fish, waterfowl, insects, and aquatic life are threatened by used oil in waterways. Floating plankton and algae (a basic food source) are killed by oil.
  - Very small amounts of oil rinsed over shellfish beds can ruin the taste of clams and oysters.
  - Less than 300 parts per million can spoil the taste of fish.[1]
  - Used oil thrown out in the garbage may seep through the landfill to contribute to leachate

(see Glossary) and contamination of ground water.

- One quart of oil will foul the taste of 250,000 gallons of water.[2]
- Used oil can be re-refined into good-as-new lubricating oil. Oil never wears out, it just gets dirty.
- It takes 42 gallons of crude oil to produce 2 1/2 quarts of lubricating oil. But just one gallon of used oil can be re-refined into the same high quality 2 1/2 quarts of lubricating oil.
- Used oil can be reprocessed into a fuel oil.
- One gallon of used oil reprocessed for fuel contains about 140,000 Btu's of energy and can be burned efficiently.
- To recycle used automotive oil, take it in a clean, sealed container, such as a milk jug, to the nearest participating recycling center or service station accepting uncontaminated used oil. For locations call the Department of Ecology's toll-free Recycling Hotline 1-800-RECYCLE.
- Used oil should never be mixed with antifreeze, gasoline, paint thinner, solvents, cooking oil, or other contaminants, since these interfere with reprocessing and may make the used oil hazardous to reprocess.

Materials

- A small quantity (a film canister) of either used or new motor oil, Lycopodium powder, or sifted flour
- Red tempera poster paint (water based)/ or coloring
- One glass bowl
- One eye dropper
- One funnel
- Very fine aquarium or paraket gravel or sand (natural color)
- One quart or gallon jar
- One measuring cup
- Water

Pre & Post Test Questions

1. When you change the motor oil in your car, truck, motorcycle, or boat, what should you do with it? What should you not do with it? Why?

2. How much crude oil does it take to make 2 1/2 quarts of lubricating oil?

3. How much used oil can be refined to make 2 1/2 quarts of lubricating oil?

4. How large an oil slick can one pint of oil produce?

What is ground water? What is the difference between surface water and ground water ?

Used automotive oil contributes (_) percent to the total oil pollution of our nations waterways.

Learning Procedure

Note: You may want to substitute sifted flour or lycopodium powder or chalk dust for oil in steps 1 and 2 of the learning procedure.

1 Ask Pre and Post test questions, discuss the information from Teacher Background. Conduct the following two demonstrations with or for the students.

2 Surface Water

Fill the glass bowl with water. Place several drops of used oil or lycopodium powder on the surface. Note how the oil spreads across the surface in a thin film. **Ask:** "What would happen to marine or freshwater surface organisms like plankton and insect larvae in this water?" (Oil interferes with the life cycle of organisms which use the surface layer as a nursery

1 Washington State Department of Ecology, The Used Oil Problem, (brochure) Olympia, WA.: Washington State Department of Ecology, # 90-BR10.

2 ibid.

ground. For a detailed description of the importance of this surface layer, see "Contamination of the Water Surface of Puget Sound" listed in the bibliography.)

Ask: "Can you get the oil out of the water?"

Ask: "Could the oil and water be separated now?"

Ask: "Would you drink this water?" "Could fish thrive in this water?" "What would happen if the oil coated their gills?" (They would suffocate.) "If they absorbed or ingested the toxic contaminants in the oil?" (They could develop skin or liver cancer.)

3 Ground Water

Tell students that 60 percent of Washington's population relies on ground water for drinking water. Ground water is not usually in underground streams and lakes. It's usually stored in pores between rocks and gravel. These water bearing layers are called aquifers.

Put a screen at the bottom of the funnel and pour in 1/2 cup of fine aquarium gravel or sand. Place the funnel over a jar. Measure out 1/2 cup of water and pour it into the gravel. Measure how much flows into the jar. **Ask:** "Where is the rest of the water?" (Held in the spaces between particles of gravel. This is how ground water is stored in aquifers.)

Say: "When someone dumps dirty oil on the ground it can seep into this ground water. You can taste as little as one part per million (ppm)."

(1 ppm = 1 gallon of used oil in one million gallons of water or = 1 minute in the life of someone 2 years old.)

Drop two or three drops of red water based paint or food coloring onto the water soaked gravel in the funnel. (Do not use oil based paints, they bond to the epoxy coating on some aquarium gravels.) Pour 1/2 cup of water through it (rainfall). Note how much oil or paint flushes through and how much remains in the gravel. Pour additional cupfuls of water over the gravel. Note how many volumes of water are needed to rinse the gravel clean. **Ask:** "Would you want to drink this water?"

Ask: "Once used oil or other pollutants got into ground water, how would you get them out again?"

4 **Ask:** "How can we keep used oil out of surface and ground water?"

(Used oil should be collected in a clean sealed container, like a milk jug, and taken to a participating recycling center or service station. Never mix with other liquids! For locations call the toll-free Department of Ecology Recycling Hotline, 1-800-RECYCLE.

Extended Learning

1 Take a field trip to the Seattle Aquarium's State of the Sound exhibit showing pollution threats to Puget Sound and how individuals can make a diference in protecting the Sound.

2 Call your local public works department or Department of Ecology at 1-800-RECYCLE to order storm drain stencils that warn "Dump No Waste, Drains to Stream." (or bay, lake, or ground water) Have students contact local public works departments to locate street storm drains in business and residential areas. Have students apply stencilled messages next to storm drains to help prevent used oil dumping and water pollution.

3 (Grades 4-8) Have a "Save the Sound" (Stream) or "Revive our River" campaign promoting reuse of oil by making posters to use with the stencil campaign. Make a city map showing where you can recycle oil products.

4 Call or write the Department of Fisheries and Wildlife for an in-class salmon or trout project. Students release fish to streams and help protect their habitat by stencilling storm drains leading to the streams.

Resources - *See page 233.*

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What You Can't See Still Counts

Subject: Science
Grade: 5-12
Teaching Time: One Class Period
Focus: Water Contamination, Solution, Suspension, Waste and Water

Rationale

Water which looks clear may not be pure. While many contaminants, including landfill leachate, are obvious, others can be deceptively clear.

Learning Objective

Students will:

- Learn the difference between solutions and suspensions.
- Learn the basics of how natural and manufactured filtering systems work.
- Learn that some hazardous materials cannot be filtered out by passing through soil.
- Discuss waste, soil, and water.

Materials

- Funnel
- Cheesecloth or coffee filter
- Aquarium gravel or sand
- pH paper and/or pH meter
- White vinegar (acid)
- Two large beakers

Pre & Post Test Question

What is the difference between chemicals in solution and chemicals in suspension?

Learning Procedure

1 Put the coffee or cheesecloth filter in place at the bottom of the funnel. Fill the funnel with aquarium gravel.

2 Blend very small pieces of clean paper into a large beaker with 200 ml of water and then add 20 ml of the acid. Demonstrate the presence of acid using the pH paper.

3 Pour the mixture of suspended solids and acidic solution onto the gravel in the funnel. Drain the mixture into a clean beaker. Observe how the gravel filters out the suspended solids. Tell students that the aquarium gravel represents the soil or gravel under a landfill.

4 Test the liquid for acid. **Ask:** "Why is the acid still present?" "Does the water look clear?" "Is it pure?" "Would you want a local soda pop bottling plant to use this water in their product?" If you use a pH meter, note whether there is any difference between the two readings. (This experiment can be performed by the students themselves.)

5 Discuss the differences between suspensions and solutions. Point out that suspensions contain larger particles in the water and that these particles can be trapped in the gravel, while chemicals in solution are so small that most are not filtered out by passing through gravel or soil.
Explain that this is the case for some liquid hazardous wastes if they are dumped on the ground or poured down storm sewers or into septic tanks and drain fields. For example, some household drain cleaners are more acidic than the solution in this demonstration. Explain that most landfills in Washington do not have liners to keep solutions of household hazardous waste and rainwater from migrating into the soil.

6 Use examples from the activity "What Waste Went Where?" (p. 255) to illustrate how hazardous waste in solution can migrate through soils without being filtered and contaminate drinking water.

7 **Ask:** "What can you do with household hazardous products to avoid contaminating ground water?" For answers, do the activity "What Goes Around Comes Around," p 331.

Extended Learning

1 Call your county or city waste utility and arrange a trip to a landfill or a wastewater treatment plant.

2 Do the activity "Making Acid Rain," p. 29.

Resources - *See page 233.*

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A Little Can Go A Long Way

Subjects: Earth Science, Math
Grades: 6 - 10
Teaching Time: One Class Period
Focus: Aquifer, Water Quality, Hazardous Waste and Ground Water Pollution, Contaminated Drinking Water

Rationale

More than half of Washington counties depend on ground water for more than three-quarters of their domestic water.

Even small quantities of certain pollutants can contaminate large volumes of drinking water.

Learning Objective

Students will:

- Understand the potential damage hazardous wastes can do to ground water.
- Understand that once contaminated, aquifers are difficult, if not impossible, to purify.

Teacher Background

To understand some of the ways ground water can be contaminated, read the information sheets in the activity "What Goes Around Comes Around" p. 331, and the brochure Protecting Our Ground Water.

Review the activity "What Waste Went Where?" p. 255 to learn more about actual examples of ground water and aquifer contamination in Washington State.

Materials

- EPA brochure Protecting Our Ground Water (See Bibliography)
- A kitchen funnel with at least one cup capacity (A clear funnel makes the demonstration easier to see.)
- An empty, clear gallon jug
- Paper coffee filter or cheesecloth
- Parakeet gravel
- Red food coloring
- Eyedropper
- Overhead: "Water in Soil" p. 206

Pre & Post Test Questions

1. What is ground water?

2. What is an aquifer?

3. What percentage of an aquifer area is occupied by water?

4. What are some other substances found in aquifers?

Learning Procedure

1 Using the information provided in the teacher background, discuss the problems of ground water contamination to introduce the laboratory activity.

2 In a lab setting, each working group can do this experiment. As a demonstration, the teacher can have individual students from the class assist in each step of the demonstration.

3 Place the paper filter or cheesecloth in the bottom of the funnel. Fill the funnel with parakeet gravel. Tell students that the gravel represents the soil and gravel of the ground. **Ask:** "What will happen if we pour water into the funnel with the gravel?"

4 Place the funnel in the gallon jug. Pour a measured amount of water into the funnel until the gravel is saturated. This occurs when the water begins to drip into the jug. Show the overhead "Water in Soil." Explain that the water is filling the air spaces between the gravel. Explain that this is how ground water is stored, that this saturated gravel is like an aquifer, where much of our drinking water comes from. In the ground, the aquifer area will have a porosity (water holding capacity) of 5 to 50 percent.[1]

1 R. Allen Freeze and John A. Cherry, Groundwater, Englewood Cliffs, N.J.: Prentice-Hall, 1979, p. 37.

5 Add one or two drops of red food coloring or dye onto the saturated gravel. Explain that the dye represents hazardous wastes or toxicants that, if improperly disposed of, can contaminate ground water. Use examples from "What Waste Went Where?" p. 255 to illustrate ground water contamination in Washington.

6 Compare the volume of water in the funnel to the volume of contaminant. (5,000 drops are approximately equal to 1 cup or 240 ml.) Note how the "contaminant" begins to disperse throughout the "aquifer."

7 Drain the water from the funnel and note its color. Attempt to clean the "aquifer" by refilling and redraining. Record the volume of water needed to flush the dye completely out of the system. Compare this volume to the amount of dye that contaminated the system. (Four cups equal approximately 20,000 drops.)

8 **Ask:** "What conclusions can we draw from this demonstration?" (That contaminants are difficult or impossible to remove from aquifers; that it may take a long time to flush a contaminent from an aquifer.) Have students discuss what factors might affect the way hazardous chemicals get into drinking water. Some items to think about are:

- How fast a contaminant could move through the ground water. (This can range from much less than an inch to several feet a day.)
- Whether the movement of a substance would be the same every day. (Movement or "migration" of a chemical can vary with the time of year, the amount of rainfall, how much water is being drawn from the ground, how quickly the aquifer is recharged, etc.)
- Which soils or rock water moves through the fastest. (Sandy soils; granite with lots of cracks, etc.) Which retard flow. (Clay, certain very solid rock formations.)

9. **Ask:** "What are some of the ways a toxic substance might get into ground water?" (Runoff from agricultural uses of fertilizer and pesticides; leachate from landfills; improper storage of toxic substances; pouring hazardous substances, such as motor oil, or certain paints down the drain; etc.) **Ask:** "How can we protect our ground water from contamination?" (Develop alternative ways to protect crops from pests, recycle, keep hazardous substances out of landfills, regulate the storage and treatment of toxic chemicals, reduce waste at its source.)

Extended Learning

1 Call your local water district to determine the source of your water supply. Determine how much of your drinking water is supplied by aquifers and ground water.

2 Have upper-grade level students do the activity "How Very Little It Must Be," p. 285. Have them calculate the parts per million of contaminant dye in the volume of water required to cleanse the "aquifer."

Resources *See page ______*

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Treatment Plants

Subjects: Science
Grades: K-12
Teaching Time: 2 class periods
Focus: Wetlands, Water Quality

Rationale

Students will understand that wetlands are valuable because they filter pollutants in a watershed.

Learning Objective

Students will:

- Create a demonstration that illustrates the way plants purify water in wetlands.

Teacher Background

Water Quality. Wetlands help purify the water that flows through them. Sediments suspended in the water are "trapped" while passing through the wetland and settle to the bottom as the flow rate of the water decreases. Generally, the more plants in a wetland, the slower the water flows. Sediments settle to the bottom more readily in slow-flowing water. The settling of sediments is important because excessive sediment in the water can be harmful to many species of animals: smothering bottom-dwellers such as oysters, mussels or aquatic insects; impairing fish spawning by covering sensitive eggs; reducing visibility for sight-feeders; and lowering the level of dissolved oxygen available for aquatic organisms.

Wetland plants also remove pollutants such as excess nutrients, heavy metals, and petroleum-based hydrocarbons from the water. In some areas, artificial wetlands have been created for use in treating wastewater.

Materials

- Celery stick
- Jar
- Food coloring

Pre & Post Test Questions

1. Why is the water remaining in the beaker still polluted? *(Plants can only do so much. As new water (hopefully clean) flows into the system, the pollutants will be diluted and the water less polluted.)*

2. Where does the water go after uptake into the plant? *(Transpired out through the pores (stomata) and usually evaporated.)*

3. What happens to the pollutants? *(Stored in the plant tissue and then re-released into the environment when the plant dies.)*

4. Why can't we dump all of our wastewater into wetlands? *(Wetlands can only do so much. Too many pollutants will harm or destroy a wetland. The best solution is to reduce pollution.)*

Learning Procedure

1 This activity is best if spread out over two days. The first day, assemble everything. The second day, observe the results and answer questions.

2 Each group of students prepares a solution in a jar by adding several drops of food coloring to water. Explain that food coloring represents pollution by a toxic substance (for example, a pesticide).

3 Ask students to imagine water flowing into a wetland with many wetland plants. Tell them that the celery stalks are like the plants of a wetland (cattails, sedges, grasses, etc.).

4 Cut off the bottom half inch of the celery stalks and place the stalks in the water overnight. Over time, the colored water will visibly travel up the stalks, showing how plants can absorb pollutants when they "drink." If the colored water is not visible on the outside of the stalk, break it open to see the colored water inside the plant tissue.

5 Grade level variations:

K-2: You will need to cut celery for younger students. Cut right before being placed into the water, or else the plant will lose its ability to draw water well.

9-12: Older students can research how water is transported up the plant. The plant expends no energy, but simply allows the energy of the sun and the properties of water to move water up its tissues. Imagine, 200-foot tall trees transport water to their upper leaves expending no more energy than a 2-inch blade of grass.

Resources - *See page 233.*

Watershed Model

Subjects: Earth Science, Environmental Education

Grades: 3-8; with variations for K-2 and 9-12

Teaching Time: 30 minutes

Focus: Watershed, Non-point pollution

Rationale

Students will understand the concept of a watershed.

Learning Objective

Students will:

- Observe the a watershed model

Teacher Background

Wetlands are a part of the total picture of water's journey over the surface of the land and throughout the ground, and eventually to the ocean. It is critical that students understand the connection between a wetland and the rest of the watershed. The watershed is the entire land area drained by a stream or river.

Materials

- Large, light colored plastic trash bag
- 2' x 3' board
- Spray bottle
- Towel
- Newspaper
- Colored drink mix crystals

Learning Procedure

1 Create a simple water model by draping a large, plastic trash bag over some crumpled newspaper "mountains" on a slightly slanting board. (The mountains should be at the top of the board and down along the sides, forming a "valley" in the center. Allow the plastic to extend off the lower end of the board where it is flat. Place a rolled-up towel in a U-shape at this end of the model.) Use a spray bottle to make it "rain" in the mountains. Have students observe how precipitation collects in low spots in the mountains, forming lakes when "deep" and swamps or bogs when shallow. Also observe how water eventually flows down into the valley, again collecting in certain areas to form "marshes." You may need to adjust the plastic to help make a river channel that eventually flows to the "sea."

2 Explain that a watershed is all the land that drains to the same place (in this case, the "bay" at the end of the board). Discuss where different types of wetlands would likely be found in a watershed. Where would a saltmarsh/estuary be located? (In this model it would be the "bay" that forms in front of the towel.) Discuss how this model is the same and different from a real watershed. (This model obviously doesn't show ground water activity.)

3 Discuss where people would likely live in a watershed and why. What activities would people do to make a living or for recreation? How would these activities impact wetlands? (Would farmers desiring the flat land along the river want to drain the marshes or dike the rivers? Would industries want to dredge the estuary to create deeper ports for commerce?)

4 Sprinkle some colored drink mix crystals in the mountains or other upper sections of the watershed. Spray water onto the landscape again and watch the crystals dissolve and eventually color the streams and even the bay. Discuss how pollution on the land (pesticides, oil from cars, soaps) washes into streams (sometimes through storm drains) and is carried throughout the watershed. Identify sources of non-point pollution in your watershed. (Examples may include animal waste on farm fields, lawn fertilizers and pesticides, oil and gas leaking from cars, and leaking septic systems.)

5 **Grade level variations:**
K-2: Younger students will need simplified descriptions and less information. They will enjoy making the rain.

9-12: Use topographic maps as a guide to building scale models of the watershed. Students can do reports on non-point pollution in their watershed.

6 Evaluation: Students write a paragraph describing water's journey from the upper regions of the watershed to the receiving water body.

Extended Learning

1 Use a white plastic bag to form the land surface of the watershed. Before spraying "rain," draw in where your school would be located, along with other land uses in the watershed such as a town, residential development, farm lands, parking lots, malls, etc. When placing colored drink mix crystals, specify what type of non-point source pollutant they represent.

2 Scale models of the watershed can be built using topographic maps as a guide. They can be assembled using cardboard layers, clay or other materials. A video tape of this process called "No Water, No Life" may be borrowed from your E.S.D. library.

Resource *See page 233*

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Discover Wetlands. Washington State Dept. of Ecology, PO Box 47600, Olympia, WA. 98504-7600.

Global Rivers Environmental Education Network (GREEN) In Washington State. contact GREEN Northwesst, 119 North Commercial Street, Suite 1110, Bellingham, WA 98225.

Project WILD Aquatic. Project WILD, 5430 Grosvenor Lane, Bethesda, MD 20814. (Or in Washington State, Dept. of Fish & Wildlife, Watershed & Wildlife Education, 600 Capital Way North, Olympia, WA 98501-1091.)

Project WET. (Water Education for Teachers). The Watercourse, 201 Culbertson Hall, Montana State University, Bozeman, MT. 59717-0057. (Or in Washington State, Dept. of Ecology, Education & Information Office, PO Box 47600, Olympia, WA 98504-7600)

Washington State Office of Environmental Education, 17011 Meridan Avenue North, Seattle, WA 98133, Phone: (206) 542-7671.

Water You Doing? (Teachers Manual, Field trip directory, CD-Rom & Resource Guide), Seattle Drainage and Wastewater Utility, 660 Dexter Horton Building, Seattle, WA 98104.