A-Way With Waste

Fourth Edition

Washington State Department of Ecology

Air Quality Program

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This curriculum is dedicated to all those who would educate or be educated about waste management at home, at school, and in the community.

Acknowledgments

Senior Editor: Jan Lingenfelter

Editors: Susan Campbell - Fourth Edition
Tim Gaffney - Third Edition
Todd Peterson - Second & Third Editions

Writers: Fourth Edition: Susan Anderson, Susan Campbell
Third Edition: Paige Sorensen, Tim Gaffney, Jane Keefer, Todd Peterson
First & Second Editions: Jeannie Summerhays-Ayco, Lynne Guza Ferguson, Todd Peterson

Illustrations: Tim Schlender, Kate Allen, Sue Smith

Word Processing: Sonya Kirkendall

Co-Coordinators: Fourth Edition: Ann Butler, Sandi Newton
Third Edition: Kip Eagles

Educational Advisor: Tony Angell, Environmental Education Supervisor, Office of Superintendent of Public Instruction

Educational Reviewers

Fourth Edition Educators

CJ Keables, Scott Killough

Third Edition Educators

Elementary: Anne Babcock, Ann Botkin, Laurie Dyker, Steve Gerwels
Middle School: Maura Broderick, Dutch Day, Bill Gruner, Gaylord Jones
Senior High School: Jim Bailey, Larry Parton, Mary Porter, Deb Schuldt

Second Edition

Elementary: Irene Bach, Marjorie Ebel, Cathy Profilet, Daryl Starkovish
Middle School: April Benham, Laurie Dyker, Paula Tweten
Senior High School: Mike Harves

First Edition

Elementary: Lynn Gaza Ferguson, Jeb Baldi, Leslie Getchell, Trina Hendrickson, Laurie Lindgren Dyker, Darlene Weller
Middle School: Larry Broder, Todd Peterson, David Spies, Gordon Watanabe, Henry Yonce
Senior High School: Dick Dixon, Claire Dyckman, Deb Schuldt, Diana Townsend, Barbara Schultz, Scott Stowell

Classroom Field Testers - First through Third Editions

Elementary

Sherry Anderson, Susan Bell, Rich Benton, Ann Botkin, Joan Brings, Mike Gebhardt, Ben Loftin, Alexis Mason, Ken Maus, Kathy McNally, Joy Meuler, Sue Ness, Diane Nuetzman, Diana Rennie, Nanci Lee Kilmer-Sloan, Janice Thorson, Margie Walker, Sandra Young

Middle School

Maura Broderick, Vicki Carter, John Donnelly, Sharon Hanson, Gaylord Jones, Joe Nevius, Richard Sauers

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Beryl Berringer, Jim Clem, Fred Dahlem, Carol Davis, Aaron Feik, Emily Gorlich, Lee Guilford, Donald Hodgson, Sarah Newman, Greg Person, Mary Porter, Larry Reid, Jennifer Roberts, Hartmut Schmakeit, Deb Schuldt, David Swartz, Lu Ann Thompson, Ken Vandenheuval, Gerald Yenne

Curriculum Review

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Joan Bartz, Vicki Colgan, Rhonda Hunter, Dan Kruger, Gary Lambacher, Joan Letourneau, Jan Lingenfelter, Robin Munroe, Annie Phillips, Dee Ragsdale, Jean Rushing

Non-Ecology Staff

Susan Alotrico, Harriet Ammann, Tony Angell, Barbara Baar, Laura Curley, Jenna Glock, Anne Mills, Shirley Pauls, Judy Porter, Misha Vakoc

Introduction

Solid and hazardous waste problems exist in every community in the world. Society as a whole and each of us as individuals contribute to the problem. By individual and collective choices and actions we will provide solutions to these problems.

This curriculum is written and organized to present integrated waste management concepts affecting land, air and water in the ecosystem. Environmental, economic, and political issues are addressed. The activities are designed to promote **awareness, attitude,** and **actions** to solve waste management problems at home, in school and in the community.

This is the fourth edition of A-Way With Waste. Research and development for the first edition began in January 1982. The first edition was published in July 1984 and a second expanded edition was published in July 1985. The school program for grades K-12 in Washington started in September 1984. Since that time over 3,600 Washington educators have attended A-Way With Waste workshops. In addition, over 4,500 copies of the curriculum have been distributed nationally and internationally.

The A-Way With Waste curriculum was written and developed by the Department of Ecology with written contributions and expertise provided by teachers, principals, environmental educators, citizen organizations, businesses, industries, and local and state government representatives.

Each classroom activity was written, reviewed, revised, then field tested in Washington classrooms by teachers. Activities were finalized based on field test and review commentary before being included in the curriculum.

The activities, written for grades K-12, are interdisciplinary and action oriented. They provide opportunities for students to participate in cooperative problem-solving and decision-making tasks involving waste management, litter control, and science, technology, and society.

Information and fact sheets introduce each section. State and national waste management legislation, regulation, research and survey information is included. The curriculum also contains a glossary of terms.

The fourth edition of A-Way With Waste includes 50 updated activities from the third edition with over 20 new lessons on air quality and two new water quality lessons. Fact sheets and activities have been updated. (Note: The third edition references and bibliography have not been updated. New resources, however, have been added when applicable.)

Finally, the Washington State Department of Ecology wishes to gratefully acknowledge the many contributors, supporters, and people who make use of A-Way With Waste.

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Air Pollution Introduction

The Air Around Us

Earth's atmosphere is composed of a mixture of gases, mostly nitrogen (78 percent) and oxygen (21 percent). Argon, carbon monoxide, methane, ozone, sulfur dioxide, carbon dioxide, and carbon monoxide make up the rest of the air. In addition to "pure air," our atmosphere also carries water vapor, solid particles, and human-caused pollution.

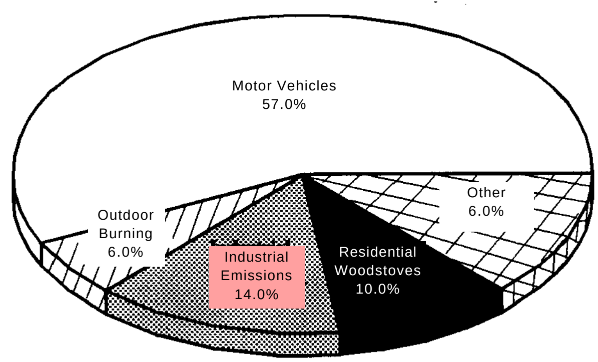
The atmosphere surrounding the earth is very thin and fragile. Think about how thin the skin of an apple is in proportion to the rest of the apple. This is about how thin our atmosphere is compared to the earth. Our atmosphere is made up of different layers. The layers begin at the earth's surface and extend into space. Close to the earth is the troposphere. This layer is warm, contains a lot of oxygen, and extends only ten miles from the earth's surface. The outer layers (stratosphere, mesosphere, and thermosphere) are cooler and have less oxygen. That is why airplanes need to carry oxygen in case of an emergency.

One of air's most important jobs is to provide living plants and animals with the gases they need. Humans and other animals breathe in the oxygen they need; then they use that oxygen to break down their food. Oxygen is used to break down a sugar called "glucose" into carbon dioxide, water, and energy (a process called "**respiration**"). The carbon dioxide and water are released into the air when we breathe out. Plants respire too, but they also use the carbon dioxide, sunlight and water to make their own food in the form of glucose (a process called "**photosynthesis**"). The plants release most of the oxygen produced in this process into the atmosphere through their leaves.

Importance of (Clean) Air

If you could spread your lungs completely flat, they would be as big as a tennis court. Each day, you breathe about 35 pounds of air. Your lungs take in the oxygen, and then your heart pumps it throughout your body. When we exercise, our

Statewide Pollution Sources and Their Contribution



bodies need more oxygen, so we breathe harder and our hearts pump faster. If the air is dirty, our lungs cannot absorb as much oxygen as they need. Smoking cigarettes brings in dirty air that has this same effect on our lungs. Air pollution also affects us more when we exercise.

Air pollution has a greater effect on children, the elderly, and people with lung problems such as asthma, allergies, and emphysema. Children with asthma may need to stay inside in the winter when their neighbors are using wood stoves that release smoke into the air. There are more deaths and emergency room visits for lung problems when the air is heavily polluted.

Upsetting the Balance

Many of the things we do pollute the air. Industry, transportation, and everyday activities, such as mowing the lawn, all cause air pollution. In Washington State, about 57 percent of our air pollution comes from motor vehicles, 14 percent from industry, 10 percent from burning wood stoves and fireplaces, 6 percent from outdoor burning (slash fires, agricultural burning, yard waste burning, etc.), and 13 percent from other (including non-road vehicles, lawn/ garden equipment, and recreational vehicles/boats).

The federal government regulates six pollutants through the Clean Air Act. They are:

- Carbon monoxide
- Sulfur dioxide
- Particulate matter
- Nitrogen oxides
- Ozone
- Lead

See the Focus sheets in the appendix for more detailed information on each of these pollutants (except lead) and their health effects. Lead is not included because it is not much of a problem in this state. In addition, it is becoming less of a problem nationwide because leaded gasoline has not been available since January 1, 1996. Other air pollutants, such as toxics, do not have federal health-based standards. They are regulated at the source through pollution prevention efforts and improved technology.

Plants and Air Pollution

Because plants absorb carbon dioxide and release oxygen, they can improve air quality---both outside and inside houses. They may also absorb some pollutants. Many people keep house plants for this reason. In addition, greenbelts containing shrubs, trees and other vegetation are often planted along roads to reduce air pollution.

Plants are affected by air pollution. Some forests in Europe and the United States have been damaged by acid rain. Smog has impacted citrus and grape crops and lowered their annual yields in the Los Angeles region. In the San Bernadino National Forest, it appears to have stunted the trees and caused them to lose their leaves.

One common plant---the lichen---is very sensitive to air pollution and can be an indicator of how much pollution is in the air (see activity, "How are Plants 'Lichen' the Air?" on p. 17.

Weather, Topography

The weather and topography (the contours of the land) can affect air pollution because they affect the way air moves. The sun warms the earth's surface unevenly, which gives us different climates around the world. Local temperature differences, such as those between land and water, cause breezes to blow. These winds are important because they help disperse air pollution. They spread out solid particles or poisonous gases over a large area so that dangerous concentrations are less likely to occur. But these winds can also carry air pollution to areas far from the source of the pollution.

<u>Wintertime Inversion:</u>

In the winter often there is no wind and no mixing of different layers of air. A layer of warm air can settle over an area and prevent the cooler air below it from rising. This is called a "thermal inversion." The lower layer with its pollution (often wood stove pollution in our part of the world) is kept close to the earth. It becomes increasingly dirty as more and more pollutants are released into it. A thermal inversion can combine with topography to make the pollution problem worse. For example, inversions often occur in valleys because air can get trapped in them.

<u>Summertime Smog:</u>

You may have noticed that smog is usually worse in the summertime. This is because in the summer, sunlight reacts with air pollutants, hydrocarbons and oxides of nitrogen, to form low level ozone or "smog." This can collect in cities if there is not much wind, or it can be transported to other areas. Of particular concern is the effect of this pollution on national forests, parks, and rural valleys downwind from urban areas. Ozone can affect human health by reducing resistance to colds and causing chest pain. It can reduce plant growth and reduce plants' immunity to diseases and pests.

Ozone Depletion and Global Warming

High altitude ozone protects us from the sun's ultraviolet rays. (Lower altitude ozone is a pollutant; see above). But there is mounting evidence that an ozone hole may be developing over the northern hemisphere, in addition to an already existing hole over the southern hemisphere. The chief agent responsible for this depletion is a family of gases called "chlorofluorocarbons," or CFCs. They are used as coolants for refrigeration and air conditioning, solvents, blowing agents for foam insulation and various other uses. Ozone depletion results in increased exposure to ultraviolet rays. Over time, such exposure can cause skin cancer, immune system damage, and eye ailments, including cataracts. In addition, ozone depletion can detrimentally affect crops and forests. (See Ecology publications: AirLines, Summer 1992, What's All the Fuss About the Ozone Layer?; Brochure, Ozone Layer Depletion: An Action Guide, #93-BR-06).

CFCs are also powerful "greenhouse gases," as is carbon dioxide. Greenhouse gases contribute to warming of our atmosphere. Rain forests and grasslands take in large amounts of carbon dioxide during photosynthesis. If these areas of vegetation are destroyed through development and logging, the amount of carbon dioxide in the air increases. If forests (and other fuels, such as fossil fuels in cars) are burned, more carbon dioxide goes into the atmosphere. This build-up of carbon dioxide (and other gases) can cause the warming of our atmosphere which is known as the "Greenhouse Effect," or global warming. The gases prevent the sun's heat from escaping the earth's atmosphere.

There are many uncertainties in the scientific predictions related to global warming, or the greenhouse effect. But the Intergovernmental Panel on Climate Change, a group of several hundred scientists from 25 countries, generally agree that:

- Greenhouse gases are accumulating in the atmosphere and this accumulation may cause the average global temperature to gradually increase about 2 to 9 degrees F over the next century. (Note: The average daily temperature during the Ice Age was only 11 degrees F colder than today's average.)
- This warming could significantly alter wind, precipitation, and other climatic patterns. The warming of oceans and melting of glaciers could cause a sea level rise of 0.5 to 3.5 feet by the year 2100.
- Global warming may also affect agriculture, forestry and natural ecosystems.

Industry

Industry used to be the main source of air pollution in the United States. In the last 25 years, its contribution has decreased, so that in Washington State it now contributes about 25 percent of our air pollution. Industries installed millions of dollars worth of air pollution controls in order to decrease their emissions. Small businesses, such as dry cleaners, auto shops, and print shops, have also worked to decrease their contribution to air pollution, especially in the area of toxics.

Toxics and odors are still a concern for industrial and small business emissions. Neither of these pollutants have federal health-based standards.

Regulation of Air Pollution

Air pollution is regulated on three levels—federal, state, and local. The Environmental Protection Agency (EPA) regulates pollutants at the federal level, through the Clean Air Act. The Washington State Department of Ecology regulates air pollution at the state level, through legislation such as that passed in 1991, the Washington Clean Air Act. There are also local air pollution control agencies that regulate air pollution at the local level. (See next page for listing of local and state contacts.)

The federal government has set health-based standards for some air pollutants (the six "criteria pollutants," see p. 1). Areas of the state that do not meet these standards are called "nonattainment areas." There are 13 nonattainment areas in Washington State at this time.

Air pollution from the six criteria pollutants has decreased dramatically in Washington State in the last 25 years. All but 2 of our 13 nonattainment areas are monitoring attainment now. (They are waiting to be reclassified as attainment by EPA.)

This improvement is due to better industrial controls, less polluting cars, motor vehicle inspection program, and a recognition that individual lifestyle choices (wood stoves, outdoor burning) do make a difference.

Our future challenges will be to maintain our current air quality despite increases in the use of cars and increased population growth. There are also air pollutants that are not now regulated or monitored that we need to work on, including some toxics and very small particles that can affect visibility.

For more information on nonattainment areas and trends in air quality in Washington State, see the following Ecology publications: (in Appendix)

1. Ecology Focus sheet, Redesignating Nonattainment Areas, #FA-94-1

2. Washington State Air Quality: A Status Report, #95-220

Sources of Information about Air Pollution in Washington State

1.	**Olympic Air Pollution Control Authority** *(Clallam, Grays Harbor, Jefferson, Mason, Pacific, Thurston Counties)* 909 Sleater-Kinney Road SE, Suite 1 Lacey WA 98503-1128 Charles E. Peace, Executive Director *Telephone:* (360) 438-8768 or 1-800-422-5623 *Fax:* (360) 491-6308; *E-mail:* oapca@wln.com Internet: http://www.wln.com/~oapca	**2.**	**Department of Ecology Northwest Regional Office** *(San Juan County)* 3190-160th Avenue SE, Bellevue, WA 98008-5452 *Telephone:* (425) 649-7000 *Fax:* (425) 649-7098, *TDD:* (425) 649-4259
3.	**Northwest Air Pollution Authority** *(Island, Skagit, Whatcom Counties)* 1600 South Second Street Mount Vernon, WA 98273-5202 Terry Nyman, Air Pollution Control Officer *Telephone:* (360) 428-1617 *Telephone:* 1-800-622-4627 (*Island & Whatcom*) *Fax:* (360) 428-1620; *E-mail:* nwapa@pacificrim.net Internet: http://www.pacificrim.net/~nwapa	**4.**	**Puget Sound Air Pollution Control Agency** *(King, Kitsap, Pierce, Snohomish Counties)* 110 Union Street, Suite 500 Seattle, WA 98101-2038 Dennis J. McLerran, Air Pollution Control Officer *Telephone:* (206) 343-8800 or 1-800-552-3565 1-800-595-4341 *(Burn Ban Recording)* *Fax:* (206) 343-7522; *E-mail:* psapca@wolfenet.com Internet: http://www.psapca.org
5.	**Southwest Air Pollution Control Authority** *(Clark, Cowlitz, Lewis, Skamania, Wahkiakum Counties)* 1308 NE 134th Street Vancouver, WA 98685-2747 Robert D. Elliott, Executive Director *Telephone:* (360) 574-3058 or 1-800-633-0709 *Fax:* (360) 576-0925; *E-mail:* swapca@worldaccessnet.com Internet: http://www.swapca.org	**6.**	**Department of Ecology Central Regional Office** *(Chelan, Douglas, Kittitas, Klickitat, Okanogan Counties)* 15 West Yakima Avenue, Suite #200 Yakima, WA 98902-3401 *Telephone:* (509) 575-2490 *Fax:* (509) 575-2809, *TDD:* (509) 454-7673
7.	**Yakima Regional Clean Air Authority** 6 South 2nd Street, Room 1016 Yakima, WA 98901 Les Ornelas, Director *Telephone:* (509) 574-1410 or 1-800-540-6950 *Fax:* (509) 574-1411; *E-mail:* les@yrcaa.org (please also cc: tom@yrcaa.org and gar@yrcaa.org on e-mail inquiries)	**8.**	**Department of Ecology Eastern Regional Office** *(Adams, Asotin, Columbia, Ferry, Franklin, Garfield, Grant, Lincoln, Pend Oreille, Stevens, Walla Walla, Whitman Counties)* 4601 N. Monroe Street, Suite 202 Spokane, WA 99205-1295 *Telephone:* (509) 456-2926 *Fax:* (509) 456-6175, *TDD:* (509) 458-2055
9.	**Spokane County Air Pollution Control Authority** W 1101 College Ave, Suite 403 Spokane, WA 99201 Eric Skelton, Director *Telephone:* (509) 456-4727 *Fax:* (509) 459-6828; *E-mail:* scapca@iea.com	**10.**	**Benton County Clean Air Authority** 650 George Washington Way, Richland, WA 99352 Dave Lauer, Director Telephone: (509) 943-3396 Fax: (509) 943-0505 or 943-2232; *E-mail:* bccaa@3-cities.com Telephone: (509) 946-4489 *(Burn Ban Recording)* Internet: http://www.cbvcp.com/bccaa

Other Sources of Information about Air Pollution in Washington State

Washington State Department of Ecology
Air Quality Program
PO Box 47600, Olympia, WA 98504-7600
Telephone: (360) 407-6800
Fax: (360) 407-6802, *TDD:* (360) 407-6006
Internet: http://www.wa.gov/ecology/air/airhome.html

Pulp Mills, Aluminum Smelters
Department of Ecology - Industrial Section
PO Box 47600, Olympia, WA 98504-7600
Telephone: (360) 407-6916
Fax: (360) 407-6902

Department of Ecology Southwest Regional Office
PO Box 47775
Olympia, WA 98504-7775
Telephone: (360) 407-6300
Fax: (360) 407-6305, *TDD:* (360) 407-6006

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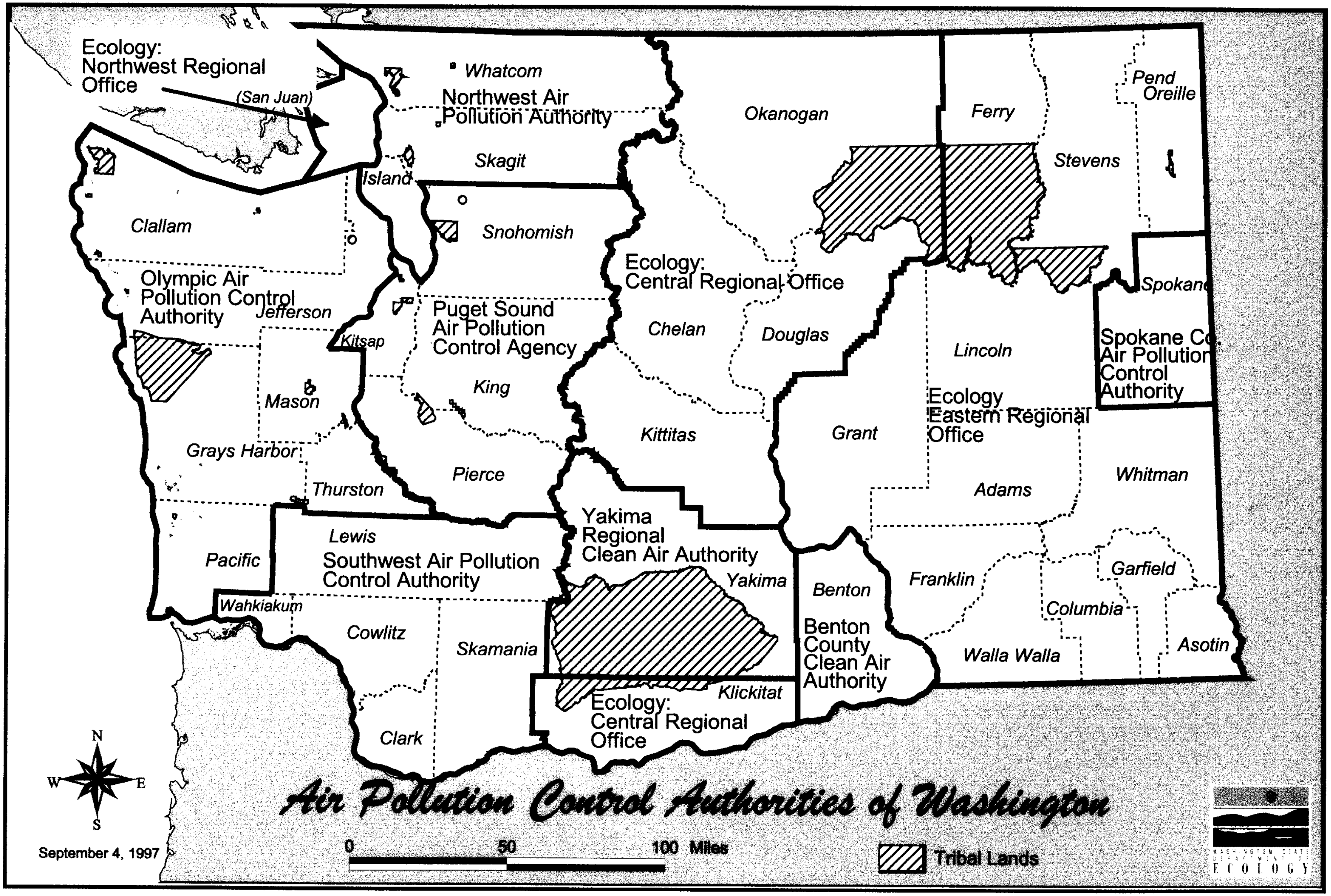

Air Pollution Control Authorities of Washington

Leaf Me Alone

Subjects: Science, Biology, Botany

Grades: 5-12

Teaching Time: (Once seeds are germinated) 1 class period for set-up; 20 minutes daily for 2 weeks for data collection

Focus: Air Pollution, Plants

Rationale

Air pollution can affect plants as well as animals.

Learning Objectives

Students will:

- Set up and carry out a control experiment to investigate the effects of air pollution on plants.
- Analyze the data they generate and draw conclusions from it.

Teacher Background

(Explain set-up of activity.)

Materials

(For one set-up of whole experiment.)

- 5 plastic cups
- 5 bean seeds
- Potting soil
- 5 clean 2-liter soda bottles with caps; bottom removed (these are the plant chambers)
- 5 plastic lids to place under plants
- 5 plastic strips (pieces of transparency) 2cm x 10cm
- Vaseline
- Thread
- 3 balloons
- 3 Twist ties
- 5 Ozone test strips (available from Vistanomics, Inc., 230 N. Maryland Ave. S., Suite 310, Glendale, CA 91206)

For concentrated CO_2 chamber:

- 1 empty 750 ml wine bottle
- Baking soda (15 ml)
- Vinegar (100 ml)

For wood smoke chamber:

- Matches
- Fireproof container (e.g., pyrex)
- 1 Straw
- Aluminum foil to cover container
- 50 ml syringe

For exhaust chamber:

- 1 Car/bus
- Gloves
- Top of 2 liter bottle (to act as funnel)

Pre & Post Test Questions

1. What effects did air pollutants have on plants in your experiment?

Learning Procedure

Options:

- Have groups of 4-6 students perform the whole experiment (5 chambers).
- Divide the class into 5 groups and make each group responsible for one chamber.

1 **One week before set-up,** germinate bean seeds in potting soil in plastic cups. For drainage, poke holes in the bottom and place on plastic lids.

2 Set-up plant chambers:

- Attach thread to plastic strip. Coat the strip with a thin layer of vaseline, and suspend it inside the plant chambers.
- Tape an ozone strip inside each chamber.
- Put chamber over plant.
- Label chambers: control, concentrated CO_2, vehicle exhaust, wood smoke, and outside air.
- Observe all plants (height, temperature, particulates, ozone test, and general plant condition) before air samples are added, and record observations on data sheet p. 10.

3 Collect air samples for experimental chambers.

- **Concentrated CO_2** -- Pour 15 ml of baking soda into wine bottle. Add 100 ml vinegar. Quickly cover top with balloon. When partly full (see above), tie balloon with twist tie. Remove the plant chamber cap, and put the balloon opening over the mouth of it. Squeeze the balloon into the chamber. Remove the balloon and put the cap on for ten minutes. Then remove the cap and leave it off.
- **Vehicle exhaust** -- CAUTION: Wear gloves and avoid touching tailpipe. Place balloon over narrow end of pop bottle funnel. Start car/bus. Holding onto edge of balloon, hold funnel over tailpipe. When inflated (see above), pinch off the neck of balloon and tie with twist tie. Add sample to chamber as described for "Concentrated CO_2" above. Cap for ten minutes, then uncap.
- **Outside air** -- Use a bicycle pump to collect a sample of outside air near a road. Place the balloon opening over the pump valve. Pump in the air to partly inflate the balloon and tie off with a twist tie. Add sample to chamber as described for "Concentrated CO_2" above. Cap for ten minutes, then uncap.
- Wood smoke -- Make a foil cap for the pyrex container. Fit the straw through it. Remove the camp and add a burning match. Replace the cap, and put the syringe into the straw. Use it to take up the smoke. Empty the syringe directly into the plant chamber. Collect six more samples and empty into the chamber. (You may have to add more smoke to the flask.) Cap for ten minutes, then uncap.

4 Make sure plants receive adequate water and the same amount for each plant.

5 Add air samples to each chamber every school day for two weeks. Each day, after adding samples, make observations of plant height, chamber temperature, appearance of particulates on vaseline strip, changes in the ozone strip, and anything notable about the plants' condition. Record data on data sheet.

6 At the end of two week period, remove the particulate strips from the chambers and using a dissecting scope, collect the particles on each strip. Record on data sheet.

7 Graph the results for temperature, plant height, particulates count, and ozone test for each chamber. (Examples: Line graph of time vs. height with a different colored curve for each chamber; bar graphs of net growth for each chamber, particulates/cm^2 for each chamber, etc.)

8 Look at the graphs. What relationships do you see between added air pollutants and plant growth? Which plant grew the least during the experiment? Which grew the most? Did plants in any of the chambers exhibit any unusual traits (spotting, deformed leaves, discoloration)? How does your data compare to that of other groups? What significance might this have outside the classroom?

Resources:

Air, Pollution. Air and Waste Management Association. Pittsburg, PA. 1991.

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Global Climates -- Past, Present, and Future. Activities for Integrated Science Education. The Environmental Protection Agency. Office of Research and Development. June 1993.

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MacRae-Campbell, Linda and McKisson, Micki. Our Troubled Skies. Zephyr Press. Tucson, Arizona. 1990.

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Acknowledgments

This activity was adapted from “What Is Happening to the Citizens of Silent-springs?” by Barbara Baar, Janet Charnley, and Jennifer Glock.

Air Pollution Data

Name: ___________________________________

Date	Plant Chamber		Height	Temperature	Particulates	Ozone Test	Observation
	Control						
	Exhaust				#		
	CO_2				#		
	Smoke				#		
	Outside Air				#		
					#		

Life = Air

Subjects: Science, Art
Grades: K-3
Teaching Time: 30 minutes
Focus: Lungs, Air, Oxygen

Rationale

Air is all around us but can't be seen. We all need air for oxygen. Lungs can be damaged by air pollution.

Learning Objectives

Students will:

- Know that air is all around us.
- Know that living things need air in order to breathe.
- Understand that dirty air can hurt lungs and our ability to breathe.

Teacher Background

If you could spread your lungs completely flat, they would be as big as a tennis court. Each day, you breathe about 35 pounds of air. Your lungs take in the oxygen, it's dissolved in your blood, and then your heart pumps it throughout your body. When we exercise, our muscles need more oxygen, so we breathe harder and our hearts pump faster. If the air is dirty, our lungs cannot absorb as much oxygen as they need so air pollution affects us more when we exercise. The same thing happens when you smoke; your lungs cannot absorb the oxygen they need.

(See also background for activity, "Lungs at Work," p.13. for more information on the respiratory system.)

Air pollution has a greater effect on children, the elderly, and people with lung problems such as asthma, allergies, and emphysema. Children with asthma may need to stay inside in the winter when their neighbors are using wood stoves that release smoke into the air. There are more deaths and emergency room visits for lung problems when the air is heavily polluted.

Materials

- 35-lb. bag of dog food, bird seed, etc.
- Watch with second hand
- Glass of water
- Paper
- Crayons

Pre & Post Test Questions

1. Where is air? (All around us!)

2. What things on earth need air? Why? (Almost all living things; to stay alive)

3. How can polluted air hurt us? (It hurts the delicate tissues in our lungs that help oxygen get into our blood)

Learning Procedure

1 Ask for (or designate) two student volunteers to come to the front of the class. Give one a glass of water. Tell them and the class that you are going to ask the student with the water to go without water for one minute, and the other student to go without air for one minute. Use the watch to keep track. Check in with each student after 10 seconds; then again after another 10 seconds, until the "airless" volunteer is clearly ready to stop. Ask all students which we can live without for longer (water, of course!)

2 Have the 35-lb. bag of dog food, etc. at the front of the class. Ask for a volunteer to try to lift the sack (knees bent, back straight). Tell the class that this is the weight of the air we breathe in one day.

3 Have students look for evidence of air outside on the playground.

4 Have students draw or tell examples of living things that need air to breathe. Have them give examples of non-living things that don't need air (rocks, dirt, shoes, etc.).

5 Have students jump on one foot until they feel winded. Discuss what it feels like to begin to run out of air. Connect this to people with lung problems and their inability to breathe with too much air pollution.

Lungs At Work

Subjects: Science, Health
Grades: 3-8
Teaching Time: One class period
Focus: Lungs, Air Pollution, Health

Rationale

We all need air to breathe. Our lungs enable us to take in and filter air so that our bodies can use it. Air pollution can damage the filtering capacity of the lungs.

Learning Objectives

Students will:

- Identify parts of the respiratory system.
- Construct a model of the respiratory system.
- Describe how the lungs can be affected by air pollution.

Teacher Background

"Would you be tempted by an ad for an air-distribution system that automatically warms and filters the air, is self-lubricating and self-repairing, and offers such attractive 'extras' as a built-in speaker and a chemical detector? You already have one."[1] It's your respiratory system. The respiratory system includes the body's entire system for breathing, including the nose, throat, and lungs. The respiratory system serves to bring oxygen into the body and to eliminate the carbon dioxide formed in reactions in body. The respiratory system consists of:

- Nasal passages
- Pharynx
- Trachea - "Windpipe"
- Lungs
  - Bronchi
  - Bronchioles
  - Alveoli
- Diaphragm

Air passing through the nasal cavity is warmed, moistened, and cleaned. From the nasal cavity, the air passes through the pharynx and enters the trachea or "windpipe." At its lower end the trachea divides into two branches called the "bronchi." The trachea and the bronchi are lined with cilia that carry dust or dirt taken in with air toward the mouth. The bronchi branch into bronchioles which in turn branch into tiny clusters of sacs called "alveoli." Through the alveoli, gases are exchanged between the capillaries and the lungs. The lungs are cone-shaped organs containing the bronchi, bronchioles, and alveoli.

The body takes care of moderate amounts of dirt coming into the respiratory system by providing a protective lining of mucus on these surfaces, and small hairs called "cilia" that help to move the mucus up and out of the system.

When the number of dirt particles is very high, however, (from smoking or breathing in very polluted air), the mucus layer thins and deteriorates, and the tissues lining the respiratory system become irritated. Alveoli walls can break down, significantly reducing the lung surface area available to absorb oxygen and give off carbon dioxide.

Materials

- Overhead transparency of respiratory system diagram
- Copy of respiratory system diagram for each student

(For each group)

- Funnel
- Coffee filter (to fit the funnel)
- Container for filtered water
- Potting soil
- Water in yogurt cup
- Spoon/scoop

[1] Alvin Silverstein, Human Anatomy and Physiology, John Wiley and Sons, New York, 1980, P.523.

(Possible for Step 1)

- Glass of water
- Watch with second hand
- 35-lb. bag of dog food, bird seed, etc.

Pre & Post Test Questions

1. Name the parts of the respiratory system. (See diagram.)

2. How does pollution in your lungs affect your ability to breathe? (It harms the tissues that transfer oxygen from your lungs to your blood.)

Learning Procedure

1 If you haven't already used it, do steps 1 and 2 in the preceding activity ("Life = Air")

2 Show the students the diagram of the respiratory system included in this lesson or a model of it if available. Talk to them about how the air is taken into the lungs and where it goes.

3 Give students a copy of the diagram and vocabulary about the respiratory system.

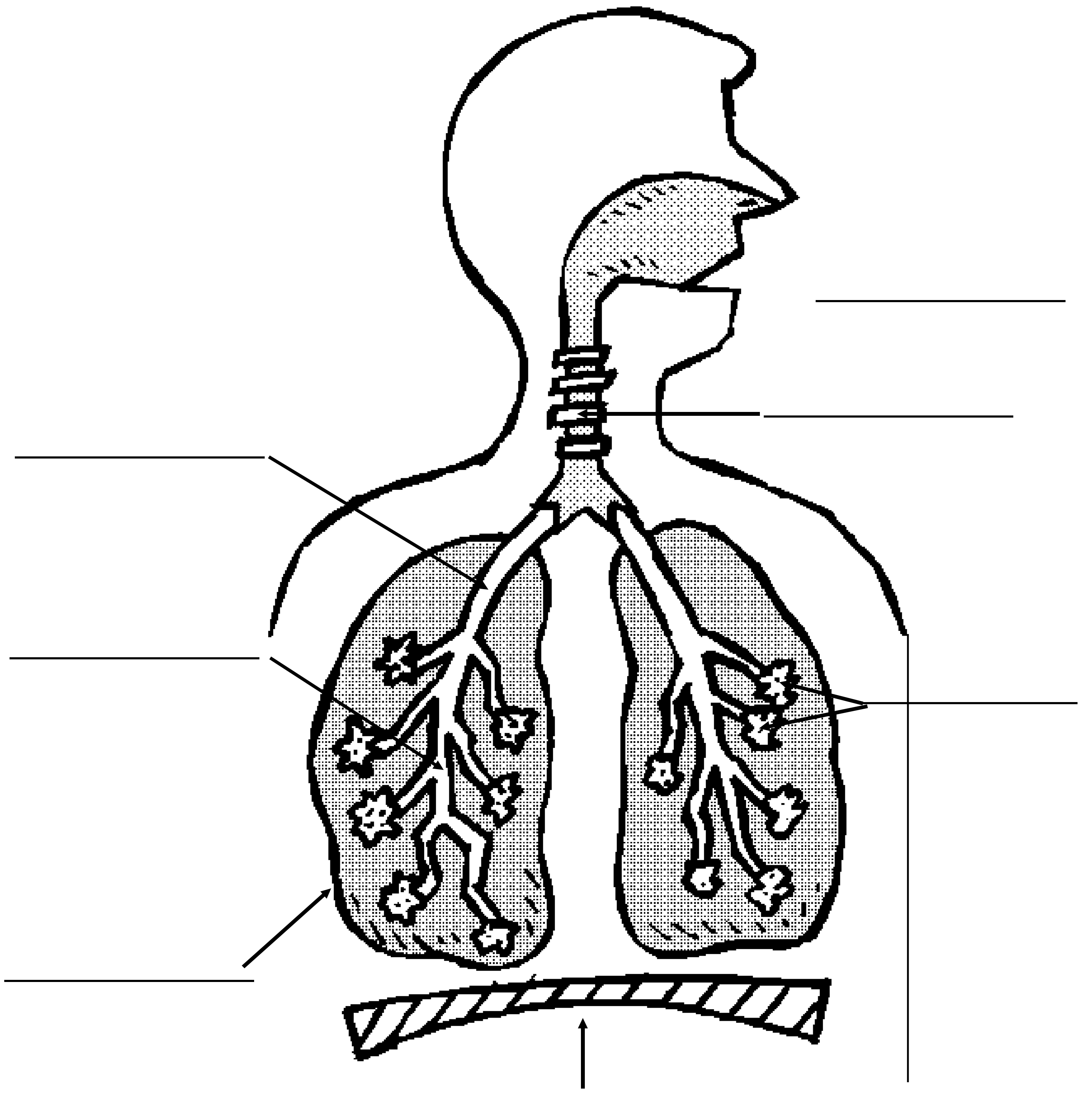
Have them work individually or in pairs to label the various parts of the respiratory system on the diagram, and devise a quiz on the parts. Have them explain to each other how this system works.

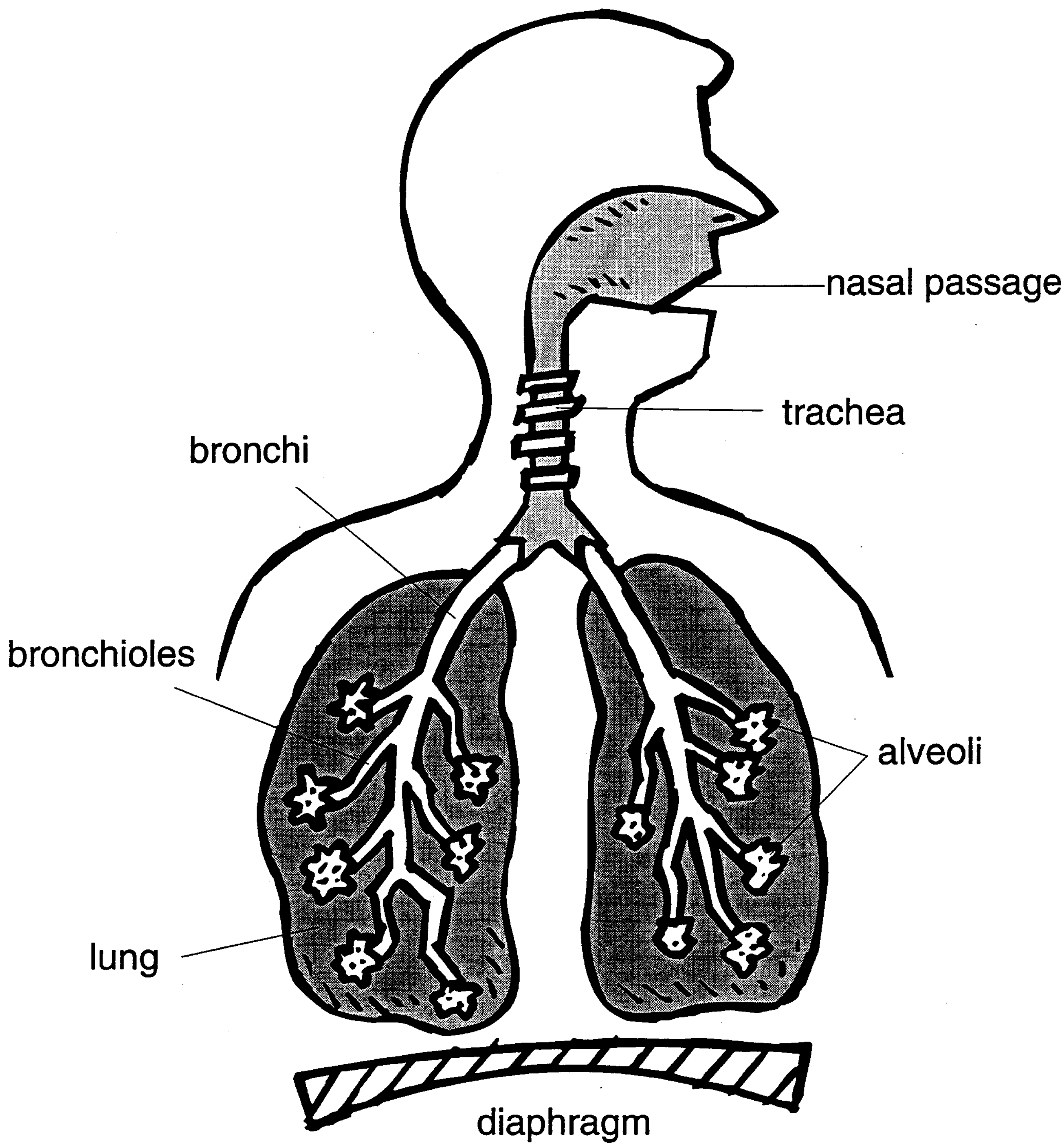
4 Divide students into groups. Each group should set up a filter, funnel, and container, and then add a medium amount of soil to the filter.

5 Discuss together how some small particles came through the filter, just like some small particles get through your respiratory system to the alveoli. These are the most dangerous particles. List some sources of this pollution (cigarettes, wood stoves, factories, cars).

Extended Learning

Follow up with a service project (with interested volunteers) for individuals suffering from lung disease.




nasal passage
trachea
bronchi
bronchioles
alveoli
lung
diaphragm

How Are Plants "Lichen" The Air?

Subjects: Science, Botany
Grades: 6-12
Teaching Time: One 30-minute session (additional time if field trip taken)
Focus: Air Pollution, Plants/Fungi

Rationale

Air pollution can have a visible effect on things other than people.

Learning Objectives

Students will:

- Identify lichens (3 types).
- Compare lichens from urban and rural environments.

Teacher Background

Lichens (pronounced "like-en") are a symbiotic (mutually beneficial) relationship between two different organisms – a fungus and an alga. They can be very sensitive to air pollution. Though there are a variety of reasons why lichen grow where they do, it is clear that some types of lichens do not grow when air pollution levels (particularly acidic air) get too high. This lesson looks at three types of lichens, where they usually prefer to grow and how air pollution affects them. Students are then asked to look at branches of similar trees from urban and non-urban areas to see the difference in lichen growth.

The tree types of lichens are:

- foliose (leafy)
- fruticose (shrubby)
- crustose (crusty)

Foliose lichens are usually leafy in form and are loosely attached to their surface. They have an upper surface that is different from the lower, either in color or surface features. They are sensitive to air pollution. Even the oldest trees in an urban, polluted area will not have these lichens on their branches. In smaller, less polluted areas, there may be lichens on the branches of older trees, but there will be fewer than on trees in a relatively pristine, old growth forest.

Fruticose lichens grow on old fences, trees, and walls. They have simple or divided branches that are round to flattened with little difference between the upper and lower surfaces. They may be long, pendulous strands hanging from tree branches or erect hollow stalks on old fence posts or walls. They are also sensitive to air pollution and will not be found in more polluted areas. They are especially abundant in old growth forests.

Crustose lichens appear to be less sensitive to air pollution. They grow on rocks and trees and are the first colonizer on a rock surface. They adhere so closely to the surface that usually the collector must take some of the substrate in order to get all of the lichen. They are not the focus of this activity since they are less sensitive to air pollution, but it is important to be able to recognize them to differentiate them from the other two.

In this lesson, collect fallen branches from trees and samples of other surfaces (fences and walls, etc.) that might have foliose and/or fruticose lichens. Also collect some from around the school. Then collect fallen branches from similar trees (i.e., old, Douglas Fir) from a more "natural" area. (You could do this, or students could do it on a field trip.) Comparing the amount of lichen growth on the two branches (or other surfaces) is one indication of the presence or absence of air pollution. If both branches have some lichens, have the students devise a way to measure the percent of the branch covered or the bushiness of the lichen. (Branches from more polluted areas should have fewer lichens and less dense growth. Branches from cities should have almost no lichens. Again, compare branches from trees of the same kind and similar size and age.)

Materials

(One for each group)

- Downed branches, stones, fence posts, etc. from urban/suburban area with little lichen growth
- Downed branches from natural area with examples of several lichens (all 3 types, if possible).

Note: If money is available for field trips, students could collect these samples. If not, the teacher will need to collect them.

Pre & Post Test Questions

1. What is a lichen? Draw and describe the three types of lichens. (Lichen is a symbiotic relationship between an alga and a fungus. See illustration for for the three types.)

2. How does lichen growth differ in populated and less-populated natural areas? Why? (More in old-growth and unpolluted areas; less in urban areas. Lichens are sensitive to air pollution.)

Learning Procedure

1 Teach students what lichens are and the three types of lichens.

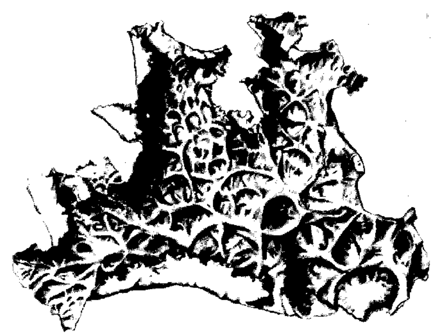
2 Break students into groups and give each group an "urban branch" and a "non-urban branch." Have students look for lichens on each and jot down their findings.

3 As a class, discuss any differences in lichen growth noted between the two types of branches, and possible reasons for these differences.

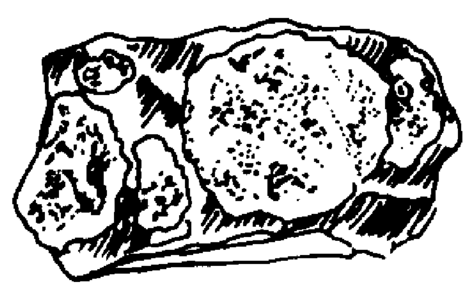
Extended Learning

Have students look for lichens in their neighbor-hoods (leaving them where they find them) and report back on what they see. Try to determine if the same pattern exists (little lichen growth in urban areas; more in non-urban).

FRUITICOSE



FOLIOSE



CRUSTOSE

Lighter Than Air

Subjects: Earth Science, Health
Grades: 6-12
Teaching Time: One 50-minute session
Focus: Air Pollution, Air Inversion, Vertical Mixing

Rationale

Air quality is important all year round.

Air inversions increase pollution build-up.

Learning Objectives

Students will:

- Understand how air inversions are formed.
- Understand the contribution of weather, seasons, and topography to air pollution.

Teacher Background

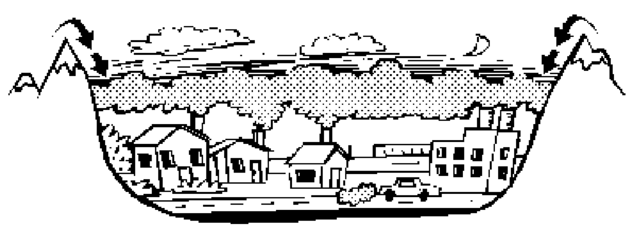
In the winter often there is no wind and no mixing of different layers of air. A layer of warm air can settle over an area and prevent the cooler air below it from rising. This is called a "thermal inversion." This can happen in several ways. On a cold night the ground can get very cold. This cold air can rise slowly up and cool the air above it. Without wind or rain to mix the air, the bottom layer can stay cooler than the upper layers. Another way for the bottom layer to be colder is when Arctic air from the north moves down to this region and settles in. Sometimes a storm off the Pacific then moves into the area. This warmer air from the water settles on top of the cold air already there. The lower layer with its pollution (often wood stove pollution in our area) is kept close to the earth. It becomes increasingly dirty as more and more pollutants are released into it. A thermal inversion can combine with topography to make the pollution problem worse. For example, inversions often occur in valleys because air can get trapped in them.

Materials (per group)

- Large glass jar
- Red, blue and green food coloring
- Tap water
- Salt
- Measuring cup
- Funnel
- Rubber tubing (about 50 cm long, wide enough to fit on the funnel)
- Watering can (container with holes in lid)

Pre & Post Test Questions

1. What is an air (thermal) inversion? (Warm air settles over an area and prevents colder air from rising.)



An air inversion can trap pollution close to the ground.

2. How does an air inversion affect air pollution? (Lower layer with its pollution is kept close to earth and becomes increasingly dirty.)

3. During which season are air inversions most likely? Why? (Winter, no wind and no mixing of different layers of air.)

4. What kind of weather affects air inversions? (Rain and wind can mix layers and break up an inversion.)

5. What kind of topography makes air inversions more likely? (Valleys.)

Learning Procedure

(This may be done as a demonstration or as a group activity. It could also be done as an inquiry lesson, by not telling students what each thing represents and instead, having them figure that out.)

1 Teach students what an air inversion is.

2 Fill the container a little less than half full with tap water. Put 6-8 drops of red food coloring in.

Say: "This red water represents warm air which is lighter than cold air." (Explain that you are using water because air is hard to see.)

3 Fill a measuring cup with tap water and saturate it with salt (add salt until no more will dissolve). Put 6-8 drops of blue food coloring in it.

Say: "This salty blue water represents cold air, which is heavier than warm air."

4 Use the funnel with the rubber tubing fit snugly on the end. Pour the blue water slowly and carefully through the funnel. Make sure the tubing is on the bottom of the container. There should be two layers - blue on the bottom and red on the top. Say, "This is what happens when there is an air inversion - the heavy and light air do not mix."

5 Take green food coloring and put 6 drops into the container drop by drop stopping 1-2 seconds between each drop. Tell the students the green food coloring is pollution. It will layer out between the red and the blue. Say, "This is what happens in an inversion - the pollution concentrates and stays in the one layer near the ground."

6 Add "rain" (salt this "rain" water a bit to make it more dense) with the watering can and blow through the rubber tubing or a straw, all the way to the bottom to stir up the contents in the container and mix the layers. Tell students that this is called "vertical mixing" and it dilutes the pollution. Wind and rain can mix the layers so there's less pollution close to the ground.

7 Have students discuss in groups and share their answers to the following questions:

1. Do you think air inversions happen more in the summer or winter? (Winter) Why? (Light warm air traps cold air underneath it.)
2. What do people do in the winter that increases air pollution? (Burn wood, oil, natural gas; drive places they might walk/ bike in summer.)
3. How does mixing happen in the atmosphere? (Wind and rain)
4. In which of the following places is an inversion most likely to happen: mountain top, valley, or beach front? Why? (Valley; air is easily trapped.)

Extended Learning

- Students could determine the densities of the red and blue solutions by weighing an empty container, and then weighing a predetermined volume of each solution in the container. (density = mass / volume).
- Older students may compare air inversions with temperature stratification of large bodies of water in summer and winter.

Now You See It . . .

Subjects: Science
Grades: K-3
Teaching Time: 30 minutes
Focus: Air Pollution, Odor, Dust

Rationale

Sometimes we can smell and see air pollution.

Learning Objectives

Students will:

- Identify causes of air pollution in their neighborhoods
- Identify visible sources of air pollution.
- Know that not all pollutants are visible or have an odor.
- Suggest solutions for some indoor/outdoor air pollution

Teacher Background

Much of the visible air pollution is particulate matter pollution. (Ozone is also visible after it reacts with sunlight.) Particulate matter is monitored in sites throughout the state where there is likely to be a particulate matter pollution problem. Monitors are located in the Puget Sound area, Wenatchee, Yakima, Tri-Cities, Spokane and Southwest Washington. Monitors are called "high volume samplers." They work by drawing air into a covered housing through a filter of a known weight. The filter is weighed after the sampling. The weight gain of the filter is due to the suspended particulate matter collected. The sampler is built to assure that only particles of 10 microns or smaller diameter get in. (A micron is 1/1,000,000 of a meter, or 1/1,000 of a millimeter. See also background of Activity "Particular Particles Pollute," on p. 25 for more information on particulate matter.)

Materials

- Strong flashlight or slide projector light
- Erasers filled with chalk dust or flour (for hands)
- Particulate matter filter pictures p. 23.

Pre & Post Test Questions

1. Where does air pollution come from in your neighborhood? Can you see it? Can you smell it? (Answers will vary.)

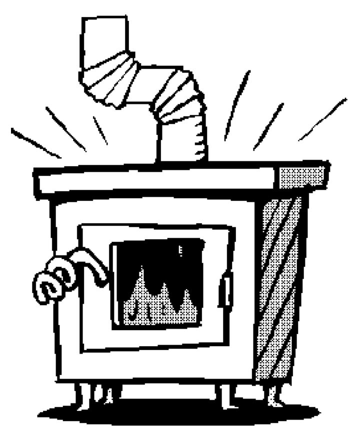
2. What kind of air pollution can you see? (Answers will vary.)

3. Is there air pollution that you can't see or smell? (Yes.)

4. What are some things we could do to reduce indoor/outdoor pollution?

Learning Procedure

1 Ask students to think about what air pollution looks like and what it smells like, and then share their ideas with the class. Discuss and list the visible or smellable sources in their neighborhood (fireplaces, burning leaves, dust, etc.).



2 Darken the room and turn on the flashlight or slide projector light. Have students observe the air in front of the light and tell what they see.

3 Clap two dusty erasers in front of the light or dip your hands in the flour and clap (caution: do not breathe this directly) and have students tell what they see now. Ask them to think about and share what might happen if too much of the dust got into their lungs.

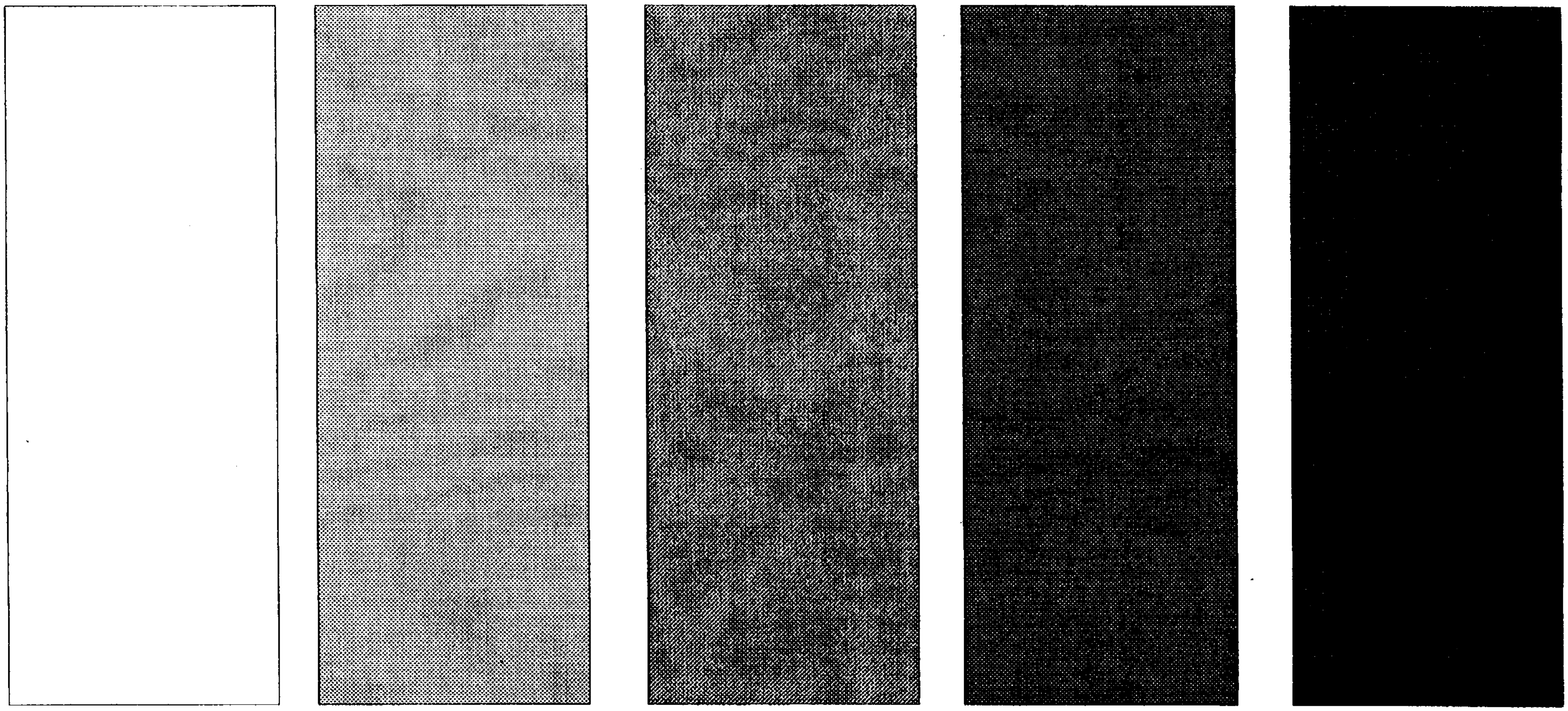
4 Ask students if they know of any air pollution that they can't see or smell. (If they get stuck, you can ask about pollen allergies or carbon monoxide detectors.) Show them the pictures of filters from the particulate matter monitors that collect primarily visible air pollutants. Ask them what part of their bodies acts like these filters and how this pollution might affect them.

5 Brainstorm and chart causes and solutions for indoor/outdoor air pollution

Resources

1) Local air agency (see list, p. 5)
2) For information on air quality trends in Washington State, see Ecology's "Washington State Air Quality: A Status Report," 95-220. (In Appendix)

Filters from Particulate Matter Monitors



	Nov.13, 1990	Nov. 11, 1990	Jan. 10, 1993	Dec. 15, 1985
Clean	**Average day approx. 25 $\mu g/m^3$ (which is good air quality)**	**Winter day approx. 48 $\mu g/m^3$ (which is good air quality)**	**Burn ban day approx. 69 $\mu g/m^3$ (which is moderate air quality)**	**One of the worst days approx. 255 $\mu g/m^3$ (which is unhealthful air quality)**

Particular Particulates Pollute!

Subjects: Science

Grades: 3-8

Teaching Time: Two 30-minute sessions, one week apart

Focus: Air Pollution, Particulate Matter

Rationale

Particulate matter air pollution is everywhere, and it affects our health.

Some air pollution is visible, and some is invisible.

Learning Objectives

Students will:

- Identify particulate matter pollution and its sources.
- Collect and measure particulate matter pollution.
- Describe the health effects of particulate matter pollution.

Teacher Background

Particulate matter is small particles of solid and liquid matter found in the atmosphere, including soot, dust, organic matter, smoke, or smog. Particulate matter that measures ten microns in diameter or less is called PM_{10}. Thousands of these particles could fit on the period at the end of this sentence. (See pages 1 and 3 of the Background, and Ecology Focus sheet, #FA-92-29, "Major Air Pollutants: Particulate Matter." in Appendix)

The sources of particulate matter are cars, wood stoves, industry, road dust, backyard burning, slash burning, and agricultural burning. Particulate matter can be decreased through controls on industry, wood stove regulations, restricted backyard and land clearing fires, reduction in slash burning and agricultural burning, paving of roads, decreased traffic and decreased use of single-occupant vehicles. You and your students can help decrease particulate matter pollution by composting yard waste instead of burning it; using a form of heat other than wood or making sure your wood stove is burning cleanly; obeying all burn ban days; and using your car less.

Particulate matter larger than ten microns in diameter collects in the upper respiratory system (throat and nose) and is eliminated. (See Lesson "Lungs at Work," p.13. Smaller particles can get past the filters of the respiratory system and penetrate deep into the lungs, and so are a more serious health threat. In the lungs they can cause structural damage and chemical changes. Poisonous and cancer-causing chemicals may stick to the particles and enter the lungs along with them. Chronic diseases such as emphysema, asthma, chronic bronchitis, cancer and heart disease have been associated with exposure to small particulate matter.

Recent health studies show that death rates and respiratory illnesses increase when fine particulate air pollution increases, even when the pollutant levels meet the federal health-based standard. Because of this information, the standard may eventually be changed and may become $PM_{2.5}$ instead of PM_{10}. Discussions are occurring with the EPA in 1996 about the standard and a new standard should be established by 1997.

Particulate matter is monitored in sites throughout the state where there is likely to be a particulate pollution problem. Monitors are located in the Puget Sound area, Wenatchee, Yakima, Tri-Cities, Spokane and Southwest Washington. PM_{10} monitors are called "high volume samplers." They work by drawing air into a covered housing through a filter of a known weight. The filter is weighed after the sampling. The weight gain of the filter is due to the suspended particulate matter collected. The sampler is built to assure that only particles of 10 microns or smaller diameter get in. (1 micron is 1/1,000,000 of a meter, or 1/1,000 of a millimeter.)

Materials (for each group)

- Glass slides or white container lids
- Petroleum jelly
- Hand lenses or dissecting scopes
- PM_{10} filter pictures, p. 23.

Pre & Post Test Questions

1. What is particulate matter pollution? (Pollution consisting of very small particles of soot, dust, pollen, etc.)

2. Where does it come from? (Cars, wood stoves, industries, road dust, backyard burning, slash burning)

3. What can be done to decrease particulate matter pollution? (Fewer wood stoves, proper burning techniques, industry controls, paving of roads, less car use, composting, alternative logging and farming practices.)

Learning Procedure

(First session)

1 Tell students that particles in the air can be harmful. Ask them to think about where they may have seen air pollution and share this with the class.

2 Talk together to decide on several places close to the school where it would be interesting to test for air pollution.

3 Divide students into groups (the same number of groups as you have places in #2). Have each group prepare an air pollution collector by putting a thin smear of petroleum jelly on a slide/lid. Then have each group put their slide/lid in one of the test locations. (Group members may need to devise a way to protect the slide/lid from disturbance while not hampering its ability to sample the air.) Leave the slides/lids in the test location for one week.

(Second session - one week later)

1 Have students examine the slides with a hand lens.

Ask: Are there additional particles that you can't see? (The most harmful particles are the little ones, too small to see, that can go deep into the lungs and cause lung diseases or irritation.)

2 Have students compare their slides with the PM_{10} filter photographs.

3 **Ask:** What have we learned about particles in the air? (Some are too small to see, variety of types, smaller particles are the most dangerous.)

4 **Ask:** What are the sources of particulate matter pollution? (Cars, wood stoves, industry, road dust, open burning, slash burning, agricultural burning.)

5 **Ask:** How could this type of pollution be decreased? (Fewer wood stoves, proper burning techniques, industry controls, paving of roads, less car use, composting, alternative logging, and farming practices.)

Acknowledgments

Jon Bennett, Department of Ecology, Air Quality Program

Resources

1) Local Air Agency (see list, page 5)
2) For information on air quality trends in Washington State see Ecology's "Washington State Air Quality: A Status Report," 95-220, in Appendix

The Acid Test

Subjects: Science, Biology, Chemistry, Botany
Grades: 8-12
Teaching Time: Two 45-minute class periods
Focus: pH, Acid Rain

Rationale

Acid rain affects soil and water, creating toxic conditions for some plant and animal life.

Learning Objectives

Students will:

- Understand what "pH" is
- Use pH paper to test the pH of liquids
- Test the pH of local rain and local bodies of water
- Understand the effects of acidic rain on trees and fish

Teacher Background

Acid Rain

Acid rain is a combination of air and water pollution caused by toxic emissions (mainly oxides of nitrogen and sulfur dioxide) from industry, transportation, and home heating. These pollutants rise into the air and combine with moisture in the clouds to form sulfuric acid (H_2SO_4) and nitric acid (HNO_3). The clouds release this acidic moisture in the form of rain, sleet, snow, hail, or fog — called "acid rain."

The acidity in acid rain affects soil and water. As acid rain falls it damages the makeup of the soil by washing away (leaching) important nutrient salts and metals that plants need to thrive and grow. As acid rains continue to fall, the leached metals, salts, and acids flow into rivers and lakes, changing the chemical makeup of the water. The buildup of pollutants over time destroys the lake's ability to maintain both plant and animal life.

Plants are also affected by acid rain. Trees' leaves or needles turn yellow or brownish, and growth is hindered or the tree dies. Acid rain can damage buildings and monuments by corroding the stone of which they're made.

Acid rain is more of a problem in the central and eastern parts of the United States. In Washington State, there is only one coal burning power plant that produces sulfur dioxide. It is located in the southwestern part of the state. We include activities on acid rain because it is an important concept in air pollution studies.

Materials

- pH test paper
- Small cups (7-10 per group)
- Vinegar, lemon juice, and baking soda solutions made with distilled water
- Recently collected samples of rain and local pond/lake/stream water

Pre & Post Test Questions

1. What is the pH of a substance? (A number that tells how acidic or basic it is.)

2. How can we test pH? (Litmus paper or pH paper)

3. Is rain in your area acidic? (Answers will vary.)

4. What are the effects of acid rain on fish and trees? (It can kill fish and weaken or kill trees.)

Learning Procedure

1 Before the first class period, ask students to collect (in clean glass jars) and label samples of rainwater or water from local ponds, lakes, or streams. Make up the testing solutions by using 1 part liquid to 1 part distilled water for baking soda.

2 **Day One**
Teach students the following facts about the pH scale (the scale on p.28 may be made into a transparency or duplicated for students):

- The pH scale is a way of measuring how acidic a solution is.

- Solutions with a pH less than 7 are said to be acidic; those with a pH of 7 are neutral; those with a pH greater than 7 are alkaline or basic.
- The pH scale is a logarithmic scale like the Richter scale, so a 1-unit decrease in pH means a 10-fold increase in acidity.

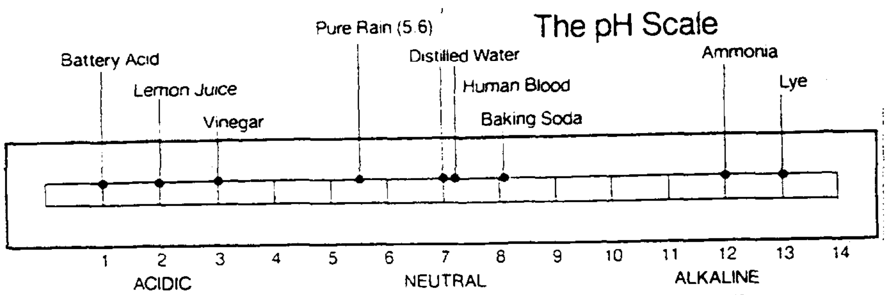
3 Break students into small groups. Each group needs a set of the sample solutions (lemon juice, baking soda, vinegar, and plain distilled water) and pH test paper.

4 Have students test and record the pH of each solution, and plot it on their pH scale.

5 Compare class results for each solution. Students may be interested to know the pH of a few other solutions: battery acid (1.0), blood (7.4), seawater (8.3), ammonia (11.2), lye (13).

6 **Day Two**
Ask students to predict the pH of "pure" rainfall (rain that falls far from any industrial/human activity) and give their reasons. Tell others that the pH of "pure" rain is around 5.6, acidic because carbon dioxide in the atmosphere reacts with moisture to produce dilute carbonic acid.

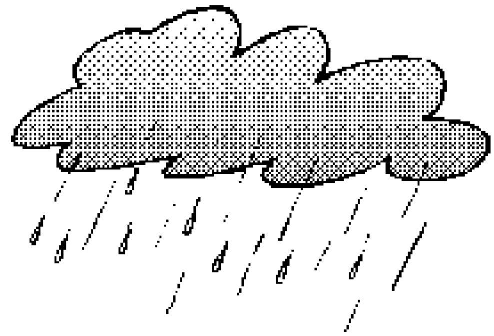
7 Have students break into groups again to test the locally collected samples of rainfall and water. Plot these samples on the pH scale.



The term acid rain generally includes deposition with pH below 5.6. The logarithmic pH scale expresses acidity and alkalinity in a range from 0 to 14. Seven, the midpoint, is neutral.

Making Acid Rain

Subjects: Science, Chemistry, Biology
Grades: 9-12
Teaching Time: 40 minutes
Focus: Incineration, Water Pollution, Acid Rain, Waste and Water



Rationale

Incineration reduces the volume of wastes to be disposed, but poses problems including the production of acid gases that can contribute to acid rain.

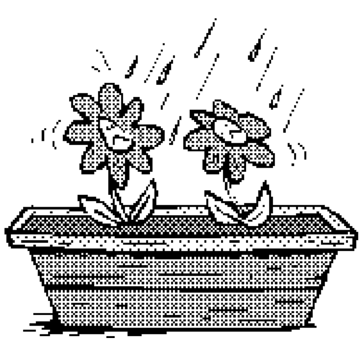
Learning Objective

Students will:

- Learn that burning nonmetals produces oxides called acid anhydrides that, when combined with water, form acids. As gases, acid anhydrides may dissolve in rain to form acid rain.
- Understand the potential harm to the environment from acid rain.
- Understand how scientific information is used in making decisions about waste management.

Teacher Background

It is necessary for the safety of the class to have a lab with a hood and a fan to preserve the air quality. For other instructions, see the introduction on the Lab Instructions Sheet.



Materials

- See Lab Instructions sheets

Pre & Post Test Questions

1. What causes acid rain? How is acid rain formed? (See background on acid rain in previous lesson.)

2. What are two sources of toxic acid gases from burning unsorted garbage? (Hydrogen chloride can be released from burning plastics. Sulfur dioxide is formed when sulfur-containing substances are burned.)

3. What are three effects of acid rain on the environment? (It can kill fish, weaken or kill trees, make lakes acidic.)

Learning Procedure

1 Tell students this experiment will investigate the burning of nonmetals such as might occur in the incineration of garbage. Explain that although incineration is already being used by some 70 cities and counties in this country as well as by many European countries, concern is high that gases emitted from such operations have the potential to cause serious environmental harm.

2 Tell students this experiment will investigate the release of acid anhydrides from the burning of nonmetals that might be part of the refuse burned in an incinerator. Explain that acid anhydrides such as sulfur dioxide and nitrogen oxides are a major source of acid rain. Acid rain has been linked to fish kills and destruction of forests, as well as damage to microorganisms that are vital to our environment.

3 Have students work in pairs. Hand out the Lab Instructions sheet. Go over the laboratory procedure with the students.

4 Have students do the experiment and answer the questions on the lab sheets.

5 When all the students have finished, **Ask:** "What does this demonstration show us about how acid rain is formed?" "What is the potential relationship between waste and acid rain?"

6 **Ask:** "How might the acid gas emissions from waste incinerators be controlled?" (Neutralization of the acids with an appropriate base.) Explain that the best incinerators are equipped with devices called scrubbers. In Washington State, scrubbers are required to comply with air emission standards. As refuse is burned, the gases released are mixed with a lime (calcium oxide) and water solution which is sprayed into the chimney flue. The lime slurry neutralizes the acid gases to nontoxic calcium salts. At present, most incinerators in this country are not equipped with scrubbers.

7 Discuss with students some of the other processes that contribute to acid rain. (Auto exhaust produces nitrogen oxides; coal fired electric generators and many smelters produce sulfur dioxides.) **Ask:** "What are some natural sources of acid rain?" (carbon dioxide)

Extended Learning

1 Have students research the causes of acid rain in the U.S., the areas most affected, and the effects on the environment.

2 Determine which acids could be formed from burning the following: nitrogen, phosphorus, and carbon. Which would be the most acidic?

3 Invite a speaker from the Department of Ecology or your local municipal engineering department to speak on incinerators and waste management problems.

Acknowledgment

Parts of this experiment are based on material from Educators for Social Responsibility. Investigations: Toxic Waste (a science curriculum) Boston Area Educators for Social Responsibility: Cambridge, MA, 1984.

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Lab Instructions - Making Acid Rain

Name______________________________ Date___________

Introduction

Both federal and state governments now impose strict requirements on the disposal of wastes in landfills. Many municipal governments faced with the closing of old dumps are considering incineration to be an attractive alternative. Incinerators not only reduce the volume of garbage disposed, but they also generate electricity. However, concern about the potential for environmental harm is high.

The burning of nonmetals produces oxides called acid anhydrides which form acids when dissolved in water (acid rain). Burning plastics can release hydrogen chloride gas which is also very acidic when dissolved in water. Acid rain has been linked to fish kills, the dying off of forests, and the destruction of microbes that are vital parts of our ecosystem. Damage to marble statues and concrete buildings that contain limestone (calcium carbonate) has also been reported.

The burning of metals produces oxides called basic anhydrides which form bases when dissolved in water. Basic anhydrides are mostly solids. So when metals are incinerated they produce solid basic anhydrides, some of which end up as particulates in incinerator fly ash. Many heavy metals are toxic or carcinogenic when ingested over a long period of time.

Naturally occurring substances such as carbon dioxide have always caused rainwater to be slightly acidic. The dilute solution of carbonic acid that results means that most rainfall has a normal pH of around 5.6. In the northeastern United States, the acid anhydrides of sulfur and nitrogen emitted from a variety of sources have lowered the pH of rainwater to around 4.0 to 4.5. (Cars are large producers of oxides of nitrogen.) Sometimes a pH as low as 3 has been observed. (Orange juice has a pH of around 4.5; a pH of 3 is about that of vinegar.) The main reactions are:

$$H2O + SO2 ——— H2SO3$$

$$H2O + SO3 ——— H2SO4$$

$$H2O + 2\ NO2 ——— HNO3 + HNO2$$

Materials

Sulfur flowers or powder

- Gas bottle - size 100 ml

Deflagrating spoon

- Cover plate (glass plate)

Litmus paper and pH paper

- Stirring rod

Magnesium ribbon

- Test tube
- Paramecium or Euglena (or mixed) culture in solution
- Microscope slides
- Microscope

Procedure

1 Pour about 1/2 inch of distilled water (10 ml) into a gas bottle. IN A FUME HOOD, place a BB sized amount of sulfur in a deflagrating spoon and start it burning. (Ignite sulfur in a fume hood to protect students from fumes.

2 Quickly lower the spoon into the gas bottle near the water. Cover the mouth of the bottle as much as possible to prevent the escape of the SO_2 gas being produced. (See illustration.)

3 When the sulfur has burned completely, remove the spoon and cover the top completely to trap the SO_2 gas.

4 Shake the bottle for about a minute to mix the SO_2 and water. (Be certain the cover is securely in place before shaking the bottle.)

5 Using a stirring rod, place a drop of distilled water on pieces of red and blue litmus paper and on a piece of pH paper. Record your observations.

Red litmus paper_____________________.

Blue litmus paper_____________________.

pH = _________________ of distilled water.

6 Extract about 2 ml of "acid rain" from the bottle into a test tube. Repeat the above tests on this sample. Record your results.

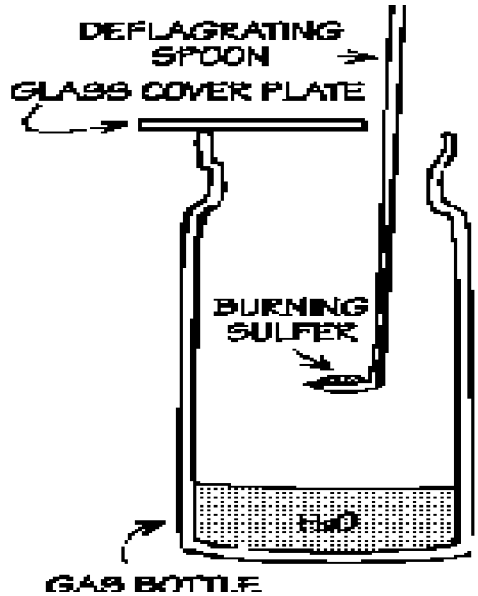
Red litmus paper_____________________.

Blue litmus paper_____________________.

pH = _________________ of "acid rain" water.

7 Place a drop of bacteria culture (Paramecium or Euglena or mixed) on a microscope slide. Examine it under the microscope for three minutes. Record your observations.

Add three drops of "acid rain" to the slide. Be sure the drops fall evenly over the original drop. Observe the effects under the microscope for three minutes and record your observations.



8 Place a 1 cm length of magnesium ribbon into the test tube containing 2 ml of "acid rain." Observe it for at least three minutes. Record your observations. Repeat this experiment with a piece of chalk. Record your observations.

9 (Optional) Repeat Step 7 with salt solutions of varying concentrations. Repeat Step 7 using stock solutions of acid of varying concentrations. Record your observations for each different pH and salt concentration.

Questions — Answer on a separate sheet of paper

1. What is the equation for the burning of sulfur in air?

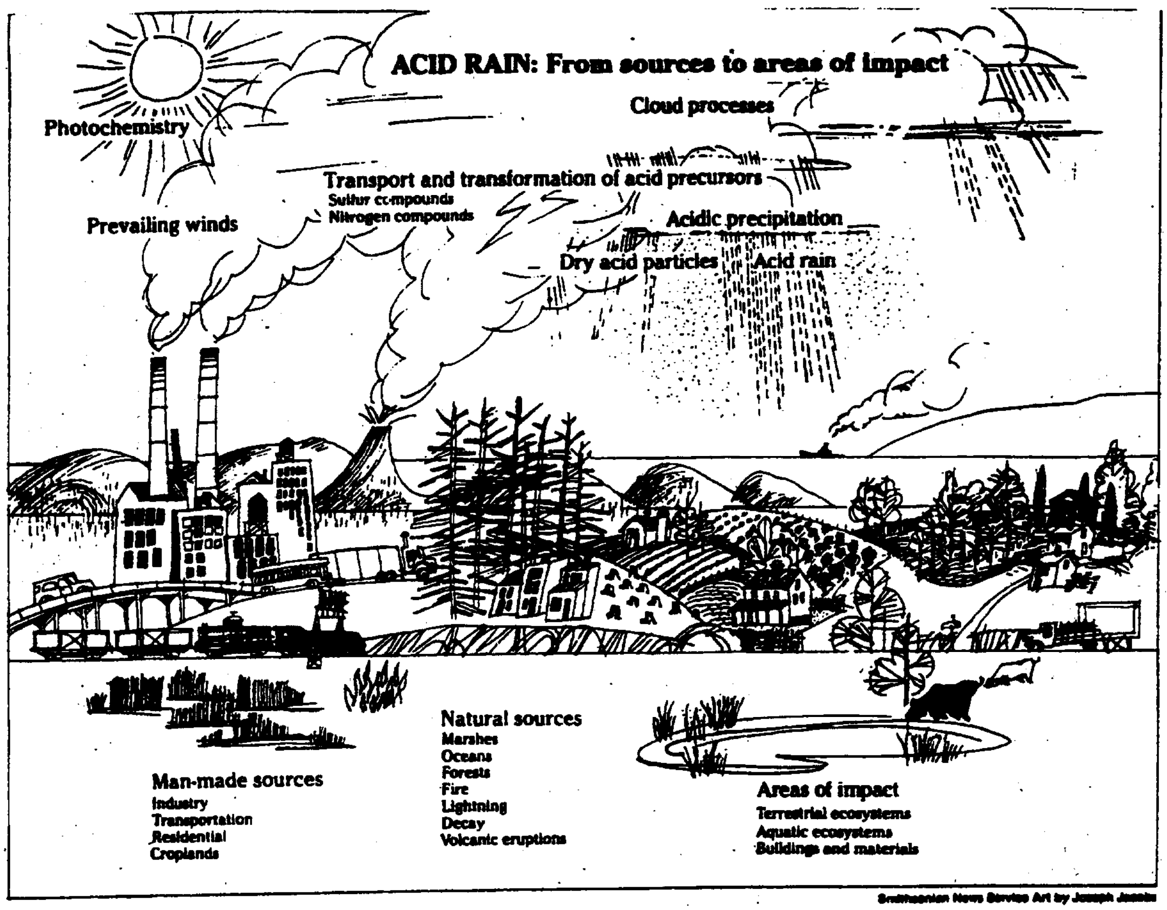
2. How was the acidity of the water affected by the gas produced from the burning of the sulfur?

3. What happened to the bacteria culture when the “acid rain” was added? What might happen to a small lake or pond if such a solution was added over a long period? What kind of lakes might be more affected than others?

4. If a liquid similar to our “acid rain” solution was allowed to stand on a marble statue or the steel supports of a bridge, what effects would you predict?

5. Is pH a good predictor or indicator of water contamination?

6. What other information or scientific data might you want to answer questions 3 - 5?



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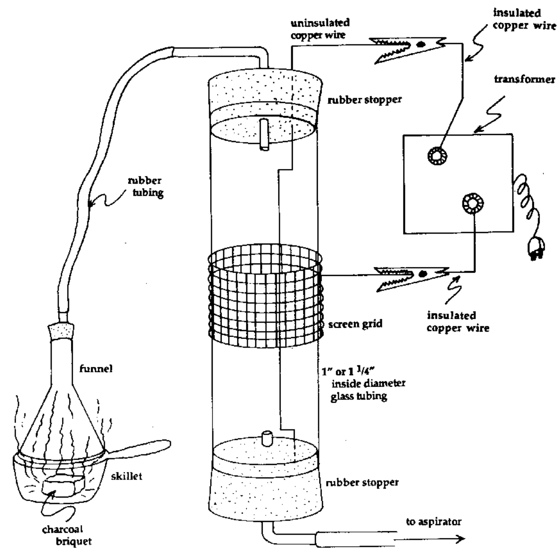
Simply Shocking

Subjects: Science, Chemistry, Electricity/ Electronics

Grades: 9-12

Teaching Time: 2 class periods

Focus: Industry, Pollution Controls



A Model Electrostatic Precipitator

Rationale

Electrostatic precipitators make it possible to trap industrial particulate matter pollution.

Learning Objectives

Students will:

- Identify how pollution is controlled in coal-fired power plants.
- Observe and participate in the construction of an electrostatic precipitator model.
- Know how an electrostatic precipitator functions and its importance as a pollution control device.

Teacher Background

Particulate matter pollutants include dust, smoke, soot, and ash. Some sources of particulate pollutants are power plants, steel mills, cement plants, smelters, diesel engines, and wood stoves. These particulates have both short-term and long-term health effects ranging from eye and throat irritations to bronchitis and permanent lung damage. They are also creating serious visibility problems in some western national parks and other areas. Since the Environmental Protection Agency (EPA) issued the 1971 National Ambient Air Quality Standards and the 1987 EPA new standards on particulate matter size, EPA and the states have worked to limit particulate emissions from industrial facilities and power plants. The regulations set standards on the quantity of particulate matter smaller than ten microns (PM_{10}), or 1/25,000 of an inch, in diameter in the ambient air.

Currently, over half of the electricity generated in the United States is produced by coal-burning power plants. When coal is burned, the heat energy that is released is used to boil water and produce steam. The kinetic force of the pressurized steam spins huge turbines that are connected to generators. As the turbines spin the generators, electricity is produced. When electricity demands increase, more coal must be burned. However, coal-fired power plants have three major air pollution problems — release of gases implicated in acid deposition (primarily sulfur dioxide with some nitrogen oxides), release of large amounts of carbon dioxide (a greenhouse gas), and release of large amounts of particulate matter.

When coal is burned, a chemical reaction takes place. Heat causes hydrogen, carbon, and other substances in coal to combine with oxygen to produce gases, ash, and energy in the form of more heat. The combination of oxygen in the air and sulfur from the coal produces sulfur dioxide, a harmful pollutant if released into the atmosphere.

At existing power stations, sulfur dioxide emissions can be controlled in three principal ways: burning low-sulfur instead of high-sulfur coal, utilizing washing plants that clean the coal before it is burned, and using scrubbers, devices that inject a mist of lime-treated water to remove sulfur dioxide from the air stream in the scrubber vessel after the coal is burned. New technologies for future coal-powered stations are being developed to remove the sulfur before or during the coal burning.

Particulate matter removal is accomplished in a different way. As the coal burns, heavy ash drops to the bottom of the furnace and is collected either for disposal in settling ponds or for other uses such as making construction materials. Fine ash, called "fly ash," becomes ingrained in the combustion flue gases and flows out of the furnace into emission- cleaning equipment; a large fraction of it is collected by devices called "electrostatic precipitators (ESPs)." Electrostatic precipitators use an electric field to charge the fly ash which then precipitates, or is attracted to the collector plates of opposite charge (polarity). Electrostatic precipitators can reduce the emission of particulate matter by as much as 99.5 percent. The use of pollution control devices is required in the United States as well as in Canada, Japan, and Western Europe. Particulate levels have decreased by 23 percent from 1977 to 1986 in North America due to the use of this technology.

Materials

- One glass tube 10-12" long and 1-1/2" in diameter (may be available from local college)
- Two large buret clamps
- Tall ring stand
- Two 18" pieces of #18 insulated copper wire
- One 18" piece of #8 or #10 uninsulated copper wire
- 8" x 3" piece of metal screening
- Two 1-hole rubber stoppers (size required by 1-1/2" glass tube is #8)
- Cork borer
- Two 3' lengths of rubber tubing that fits snugly over glass tubes
- Two 6" glass tubes, each bent at a 90^o angle in the middle
- Mineral oil or glycerine
- 1-2 clear glass funnels
- One short (3" or less) piece of glass tubing tape
- Power supply (high voltage - 50,000v)
- Two alligator clips
- Aquarium pump
- Soldering iron
- Matches or lighter
- Cast iron skillet (alternative: small table grill)
- 1-4 self-igniting charcoal briquettes (or cigarettes
- Transparency or student sheet (master provided)
- Overhead projector (optional)

Pre & Post Test Questions

1. What are four different ways pollution can be controlled in coal-fired power plants? (Burning low-sulfur coal; cleaning coal before burning; using scrubbers to remove sulfur-dioxide; using electrostatic precipitators to remove particulate matter.)

2. How does an electrostatic precipitator work? Why is it important? (An ESP uses an electric field to charge the particulate matter, which is then attracted to plates of the opposite charge. It removes almost all the particulate matter, which might otherwise cause health problems.)

Learning Procedure

1 Ask the students to identify particulate pollutants and their sources. Discuss the Environmental Protection Agency's role in establishing standards for industrial facilities and power plants. Explain the function of pollution control devices such as electrostatic precipitators and scrubbers at coal-burning electrical power plants.

2 Using the diagram on p. 35, explain in more detail how electrostatic precipitators work to reduce the emission of particulate matter by as much as 99.5 percent. Describe the procedure for the construction of the electrostatic precipitator model and explain what the end result should be.

3 Construction of an electrostatic precipitator model (see illustration “A Model Electrostatic Precipitator”):

A. Preparation of the rubber stoppers:

1. If 1-hole rubber stoppers are not available, solid stoppers may be used. Use the cork borer to bore holes completely through the center of each of them.
2. In the stopper that will be used in the top of the large glass tube, bore another hole
3. In the stopper that will be used in the bottom of the large glass tube, on the smaller side of the stopper, bore a hole about 1/2" deep to the right of the center hole. (Do not bore all the way through the stopper.)

B. Preparation of the central electrode:

1. Use the #8 or #10 uninsulated copper wire. Bend the wire so that it will be centered in the large glass tube. (See illustration)
2. In the bottom stopper, place the end of the central electrode into the 1/2" hole and one of the right angle glass tubes through the center hole. Place the stopper in the large glass tube. CAUTION: Do not attempt to force the glass tube through the hole in the stopper. Use a very small drop of mineral oil or glycerine on the end of the glass tube for lubrication and gently insert the tube through the stopper.
3. Put the remaining right angle glass tube through the center hole in the top stopper (see the CAUTION above) and put the central electrode wire through the off-center hole. Place the top stopper in the glass tube. Cut the wire about 1-1/2" from the top of the stopper.

C Preparation of the screening:

1. Weave the remaining unattached, uninsulated copper wire through the screening, leaving a free end about 1-1/2" long.
2. Solder the wire to the screen in 4 or 5 places.
3. Wrap the wire and screening tightly around the outside of the large glass tube.

D. Mount the model on the ring stand in an upright position using the large clamps.

E. Final wire connections:

1. Cut the piece of insulated wire in half. Attach the ends of the uninsulated wires to the 2 pieces #18 insulated copper wire using the alligator clips.
2. Then, attach both pieces of insulated copper wire to the power supply terminals. NOTE: Positive and negative terminals are unimportant in this demonstration as long as each is connected to a different wire.

   CAUTION: Make sure a proper contact is made with the wires on the precipitator. Have students stand 6 feet away from the apparatus when you are testing to avoid a possible electric shock. Use as low a voltage as possible. Too much voltage will cause a spark to other conductors in the immediate area.

F. Final rubber tube connection:

1. Attach a rubber tube to the end of each of the small glass tubes.
2. Attach the top rubber tube to the funnel using a short piece of glass tubing. Insert one end of the glass tubing snugly into the rubber tubing and the other end into the stem of the glass funnel. Secure it with tape. (Use a 1-hole stopper in the stem if you can find one that will fit.)
3. Attach the bottom rubber tube to the aquarium pump.

4 Demonstration of the electrostatic precipitator:

A. Place one self-igniting charcoal briquette* in an iron skillet. Take it outdoors to light it. When the flame has diminished and the briquette is gray in color, carefully carry the iron skillet back to the location of the electrostatic precipitator. CAUTIONS:
(1) A flaming briquette will melt rubber tubing.
(2) Too much smoke may activate smoke detectors close by, so be careful where you set up the demonstration.

*If you use a cigarette, you do not need to light it outdoors and may perform the experiment immediately.

1. Place the iron skillet close to the funnel. Place the funnel over the briquette, but do not set it flat in the skillet. Allow some air to enter the funnel to keep the briquette burning. Turn on the pump, adjusting it to obtain an even flow of smoke. The pump may also be adjusted to give different rates of smoke uptake.
2. Run the model for 10-15 minutes without the power supply to the electrostatic precipitator on. This serves as a control observation.
3. Plug in the power supply and run the model for another 10-15 minutes.
4. The expected effects after the power supply is turned on are (1) less smoke coming from the pump and (2) particulate matter sticking on the inside of the glass tube.
5. Optional suggestions for demonstration:

a. Use a small table top grill or hibachi instead of a skillet. Set the funnel on the cooking surface, above the briquette; this will allow the briquette a ready air source.

b. Because you will need smoke from the briquette for 20-30 minutes, use 3 or 4 briquettes lighted at slightly different times to keep up a steady volume of smoke. When one dies down, it can be replaced by another.

c. Another clear glass funnel (or some transparent, but not airtight, container) can be placed on the outlet valve of the pump to slow dissipation of the smoke, enabling the students to see even more clearly how the electrostatic precipitator reduces the amount of smoke (particulate matter).

5 Review the function and purpose of the electrostatic precipitator. Share with the students the illustration “Coal-Fired Generating Plant,” and have them identify the anti-pollution devices and what they do. NOTE: The illustration may be used as a master for a transparency or may be copied for distribution to the students.

Extended Learning

- Have the students compare power plants using different energy sources: fossil fuels, hydropower, and nuclear power. What are the pollutants produced by each different energy source? Which type of power plant contributes the most to air pollution? Why?
- Arrange a field trip to a coal-fired power plant. If this is not feasible, a person in a related profession could be asked to speak to the class.

Acknowledgments

Adapted with permission from the Air and Waste Management Assocation Environmental Guide (ERG) - Air Quality, Grades 6-8, copyright 1991; Air & Waste Management Association, Pittsburgh, PA 15222.

Resources

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“Using a Model Electrostatic Precipitator.” Chemistry Supplements for Pre-High School Classes. Madison; University of Wisconsin, 1985.

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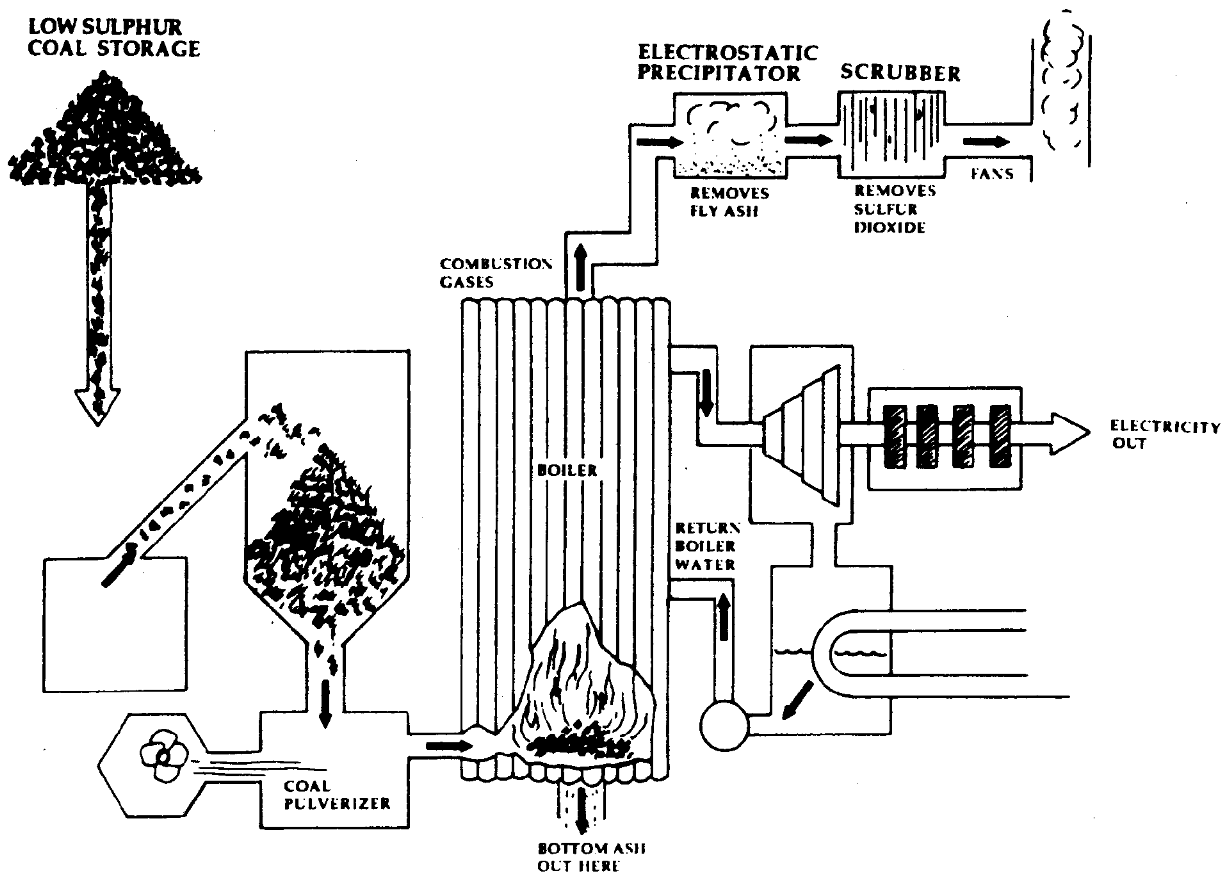


Coal-Fired Generating Plant

Hazy Days

Subjects: Social Studies, Driver's Education, Health Education

Grades: 8-12

Teaching Time: Two or three 45-60 minute periods

Focus: Industry, Cars, Wood Stoves, Health, Economic Growth, Recycling

Rationale

The causes and effects of air pollution are varied and complex. Solutions to pollution problems require a thorough understanding of this complexity and a willingness to engage in creative problem-solving.

Learning Objectives

Students will:

- Demonstrate understanding of the complexity of air pollution issues by examining them from the perspective of a person involved in and affected by the issue.
- Problem-solve with people of diverse points of view to find mutually acceptable solutions.

Teacher Background

In order to reap the considerable critical-thinking benefits of an activity such as this, students should already be familiar with the basics of air pollution: pollutants from cars, from outdoor burning, and from industry, and their environmental and health effects. If this is the only activity you plan to do from this curriculum, you might have students read a few of the more comprehensive Focus Sheets in the Appendix to gain necessary background information.

Roles for 26 students have been provided; you may need to add or delete a few depending on your class size. You may find that you'll need to help individual students to understand the role they are portraying and the issues they represent in the community.

Materials

- Copy of "Mount Fairbanks" for each student
- Role description and questionnaire for each student
- Copy of "Commissioners' Questionnaire" for the commissioners
- Several copies of Focus Sheets from the Appendix

Learning Procedure

1 Hand out copies of "Mount Fairbanks." Have students read it silently, or read it aloud together. Explain to the students that they will each be assigned a role to play in developing testimony for the county hearing on the permit for the paper recycling plant.

2 Hand out role descriptions and questionnaires to the students. Give them ten minutes to read and fill out the questionnaires. Give the three commissioners a copy of the "Commissioners' Questionnarie" to fill out together.

3 Designate one side of the room for people who will be urging the commissioners to issue the permit, and the other side for those who want them to refuse. Each group's meeting should begin with introductions of the members and brief summaries of their views on the permit issue. Then the group must discuss the situation and develop a yes or no position or statement and choose three people to testify on their behalf at the hearing. Emphasize that everyone must give their input to make sure that this testimony includes all the important reasons why the commissioners should vote for/against the permit. Students may need to do some research in order to write convincing and accurate testimony. Members of the "For" group need to keep in mind the state law that prohibits increasing net air pollution levels. Make sure that copies of the Focus Sheets listed in the "Materials" section are available to them.

4 Set up a time for the hearing that allows sufficient time for preparation of the testimony. Try allowing 45-60 minutes of preparation time initially, and then adjust as necessary. The time required may vary substantially from group to group. Preparation time could be a homework assignment.

Hearing Format

- "Hearing Facilitator" (the teacher or one of the commissioners) calls the hearing to order, explains the reason for the hearing, and describes how it will progress.
- Speakers for the "For" and "Against" groups alternate giving testimony, with three speakers testifying on each side. After each speaker, the commissioners have an opportunity to ask that speaker questions about the testimony.
- After all designated speakers have testified, other county residents have a brief opportunity to add a comment or ask a question.
- The Hearing Facilitator asks each commissioner for her/his vote on the issuance of the permit for the paper recycling plant. At least two commissioners need to vote "yes" for the permit to be issued. Commissioners are free to add "contingencies" to the permit — things that must happen in order for the permit to be given final approval — but for a contingency to stick, it must be approved by at least two of the commissioners.

Mount Fairbanks

Mount Fairbanks is a beautiful, snow-capped peak, one of the highest mountains in the Oceanic Range. A National Park and a destination for tourists from around the country, Mount Fairbanks is also well-loved and much visited by those who live in the cities and towns an hour or two away. Hiking trails and campgrounds abound, as do opportunities for fishing, skiing, snowshoeing, and bird watching. One road extends about halfway up the mountain and receives a steady stream of traffic on summer days and winter weekends.

Two cities (Alandale and Glenmore) and several small towns lie within an hour of Mount Fairbanks. The cities are connected by a freeway that becomes quite congested during rush hour. While each city has its own mass transit system, there is little public transportation between the cities.

The economies in the cities and towns near Mount Fairbanks have flourished because of the area's rich resources. An aluminum plant takes advantage of cheap electrical power; the abundance of timber supports two pulp mills; a coal mine produces enough soft coal to power a small electrical plant. These industries employ many people. The tourist industry is an important contribution to the local economy. Visitors to the mountain support motels, restaurants, shops, and guide services. Several electronics firms have located in the area because it is a wonderful place to live, so they have no trouble attracting and keeping highly qualified people. These residents stimulated the development of many small businesses, including clothing and grocery stores, gas stations, dry cleaners, and auto repair shops. The abundance of jobs and the natural beauty encourage a healthy real-estate market, with property values rising especially quickly for housing with a view of Mount Fairbanks.

Recently, concerns have been raised about air quality in the Mount Fairbanks area. In the past, the air was often hazy on cold days when many people used their wood stoves; now, visibility is poor on many days during any season. Doctors are seeing more people with respiratory illnesses. Naturalists in the Mount Fairbanks National Park have documented a decline in the number of young trees in the forests, and some yellowing of mature trees, as well as slightly increased acidity in lakes. Some sport fishermen say that there seem to be fewer fish in area lakes and streams. Realtors complain that it is becoming harder to sell homes with a mountain view that is increasingly smoky.

Research shows that the air pollution in the Mount Fairbanks area has several causes: motor vehicles contribute 57%; industries are responsible for 14%; wood stoves and fireplaces cause 10%; and the rest is produced by a variety of sources, primarily off-road vehicles, recreational vehicles, lawnmowers, and the like.

Paper Again, an international paper company, has just proposed the construction of a state-of-the-art paper recycling plant, the largest in the nation, in the Mount Fairbanks area. The planning team for *Paper Again* has located and put a deposit on a site for the plant, and is now seeking a permit from the county. While many area residents welcome the new jobs and economic opportunities such a plant would bring, others are concerned about adding to the pollution problems that already exist and wonder if the area really needs to add another large industry. Pollution monitoring from other paper recycling plants shows that this plant would increase air pollution in the area. The three county commissioners are already being besieged by residents wanting to meet with them to argue either for or against issuing a building permit for the new plant. They have decided to hold a hearing on the issue, and will decide on the permit after this hearing.

The commissioners must act in accordance with a state law that says that a new industry or activity in an area cannot negatively impact the air quality unless other steps are taken to compensate for it (by reducing other existing causes of air pollution).

Roles

County Commissioner #1:	You are a long-time resident of this area. You are an avid fisherman and birdwatcher.
County Commissioner #2:	You moved to this area seven years ago to work for the aluminum plant. Your 3-year old son has asthma.
County Commissioner #3:	You have lived in the largest city in the area for the past twenty years, but have recently bought a house (with a view of Mount Fairbanks) in the more rural part of the county. You own a dry cleaning business.
Owner, Shamrock Realty:	
Owner, Burn-Rite Wood and Pellet Stoves:	
Planner, County Transportation Department:	
Owner, Spiffy Auto Painting:	
Chief Executive Officer (CEO), Paper Again:	
Chief Executive Officer (CEO), Fairbanks Coal & Power:	
Chief Executive Officer (CEO), Liteline Aluminum:	
Chief Executive Officer (CEO), Presto Pulp Mill:	
Owner, Fred's Food Giant:	
President, Industrial Workers' Union:	
Owner, Build-It Home Construction:	
Owner, Brook's Bikes:	
Owner, Gary's Gas Mart:	
President, Mt. Fairbanks Hiking Club:	
Superintendent, Mount Fairbanks National Park:	
Owner, Fishing Fun Bait and Tackle Shop:	
Owner, Mounthaven Hotel:	
Outdoor Guide, Fairbanks Guide Service:	
Family Practice Doctor, Mount Fairbanks Clinic:	
Superintendent, Fairbanks Regional School Dist:	
Owner, Sunspot Heating and Air Conditioning:	
Executive Director, Alandale Public Transit:	
Director, County Solid Waste Program:	

Commissioner’s Questionnaire

Your Name:____

Your Role: ____

1. Given your described situation, what might be some benefits to you and to the county of having the *Paper Again* paper recycling facility locate in your area?

2. What might be some negative impacts to you or the county of having the plant in your county?

3. How might you resolve this issue in a way that will benefit and protect human health and the environment? What might be some economic drawbacks to the community?

Role Questionnaire

Your Name:____

Your Role: ____

1. If the *Paper Again* paper recycling plant were to locate in your county, what would be the benefits for human health and the environment? How might you benefit?

2. If the plant located here, what negative effects on human health and the environment might result? What might be some negative impacts on you or your business/profession?

3. In what ways might you or your business be able to reduce air pollution in the Mount Fairbanks area?

Cars and Pollution

Cars and Pollution
Motor vehicles, including cars, trucks, and buses, are the largest source of air pollution in Washington State. They account for about 57 percent of the air pollution in Washington State (see p. 1 for pie chart). The three major pollutants that result from the burning of gasoline (a carbon-based fuel) in a car's engine are carbon monoxide, ozone (smog), and particulate matter. Car exhaust also emits carbon dioxide which adds to the global warming problem and contributes to acid rain (from oxides of nitrogen). Ozone pollution results from hydrocarbons and oxides of nitrogen, plus sunlight. In addition, cars and trucks stir up particles of dirt, especially on dirt roads, which add to particulate pollution.

Newer cars are equipped with catalytic converters and other devices that "clean" exhaust fumes. Cars today produce about 90 percent less pollution than cars did 20 years ago. Unfortunately, however, Americans (and Washingtonians) are driving their cars so much more that pollution isn't decreasing as fast as it might. People are driving more and they are driving in vehicles by themselves (single occupant vehicles or SOVs).

Ways that federal and state governments have been working to reduce air pollution from cars include:

- Reformulating gasoline so it produces less pollution,
- Developing cars that run on other fuels[1],
- Inspecting and repairing polluting vehicles,
- Encouraging people to drive less and drive with other people, and
- Linking improved air quality to transportation planning.

Alternative fuels and reformulated gas are not addressed in any activity, but information on these topics appears in the Appendix.

What can you and your students do?

Carpool

Combine errands, so you take fewer trips

Keep your car tuned

Keep the gas cap sealed

Replace the air filter regularly

Walk, bike—get out of your car!!

Warm up your car by driving slowly for a few minutes rather than letting it idle

Keep tires properly inflated

Decrease pollution from other motorized appliances. Use a push mower instead of a power mower!

Emission Check Program
In Washington State, we have a vehicle emission check program in counties where carbon monoxide or ozone pollution is a problem (Clark, King, Pierce, Snohomish, and Spokane counties). Emission inspections help curb pollution by identifying the vehicles generating the most pollution and by requiring their owners to make the necessary repairs to meet emission standards. Vehicles must pass an emission test before license tabs are renewed.

For more information on cars and air pollution, see Focus sheets in the Appendix:

1. Transportation Demand Management: Commute Trip Reduction, #FA-92-17
2. Vehicles: Air Quality and Your Health, F-AIR-93-25
3. Benefits of Washington's Emission Check Program, # F-AIR-93-26
4. Emission Check Program Areas, #FA-93-18A
5. Oxygenated Gasoline, #FA-93-37
6. Alternative Motor Vehicle Fuels, #FA-92-18

[1] A study by the Washington State Energy Office has concluded that no fuel is inherently clean. Even alternative fuels such as natural gas produce pollutants and need devices to "clean" their exhaust. Electric cars produce pollution at the site where the electricity is generated.

Count the Cars!

Subjects: Science, Math, Social Studies
Grades: 5-12
Teaching Time: Two 30-minute periods
Focus: Traffic, Car Pooling, Single Occupancy Vehicle

Rationale

Cars produce more than half of all air pollution. Many people drive alone, increasing air pollution by increasing the number of cars on the road.

Learning Objectives

Students will:

- Become aware of the number of people who drive alone.
- Understand traffic and pollution problems from cars.
- Present data in graph form

Teacher Background

Vehicles account for about 57% of the air pollution in Washington State. Most people drive to work alone. The state's Commute Trip Reduction program is trying to get people to carpool. It requires employers of 100 people or more in Washington's eight largest counties to offer programs that encourage alternatives to driving to work alone. However, up to 75% of the auto trips made each day are for errands, day care, and sporting events. It's often hard to fit these relatively short, frequent trips into a carpooling or transit plan.

See Resource list below for related Focus sheets. Also see introduction to this section p. 47.

Materials (per group)

- Pencils
- Graph and/or poster paper
- Traffic count survey form

Pre & Post Test Questions

1. What percentage of vehicles have only one occupant? (Estimate before activity; verified by survey results)

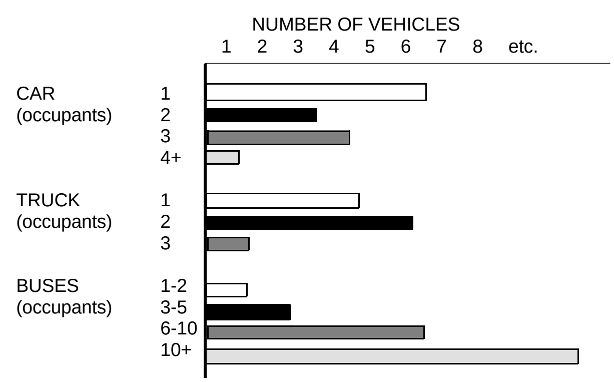
2. What effects would lowering this percentage have on traffic and pollution? (There would be fewer cars on the road, and less pollution in the air.)

Learning Procedure

1 Find a location near the school where traffic passes frequently that is also safe for students to observe traffic - preferably two sites, one on each side of the road. If your class is large, it would help to recruit parent volunteers so that several smaller groups of students could do the survey. Alternatively, small groups could go out for ten minutes at a time while the rest of the class works on something else, or the surveys could be assigned as homework.

2 Using the traffic count survey form p. 51, have students record the number of vehicles that pass during a 10-minute period and how many people are in each one. If a bus passes by, have them count or estimate the number of people on the bus.

3 Have the students make a bar graph to show the results using the type of vehicle and the number of people inside. Have them determine the average number of vehicles and people inside each vehicle. Ask students to estimate how many people, cars, trucks, buses, etc. would pass along that street every day. Also have them predict how the volume of traffic might change over the course of a day, by day of the week, or on a holiday.



4 Ask students to jot down:

- What these numbers tell us. (Lots of cars with only one occupant.)
- What we could do to reduce the number of vehicles on this road. (Encourage carpooling, bicycling, walking, more convenient bus service or use of existing services, telecommuting, light rail trains.)

5 Survey students on the following and discuss the results:

- How many cars does your family have? How many drivers?
- How do you get to school?
- If you go by car, is there another, less polluting option you'd be willing to try? (walking / biking may not always be a safe option.)
- How often is each car tuned up? Tire pressure checked? Oil changed?

Resources *(See Appendix)*

Ecology Focus sheets:

1) Transportation Demand Management: Commute Trip Reduction, #FA-92-17
2) Vehicles: Air Quality and Your Health, #F-AIR-93-25
3) Benefits of Washington's Emission Check Program, #F-AIR-93-26

"Facts about Smart Commuting" from Partners for Smart Commuting

Traffic Count Survey

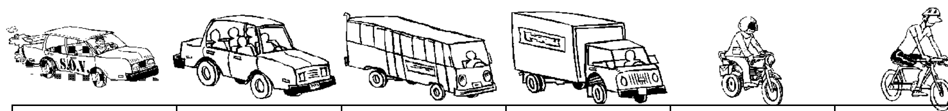
Use tally marks for single occupant vehicles (卌); record high occupant vehicles (cars, buses, commercial trucks, motorcycles, and bicycles) with the estimated number of occupants (2, 3, 2, 9, etc.).

Name:________________________________

Date:________________________________

Time: ________________________________

Location: ______________________________



	SOVs (Single Occupant Vehicles)	HOVs (High Occupant Vehicles)	Buses	Commercial Trucks	Motorcycles	Bicycles
Total Occupants						
Total Vehicles						
Average Occupants Per Vehicle						
Percent of Total Vehicles						

Where Do We Go?

Subjects: Math, Social Studies

Grades: 3-12

Teaching Time: 15 minutes to explain at beginning of week; one hour at end of week (To do in conjunction with Activity "Oil Smart," p. 61; do in March, Oil Smart month)

Focus: Transportation, Single Occupancy Vehicles, Alternative to Cars

Rationale

We all contribute to air pollution through the choices we make every day. Cars contribute more than half of the air pollution in Washington State.

Learning Objectives

Students will:

- Become aware of their families' driving patterns.
- Understand how we all contribute to air pollution.
- Explore alternatives to single occupancy vehicles.
- Understand how transportation planning can address air problems.

Teacher Background

In this activity, students are looking at their own families' transportation habits and examining possibilities for changes that would reduce air pollution. They will also be looking at how planning for new development in their communities handles transportation demand. You should be able to get a copy of your county's comprehensive plan from the county planning department. You may need to extract and rewrite the important elements for younger students.

Transportation is addressed at the federal, state, and local government levels. When states request federal money for highways, they must prove that these new or widened roads will not increase air pollution levels. "HOV lanes" (special lanes for "high-occupant vehicles," or vehicles with two or more people) are one way of decreasing traffic congestion without necessarily increasing pollution.

Washington State law (Clean Air Washington Act) requires companies with 100 or more employees to submit a "commute-trip reduction" plan to decrease the number of people driving to work alone. Employers have developed a variety of strategies to encourage people to car pool, bike, walk, use mass transit, or telecommute.

County comprehensive plans now must include a transportation element, too, that determines a level of transportation service for each area and then insures that land use plans are consistent with that level of service. If a proposed development would negatively impact the level of service (for example, an apartment complex would increase traffic in an area), the county must insure that transportation improvements or strategies are made to compensate for it (for example, increased mass transit or a ride share program, etc.).

Materials

- Pencils
- Travel log
- Graph and/or poster paper
- Copy of the Growth Management Plan for your county

Pre & Post Test Questions

1. How do we all contribute to air pollution? (We drive or ride in vehicles that pollute.)

2. How much air pollution comes from cars and other motor vehicles? (Over 50%)

3. What alternatives are there to driving a car? (Carpooling, mass transit, biking, walking)

4. What is transportation planning? How can people influence it? (Planning for roads, traffic, etc. Comment on local comprehensive plans, attend public meetings)

Learning Procedure

1 Have students record for one week on the travel log provided how they and their families get around to various activities (school, work, sports, errands, store, etc.).

2 Using the information collected, have the students make individual and class charts on various types of transportation, how often it is used, how many people in the family use it, how many times there is more than one person in a vehicle, where they are going, distance traveled per trip, number of errands per trip, etc.

3 Have students break into small groups to discuss and record group answers to the following:

- Why do we use our cars so much?
- What is it about cars that make them status symbols?
- What alternatives are available to us?
- What would be some of the difficulties in giving up a car, or not using it so much?
- What would be some of the benefits?

Share group answers with the large group.

4 Look together at your county's Growth Management Plan. Discuss how much it could improve possibilities for mass transit. Share your ideas with county commissioners.

Extended Learning

- See Activity, "Oil Smart," p. 61.
- For extra credit, have students follow up in small groups or with their families by reviewing their travel diaries and noting where miles could be saved with slight alterations in schedules/convenience. They could develop a new "family transportation plan" and calculate the saved miles.

Acknowledgments One Less Car Program, Bellevue, Washington.

Family Travel Log for One Week:
"Where Do We Go?"

Student Name: ____

Week beginning ____

And ending ____

Instructions:

Try to sit down with your family each evening to remember all the places each one of you went during that day and how you got there. Then record this information in the chart.

For instance, if Mom goes to work on Monday, fill that in under "Day." List "work" under "Destination" and "Mom" under "Who went?" If she took the bus both ways, put "2" under "City bus" and "2" in "Total trips." Then **estimate** the number of miles she covered in those two trips.

If you rode your bike to school both ways, list your name under "Who went?" and "2" under "Bike" and "2" under "Total trips." Again, estimate the number of miles you covered. If you took the school bus one way, then walked home, everything else would be the same, but you'd list "1" under "School Bus" and "1" under "Walk."

Note that unless there were more than two in the car, that trip counts as "Single Car" for the purposes of this survey, since you're not really "saving a car trip" by riding with your parent.

When you're done, fill in the totals. Then bring your log to school to compare your family's travel habits with those of your classmates' families.

TRAVEL LOG										
DAY	DESTINATION	WHO WENT?	SCHOOL BUS	CITY BUS	3+CAR POOL	SINGLE CAR	BIKE	WALK	TOTAL TRIPS	TOTAL MILES

TRAVEL LOG

DAY	DESTINATION	WHO WENT?	SCHOOL BUS	CITY BUS	3+CAR POOL	SINGLE CAR	BIKE	WALK	TOTAL TRIPS	TOTAL MILES

Sock Your Exhaust

Subjects: Science, Health
Grades: 5-12
Teaching Time: One hour
Focus: Motor Vehicle Pollution (Particulate Matter)

Rationale

Motor vehicles contribute more than half of the air pollution in Washington State. Older vehicles usually produce more pollution. It is important to keep cars tuned up so they produce less pollution.

Learning Objectives

Students will:

- Understand that pollution comes from motor vehicles.
- Identify which vehicles produce less pollution.
- Know the health effects of the 3 pollutants that come from motor vehicles.

Teacher Background

Cars are the main source of air pollution in Washington State and around the country. There are three main pollutants from cars: carbon monoxide, particulate matter, and ozone (a component of smog). Ozone is not directly emitted from cars, but is formed when two other chemicals, hydrocarbons and oxides of nitrogen, react in the presence of sunlight.

In this lesson white socks are put on the exhaust pipes of several different cars to give a visual idea of the particulate matter coming from these cars. Since newer cars pollute less than older cars, it is important to have older cars (pre-1982) and trucks to compare with newer ones. Diesel vehicles produce less carbon monoxide than other vehicles, but more particulate matter. It is a good idea to include diesel cars and trucks in your lesson. If cars are too new all the socks will be white and no comparison can be made.

This lesson gives a graphic example of particulate matter pollution from older and/or diesel cars and trucks. This is because it is relatively easy to capture particulate matter from an exhaust pipe. The other pollutants are not as easily visible. Particulate matter, however, is not the most important pollutant from cars. It is therefore important to emphasize all three pollutants (particulate matter, carbon monoxide and ozone). For activities on the other pollutants, see "Leaf Me Alone," p. 7, for an examination of the effect of exhaust on plant growth and "Smog," p. 65 for a graphic model of ozone pollution. See the Focus sheets on the individual pollutants listed in the "Resources" section and found in the Appendix.

Materials (per group)

- Several different types of motor vehicles - school bus, car, truck, van, motorcycle, etc. Be sure to have at least one diesel vehicle and vehicles of different ages. If possible, have a maintenance schedule for each vehicle (last tune up, oil change)
- White tube socks
- Oven mitts
- Big, wide rubber bands
- Sensitive scale

Pre & Post Test Questions

1. Do all motor vehicles produce the same amount of air pollution? Which ones would produce the most pollution? (No, older ones produce more pollution; so do vehicles needing a tune-up.)

2. What pollutants are released by motor vehicles? (Particulate matter, carbon monoxide, and hydrocarbons and oxides of nitrogen [which form ozone])

3. Which are the health effects of vehicle emissions? (Particulate matter penetrates into lungs, causing structural and chemical changes. Carbon monoxide interferes with the body's ability to supply tissues with the oxygen they need to function. Ozone can irritate breathing passages,

reduce resistance to lung infections, and worsen existing conditions, such as asthma, bronchitis, and emphysema.)

Learning Procedure

1 Before doing this activity with your students, find an older vehicle (1960s, if possible) to compare with newer vehicles. Ask your local high school if any students have an old car you can use. Try out the activity first to make sure that the socks will collect enough particulate matter to show a difference between vehicles. Also check the weight of the socks before and after collecting the exhaust to see if there is a significant difference.

2 Using the diagram on p. 59, explain briefly how an engine works, and what pollutants are produced by it.

3 Label each sock for a particular car. Weigh each sock and record its weight.

4 Let vehicles cool down for several hours, if possible. Have students put one sock over each tailpipe with the rubber bands. Make sure the vehicle's emergency brake is on and students are standing in a safe place (driveway, parking lot, sidewalk--not in street). The driver should have the window open.

5 Turn on the engine. After five minutes turn off the engine. Use oven mitts to remove the socks from the tailpipe. Don't touch the tailpipe–it's HOT! While students wait, have them note down the maintenance record for the vehicle.

6 Have the students weigh the socks again. The difference in weight is the amount of particulate matter collected.

7 Have the students turn the socks inside out and display them on the bulletin board. Label each to describe the type of vehicle and fuel used.

8 **Ask:** Which vehicle had the most pollution? (Usually the oldest or one that needs a tune-up.) Explain that the sock is capturing only some of the particulate matter from the vehicles. Carbon monoxide, hydrocarbons, and oxides of nitrogen were also produced, but aren't visible on the sock.

9 Explain health effects of each pollutant.

Extended Learning

- A field trip to an emission test station, if there is one in your area, would enhance this activity.

Resources

1) Washington State Energy Office has produced a chart on the relative emissions of different cars. It is attached.
2) Ecology Focus sheets (in Appendix)
   a) Emission Check Program Areas, #FA-93-18A
   b) Motor Vehicle Emission Check Program, #FA-92-31
   c) Major Air Pollutants: Particulate Matter, #FA-92-29
   d) Major Air Pollutants: Ozone, #FA-93-07
   e) Major Air Pollutants: Carbon Monoxide, #FA-92-132
   f) Vehicles, Air Quality, and Your Health, #F-AIR-93-25

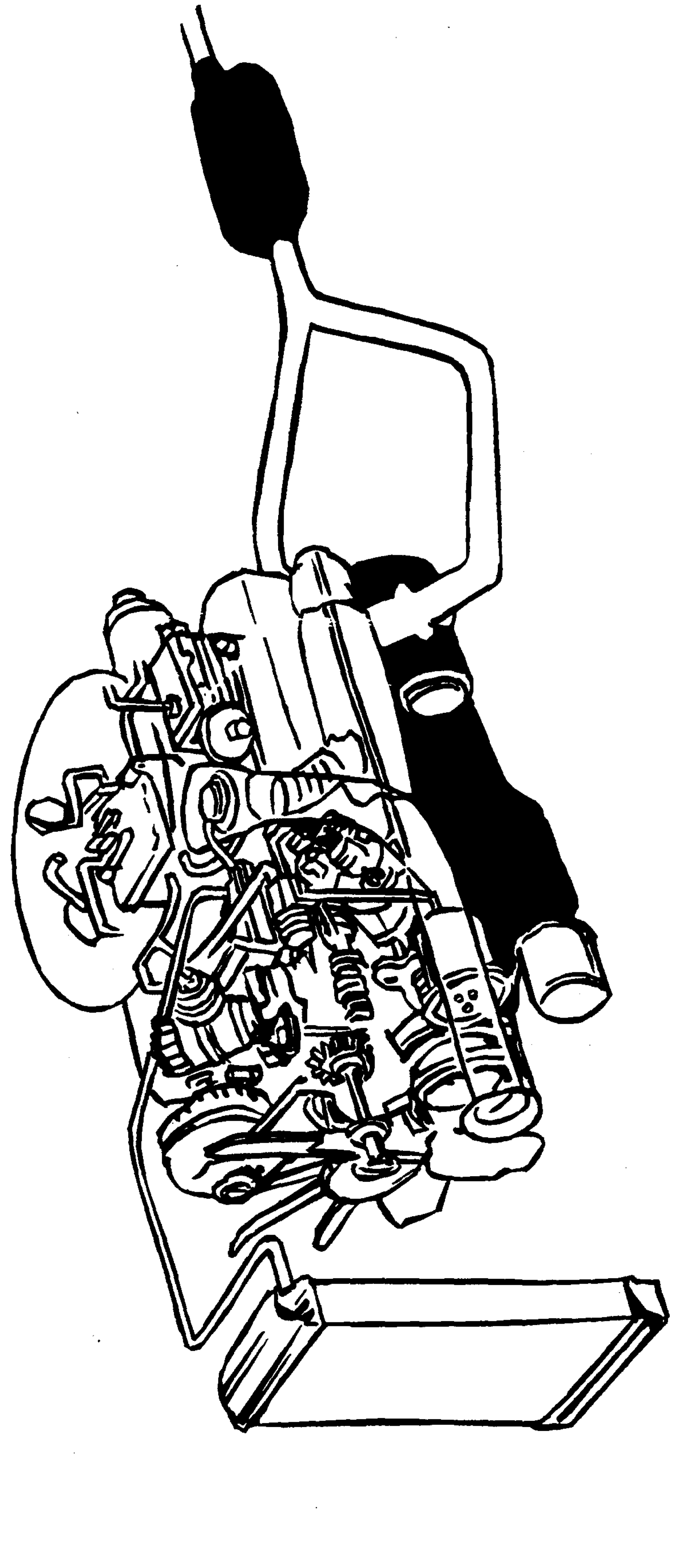


Table 5-2

Average HC, CO, and NOx Emissions For Each Vehicle Class

Class	Description	# Vehicle Tests	HC Emissions (grams/mi)	CO Emissions (grams/mi)	NOx Emissions (grams/mi)
1	AUTO, 2-SEATER/SPORT	63	0.15	1.18	0.27
2	AUTO, MINI-COMPACT	59	0.17	1.50	0.20
3	AUTO, SUB-COMPACT	348	0.17	1.34	0.25
4	AUTO, COMPACT	308	0.17	1.38	0.22
5	AUTO, MIDSIZE	152	0.17	1.40	0.25
6	AUTO, FULLSIZE	45	0.18	1.69	0.29
7	UTILITY, SPORT	36	0.17	2.16	0.19
8	UTILITY, COMPACT	89	0.21	2.08	0.31
9	UTILITY, FULLSIZE	15	0.26	2.62	0.73
10	UTILITY, CARRYALL	4	0.40	5.28	0.33
11	VAN, COMPACT	59	0.20	1.83	0.30
12	VAN, FULLSIZE	48	0.29	2.84	0.72
13	PICKUP, SMALL	161	0.21	2.36	0.22
14	PICKUP, 1/2 TON	102	0.29	2.32	0.67
15	PICKUP, 3/4 & 1 TON	29	0.36	3.32	0.74
16	PICKUP, CAB/CHASSIS	7	0.19	1.99	0.31

From WSEO: A Low Emission Vehicle Procurement Approach for Washington State, June 1992

Oil Smart

Subjects: Social Studies
Grades: 8-12
Teaching Time: Several class periods during the month of March
Focus: Alternatives to Single Occupancy Vehicles, Air Pollution

Rationale

We can all learn to use our cars less to reduce air pollution.

Learning Objectives

Students will:

- Identify several alternatives to single occupant vehicles.
- Conduct, tabulate, and analyze the results of a survey.
- Explore the relationship between incentives and behavior change.
- Design and implement a trip reduction program for the school/community.

Teacher Background

"Oil Smart Wednesdays" is a statewide campaign to encourage people to use an alternative to driving alone to work on the Wednesdays in March. It has been in existence since 1991.

Materials

Oil Smart materials available from county, city, local environmental groups, and local air pollution control authorities.

Pre & Post Test Questions

1. What are four alternatives to using a single occupancy vehicle? (Carpooling, using mass transit, walking, biking)

2. What incentives do people need to use their cars less? (Answers will vary)

Learning Procedure

1 Have students survey or interview students and staff about their driving habits. (A sample format follows, but you may want to design your own together.)

2 Have students collate and analyze the information collected.

3 Ask students to develop strategies for reducing the use of SOVs (single occupant vehicles) among staff and students. These are called, "trip reduction plans." Depending on your results, you may want to focus on commuting to/from school, non-commuting trips or both. Keep in mind that the goal is to reduce the number of SOVs.

4 Implement your trip reduction plans! Be sure to include incentives for people to change their habits. Some ideas that have worked in the past are special class participation awards or designated parking spaces. Publicizing the cost savings can also help.

5 A follow-up survey can help you assess your impact and plan for next year.

Staff and Student Survey / Interview

1. How do you normally get to school?
   ___ Walk ___ Bus ___ Bicycle ___ Drive Alone
   ___ Carpool (drive/ride with someone else who attends this school)
   ___ Driven alone by person who does not attend the school

2. Outside of commuting to and from school, what are the two most frequent places to which you travel, and how do you get there?

   A. Place *(choose one)* Mode of Travel
   (choose one) Times/Week

Place	Mode of Travel	Times/Week
___ Work	___ Walk	___
___ Shopping	___ Bus	___
___ Sports/Other Practice	___ Bicycle	___
___ Visiting Friends	___ Carpool	___
___ Special Events	___ Drive Alone	___
___ Doctor/Dentist Appointment		
___ Other (Specify ____________)		

   B. Place *(choose one)* Mode of Travel
   (choose one) Times/Week

Place	Mode of Travel	Times/Week
___ Work	___ Walk	___
___ Shopping	___ Bus	___
___ Sports/Other Practice	___ Bicycle	___
___ Visiting Friends	___ Carpool	___
___ Special Events	___ Drive Alone	___
___ Other (Specify __________		

3. What kinds of incentives would be most likely to encourage you to change your driving habits? Check all that apply.
   - ___ Money
   - ___ Recognition
     - ___ Media (newspaper, television)
     - ___ School newspaper
     - ___ Award Ceremony
   - ___ T-Shirt
   - ___ The knowledge that I'm contributing to a healthier environment
   - ___ Free bus pass

Ad It Up!

Subjects: Science, English, Art, Social Studies
Grades: 3-12
Teaching Time: One or two 40-50 minute class periods
Focus: Single Occupancy Vehicles

Rationale

Advertising affects the choices we make. Ads can help convince people to use means other than driving alone to get around.

Learning Objectives

Students will:

- Describe connection between single occupancy vehicles (SOVs) and air pollution, and between advertising and behavior.
- Create ways to convince people to carpool, use mass transit, bike, or walk.

Materials

- Magazines
- Poster paper
- Markers, crayons, etc.

Pre & Post Test Questions

1. How do SOVs impact air pollution? (More cars on the road, more air pollution)

2. What are strategies that advertisements use to change our behavior? (Answers will vary.)

Learning Procedure

1 Discuss with students the impact of SOVs on air pollution. (see Activity, "Oil Smart," p. 61.)

2 Have students look through magazines and mark effective advertisements, noting down what made each ad effective. Then put students in groups of 3 - 5. Each member of the group should share the ads s/he found effective and discuss what strategies the advertiser used.

3 Ask students to, individually or in groups, create an advertisement for decreasing SOVs and/or increasing carpooling, mass transit, biking, walking, etc.

4 Display these ads in the school or local businesses. You may want to try to have some put on the side of a local transit bus, billboard, or grocery store bag.

Extended Learning

- Have students create radio and television commercials, or music jingles that encourage alternatives to SOVs

Smog

Subjects: Science, Health
Grades: 3-8
Teaching Time: 30 minutes
Focus: Cars, weather, health effects of air pollution

Rationale

Two pollutants emitted by motor vehicles react to form ground-level ozone or smog which can cause respiratory problems and reduce visibility.

Learning Objectives

Students will:

- Understand how "real" smog occurs.
- Understand the connection between vehicle use and smog
- Use a model of smog to learn about its appearance and behavior
- Know the health effects of smog

Teacher Background

When the sun heats two types of air pollutants (hydrocarbons and oxides of nitrogen), it causes a chemical reaction that produces ground-level ozone (O3), often called "smog" from a combination of the words "smoke" and "fog." (This ozone is different from the thin layer of atmospheric ozone that protects the earth from harmful ultraviolet radiation. See the Appendix for Focus sheet #F-A-93-07, "Ozone.")

Over two-thirds of the smog-producing pollutants come from vehicles; most of the rest come from smoke stacks and fumes from chemical solvents. Thermal inversions (see the activity, "Lighter Than Air") or a lack of wind can cause smog to be trapped over an area. In addition to reducing visibility, smog has effects on our health including irritation of the respiratory system; reduced resistance to lung infections; and aggravation of asthma, emphysema, and bronchitis.

In this activity, students will not create ozone smog, but rather a model of smog that will demonstrate what it looks like and how it behaves. It mimics the conditions that existed in London in the late 1800s, when the term "smog" was first used to describe the haze produced by the condensation of water vapor on soot particles.

Materials (for each group)

- Clean, dry wide-mouth canning or mayonnaise jar
- Heavy-duty aluminum foil (6" x 6" square)
- 2 - 3 ice cubes
- 6" x 2" strip of paper
- Matches
- Salt

Pre & Post Test Questions

1. What is smog and how does it occur? (Ground-level ozone haze; formed by sunlight causing a reaction between two gaseous air pollutants, hydrocarbons and nitrous oxide.)

2. How does vehicle use affect smog levels? (Over two-thirds of smog-producing chemicals come from vehicles.)

3. What are some of the health effects of smog? (Irritation of respiratory system; reduced resistance to lung infections; aggravation of asthma, emphysema, and bronchitis.)

Learning Procedure

CAUTION: Students will need close supervision with matches. This is perhaps done best as a demonstration with younger children. Be sure to have a fire extinguisher close at hand. DO NOT let anyone breathe the "smog," and release it outside when the experiment is over.

1 Ask students for examples of how sunlight can change substances (melt wax/plastic, fade colors, melt ice, cook food in solar cooker, etc.). Explain that sunlight also produces some changes that we are less aware of, including changing two of the pollutants that come from our cars into a gas that's harmful at ground level, ozone. Distinguish between the ozone layer that protects the Earth from ultraviolet radiation, and ground-level ozone, a harmful pollutant. Tell students that this ground-level ozone is called smog, and that today they will be making, not real smog, but a model of it to show what it looks like and how it acts.

2 Divide students into groups of 3-4. Have one person from each group fold the piece of paper in half lengthwise and twist it into a rope.

3 Other group members should make a snug lid for the jar out of the piece of aluminum foil. Be sure to make a slight depression in which the ice cubes can rest without sliding off. Remove the lid and set aside.

4 Have students put a little water in the jar, swish it around to wet the whole inside of the jar, and pour it out.

5 Have students light the paper rope with a match, and drop it AND the match into the moist jar. Then, QUICKLY put the foil lid back on the jar, seal tightly, and put the ice cubes on top of the lid. (This will make the water vapor condense.) Sprinkle a little salt on the ice to help it melt.

6 Students should watch what happens and be ready to describe it. Discuss how what you have observed is like real "smog" and how it is different. (Like: decreases visibility, produced by air pollution; Unlike: soot and water vapor are interacting in the model, rather than hydrocarbons and oxides of nitrogen and the smog isn't ozone.)

7 Ask students for times that they might have noticed decreased visibility due to smog.

8 Ask students how smog might/does affect their health. Tell them about the three main health effects of smog.

Air Pollution from Wood Stoves and Outdoor Burning

Wood Stoves and Outdoor Burning

In Washington State, about 10 percent of all our air pollution comes from wood stoves and 6 percent from outdoor burning (agricultural, forest slash, construction waste, yard waste). Together they are the second largest source of air pollution in the state. In the wintertime 80 percent of fine particulate pollution is from wood smoke. This pollution can be quite visible, since a large outdoor fire or a poorly maintained wood stove can emit plumes of smoke.

Wood Stoves

Nearly half of Washington's households have wood burning devices. Wood stoves and fireplaces can emit hundreds of times more pollution than other forms of heat such as natural gas, electricity, or oil. Pollution from wood stoves can greatly affect local neighborhoods in the wintertime. It takes just half the year for wood smoke to become Washington's third leading source of air pollution. A common feature of Washington's winter climate is stagnant air. Wood smoke does not disperse under such conditions, but instead is trapped near the ground and accumulates in the neighborhood air.

The smoke from wood stoves and fireplaces can cause serious health problems. Breathing air containing wood smoke contributes to cardiovascular problems, lung irritation and diseases, headaches, eye irritation, and allergic reactions. There are hundreds of chemical compounds in wood smoke, including many that are irritating and potentially cancer-causing. University of Washington studies show decreased lung function in both healthy and asthmatic children exposed to wood smoke in some Seattle neighborhoods.

Particulate matter (small matter that make up smoke and soot) may be the most insidious component of wood smoke pollution. Most of the particles are so small they can lodge in the deepest part of the lungs. There they can cause structural and biochemical changes. The federal government regulates particles called PM_{10}. These are particles that are less than one one-hundredth of a millimeter across (thousands can fit on the period at the end of this sentence). The Environmental Protection Agency (EPA) is now studying whether they should change how they regulate current particulate matter. It appears that the current PM_{10} standard may not be protective of human health.

Local air pollution control agencies have the authority to impose burn bans when stagnant air covers an area for several days. Under a Stage I burn ban, outdoor burning and the use of fireplaces and uncertified wood stoves are prohibited, unless a wood stove or fireplace is the only source of heat. A Stage II burn ban extends the ban to include certified wood stoves (unless they are the sole source of heat).

What can you and you students do to control wood stove pollution?

- Convert to other forms of heat. Upgrade your existing heating source with an efficient natural gas, propane, electric or oil furnace.
- Trade in your old stove for a newer certified or pellet stove or natural gas or propane stove or fireplace. Look for the words "EPA certified."
- Burn compressed sawdust logs or pellets. The compressed wood logs burn hotter and more completely than regular pieces of stick wood.
- Burn dry wood only. Dry your wood for six months or longer before burning it. Make sure your fire has plenty of air.
- Obey all burn bans

For more information on wood stoves, see these Focus sheets in the Appendix:

1. Particulate Matter, #FA-92-29
2. Controlling Wood Smoke Pollution, #FA-91-127
3. Episodes and Impairments, #FA-91-102

Outdoor Burning

Outdoor burning includes forest slash fires, agricultural burning, and open burning – the burning of home, yard, and construction waste. The Washington State Department of Natural Resources regulates forest slash fires. They are working to reduce forest slash fires by 50 percent by the year 2001. Farmers use fire to dispose of stubble left in the field after harvest and branches left after pruning. Burning is also used to control weeds and plant diseases and to clear rows and ditches. For certain crops, farmers use fire to increase crop production (seed grass). Open burning can be a problem when too many people burn their yard waste, especially in the summer and fall.

What can you and your student do to reduce pollution from outdoor burning?

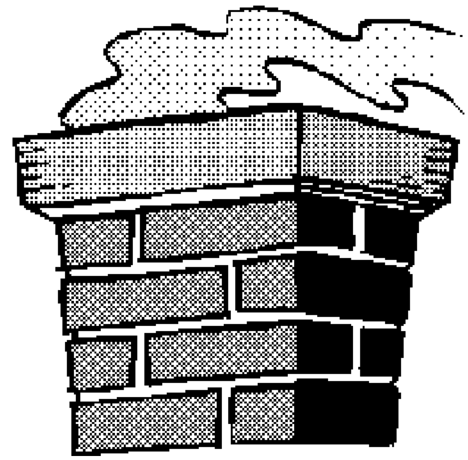
- Compost and chip yard waste. This will give you natural nutrients and mulch for your garden. Leave your lawn clippings in place to help retain moisture.
- Develop a landscape design that leaves trees and native plants in place.

For more information on open burning, see the following Focus sheets in the Appendix:

1. Open Burning, #FA-92-04
2. Open Burning: Prohibited Materials, #FA-94-04
3. Forest Slash Fires, #FA-92-14
4. Agricultural Burning, #FA-93-01

Chimney Chokers

Subjects: Science, Social Studies, Health
Grades: 2-12
Teaching Time: 45 minutes
Focus: Wood Stove Pollution, Wood Smoke



Rationale

Wood stove pollution can be a problem, especially in localized areas in the winter.

Learning Objectives

Students will:

- Identify wood smoke sources in their neighborhoods and near their school.
- Understand the connection between proper burning techniques and pollution.
- Understand the connections between air pollution (and wood stoves) and health.
- Design a program to educate neighbors on burning wood cleanly.

Teacher Background

Chimney smoke contains suspended particles and soot (called "particulate matter"). Particulate matter is potentially damaging to our health. The students will be breathing whatever is in that smoke. Dense, thick smoke contains more particles than smoke that you can see through. Dry, well seasoned firewood burned in a fire with adequate air supply should produce little smoke and only heat waves. Burning garbage, trash, household waste, and treated or painted wood will produce lots of unhealthy smoke. Using wood that is wet or green, or starving a fire for air (by closing the damper too much) will also create too much smoke.

If the smoke from a chimney is fairly clear and light - almost transparent - this means combustion is more complete with less particulate matter. In fact, the best thing is to see no smoke and only heat waves coming out of the chimney.

Your body cannot keep the smaller particulate matter out of your lungs. Tiny particles collect in the most remote portions of the lungs, the alveoli- air sacs where oxygen enters the blood stream. These small particles can damage the alveoli.

Pre & Post Test Questions

1. What does it mean if you can easily see smoke coming from a chimney? (Particulate matter pollution; poorly maintained fire)

2. Name three ways to decrease pollution from wood stoves. (Don't burn trash, use dry wood, give enough air to fire.)

3. Tell two ways air pollution can affect your health. (Damage to alveoli, asthma)

Learning Procedure

1 On a cool day in late fall or winter, walk around the neighborhood looking at wood stove chimneys for examples of smoking chimneys and clean burning chimneys.

2 Discuss with students the health effects of wood burning.

Ask students to share, if they wish, any respiratory health effects (asthma, bronchitis) they may have noted periodically that seem to be connected to air quality in general and wood smoke in particular.

3 Show and tell students the ways to reduce pollution from wood burning. Have them repeat these to each other to become familiar with them.

4 Design a community program to educate neighbors and/or other students about how to burn cleanly and why it's necessary. (See also "Wood Stove Case Study," p. 73.)

Resources

1) Ecology Focus sheet, Controlling Wood Smoke Pollution, FA-91-127 (in Appendix).

What Goes Up Doesn't Go Away

Subjects: Social Studies, Science
Grades: 3-12
Teaching Time: 30 minutes
Focus: Outdoor Burning, Composting, Yard Waste

Rationale

Outdoor burning of yard waste contributes about 6% to the air pollution in Washington State. Each of us can learn alternatives to burning such as composting and chipping.

Learning Objectives

Students will:

- Know the contribution of outdoor burning to air pollution.
- Know which materials (if any) can be legally burned outdoors in their locality.
- Know the alternatives to burning garbage/ yard waste.

Teacher Background

Burning of house waste (paper and garbage) is illegal at all times. It is also always illegal to burn construction waste. Burning of yard waste is illegal in some urban areas of Washington and regulated in others. Where it's allowed, it can be a problem when too many people do it. It produces carbon monoxide and particulate pollution that can cause health problems, as well as ozone pollution (smog) and a smokey haze that can block scenic views. This often happens in the summer and fall.

Materials

- Junk mail
- Milk carton
- Painted scrap wood
- Unpainted scrap wood
- Plastic milk jug
- Paper bag
- Cardboard
- Grass clippings (dry)
- Tree prunings

Pre & Post Test Questions

1. How much does outdoor burning contribute to air pollution? (6%)

2. What can legally be burned where you live? (Statewide - dry natural vegetation; clean, dry, untreated, unpainted wood. Local answers will vary.)

3. What can you do instead of burning it? (Compost, recycle, reuse materials, chip vegetation)

Learning Procedure

1 Display around the classroom the items listed under "Materials." Give each item a number.

2 Have students take a piece of paper and number it 1 - 9 (if you use all nine items suggested), with A) and B) for each number. Ask them to walk around to each item and by its number, write A) what the item is, and B) "yes" if it can be legally burned in their community, or "no" if it cannot.

3 When all students have finished, have them return to their seats. Tell them that of all these materials, only the grass clippings and tree prunings can be legally burned, and those only if they're dry, only in some areas, and only on some days. (Be aware in advance of regulations in your area, or have students contact their local air agency to find out what is legal to burn.)

4 Together make a list on the board of the alternatives to burning (chipping, composting, recycling, reducing by avoiding the product, landfilling, stopping junk mail – your name can be removed from direct mail lists by writing to Mail Preference Service.)

5 Hold up each item and discuss together which of the alternatives would work for that item.

Extended Learning

If your area has a Master Composting Program, invite a speaker from this program to talk with the class.

Resources

Ecology Focus sheets: (in Appendix)
1) Open Burning: Prohibited Materials, FA-94-04;
2) Open Burning, FA-92-04
3) Outdoor Burning: Legislative Changes, 95-1003-Air
See also publication #93-106, Sources of Information about Air Pollution in Washington State (in Appendix)

Wood Stove Case Study

Subjects: Science, Social Studies
Grades: 9-12
Teaching Time: One 45-minute period
Focus: Wood Stoves, Burn Bans

Rationale

Wood stove or fireplace smoke generally affects the neighborhood where it is produced. By studying a community where wood smoke is a problem, we can make some generalizations about the wood-burning public and devise ways to minimize this kind of pollution.

Learning Objectives

Students will:

- Understand and evaluate the pros and cons of wood burning.
- Develop strategies to promote the reasonable use of wood burning.

Teacher Background

Local air agencies have the authority to call burn bans when stagnant air covers an area for several days. Under a Stage One burn ban, outdoor burning and the use of fireplaces and uncertified wood stoves are prohibited, unless a wood stove or fireplace is the only source of heat. A Stage Two burn ban eliminates all indoor burning (unless it is the sole source of heat). (see FOCUS sheet: Episodes and Impairments, #FA-91-102.)

In the winter often there is no wind and no mixing of different layers of air. A layer of warm air can settle over an area and prevent the cooler air below it from rising. This is called a "thermal inversion." The lower layer with its pollution (often wood stove pollution) is kept close to the earth. It becomes increasingly dirty as more and more pollutants are released into it. A thermal inversion can combine with topography to make the pollution problem worse. For example, inversions often occur in valleys because air can get trapped in them. (see Lesson, "Lighter Than Air," P. 19.)

Materials

- Copy of Marysville Case Study and PSAPCA strategy for each student (p. 75)

Pre & Post Test Questions

1. Why do people burn wood for heat? (It can be less expensive.) What are some of the negative effects of this on air quality? (Wood-burning can cause particulate matter pollution.)

2. What weather conditions make a burn ban necessary? (Thermal inversion.)

3. How can people be encouraged to use their wood stoves responsibly? (Answers will vary.)

Learning Procedure

1 Have students read the study about wood smoke and Marysville. (Do not yet give them the strategy developed by the Puget Sound Air Pollution Control Agency, or PSAPCA.) Have them identify and list various interested parties who might take sides in the issue (e.g., residents who use wood stoves, residents who don't, doctors, asthma sufferers, wood stove dealers, electric utility representatives, natural gas utility representatives, PSAPCA representatives, etc.).

2 Ask the students to set up a discussion between parties that don't think a burn ban is fair and those who want to convince residents why a burn ban is sometimes necessary. This might be done by assigning students roles from the list they have developed. The class could be divided into two or three smaller groups for this; alternatively, one group that includes each of the interested parties could conduct a "fish bowl" discussion. In a "fish bowl" discussion, the role-players would sit in the center and discuss the issue while the rest of the class sits around the periphery to listen. Listeners may tap and replace role-players when they have a comment to make that would be "in character."

3 Have the students develop a plan to address the problem of wood stove smoke in Marysville. Then pass out the description of the PSAPCA response. Have them compare and evaluate the two ideas.

Extended Learning

Compare/contrast Marysville's approach to wood burning problems with approaches used in your area. It would also be interesting to find out what regulations and solutions people in other states have developed.

Resources

Ecology Focus sheets (in Appendix)

1) Controlling Wood Smoke Pollution, FA-91-127
2) Episodes and Impairments, FA-91-102

Marysville Case Study

In 1993, high air pollution levels in Marysville triggered several burning bans when people were not allowed to use their wood stoves for heat. Many residents were upset by this as electricity is expensive in Marysville. The local newspaper editor questioned the placement of air quality monitoring equipment and the accuracy of the measurements by the Puget Sound Air Pollution Control Agency (PSAPCA).

The population of Marysville is centered in a valley with homes, apartment complexes, and senior housing projects. There are eight elementary schools in the area.

(Cut here and distribute bottom half later)

PSAPCA Strategy for Marysville

Strategy: PSAPCA surveyed residents of Marysville about wood smoke issues. What they found out was that personal health and money considerations were more likely to motivate people to change their behaviors; protecting the environment was not sufficient to make people change their habits.

PSAPCA used a local physician as a spokesperson on the health effects of wood smoke, and recruited the American Lung Association to help. The gas and electric utilities, along with Northwest Hearth Products Association, joined forces to promote converting to natural gas heat and upgrading old, uncertified stoves. Gas heating for homes and water was encouraged as a conservation measure. Discounts were given to Marysville residents who signed up for natural gas and/or bought new EPA-certified stoves.

PSAPCA mailed brochures to all households. These included information about clean heating and burning and about the discounts being offered.

Special efforts were made to involve the media. A list of people who had converted to cleaner burning methods was suggested for media interviews. Ads also were placed in the newspaper and on the radio talking about discounts for clean burning systems.

PSAPCA held a community fair in October 1994, where they explained the program and demonstrated the products they were promoting. Presentations were made to schools and community groups. Information was included in several community newsletters.

Outcome

Since these actions were taken, particulate matter air pollution in Marysville has declined by 38 percent from levels in 1988-1989.

The Nose Knows

Subjects: Science
Grades: 6-12
Teaching Time: 10 minutes per day for 3-4 weeks; one hour at end of this period
Focus: Air Pollution, Odors, Burn Bans

Rationale

Students can become aware of the air quality in their community by monitoring it for several weeks during the winter months.

Learning Objectives

Students will:

- Become aware of the visible and odor pollution and its sources.
- Collect qualitative and quantitative information on local air quality.
- Analyze the information collected.

Teacher Background

There are several ways some newspapers report daily on air pollution levels. Air pollution agencies must report the Air Quality Index (also called "Pollutants Standards Index" or PSI) daily for at least five days per week in all urban areas. This index is used to convert data from air monitoring stations at various locations around a community to a scale of 0-500. This number indicates the potential effects of measured levels of various pollutants on human health, property, and vegetation. It is usually expressed for certain pollutants, such as carbon monoxide, particulates, and ozones. A daily pollen count is also sometimes given.

Some papers give a forecast for the exposure level of ultraviolet (UV) radiation, so that people can take precautions to reduce their exposure to UV radiation. This is provided by the National Weather Service and is based on observed and predicted changes in stratospheric ozone levels. UV radiation values are reported on a scale of 0 to 10, ranging from minimal to very high. Many scientists are concerned that the risk of skin cancer from the sun's rays is increasing because synthetic chemicals (chlorofluorocarbons) are destroying the ozone layer. This layer protects the earth's surface from most of the sun's ultraviolet radiation. (see introduction, p 3)

Materials (per group)

- Daily local newspaper

Pre & Post Test Questions

1. What are ways in which air pollution is noticeable to you? (Answers will vary)

2. Where can you get information on the severity of air pollution on a given day? (Newspaper, local air agency)

Learning Procedure

1 Pair up students. Each day for three or four weeks in the winter have students monitor air quality by having one partner do a) and the other do b):

a) Stand outside the school and note any odor or visible pollution, or any effects on health from the air quality. Record this information.

b) Check the local paper for and record the Air Quality Index or PSI, ultraviolet index, and weather.

Also appoint one class member to call the local burn ban hotline to see if a ban is in effect, and record this.

2 At the end of the three or four week observation period, have students analyze the data they've collected. Some questions on which they might focus are:

- What kinds of relationships did you see between the weather and our air quality? (Categorizing or graphing may help to make relationships more evident - see sample table.)

Time of Day	Odor	Visibility
	wood leaves egg rubber etc.	clear foggy smoky hazy etc

- Did your first-hand observations of air quality tend to support burn bans? Why might there sometimes be bans on days on which you noticed no visible pollution?

Extended Learning

1 Share the information you have collected with your local air agency. (See Appendix to find your agency.)

2 Students can research local and state laws on odors and burn bans by calling their local air agency (see Appendix).

3 Take a field trip to the nearest air monitoring site. Your local air agency will be able to advise you. This activity would work well in conjunction with the lesson, "Particular Particulates Pollute!", p. 25.

Resources

Ecology Focus sheets (in Appendix)
1) Wood Stove Burn Ban Information, FA-92-24
2) Episodes and Impairments, FA-91-102
See also publication #93-106, Source of Information about Air Pollution in Washington State (in Appendix).

Solid Waste Introduction

The solid waste unit of the curriculum presents activities which inform the teacher and students of solid waste management problems and solutions. The activities are designed to develop awareness, attitudes, and action for waste reduction and recycling by individuals, families, schools, and communities.

The solid waste unit of the curriculum is divided into three sections. The sections reflect the Washington State solid waste management priorities.

The first section is **Reduce**. The activities in the Reduce section present strategies for reducing waste before it enters the waste stream. Activities address consumer awareness, packaging, reusing materials and composting.

The second solid waste section is **Recycle**. Activities show how to recycle, what to recycle, and why recycling is important. Activities include school recycling programs, home recycling strategies for the family, and activities that increase awareness of recycling options in the community.

The third solid waste section is **Dispose**. These activities explain the range of disposal options, list the recent improvements made in disposal and energy recovery facilities, and outline the environmental, economical, and political concerns related to the disposal of waste.

Solid waste management has been a concern for humans since the beginning of time. In early days, hunting and gathering tribes left wastes to be consumed by wild animals. Plains dwellers or nomadic people placed their wastes in one spot and when enough waste accumulated, the inhabitants moved on to a different home.

Agricultural and fishing communities gradually replaced the nomadic people. With the development of agriculture and the domestication of animals, farmers and ranchers fed their food wastes to chickens, hogs, and other farm animals. Other discarded wastes, such as pieces of metal scrap, tinned cans, and glass, were placed in pits or open dumpsites. Waste materials of wood, paper and rubber were burned in burn barrels. Large machines which had outlived their usefulness were abandoned on parcels of land unsuitable for farming.

Permanent settlements had open dumps or pits near or in villages to hold waste materials. Wastes in villages and cities were burned, buried, or simply placed in the dump. Scavenging birds and animals often infested these open dumpsites. In early settlements, tools and other items were used and reused because of limited production methods. Little packaging existed in early societies. Less waste was created, so disposal remained a small problem.

Since the industrial revolution, the influx of people into metropolitan areas has intensified problems associated with management of solid waste. Food items need extra packaging for preservation and transport from farms to cities. Technological advances have created more wastes, but also have provided more efficient ways of dealing with solid waste. Waste reduction methods, recycling programs, and modern disposal methods advance new solid waste management solutions.

Americans produced 206.9 million tons of municipal solid waste in 1993.[1] Solid waste in Washington State totaled 7.5 million tons in 1994.[2]

According to municipal solid waste sampling, each person in the United States produced 4.4 pounds of solid waste per day in 1994.[3] Educational facilities

1 EPA, Characterization of Municipal Solid Waste in the United States 1994 Update, p. 29.
2 Washington State Department of Ecology, Solid Waste in Washington State, Fourth Annual Status Report including the 1994 Recycling Survey, Publ. # 96-500, Feb. 1996, p.53.
3 EPA, Characterization of Municipal Solid Waste in the United States 1994 Update, p. 29.

surveyed in Washington State produced 240 pounds of solid waste (mostly paper and food wastes) per student in schools in 1992.[4]

Because of the growing solid waste problem, the Washington State Legislature developed a set of priorities in 1984 for the management of solid waste. These priorities for collection, handling, and management of solid waste were revised and included in Substitute House Bill 1671, passed by the Washington State Legislature in April 1989. The priorities are:[5]

1. Waste reduction (highest priority)

2. Recycling, with source separation of recyclable materials as the preferred method

3. Energy recovery, incineration or landfilling of separated waste

4. Energy recovery, incineration, or landfilling of mixed wastes

The bill further defined "solid waste" or "wastes" as "all putrescible and nonputrescible solid and semisolid wastes, including, but not limited to, garbage, rubbish ashes, industrial wastes, swill, demolition and construction wastes, abandoned vehicles or parts thereof, and recyclable materials."[6]

Reduction

The highest priority for solid waste management is waste reduction: "Waste reduction means reducing the amount or toxicity of waste generated or reusing materials."[7] Waste reduction is the prevention or elimination of waste at the point of generation. Waste reduction lessens the production or purchasing of potential waste. To distinguish waste reduction from recycling, remember that the goal of waste reduction is achieved by revising buying habits and by selective purchasing.

Composting is a waste reduction/recycling activity. It is the collection of organic materials such as lawn clippings, leaves, and kitchen scraps (no oils, fats or meats) to be covered for decomposition into fertile humus. Building and operating a compost pile of yard wastes, or using a worm bin for food wastes, provides opportunities to improve the soil and reduce the waste stream at the source. Centralized collection sites for composting are found in communities throughout the state.

Five general approaches to waste reduction are outlined by the Washington State Department of Ecology's publication Best Management Practices: Analysis For Solid Waste, 1987 Vol. 2, pp. B 12-2:

- An educational approach, aimed at consumers' purchasing habits and manufacturers' production methods.
- The incentive/disincentive approach, which utilizes economics through regulation or legislation to influence producer or consumer preference in the purchase of targeted materials (i.e., economic reward for purchasing less packaging, or a ban on certain products).
- The approach of special government programs designed to facilitate source reduction (i.e., government purchase of reusable glasses and plates rather than disposable products).
- The waste exchange approach.
- The home yard waste composting approach.

4 Washington State Department of Ecology, Solid Waste in Washington State, Fourth Annual Status Report including the 1994 Recycling Survey, Publ. # 96-500, Feb. 1996, p. 53.
5 Washington State Legislature, Substitute House Bill No. 1671, April, 1989, Sec. 1, No. 8.
6 Substitute House Bill No. 1671, April, 1989, Sec. 2, No. 16.
7 Substitute House Bill No. 1671, April, 1989, Sec. 2, No. 20.

Recycling

Recycling, which is the second priority, is "transforming or remanufacturing waste materials into usable or marketable materials rather than landfill disposal or incineration."[8] The process of recycling includes steps of separation, collection, processing, transportation to markets, and remanufacture, as well as purchase and utilization of recycled products.

Source separation recycling is the preferred method of recycling in Washington State. It occurs at the place where the waste originates, before materials enter the waste stream. Two curbside source separation recycling programs are used in Seattle. One program separates glass, paper, and metals into separate bins, the other program commingles all recyclables in one bin. Both methods separate recyclable items from household or business garbage. The Washington State Legislature set a goal "to achieve a fifty percent recycling rate by 1995. In 1994 Washington State residents recycled 38 percent of the solid waste stream."[9] On a national level, experts project that 5 to 10 percent of waste could be reduced, 25 to 30 percent could be composted, 40 to 50 percent of the waste stream could be recycled, which leaves 10 to 30 percent to be burned and/or buried.[10]

Disposal

The third and fourth priorities address disposal of solid waste. Priority three deals with energy recovery, incineration or landfilling of separated waste; priority four with the energy recovery, incineration or landfilling of mixed wastes.[11] These two priorities involve the same processes. The difference is in the composition of the waste being disposed, separated or mixed. Separated wastes have recyclable and reusable materials removed from it before disposal. Mixed wastes still contain recyclables at disposal.

Three disposal processes are listed in priorities three and four. Energy recovery reduces the volume of solid waste and converts it into usable energy by making refuse-derived fuel (RDF) or by burning solid waste in an incinerator to produce steam or electric power. Incineration is the process that reduces solid waste volume in an enclosed device using a controlled flame combustion. Landfilling is the disposal process whereby solid waste is placed in or on the land.

8 Substitute House Bill No. 1671, April, 1989, Sec. 2, No. 15.

9 Washington State Department of Ecology, Solid Waste in Washington State, Fourth Annual Status Report including the 1994 Recycling Survey, Publ. # 96-500, Feb. 1996.

10 Environmental Task Force, "Shrinking the Mountain of Waste," Resources, Vol. 6, No. 3, Summer, 1986, p. 5.

11 Substitute House Bill No. 1671, April 1989, Sec. 1, No. 8D.

Solid Waste Fact Sheets

International Facts

The average citizen in Oslo, Norway generates about 1.7 pounds of garbage per day, while the average West German, Japanese, Swiss or Swedish citizen produces 2.5 pounds of garbage per day. Source: Allen Hershkowitz, "Burning Trash: How It Could Work," Technology Review, July 1987, p. 29.

In industrial countries, packaging contributes about 30 percent of weight and 50 percent of the volume of household waste. Source: Cynthia Pollack-Shea, "Realizing Recycling's Potential," State of the World 1987, New York, N.Y.: W.W. Norton Company, 1987, p. 103.

The world is now generating between 500 million and one billion tons of solid waste per year, and those figures could double every 15 years. Source: U.S. News and World Report, "Rumors of Earth's Death Are Greatly Exaggerated," May 9, 1983, p. 84.

U.S. Facts

Americans dispose of nearly four times as much garbage as the Japanese, the world's second largest garbage producer. Source: Paul Clancy, "Recycling Efforts Take Off," USA Today, November 16 , 1987, p. A 6.

The lifetime garbage of the typical American will equal at least 600 times his or her adult weight. Source: Denis Hayes, "Repairs, Reuse, Recycling: First Steps Toward a Sustainable Society." Worldwatch Paper 23, Washington, D.C.: Worldwatch Institute, 1978.

After recycling and composting, the average person produced 3.4 pounds per day. In 1993, Americans threw away approximately, 2.1 million tons of appliances, 3.0 million tons of tires, 7.0 million tons of newspapers, 1.4 million tons of glass beverage containers, 0.9 million tons of aluminum beverage

What Goes Into the Solid Waste Stream?

Compare the 1992 solid waste stream for the State of Washington with that of the U.S.

U.S. 1992		***Washington State 1986***		***Washington State 1992***	
Paper	37%	Paper	40%	Paper	29%
Food	7%	Food	12%	Food	12%
Yard/Garden	17%	Yard/Garden	23%	Yard/Garden	12%
Glass	7%	Glass	6%	Glass	5%
Metals	8%	Metals	5%	Metals	7%
Plastics	9%	Plastics	9%	Plastics	10%
Wood	6%			Construction Debris	17%
Other	9%	Other	5%	Other	8%

Sources: EPA, Characterization of Municipal Solid Waste in the United States, 1994 Update (Rounded to Nearest Percent)
Washington State Department of Ecology 1992 Washington State Characterization Study, 1993.

Metals Recycling Energy Chart

Metals (Type)	Energy Saved By Recycling
Aluminum	96%
Copper	87%
Zinc	63%
Ferrous Scrap	62%
Lead	60%

Source: Recycling Today, April 1988, p. 77

containers, 11.7 million tons of corrugated (cardboard) containers, and 7.9 million tons of plastics.

The average U.S. citizen produced 4.4 pounds of garbage per day. Source: EPA, Characterization of Municipal Solid Waste in the United States, 1994 Update.

In 1993 in the U.S., 22 percent of municipal waste was recycled, about 16 percent was incinerated, and about 62 percent went to landfills. Source: Environmental Task Force, "Shrinking the Mountain of Waste," Resources, Vol. 6, No. 3, Summer 1986, p. 5. Ibid.

Washington State Facts

In Washington State in 1994, the average was 1.4 tons of garbage per person per year. An estimated 7.5 million tons of solid waste was produced. Source: Washington State Department of Ecology, Solid Waste in Washington State, 1996, p. 54.

One thousand tons of uncompacted waste would cover half an acre of land three feet deep. Source: U.S. News and World Report.

In Washington State in 1994, 38 percent of the waste stream was recycled. Source: Washington State Department of Ecology, Solid Waste in Washington, 1996, p. viii.

Metals

U.S. Facts

Ferrous metals such as iron and steel represented about 6.2 percent of the U.S. solid waste stream in 1993.

Aluminum represents approximately another 1.5 percent of the metals in garbage. Other non-ferrous metals such as copper and brass make up a very small share of the U.S. waste stream. The total waste stream content for metals is approximately 8 percent.

Thirty-five percent of the aluminum manufactured in the U.S. is recycled. The national rate for all metals is 30 percent. Source: EPA, Characterization of Municipal Solid Waste, 1994 Update.

Aluminum comprises only one half of one percent of the total waste stream in the U.S. By the 1990s, manufacturers plan to recycle 75 percent of all aluminum products. Source: "At a Glance," Waste Age, pamphlet, June 1988, p. 3.

If an aluminum beverage container is thrown away, as much energy is wasted as pouring out a can half-filled with gasoline. Failing to recycle a daily edition of the London Times or the Washington Post wastes just as much energy. Source: William U. Chandler, "Materials Recycling: The Virtue of Necessity," Worldwatch Paper 56, Washington, D.C.: Worldwatch Institute, 1983.

Paper

U.S. & INTERNATIONAL FACTS

County	Annual Use Per Person	Recycling Rate %
USA	580 lbs.	*26%
Sweden	477 lbs.	34%
West Germany	346 lbs.	35%
Japan	326 lbs.	45%
Spain	150 lbs.	40%
Hungry	132 lbs.	37%
South Korea	87 lbs.	37%
Brazil	64 lbs.	39%
Nigeria	7 lbs.	2%

* Waste Age reported 28% in 1986.
Source: Earth Care Paper Company. 1986 Recycled Paper Catalog. PO Box 3335, Madison, WI 53704

Paper

U.S. Facts

Approximately 38 percent of the U.S. waste stream in 1993 was paper. Source: EPA, Characterization of Municipal Solid Waste in the United States, 1994 Update, p. 29.

Paper can be recycled several times before the fibers break down. Often reused fibers are made into packaging such as cereal boxes, gameboards, ticket stubs, and covers for hardcover books. Paper products made from recycled paper use 70 percent less energy to produce. Source: Resources, Summer 1986, p. 7.

Recovering the print run of one Sunday edition of the New York Times would leave 75,000 trees standing. Source: R.W. Beck and Associates, Solid Waste Issues and Answers, Seattle, WA.: Special Issue No. 2, 1989.

In 1993, Americans recycled 45.7 percent of their newsprint and 25.4 percent of total paper produced. Source: EPA, Characterization of Municipal Solid Waste 1994 Update.

Washington State Facts

In 1992 approximately 29 percent of the waste stream was paper. Source: Washington State Department of Ecology, 1992 Washington State Waste Characterization Studies, Vol. 1: Executive Summary, Publ. # 93-45, 1993, p. I I -27.

Washington residents recycled about 40 percent of their newsprint and 27 percent of their total paper in 1986. Source: Washington State Department of Ecology, 1986 Washington State Recycling Survey, Olympia, WA.: Washington State Department of Ecology, 1987, p. 22. (Adaptation)

In 1992, Washington residents recycled 75 percent of their newsprint and 62 percent of their high grade paper. Source: Washington State Department of Ecology, 1992 Washington State Waste Characterization Studies, 1993.

Paper products made from recycled paper used 70 percent less energy to produce than paper products from virgin timber. Source: Resources. Summer 1986, p. 7.

Glass

To recycle used glass, the glass is crushed into small pieces called cullet. The cullet is melted down to make new glass products. Glass doesn't degrade, it can last for hundreds, perhaps thousands, of years.

National Facts

In 1993, approximately 22 percent of the glass made in the U.S. was recycled. Seven percent of the U.S. solid waste stream in 1993 was glass. Source: EPA, Characterization of Municipal Solid Waste in the United States, 1994 Update.

Washington State Facts

In 1992, 5 percent of the waste stream was glass, and in 1986, 24 percent of the glass produced was recycled. Source: Washington State Department of Ecology, 1986 Washington State Recycling Survey, Olympia, WA.: Washington State Department of Ecology, p. 22. (Adaptation)

Plastics

Plastics come in three basic forms. One form is thermoset plastics, which can be heated and molded only once. Such plastics are not degradable. Automobile bodies and bakelite used in nonstick cookware are examples of thermoset plastics.

The second type of plastics are called thermoplastics (e.g., plastic milk jugs) thermoplastics are recyclable. They may be remolded several times. Some reuses for Thermoplastics are boat docks, pallets, and filler for insulation in ski jackets.

The newest type of plastics are degradables. Some degradables can be broken down by light, others by salt water, and still others by biodegradation. Degradable plastics are not recyclable.

The plastic bottle industry has designed a national voluntary coding system for the most common plastics. The code number is placed on the base of the container. The acronyms and scientific names as well as the coding numbers are listed on p. 87.

U.S. Facts

Plastics were 9.0 percent by weight of the U.S. solid waste stream in 1993. Source: EPA, Characterization of Municipal Solid Waste in the U.S., 1994 Update.

New plastic polymers which are either biodegradable or photodegradable are being introduced in legislation and consumer markets throughout the U.S. The purpose is to protect animals, especially sea birds, and the environment.

In December 1987, the U.S. became the 29th nation to ratify a treaty prohibiting boats and ships from dumping plastics anywhere in the oceans. Source: Toufexis, "The Dirty Seas." Time Magazine, p. 50.

Most plastics are polymers, made up of more than one resin. Forty-six polymers are found in different plastic products available to U.S. consumers. Source: Cynthia Pollack-Shea, "Realizing Recycling's Potential," State of the World 1987, New York, N.Y.: W.W. Norton Company, p. 104.

About 8 million tons of plastic packaging was generated in the U.S. in 1993, 6.2 percent was recycled. Source: EPA, Characterization of Municipal Solid Waste in the United States, 1994 Update.

The percentage of plastics recycled nationally has risen from .3 percent in 1980 to 3.5 percent in 1993. Source: EPA, Characterization of Municipal Solid Waste in the United States, 1994 Update.

Plastics, because of their bulkiness, take up 20 to 30 percent of landfill space. Source: Fine, "Nine Lives of Plastic," Worldwatch, p. 43.

Washington State Facts

In Washington State in 1992, plastics were approximately 10 percent of the residential and commercial solid waste stream. Source: Washington State Department of Ecology Waste Characterization Study, 1993.

In 1987, 1,665 tons of recyclable plastics were recovered. Source: Washington State Department of Ecology, News Release, September 21, 1988, p. 2.

National Voluntary Plastic Container Coding System

Number	Letters	Code	Plastic Type	Example
1	PETE	1 PETE	Polyethylene Terephthalate	Beverage Containers
2	HDPE	2 HDPE	High Density Polyethylene	Milk Jugs
3	V	3 V	Vinyl/Polyethylene	Corn Oil, Shampoo Battles
4	LDPE	4 LDPE	Low Density Polyethylene	Cosmetics Packaging
5	PP	5 PP	Poly Propylene	Syrup Containers
6	PS	6 PS	Poly Styrene	Cups for Hot Drinks
7	Other	7 OTHER		

Source: The Plastic Bottle Reporter, Vol. 6, No. 3, Fall

In 1994, Washington State residents recycled approximately 29,100 tons of plastics: Source: Washington State Department of Ecology, Solid Waste in Washington State, 1996.

In 1988 a Seattle recycling company collected, compacted, and baled 50,000 pounds of plastics, mostly HDPE and LDPE, and shipped them to Hong Kong, Japan, and other ports in Asia for recycling or reuse. Source: Judith Blake, "The Complex Plastics Problem," Seattle Times, September 5, 1988, p. D3.

Washington State Litter Facts

The source for Washington State Litter Facts unless otherwise cited is: Daniel B. Syrek, Washington Litter 1987, Sacramento, CA: Institute for Applied Research, 1987. Page numbers are given in parentheses.

In Washington State in 1987, 60.9 percent of littering was deliberate littering, and 39.1 percent was accidental (i.e., unsecured loads). The most frequent litterers were pedestrians, who made 33.4 percent of all litter. Motorists were second with 20.6 percent (p. 23).

Seventy percent of all deliberate littering in Washington State is done by persons age 10 to 24. Males are responsible for 73 percent of deliberate littering (p. 25).

Fifty-one percent of accidental littering is done by people over age 35 (p. 4).

The 1995, crew of the Washington State Youth Corps cleaned 2,552 miles of highways and collected 156 tons of litter. The Corps recycled 4.2 tons of aluminum cans, 2.4 tons of scrap metal, 5.8 tons of bottles and glass, and 1.7 tons of plastic and cardboard. Another 22.6 tons of litter were collected from state parks, rest areas and other sites. Source: Washington Department of Ecology, Solid Waste in Washington State, 1996.

Washington State Solid Waste in the Workplace

Washington State Fact Source: State Department of Ecology, 1992 Waste Characterization Studies, Vol. 1: Executive Summary, Publ. # 93-45, 1992, p.11-4.

Offices generated 252 lbs. of waste per employee per year.

Dry goods retail businesses generated 1080 pounds of waste per employee per year.

Can We Do Without The Can?

Subject: All Subjects
Grades: K - 12
Teaching Time: One Week Project, Two 15–Minute Periods
Focus: Waste Reduction, Paper Recycling

Rationale

Awareness of the large volumes of paper a class throws away and informed decision making can significantly reduce a class's paper waste.

Learning Objective

Students will:

- Reduce the amount of paper they throw away.

Teacher Background

Paper Facts:

To produce one ton of paper packaging it requires:[1]

3,688 lbs. wood
216 lbs. lime
360 lbs. salt cake
76 lbs. soda ash
24,000 gals. water
28 million BTUs energy

Washington State single family households disposed of 399,331 tons of paper in 1992. This is approximately 522 pounds of paper per household:[2]

Materials

- Wastebasket
- Chart
- Graph materials

Pre & Post Test Questions

1. What percentage of the waste we produce in this classroom is paper?

2. How can we reduce the amount of paper we throw away?

Learning Procedure

1 Place the following chart on a bulletin board or wall near the basket for waste paper at a height easily accessible to students. No food wastes should be disposed of in the basket(s). Provide a small container for food wastes.

2 Ask students to write their initials and what they discarded in the appropriate space every time they throw something away. Do not discourage students from using the wastebasket(s).

3 At the end of a week, have students form small

1 Environmental Task Force, Resources, Summer 1986, Vol. 6, No. 3, p. 7.
2 Washington State Department of Ecology, 1992 Washington State Waste Characterization Study, Vol 1: Executive Summary, Publication # 93-45, July 1993, p. II-9.

	John	Sarah	Martha	George	Fay		etc. . .									
Monday																
Tuesday																
Wednesday																
Thursday																
Friday																

groups and respond to the following, drawing a bar graph from the results.

- What types of things were thrown away?
- Approximately what percentage of what was thrown out was reusable or recyclable paper?
- What additional uses could have been found for this paper?

4 Have students, working in groups, draw large butcher paper graphs plotting days on the horizontal axis and the number of visits to the wastebasket on the vertical axis.

5 Have groups compare their lists of composition, estimated percentages, and alternate uses for discards.

6 At the end of the week, conduct the activity, “Would You Do It If I Taught You? If I Paid You?,” p. 123.

7 After completing “Would You Do It If I Taught You? If I Paid You?,” put up a new chart near the wastebasket and repeat the activity.

8 Discuss and compare the results as reflected on the bar graphs. Emphasize the effect awareness and informed decision making can have on the reuse or recycling of paper and on “doing without the can.”

Extended Learning

1 With the cooperation of the custodian, remove wastebasket(s) entirely for a week. Explain to students that no classroom waste will be disposed of inside or outside of the classroom. Point out that many counties and cities across the United States are faced with this situation of producing waste but having few choices about where to put it.
Ask students to develop a plan for storing all classroom waste for one week. Explain that at the end of the week students will separate and quantify the waste.

2 At the end of the week, weigh the amount of accumulated waste to come up with a per-day and per-person average.

3 Separate materials and recycle.

4 Discuss ways to reduce the volume of waste the class produces.

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Waste, Then And Now

Subjects: Social Studies, Home Economics, American History

Grades: 5-12

Teaching Time: 30 Minutes

Focus: Waste Reduction, Packaging

Rationale

Americans are often pictured as very wasteful in the consumption of goods and materials. According to one article, "Americans are the most wasteful people on earth. Every day, 410,000 tons of banana peels, newspapers, automobile tires, and other items are discarded in the United States."[1] The complexity of our way of life contributes greatly to the amount of trash we produce. If we compare our way of life to a simpler one, such as that of the early American Indian, we may be able to get some ideas on how to reduce both our consumption and our waste.

Learning Objective

Students will:

- Identify reasons why the way of life of some Americans contributes to our country's massive trash problem.
- Identify ways to revise their way of life so as to reduce the amount of waste they produce.

Teacher Background

In industrial countries, packaging contributes about 30 percent of the weight and 50 percent of the volume of household waste.[2]

1993 containers and packaging in the U.S. solid waste stream:

(before recycling)

Steel	1.4%	3 million tons
Aluminum	1.0%	1.9 million tons
Glass	5.9%	12.2 million tons
Paper & paperboard	17.1%	35.4 million tons
(includes corrugated containers,cereal boxes, and grocery sacks)		
Plastics	4.0%	8.2 million tons
Wood	4.6%	9.4 million tons

(From: EPA Characterization of Municipal Solid Waste in the U.S., 1994 Update, p. 67-68.)

Pre & Post Test Questions

1. What is the relationship between a standard of living and the generation of solid waste?
2. What is planned obsolescence?

Learning Procedure

1 Food packaging contributes greatly to America's trash problem.

- List the trash produced through the consumption of foods (cans, boxes, plastic and glass bottles, paper products, plastic bags, and organic garbage).
- Discuss: How did the Indians obtain food? (hunting, gathering, fishing, farming, animal husbandry)
- Discuss: Did the Indians have a disposal problem? What did they do about it?

1 Ken Sands, "Garbage: A Nationwide Problem" Spokesman Review, March 17, 1985.
2 Cynthia Pollack-Shea, "Realizing Recycling's Potential," State of the World 1987, New York, N.Y.: W.W. Norton, 1987, p. 103.

- Why were trash problems then different from those now?
- Discuss: In what ways could we incorporate or modify Indian methods in order to produce smaller amounts of trash (grow our own food and animals, use biodegradable packaging, buy more unprocessed food).

2 In our society, we use tools of all kinds from disposable razor blades to electric can openers. When these items are broken or worn, we often discard them as trash.

- What tools or appliances have you used and thrown away in your household?
- What is planned obsolescence?
- What tools did the Indians use? (bones, bows and arrows, spears, knives, scrapers, bone awls, or needles)
- What might we do the next time a tool or appliances is broken? (try to repair it, compare cost of repair to replacement cost)

3 When we outgrow clothing, it goes out of style, or it gets worn, we often throw it into the trash.

- Why would Indians have been unlikely to throw away old clothing? (hard to obtain, was resewn into something else, didn't have excess clothing)
- What might you do to reduce clothing waste? (give outgrown clothing away, don't buy too much, repair worn clothing, buy durable clothing that is less susceptible to changes in style)

4 Can you think of items the Indians did not have which contribute to our trash problems? (cars, tires, newspapers, paper of all kinds, and plastic) Can you think of ways to reduce these kinds of trash?

5 Conclusion:

- Why do we produce more trash than the Indians did? (complexity of our culture – we don't make our own tools and clothing or directly obtain our own food; we use more manufactured and nonbiodegradable materials)
- What reasons can you think of for reducing waste? (reduce disposal costs, conserve energy and resources, improve the health of the environment)
- List some things you will do to reduce waste in your home.

Resources

Video Tape: Home. The Radio and TV Commission of the Southern Baptist Convention. 1972. 20 min.

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A Careful Consumer's Trip To The Grocery Store

Subjects: Home Economics, Social Studies
Grades: 6-12
Teaching Time: 40 Minutes
Focus: Waste Reduction, Resource Conservation, Consumer Awareness

Rationale

Careful buying is the first solution to the problem of too much solid waste. An individual's careful buying decisions can significantly reduce the volume of household waste.

Learning Objective

Students will understand:

- How recycled materials are used in packaging.
- Which natural resources are used in packaging and how these resources can be conserved through careful buying and recycling.
- That, because approximately 30 percent of municipal waste consists of containers and packaging,[1] responsible buying choices can reduce Washington's waste stream.

Teacher Background

Nearly a $1 out of every $10 spent for food and beverages in the United States pays for packaging.[2] The packaging bill in 1986 in the United States totaled $28 billion.[3] Americans spent more for food packaging in 1986 than farmers received in income.[4]

Materials

- Survey 1 - "Product and Packaging Chart"
- Survey 2a and 2b - "A Potato By Any Other Name"

Pre & Post Test Questions

1. Approximately what percentage of the cost of packaged foods you buy goes for packaging?

2. How can you reduce the amount of packaging you throw away?

Learning Procedure

1 For homework, have students conduct a survey of some grocery store products and packaging.

2 Review definitions of survey terms:
ORGANIC – derived from living organisms.
RENEWABLE RESOURCES – naturally occurring raw materials derived from an endless or cyclical source such as the sun, wind, falling water (hydroelectricity), fish, and trees. With careful management, the consumption of these resources can be approximately equal to replacement by natural or human-assisted systems.

NONRENEWABLE RESOURCES – naturally occurring raw materials which, because of their scarcity, the great length of time required for their formation, or their rapid depletion, are considered exhaustible. In other words, when they are gone, they are gone. Example: petroleum.

1 Franklin Associates LTD., Characterization of Municipal Solid Waste in the United States, 1960 to 2000: Update 1988, Prairie Village, KS: Franklin Associates LTD., 1988, p. 15.
2 Cynthia Pollack-Shea, "Realizing Recycling's Potential," State of the World 1987, New York, N.Y.: W.W. Norton, 1987, p. 103.
3 Ibid.
4 Ibid.

3 Review how to identify packaging made from recycled materials – look for the recycling symbol. The gray paperboard used for cereal boxes is made from recycled paper.

4 Review survey forms, distribute surveys -- "Product and Packaging Chart" and "A Potato By Any Other Name."

5 Give assignments:

Survey 1: Product and Packaging Chart

1. Choose ten products and complete the Survey 1 chart for each.
2. Choose at least two products available in a choice of packaging.
3. By examining the products you chose, answer the following questions:
   - Which products need special packaging to protect public health?
   - Which product's packaging was made from recycled materials? (Look for recycling symbol.)
   - Which products could be bought in bulk or in large containers?
   - Which products could be bought in a less processed or packaged form?
   - Which product's packaging could be improved to save energy and resources and reduce waste?

Survey 2

Find as many potato products as you can, at least ten. Use the chart "A Potato By Any Other Name" as a guide. Fill in the chart on Survey 2.

NOTE: Price-per-pound listing can be found on shelf labels beneath products. Analyze and discuss your findings:

1. What effect does processing and packaging have on a product's cost?
2. What effect does package size have on price?
3. What effect does package size have on the amount of waste?
4. What else is added to food as it becomes more highly processed?
5. List examples of recyclable packaging.
6. List examples of products for which recyclable packaging is not even a choice.
7. List examples of packaging made from recycled materials.
8. List ways people can reduce waste and increase recycling through careful buying.

Extended Learning

Visit a food co-op and see their solution to the problem of too much packaging.

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A POTATO BY ANY OTHER NAME

Product	Package Size	Price	Price Per Pound
Russets potatoes	Bulk		$ .59
White potatoes	Bulk		.49
Red potatoes	Bulk		.69
Fresh potatoes	5 lb.	$1.67	.338
Fresh potatoes	10 lb.	2.49	.249
Fresh potatoes	15 lb.	3.49	.232
Bel-Air* hash browns	2 lb.	1.29	.645
Bel-Air* french fries	2 lb.	1.59	.795
Bel-Air shoestring potatoes	20 lb.	1.39	1.12
Ore-Ida potatoes O'Brien	24 lb.	1.49	.994
Ore-Ida golden fries	32 lb.	1.69	.85
Ore-Ida dinner fries	24 lb.	1.79	1.20
Betty Crocker potato buds (box)	28 lb.	2.99	1.70
Betty Crocker potato buds (box)	13.75 oz.	1.49	1.73
Town House mashed potatoes (box)	16 oz.	1.39	1.39
Town House white potatoes (canned)	15 oz.	.57	.608
S & W whole potatoes (canned)	16 oz.	.75	.75
O'Boises potato chips	6.5 oz.	1.15	2.83
Eagle potato chips	6.5 oz.	1.09	2.68
Pringles	7 oz.	1.50	3.42
Lays potato chips	7 oz.	1.58	3.61
Lays potato chips	10.5 oz.	2.28	3.47
Ruffles potato chips	15 oz.	2.75	2.93
Nalley's potato chips	16 oz.	2.65	2.65
Small order McDonald's french fries	3.5 oz.	.67	3.06

* *Bel-Air is a Safeway Stores, Inc. private label. All store items were priced on July 13, 1989, at Safeway in Redmond, Washington; McDonald's priced on July 22, 1989, in Redmond, Washington.*

Survey 1.

PRODUCT AND PACKAGING CHART

Product	Renewable Recyclable (e.g., paper)		Nonrenewable Resource (e.g., petroleum)		Is this product necessary?	Is this product available in more than one form of packaging?	If so, which is best in terms of recycling and waste reduction?	Is there an alternative to this product?	How could the packaging be improved to save resources and energy?	What happens to this product's package when the contents are used?	Will this product's packaging become part of Washington's waste stream?
	Organic (derived from living organisms)	Renewable Recyclable Packaging	Nonrenewable Recyclable Packaging	Nonrenewable Nonrecyclable Packaging							

Survey 2

A POTATO BY ANY OTHER NAME

Product	Package Size	Price	Price Per Pound

Putting Your Product In A Package

Subjects: Consumer Education, Business, Economics, Design, Industrial Arts
Grades: 7-12
Teaching Time: 45 Minutes
Focus: Packaging, Waste Reduction

Rationale

Packaging is the largest single component of household solid waste.[1] Many materials produced for the marketplace, however, need to be packaged in order to protect them during shipping. At the retail outlet, packaging serves to advertise products and identify contents, and may be required to meet regulatory standards.

Learning Objective

Students will:

- Understand som the benefits and drawbacks of packaging.
- Understand the function packaging plays in protecting and marketing products.
- Design packages which reflect their awareness of the waste reduction and resource conservation consequences of packaging decisions.

Materials

- The packaged products listed on the worksheet.
- "Packaging Information Sheet" and "Packaged Products Worksheet."
- Materials for design/construction of prototype packages.

Pre & Post Test Questions

1. Why are products packaged?

2. What are the benefits and drawbacks of packaging?

1 Peter T. White "The Fascinating World of Trash," National Geographic, April 1984, Vol. 163, No. 4, pp. 424-457.

2 Divide students into groups. To each group distribute all products in one category. Product categories are listed on the following "packaged products worksheet."

3 Ask each student to design a new package for a product of his or her choice.

4 Discuss with students the "Packaging Information Sheet."

5 Ask students to list on the worksheet the function and design considerations they feel are important in designing the packaging of the products they are examining. **Ask:** "Why did the producer package his product this way?" "How else might this product have been packaged?"

6 Ask students to identify the packages which could be reused or recycled.

Ask: "How can we reuse or recycle the packaging materials after we have used the products?"

Ask: "What will happen to the packaging we cannot reuse or recycle?"

Ask: "How can we as consumers reduce the 7.6 pounds of waste we, in Washington State, produce everyday?"

7 Using the "Packaging Information Sheet," have students develop design specifications for the packaging they will create. Challenge students by explaining their designs must include considerations of waste reduction, reuse, and recycling, as well as public safety, product protection, shipping weight, cost of packaging material, advertising, and public demand.

8 Share with students the materials you have provided for designing and making prototype packaging for their products.

9 Ask students to present drawings/prototypes to class and explain the reasoning for their design.

Extended Learning

1 Have students write to and send their designs/prototypes to packaging manufacturers as suggestions for improvement in package design.

2 Analyzing a variety of products, measure the actual amount of the product compared to the size and shape of the product's package.

3 Invite representatives from the grocery business and the packaging industry to class to discuss packaging.

4 Research the regulatory standards packagers and retail outlets are required to meet. **Ask:** "Who sets these standards? Why are they required?"

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Packaging Information Sheet

Consumers need to consider the role packaging plays from point of production to retail market in order to understand the importance of packaging's development, design, and function. Consumers also need to understand that packaging contributes significantly to our society's volume of waste.

Function and Benefits

- Preservation and protection of contents
- Sanitation and safety, protection of public health
- Identification of product
- Prevention of theft
- Providing instruction as to product use
- Compliance with regulatory standards
- Manufacturing of packaging provides employment
- Increased profits

Drawbacks

- In industrial countries, packaging contributes about 30 percent of the weight and 50 percent of the volume of household waste.[2]
- Without reuse or recycling, the energy and natural resources that go into packaging are lost forever in landfills.
- Packaging contributes significantly to litter. Litter degrades the health and beauty of nature.
- Packaging may create false impressions about the amount or quality of products.
- Increased cost to consumers.

2 Cynthia Pollack-Shea, "Realizing Recycling's Potential," State of the World 1987, New York, NY: W.W. Norton and Company, 1987, p. 103.

Packaged Products Worksheet

Cosmetics/Drugs

lipstick - in paper/plastic
aspirin - in plastic jar/paper box
shampoo - in plastic bottle
toothpaste -in plastic tube/paper box

Fresh Produce

tomatoes - in paper or plastic
potatoes - in paper or plastic sacks
mixed sprouts - in plastic

Canned Foods

green beans - in tinned can
vegetables - in glass jar

Household Products

laundry soap - in recycled paperboard box
cleansing powder - in paper/metal can
furniture polish - in glass bottle

Frozen Foods

vegetables - in paper cartons
vegetables - in plastic bag
ice cream - in plastic tub
TV dinner - in aluminum tray

Dried Foods

cereal - in recycled paperboard box
spaghetti - in plastic

Refrigerated Perishable Foods

fresh meat - in plastic tray/wrap
milk - in plastic jug
milk - in paper cartons
eggs - in styrofoam carton
eggs - in recycled paper carton

Drink Containers

juice - in paper boxes in plastic pack
juice - in plastic six pack - aluminum/plastic serving packs
juice - in tinned cans
juice - in glass bottle or jar
juice - in aluminum can
juice - in paper/metal can

You're Eating More Energy Than You Think!

Subjects: Home Economics, Math
Grades: 10-12
Teaching Time: One Class Period
Focus: Energy, Conservation, Environmental Impact, Product Packaging, Recycling

Rationale

Every product we make or use has "hidden" energy and environmental costs.

Learning Objective

Students will:

- Understand that different forms of packaging require different amounts of energy.
- Learn that food containers differ in their environmental/energy impact.

Teacher Background

The unit of heat energy used in science is the calorie (cal.), also called gram-calorie or small calorie. It is defined as the amount of heat energy needed to raise one gram of water 1° Centigrade.

In nutrition, the unit of food energy is the Calorie (Cal.), also called kilogram-calorie, or great calorie. It is defined as the amount of heat energy needed to raise one kilogram of water 1° Centigrade. It is equal to 1,000 calories.

The small c, capital C difference is important. Only the nutritional calorie uses capital C.

Engineers use a different heat energy standard called the British thermal unit (BTU). It is defined as the quantity of heat required to raise one pound of water 1° Fahrenheit. One BTU = 252 calories.

***EXTRA NOTES:**
1 pound = 454 grams
°C = 5/9 (°F - 32)
1 kilogram = 2.2 pounds

Environmental Benefits of Recycling

Environmental Benefit	Aluminum	Steel	Paper	Glass
Energy Use Reduction	90-97%	47-74%	23-74%	4-32%
Air Pollution Reduction	95%	85%	74%	20%
Water Pollution Reduction	97%	87%	35%	—
Mining Wastes Reduction	—	—	—	80%
Water Use Reduction	—	40%	58%	50%

Source: Robert Cowles Letcher and Mary T. Sheil, "Source Separation and Citizen Recycling," in William D. Robinson, ed. The Solid Waste Handbook, New York, N.Y.: John Wiley & Sons, 1986

Materials

- Charts "Energy Used By Packaging Materials" and "Environmental Benefits of Recycling"

Pre & Post Test Questions

1. What are some different types of packaging commonly used for your favorite foods?

2. Which packaging material uses the most energy to produce? The least?

3. How can we, as careful consumers, reduce waste and the use of energy and resources, while promoting reuse and recycling?

Learning Procedure

1 Using information from the chart "Energy Used By Packaging Materials," determine and compare the energy necessary to package the sample foods.

2 Fill in the price (current value) of the foods and compare the prices with the amounts of energy required.

3 Determine the types and amounts of energy required by the individual containers. Where necessary, divide the energy per pound by the correct weight of the container being examined.

4 By referring to the chart, "Environmental Benefits of Recycling," discuss the environmental impacts of container manufacturing and disposal. **Ask:** "What are some advantages of recycling as compared to disposal in a landfill?" (saves disposal costs, conserves energy, conserves nonrenewable natural resources)

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Energy Used by Packaging Materials

Material	*kcal/lb.	*kcal/oz.	*kcal/gm	BTUs/lb	BTUs/gm
Paper	5,134	321	11.4	20,373	44.9
Glass	1,918	120	4.2	7,611	16.8
Steel	3,724	233	8.3	14,778	32.6
Aluminum	24,837	1,552	54.7	98,560	217.1
Plastic	4,670	292	10.3	18,532	40.8

Energy Used by Packaging Materials

Food	**Amount by Weight**	Energy for Container (kcal.)	**Today's Price ($)**
Fresh Potatoes			
Canned Potatoes			
Frozen Potatoes (Hashbrowns)			
Potato Chips			
Dehydrated Potatoes			

*Kcal: 1 kilocalorie = 1 Calorie

I Don’t Need A Bag

Subjects: Art, Math, Home Economics
Grades: 4-9
Teaching Time: 30 Minutes
Focus: Waste Reduction, Reuse

Rationale

Food containers and packaging consume energy and are major components of solid waste. Containers and packaging in the United States municipal waste stream increased (after recycling) from 24 million tons in 1960 to 47.6 million tons in 1993.[1] Containers and packaging were 29.5 percent of the total discards in 1960, and were 29.4 percent of total discards in 1993.[2]

Learning Objective

Students will:

- Learn the energy savings value of reusing grocery bags.
- Calculate how many BTUs would be saved in a year by using their own reusable grocery bags.

Materials

- A paper grocery bag and one plastic grocery bag
- A lightweight scale or a given weight for an average sized grocery bag

Pre & Post Test Questions

1. How many grocery bags does your family use in a week? In a year?

2. Which type of grocery bags, paper or plastic, are easier to recycle?

3. What Pacific Northwest jobs are influenced by using paper or plastic grocery bags?

4. How many ways can you recycle or reuse grocery bags?

5. Do you use paper or plastic grocery bags?

Learning Procedure

1 Discuss reasons for carrying groceries home from the store in a reusable bag.

2 Have each student figure out how many paper sacks his or her family uses in a year. Calculate approximately how many BTUs would be saved in a year if each family brought its own shopping bag. NOTE: Packaging paper takes 44.9 BTUs/g to make and packaging plastics take 40.8 BTUs/g to make.

3 Point out to students that some grocery stores give small credits to customers who reuse grocery bags.
Ask: “Does your store give this credit?”

4 In Home Economics class, discuss different possibilities for shopping bag design and decoration.

5 Discuss the pros and cons of plastic versus paper grocery bags.

Extended Learning

Using a detailed city map, pin mark the location of those grocery stores in your area that give a small cash credit for reusing grocery bags.

1 EPA, Characterization of Municipal Solid Waste in the United States, 1994 Update,
2 Ibid.

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Commercials With An Environmental Message

Subjects: English, Speech, Social Studies
Grades: 5-12
Teaching Time: Two 30-Minute Periods With Follow-Up
Focus: Waste Reduction, Consumer Awareness

Rationale

Many products, in addition to being desirable or useful to the consumer, have an impact on the environment. These effects on the environment may not normally be considered by advertisers or purchasers.

Learning Objective

Students will:

- Learn that commercials can be brief, entertaining, and promotional and still take into consideration the environmental consequences of a product. This understanding encourages students to take these environmental impacts into consideration when buying.

Teacher Background

Nearly $1 out of every $10 spent for food and beverages in the United States pays for packaging.[1]

In industrial countries, packaging contributes about 30 percent of the weight and 50 percent of the volume of household waste.[2]

Pre & Post Test Question

Why should we consider the problem of disposal before we purchase a product?

Learning Procedure

Students will revise a current commercial or write a commercial for a new product that is brief, entertaining, and promotional and presents the environmental consequences of a product. This will be performed before the class as a skit. (Videotape and play back if you have access to equipment.)

1 Notify students of the assignment and allow several days for them to view TV commercials, noting any references to environmental impacts of the products advertised.

2 Have students discuss five advertisements in detail, explaining how the commercials could have been changed to include positive environmental impacts. If a product does not have a positive environmental impact, have students create a new product.

3 Have students create a political ad highlighting a candidate's reactions or campaign promises about landfills, waste burners, recycling, etc.

4 Allow sufficient time for students to write their commercials containing environmental messages.

5 Have students present their commercials, including use of props, cue cards, etc. (Note: If commercials are to be videotaped, the teacher may want to allow extra time for students to feel at ease in front of the camera.)

Examples:
Juice in cardboard boxes versus juice in aluminum cans; returnable, refillable bottles versus nonreturnable, nonrefillable bottles; glass bottles versus plastic bottles.

1 Cynthia Pollack-Shea, "Realizing Recycling's Potential," State of the World 1987, New York, N.Y.: W. W. Norton, 1987, p. 103.
2 Ibid.

Resources - *Video Tape* *PSAs. (Public service announcements). Washington State Department of Ecology. 3 min., color.*

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Take A Bite Of The Finite

Subjects: Social Studies, Math, Science
Grades: 6-12
Teaching Time: 45 Minutes
Focus: Conservation of Resources, Nonrenewable Resources

Rationale

The earth contains a finite supply of mineral resources. Wasting resources - using them only once and not recycling - shortens the time these resources will be available. As countries become more industrialized, affluent, and developed, they consume and waste more finite resources.

Color	Beads	Finite Resource	1996 Estimates of Global Reserve Base*
Red	416	Iron in ore	100 billion metric tons
Blue	104	Bauxite	28 billion metric dry tons
Yellow	1	Tin	10 million metric tons
Silver coin	1	Silver	420,000 metric tons
Green	3	Copper	610 million metric tons
Orange	1	Lead	120 million metric tons
Purple	28	Chromium	7.4 billion metric tons
Coin	1	Platinum	66,000 metric tons
Black	20	Oil	708 billion barrels**

*"The reserve base includes those resources that are currently economic (reserves), marginally economic (marginal reserves), and some of those that are currently subeconomic (subeconomic resources)." U.S. Bureau of Mines, Mineral Commodities Summaries: 1996 Summaries, Washington, D.C.: U.S. Government Printing Office, 1996.

**Oil reserves source: Lester R. Brown and Sandra Postel, "Thresholds of Change," State of the World 1987, New York, N.Y.: W.W. Norton, 1987, p. 12.

Metric ton = 2,200 lbs.
Short ton = 2,000 lbs.
Troy ounces x .0685 = lbs.
32,150.7 troy ounces = 1 metric ton (1,000 kilograms)

NOTE: The number of beads reflects a mineral's relative, estimated total abundance, not the ease of extraction or potential availability of that mineral. The beads are not distributed in exact percentages, to allow for hypothetical and undiscovered resources.

Learning Objective

Students will:

- Understand that some resources, including resources lost to waste disposal, are finite.

Materials

- Colored beads (see chart)

Learning Procedure

Version One

1 Select beads of different colors to represent resources that often end up as wastes.

2 Hide beads and coins throughout the classroom and have students divide into teams representing countries. (Make sure some of the beads are hidden so well they will not be immediately found.)

3 Give teams time intervals of two minutes and one minute to explore for resources.

- After exploration, students are to separate and identify the mineral represented by each color of bead.
- Discuss the greater difficulty in finding resources during the second exploration.
- Discuss what is required to explore for and obtain resources (among other things, energy). **Ask**: "Is energy a renewable or nonrenewable resource?"
- "What is happening to the world population? What effect will rapid population growth have on the future availability of nonrenewable natural resources?"
- "Is competition for resources emerging among countries?" Think of examples.
- After exploring, have students jumble the resources together. **Ask:** "What is this jumble of resources like?" (A dump) "What did it take to get these resources into a usable condition in the first place?" (Energy, refining/separation?) "What is necessary to keep these resources in the cycle of use?" (Separation and recycling?)

For older students:

"What is entropy?" "Why is jumbling resources together and throwing them away an example of entropy?" "What is the Second Law of Thermodynamics?" "How is wastefulness related to the Second Law?"

4 "What can you do to extend the life of finite resources?" "What are the advantages of extending the life of these resources?"

Version Two

1 Hide beads throughout the room, keeping some colors in large groups to represent concentrated ore deposits. Hide some beads very well. Also hide one or two differently colored beads to represent rare strategic metals such as chromium and platinum. Divide students into countries: two large industrialized countries (such as the United States and Canada), two small industrialized countries (such as Japan and Sweden), four developing - Third World - countries (such as Brazil, India, Zimbabwe, Guinea). The number of countries can be changed, but the relative numbers should be kept the same. The idea is to reflect the world's unequal distribution of population and resources.

2 Have students consider the implication of the fact that some rare strategic minerals are found in countries controlled by hostile or repressive governments.

3 Have students explore the possibilities of what to do about local and future shortages of resources. Possible solutions include: recycling, conservation, trading, and treaties.

4 Given the ideas outlined in this activity, have students develop their own learning activity or game (e.g., Risk).

5 Consider extending this activity by adding money to buy resources, setting up cooperative ventures between countries, forming resource cartels, etc. ("An enterprising teacher could take this game as far as imagination and time allows.") Mike Harves, Davis High School, Yakima, Washington.

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Nonrenewable Resources: How Long Will They Last?

Subjects: English, Social Studies (Geography, Contemporary Problems)
Grades: 7-12
Teaching Time: 45 Minutes
Focus: Nonrenewable Resources, Recycling

Rationale

There is a limit to how long more and more of us can continue to make increasing demands on our finite resources. Concentrated, easily mined reserves of nonrenewable resources are being depleted. The availability of these resources can be extended by careful use and recycling. (Note: This activity highlights nonrenewable natural resources other than the fossil fuels.)

Learning Objective

Students will:

- Learn the estimated life expectancies of selected nonrenewable natural resources.
- Understand the role recycling plays in meeting the demand for certain nonrenewable resources.
- Understand the role careful use might play in extending the availability of selected natural resources.

Teacher Background

"The global demand for and consumption of most major nonfuel mineral commodities is projected to increase 3-5 percent annually, slightly more than doubling by 2000."[1]

Pre & Post Test Questions

1. What metal comes from bauxite?
2. What is a mineral deposit?
3. Define total resources.
4. Define nonrenewable resource.
5. Name ten nonrenewable resources.
6. What does "reserve base" mean?

Learning Procedure

Examine the chart "Selected Nonrenewable Natural Resources: Their Life Expectancies and Prime Consumers."

1 Which column under the heading "Life Expectancy (in years)" do you think is more accurate in estimating the length of time our nonrenewable natural resources will last? What are some factors leading to the accelerated use of resources?

2 Examine the "static use" column under the heading "Life Expectancy (in years)." Which nonrenewable natural resource will be used up first?

Ask: "Which countries have the highest reserves of the resource?" Locate these countries on a world map.

Ask: "Why does the U.S. need to be concerned with the depletion of this resource?"

3 "Which nonrenewable resource will last the longest according to the static index? According to the projected rates index?"

1 Council on Environmental Quality, Global 2000 Report to the President: Entering the 21st Century. Vol. 1: Summary. Washington, D.C.: U.S. Gov't Printing Office, 1982.

Ask: ''Which countries have the highest reserves of this resource?''

Ask: ''With which countries will the U.S. need to cooperate in order to get the amount of this resource it needs?''

4 ''Which resource is most extensively recycled?'' List items you use that contain this resource. ''Which of these items could you recycle?''

5 List the resources that will probably be used up within the next 40 years, given projected use rates. **Ask:** ''What role do recycling and careful use play in extending the availability of these resources?''

The following graph illustrates three possible depletion patterns for a nonrenewable natural resource. Pattern a shows that a rapidly expanding use of a resource without improved mining technology and increased recycling will lead to exhaustion of available quantities of that resource. Patterns b and c illustrate that this rapid rate of depletion can be significantly slowed by improved mining technology that can exploit less concentrated mineral deposits, by reduced per capita use, and by increased recycling.

''How can we determine how long a given resource might last?'' Any projections are based on two major sets of assumptions: We must estimate the potentially available supply at existing (or future) acceptable prices and with existing (or improved) technology, and we must estimate the annual rate at which the resource may be used.

"There is no danger whatever of humanity 'running out' of nonfuel mineral resources, and I have not said there is. Humanity is not destroying them. What will run out, however, is the capacity of the environment to absorb the punishment associated with mining ever-lower grades of ore or reconcentrating what is already dispersed. Secondarily, the ability to do the job at an attractive cost will also 'run out'."[2]

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2 Paul Erlich Social Science Quarterly March 1981, Vol. 62, No. 1.

Selected Nonrenewable Natural Resources; Their Life Expectancies and Prime Consumers

Resource	A. 1996 World Estimates of Reserves*	B. Countries or Areas with Highest Reserves		C. Percent of Imports in U.S. Consumption 1995	D. Life Expectancy as of 1989 (in years)		E. Amount Recycled Worldwide 1995
					Static Use at 1976 Level	Use Growing at Projected Rates	
Aluminum in Bauxite	23,000,000 thousand metric dry tons	Guinea Australia Brazil	24% 24% 12%	99%	312	63	No bauxite recycled. In the U.S., 50% of all aluminum cans were recycled.
Chromium	3,700,000 thousand metric tons	Rep. of S. Africa Kazakstan	84% 9%	78%			Chromium contained in purchased stainless steel scrap accounted for 22% of demand.
Copper	310,000 thousand metric tons	Chile European & Asian Markets U.S.A.	28% 18% 15%	6%	63	36	Old scrap - 460,000 tons or 18% of consumption. New scrap - 850,000 tons
Gold	44,000 metric tons	Rep. of S. Africa European & Asian Markets U.S.A.	41% 21% 12%	net exporter			150 metric tons, including new and old scrap.
Iron in Ore	65 billion metric tons	U.S.S.R. Australia Brazil	37% 15% 10%	18%	172	62	There is no significant recycling of iron ore.
Lead	68,000 thousand metric tons	Misc. Countries Australia U.S.A.	35% 28% 12%	15%	172	25	Recovery of lead from scrap batteries - 825,000 tons.
Platinum Group Metals	56,000 metric tons	Rep. of S. Africa Russia	89% 11%	N/A			Recovery of about 60 metric tons, including new and old scrap.
Silver	280,000 metric tons	European & Asian Markets Canada Mexico	43% 13% 13%	N/A	20	17	About 2,000 metric tons recovered.
Tin	7,000,000 metric tons	China Malaysia Brazil	17% 23% 17%	84%	41	31	Old and new scrap - 12,000 tons. 17% of tin in U.S. was recycled.

* Reserves is the part of the reserve base that can be economically extracted or produced.

N/A = Not Available.

Sources: Columns A, B, & C - U.S. Bureau of Mines, 1996 Mineral Commodities
Column D - Global 2000 Report
Column E - U.S. Bureau of Mines, 1996 Mineral Commodities

Nurture Some Nature

Subjects: Social Studies, Language Arts, Art

Grades: K-3

Teaching Time: Two 20-Minute Periods

Focus: Litter Abatement

Rationale

Any change in attitude or behavior toward litter begins with an awareness and knowledge of the problem.

Learning Objective

Students will:

- By keeping an area free of litter, become aware of their responsibility and ability to solve the problem of litter.

Materials

- Litter bags
- Art supplies

Teacher Background

Litter is "waste out of place." Washington State fresh litter samples in 1987 numbered 344 items per mile per week.[1]

Read "My Twenty Foot Swath," p. 172, for information on litter control.

Pre & Post Test Questions

1. What is litter?

2. How can we reduce litter?

Learning Procedures

1 Instruct students to pick up one piece of litter on the way to school. Hold it up in front of class. **Ask:** "What can you tell about litter from what we have gathered?" "What kinds of things commonly end up as litter?" "Why do these things end up as litter?" Have students define what waste category each litter item falls into (i.e., glass, paper, aluminum, etc.). List on chalkboard.

2 Ask students about their thoughts on litter. What they feel about litter, who litters, when, and why. "Are there any dangers associated with litter?" "Are there fines?"

3 Discuss facts about litter and recycling from the Solid Waste Fact Sheets, p. 83.

4 Divide the class into teams, giving each a litter bag. Conduct a five-minute litter hunt contest on the school grounds. Use a whistle or some other method to signal the end of the hunt.

5 Gather students into a circle or return to the classroom to see which team picked up the most litter. Have awards for quantity, volume, or weight. Have students decide if they found anything that could be recycled.

6 Complete one of the student projects using the collected litter:

- Drama — Select a piece of litter. Use it to act out a scene telling its history. Start with the components of the object and trace their history up to the point at which the article is discarded.
- Creative Writing —- Do the same assignment in written form.
- Cartoon —- Draw a picture story about litter.
- Poster —- Use a piece of litter as part of an anti litter poster for the school.
- Showcase —- Use the litter to create an anti-litter showcase or bulletin board for the school or classroom.
- Sculpture — Create a three-dimensional form with litter and display with the poster at the entrance to school.

1 Daniel B. Syrek, Washington Litter 1987, Sacramento, Institute for Applied Research, 1987, p. 8.

Resources - *Video Tapes:* In The Bag. *Walt Disney Educational Media, Coronet Films. 8 min.*
The Litterbug. Walt Disney Educational Media, Coronet Films. 8 min.

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Would You Do It If I Taught You? If I Paid You?

Subjects: Social Studies, Economics, Business, Environmental Studies

Grades: 3-12

Teaching Time: Three Weeks, Plus Conclusion

Focus: Recycling for Profit, Litter Reduction, Ethics and Economics of Recycling

Rationale

Education and a sense of responsibility for the health of the the environment will increase recycling, but immediate financial reward is also a powerful catalyst to action.

Learning Objective

Students will:

- Understand that financial reward — the profit motive — plays an indispensable role in making recycling happen.

Teacher Background

Markets for recyclables may determine if an item is recycled or incinerated and/or landfilled. Currently recyclers pay abount $15 a ton for newspapers in Washington. Some items are not always accepted for recycling now because of depressed markets.

The 1995 crew of the Washington State Ecology Youth Corps cleaned 2,552 miles of highways and collected 156 tons of litter. The Corps recycled 4.2 tons of aluminum cans, 2.4 tons of scrap metal, 5.8 tons of bottles and glass, and 1.7 tons of plastic and cardboard. Another 22.6 tons of litter were collected from state parks, rest areas and other sites.[1]

In 1994, Washington State generated about 7.5 million tons of solid waste. Washington State residents recycled 38% of the recyclable solid waste stream.[2] For further information on litter and recycling facts, see the Solid Waste Fact Sheets, p. 83.

Materials

- 1 large litter basket/newspaper recycling container
- Scale to weigh collected litter and newspaper.

Pre & Post Test Questions

1. What is the best way to motivate people not to litter and to recycle?

2. How much litter was picked up along freeways and highways in 1995.

3. Who picked it up? (Department of Ecology Youth Corps)

1 Washington State Department of Ecology, Solid Waste in Washington State, Publication # 96-500, Feb. 1996, p. 33.
2 Ibid., p. 53.

4. How much Washington municipal solid waste was reported in 1994?

5. How much was recycled?

Learning Procedure

1 Week 1. Without any prior discussion about the problems caused by litter and other solid waste, ask students to bring in litter or recyclable newspaper from outside the classroom to put in the litter or recycling basket. Stress that the litter or newspapers should not be raided from household or school trash cans. At the end of one week, weigh the collected litter and newspapers. Empty the containers and use them for Week 2.

2 Week 2. Do litter or paper recycling lessons appropriate to grade level e.g., "Nurture Some Nature," p. 121; Take A Look In Your Garbage Can!" p. 129, and "Paper From The Urban Forest," p. 143. Encourage students to act on what they've learned in these lessons by picking up litter or recycling newspaper for placement in the cans. At the end of the second week, weigh the cans again and save containers for Week 3.
What effect did education have on the amount of litter collected?

3 Week 3. Say something like "You've been doing a pretty good job bringing in litter, but I'm still noticing litter around the school and in the neighborhood, so I am going to give a reward if you pick up even more litter and things look a lot cleaner by the end of next week. I will also reward you if you bring in newspaper for recycling." Rewards might be: free time, an extra recess, story reading, money, snacks, party time, etc. At the end of the third week, again weigh the collected litter and newspaper. Give rewards, if earned.

4 Put the information from the three weeks on the chalkboard or overhead.
Ask: "What were the differences between the weeks in terms of the amount of trash collected or newspaper recycled?" "Other differences?" "During which week was the most litter and newspaper collected?" "The least?" "Why?" "Why was there a change between weeks?"

Ask: "Which would give best results?":
- Asking someone to do something (pick up litter or recycle).
- Giving reasons why and asking someone to do something.
- Giving reasons why and rewarding someone for doing something.

5 Discuss why people operate recycling centers.

6 Discuss what would happen if recyclers were not rewarded (paid). "Would others save things to be recycled?" "Why or why not?"

Extended Learning

Invite a representative from the recycling industry to visit your class and explain his/her business. Ask the recycler how many recyclables he/she handles, how much he/she pays, and how he/she makes money. Ask how your class or school might begin recycling. Begin a recycling program in your school.

Results -- Pounds Collected

Week	Motivation	Litter	Recycling
1	Request		
2	Education		
3	Reward		

Resources - *Video Tape. PSAs. (Public service announcements). Washington State Department of Ecology. 3 min., color.*

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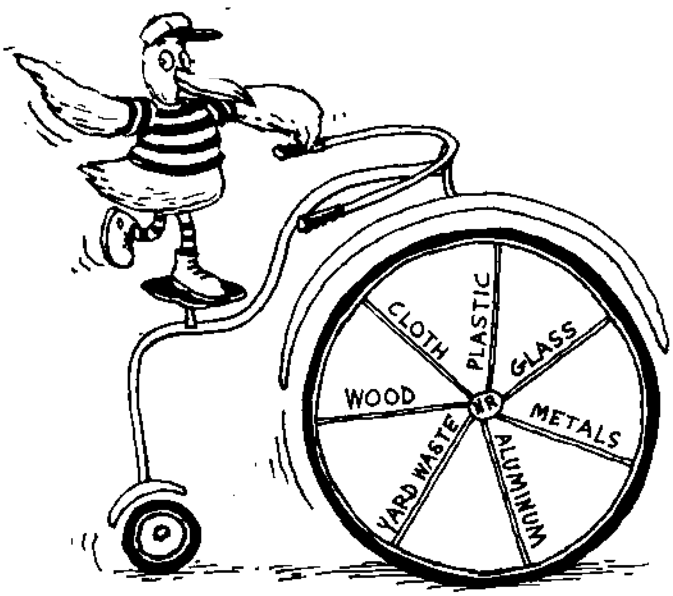
Recycle Bicycle

Subjects: Social Studies, Language Arts, Art
Grades: K-6
Teaching Time: 15 to 30 Minutes
Focus: Cycles, Recycling, Natural Resources



Rationale

To be motivated to recycle at home, students must understand the basic idea of recycling.

Learning Objective

Students will:

- Understand the roles recycling and individuals play in extending the life of resources.

Materials

- Glass bottle
- Plastic bag
- Newspaper/paper bag
- "Tinned" can
- Aluminum can

Pre & Post Test Questions

1. How are a circle and a cycle alike?
2. What are natural resources? Name three.
3. What is a cycle?
4. Why should we recycle?
5. Name three materials you could recycle.
6. Demonstrate a cycle with four or more stages.
7. What is a natural resource?

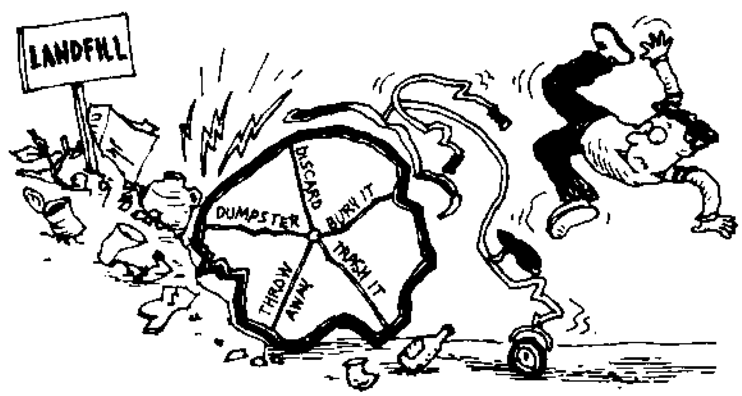
Learning Procedure

1 (Grades K-2) Draw a circle on the board in segments. Describe how it is continuous.

2 Discuss cycles including natural cycles such as the oceans - evaporation - rainwater cycle, or spring - summer - fall - winter.

3 Write the word "recycle" on the board and draw a large bicycle wheel with spokes. Write the word "bicycle" next to it and ask the children how the two words are alike. Discuss what cycles are in general, and how this concept applies to garbage.

4 List some of the things students commonly throw away at home. Bring in examples of paper, metal,



plastic, etc. Identify categories into which this waste can be grouped.

5 Label each spoke of the recycling wheel with one of these category headings. Discuss the original source of all these products and label the hub of the wheel "natural resources."

6 **Ask:** "What do you do with items from these categories once you have used them at home?" Draw a person on the rim to show that the individual has a choice to either keep the material in the cycle of use or discard the waste in a landfill where the resources and energy that it is made of are lost forever.

7 (Grades 4-6) Hold up each item and ask what natural resource is used to make that item (e.g., plastic - petroleum, newspaper - tree). Write the paired words on the board. Have the class write out all the steps in the manufacturing cycle of one of the items.

Extended Learning

(Grades 4-6) Have class members write a short paper or make an oral presentation with artwork or visual aids (photos, slides, acting) of the complete cycle of a natural resource (e.g., bauxite to aluminum to a can to the landfill or recycling center). Point out the importance of continuing the cycle for energy savings and waste reduction when you recycle.

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Take A Look In Your Garbage Can!

Subjects: Social Studies, Science, Math, Art
Grades: K-6
Teaching Time: 45 Minutes
Focus: Waste Reduction, Reuse, Recycling

Rationale

The average family garbage can contains predictable types and amounts of waste. Much of this waste is unnecessary; some is reusable and recyclable.

Learning Objective

Students will learn:

- What the average family of four throws away every day.
- What steps can be taken to reduce the amount of garbage a family generates by reusing and recycling.

Teacher Background

The average person in Washington State disposed of 5.2 pounds of daily household waste in 1994.[1] The waste stream for each employee in a restaurant in Washington State is 10 pounds per day.[2] Each student in Washington State generated about 118 pounds of waste in the 1992 school year.[3] The municipal waste stream before recycling, according to national figures, is 4.4 pounds daily of solid waste per person.[4] Study the categories of solid waste on p. 83.

Materials

- Heavy cardboard or construction paper
- Colored marking pens
- Garbage can poster/silhouette
- Masking tape, Scotch tape, or Velcro
- Scissors
- Tape measure (if you build a scale model)

Pre & Post Test Questions

1. When we fill up the garbage can, what percentage is glass? paper? metal? plastic? yard and food waste?

2. What can we do to reduce the amount of garbage we throw away?

3. What materials can be separated from our garbage and be reused or recycled?

4. What materials will a recycler pay for?

5. What is waste reduction? (see Glossary)

6. How much money a week do you pay to have your garbage picked up?

7. What happens to the garbage after it is picked up?

Learning Procedure

In this section, you will show students what is in the average family garbage can according to weight. The cans have seven categories: paper, metal, glass, plastic, yard waste, food waste, and other. Cut out seven strips of cardboard or paper for the seven solid waste categories.

1 Construct a garbage can out of cardboard, construction paper or poster board, or draw a garbage can on the chalkboard. (See diagram, p. 83

1 Washington State Department of Ecology , Solid Waste in Washington State, Publ. # 96-500, Feb. 1996, p. viii.
2 Ibid. 1992 Washington State Waste Characterization Study, Vol 1: Executive Summary , July 1993, p. II-4.
3 Ibid.
4 EPA., Characterization of Municipal Solid Waste in the United States, 1994 Update, p. 3.

For comparison, you may construct two garbage cans: one for the U.S. and one for Washington State.

2 Ask students to make a list of ten items that are in the class's garbage cans.

3 Outline for the class the seven categories of household solid waste. Have the students list their ten items under the seven solid waste categories.

4 Place the seven pieces of cardboard face down on a table and have a student choose a card. (You may wish to leave the cards for yard and food waste separate.) Have the student read what is on the card. (For younger students, the teacher may show the cards to the students or even draw a picture representation of the item.)

5 Have the class tell which items from their list fit the category of each card as it is displayed. Have them guess what percentage of the total is included in the category displayed. (You may wish to compare state and national figures, or list the percentages and have students guess which percentage fits each category.)

6 As you place a strip "in" the garbage can, discuss the following facts for each category. (You may want to predetermine the order of presentation of the cards. If you are using a chalkboard, you may draw a horizontal line across the garbage can drawing and write in the category and its percentage.)

A. Paper

In 1992:

- In Washington State, 29 percent of all waste materials came from paper,[5] whereas approximately 37 percent of the national solid waste stream was paper.[6]
- The U.S. recovered 34 percent of all paper products produced in 1993.[7]
- Washington residents recycled 74 percent of their corrugated paper; 62 percent of their high-grade paper; 74 percent of their newspapers.[8]

Ask: "What are some of the things we throw away that are paper?"

- Cereal boxes (If the inside of the box is gray, it was probably made from recycled newspaper.)
- Newspapers
- Magazines
- Letters
- Cardboard boxes

B. Glass

- Seven percent of the U.S. solid waste stream is glass.[9] In Washington State, 5 percent of the solid waste stream is glass.[10]
- Glass does not degrade for hundreds, perhaps thousands of years. However, glass can be crushed into particles (called cullet), reheated, and reformed into glass products at an energy savings of 4 to 32 percent compared with glass made from virgin products.[11]

Ask: "What do you throw away that is made of glass?"

- Food jars
- Beverage containers
- Ornamental glass
- Household cleaners

C. Metals

- Ferrous metals such as iron and steel represented about 6.2 percent of the U.S. solid waste stream in 1993.[12]

5 Ecology, 1992 Washington State Waste Characterization Study, Vol. 1: p. II-27.
6 EPA, Characterization of Municipal Solid Waste, p. 29.
7 Ibid, p. 30
8 Ecology, Solid Waste in Washington State, p. 39.
9 EPA, Characterization of Municipal Solid Waste, p. 29.
10 Ecology, 1992 Washington State Waste Characterization Study, Vol. 1: p. II-27.
11 Cynthia Pollock-Shea, "Realizing Recycling's Potential," State of the World 1987, New York, N.Y.: W.W. Norton, 1987, p. 109.

- Aluminum represents approximately another 1.5 percent of the metals in garbage.[13] Other nonferrous metals such as copper and brass make up a very small share of the U.S. waste stream. The total waste stream content for metals is approximately 8 percent.[14]
- Thirty-five percent of the aluminum manufactured in the U.S. is recycled. The national rate for all metals is 30 percent.[15]
- Seven percent of Washington State's waste stream is metal, 1 percent of which is aluminum.[16]

Ask: "Why is the recycling rate so high for aluminum?" "Do you recycle aluminum?"

What other metal items are found in garbage?

- "Tinned" food cans
- Metal caps from jars and bottles
- Automobile parts

Interesting fact: The tin in a "tinned" can is a thin layer comprising only 1 percent of the can.

D. Plastic

- Ten percent of what Washington State residents throw away is plastic.[17] Nationally, approximately 9 percent of the municipal solid waste stream is plastic.[18]

2. At least 46 different types of plastic polymers are used in products bought by U.S. consumers.[19] Interesting fact: To make a squeezable plastic ketchup bottle, six different layers of plastics are used. Each layer does a different job; such as give the bottle strength, flexibility, shape, and impermeability.[20]

E. Others

- Other miscellaneous solid waste stream items such as textiles, wood, rubber, leather, and inorganics comprise 8 percent of the Washington State waste stream. Construction debris is 17% of our waste stream.[21]
- On a national scale, these same items are 15 percent of the total solid waste stream.[22]

Examples of other items are:

- Rubber tires
- Clothing
- Toys (wooden)
- Tennis shoes

F. Compostables

Compostable items, which include yard and garden wastes as well as food wastes in the home, comprise 24 percent of the waste stream in Washington State[23] and 29 percent of the U.S. waste stream.[24]

7 Discuss how we can reduce the amount of garbage in our homes. (recycling and reduction)

Reduction is the process of buying only necessary items, or items that have little packaging, or buying items in recyclable containers.

12 EPA, Characterization of Municipal Solid Waste, p. 29.
13 Ibid.
14 Ibid.
15 Ibid., p. 30.
16 Ecology 1992 Washington State Waste Characterization Study, Vol. 1: p. II-27.
17 Ibid.
18 EPA, Characterization of Municipal Solid Waste, p. 29.
19 Pollock-Shea, "Potential," p. 104.
20 Pollock-Shea, "Potential," p. 104.
21 Ecology, 1992 Washington State Waste Characterization Study, Vol. 1: p. II-27.
22 EPA, Characterization of Municipal Solid Waste, p. 29.
23 Ecology, 1992 Washington State Waste Characterization Study, Vol. 1: p. II-27.
24 EPA, Characterization of Municipal Solid Waste, p. 29.

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Cooperative Problem Solving For The Environment

Subjects: Contemporary Problems, English, Social Studies, Science

Grades: 6-12

Teaching Time: Four or Five Class Periods.

Focus: Brainstorming, Problem Solving Process, Recycling

Rationale

Once students have been made aware of a problem, they need techniques and skills to solve that problem.

Learning Objective

Students will:

- Learn a cooperative problem solving process designed to increase recycling.
- Know how to brainstorm.
- Learn who can recycle.

Materials

Student Handouts

- # 1 --- Segments of Society to Involve in Recycling
- # 2 --- Problem Solving Process
- # 3 --- Creating Ideas

Evaluation chart

Fact sheet (in Handout 2)

The handouts may also be presented as overheads or displayed on the board.)

Teacher Background

Review the information about our nation's waste crisis in the Solid Waste Fact Sheets, p. 83.

Pre & Post Test Questions

1. Describe a problem-solving technique we could use to increase recycling.

2. Who is responsible for solving our waste disposal problem? Which segments of society need to be involved in the solution?

3. How do we determine if a suggested incentive to increase recycling is a good one?

4. What is the purpose of a task force?

Learning Procedure

1 Discuss the waste crisis in our state and country with your class. Review with them the information from the Teacher Background and facts that accompany this activity. For example, Washingtonians produced 5,123,185 tons of solid waste in 1994. Of this amount about 38 percent was recycled. The almost four million tons remaining cause environmental, economic, and political problems.[1]

Nationally, each American produces about 1,241 pounds of garbage a year.[2] In Washington State each person produces about 1,000 pounds of residential garbage per year.[3]

Another good way to focus on the our waste dilemma is for students to keep an environmental journal cataloging all radio, television, and newspaper stories about waste for five days.

1 Washington State Department of Ecology, Solid Waste in Washington State. Feb. 1996, p. viii.
2 EPA, Characterization of Municipal Solid Waste in the United States, 1994 Update, P3.
3 Washington State Department of Ecology, Solid Waste in Washington State, p.54.

2 Have students complete Handout # 1, being as specific and complete as possible.

3 Using Handout # 2 as a guide, review the following problem-solving processes:

1. Understand the problem
2. Brainstorm: Use Handout # 3 as a guide to brainstorming.
3. Analyze
4. Elaborate
5. Evaluate
6. Select the best solution

4 Divide students into groups of four. Each group is a State Recycling Task Force. Assign roles to Task Force members: recorder, discussion leader, spokesperson.

5 Tell students they have been asked by the Governor to serve on a Recycling Task Force to recommend ways to increase recycling in Washington.
Ask students to come up with solutions using the process defined in Handout # 2.

6 Time to select your best idea. Which idea for increasing recycling received the highest score? Do you think this is the best answer or do you want to combine two of your highest ranking incentives? Elaborate your best solution. Describe it clearly. Would graphs, charts, or time lines help?

7 Now present your plan to your class.
Ask for questions and comments and note ways your proposal could be improved.

Extended Learning

1 After individual groups have presented their best solutions, have the class develop evaluative criteria and come up with a class solution.

2 Invite a recycling representative to class to help evaluate the proposed solutions of the Task Force.

3 If the proposed solution has real possibilities, help students implement it in the school and community or send it to the Governor or County Solid Waste Management Office.
Considerations for implementation:

- Which groups need to know about the proposal?
- Which groups will initially oppose it and how can their concerns be satisfied?
- Which persuasive and educational techniques will be needed? (This question could lead to units on public speaking, advertising and marketing techniques, and effective educational and behavior modification methods.)
- Who will perform each task? Brainstorm tasks and draw up a plan of action with names, tasks, and dates.

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Handout # 1 ----
Segments of Society to Involve in Recycling

All segments of our society need to recycle if our solid waste problems are to be solved. Here is a list of people categorized by types of work. Add more occupations to the list, such as nurses, doctors, physical therapists, dentists.

1. Medical professionals as they work in hospitals.
   a.
   b.
   c.
   d.
2. Educators as they work in K-12 schools.
   a.
   b.
   c.
   d.
3. Communication experts as they work in TV stations.
   a.
   b.
   c.
   d.
4. Business people as they work in industry.
   a.
   b.
   c.
   d.
5. Entertainers as they work in their industry.
   a.
   b.
   c.
   d.
6. Government workers as they work in the armed forces or public service.
   a.
   b.
   c.
   d.
7. Working people as they work in factories.
   a.
   b.
   c.
   d.
8. Other professions and occupations you can think of.
   a.
   b.
   c.
   d.

Handout # 2 - Problem--Solving Process

Recycling Problem-Solving Process and Procedure for the State Recycling Task Force

1 Read the problem at hand. Write down ideas and solutions as they occur to you and underline important parts of the problem.

The Problem: In 1994 each person in the United States threw away 1,241 pounds of garbage, and as a nation the total gross discards in the municipal solid waste stream were 206.9 million tons.[4] In Washington State, 3.88 million tons of garbage were placed in landfills in 1994.[5]

The problems of waste are of space, environmental degradation, and cost. If we are having trouble finding space for waste now, where will the waste go in the future? Our enormous amounts of garbage produce volumes of leachate (the combination of rainwater and garbage that seeps through landfills that can contaminate ground water).

The decomposing garbage in landfills also produces methane. Methane is a colorless, odorless gas that is explosive when mixed at concentrations of 5 to 13 percent with air.[6] Methane forced the evacuation of homes and businesses near Seattle's Midway landfill and necessitated a multimillion dollar cleanup.

Getting rid of garbage is now very expensive. How much will you be paying when you start to pay taxes? Will leachate threaten water quality where you want to live?

Recycling is a part of the solution to this problem. Conscientious, community wide recycling is expected to reduce the waste stream by 25 percent. With composting, that percentage might be increased to 35-40 percent. Currently, Washington State residents recycle about 38 percent of the garbage they produce.[7]

Substitute House Bill No. 1671, passed into law in April 1989, called for a recycling rate of 50 percent by 1995 (Sec. 1, No. 9). You have been appointed by the Governor to serve on a Washington State Recycling Task Force. Your task is to design a plan to increase recycling to 50 percent by 2000 to meet the state requirements.

2 Time to brainstorm. Remember your brainstorming rules (Handout # 3). When brainstorming think of all segments of society to involve in answering the question: <u>What incentives can we, as members of the State Recycling Task Force, create to motivate people to recycle at home, at work, and at play</u>? Use the information you generated in completing Handout # 1.

3 Now time to analyze your ideas. Are any of the ideas you generated natural combinations? Are any of them duplications or not likely to motivate recycling? Combine or cross these out. Then select ideas with the most potential and narrow these down to the best five.

4 Elaborate on your five best ideas. For each state who, what, where, when (a general time line), and how the idea could be carried out. State why you think this idea would motivate people to recycle.

4 EPA., <u>Characterization of Municipal Solid Waste in the United States 1994 Update</u>, p. 29.
5 Washington State Department of Ecology, <u>Solid Waste in Washington State</u>, Feb. 1996, p. viii
6 Douglas M. Considine and Glenn D. Considine, <u>Van Nostrand Reinhold Encyclopedia of Chemistry,</u> 4th ed., New York, N.Y.: Van Nostrand Reinhold Company, Inc., 1984, p. 570.
7 Washington State Department of Ecology, <u>Solid Waste in Washington State</u>, Feb. 1996, p. viii

5 Evaluation of your ideas is very important. Here's a way to rank your ideas to identify the best solution.

Select five criteria to judge the merits of each idea. Some possible criteria are:

- least expensive to implement
- most readily accepted by the public
- will produce the greatest increase in recycling
- would collect the greatest number of items with long-term market value
- would involve most segments of society
- would result in greatest reduction in waste
- may be implemented quickly

Now list your five ideas and rank them on a scale of one to five, with one being the lowest rating and five the highest.

Handout # 3 - Creating Ideas

Brainstorming Guidelines for the State Recycling Task Force:

1. Don't Criticize Others
   They will lose their train of thought and stop generating ideas.

2. More Is Better.
   Write down as many ideas as you can. At this stage, don't worry about spelling, repetition, etc.

3. Connect Ideas When Possible
   If something someone says sparks a thought, say your idea. Connect parts of your ideas with theirs when possible.

4. Be Freewheeling and Don't Be Afraid of Crazy Ideas
   A crazy idea now may seem plausible and original after more thought and research.

Making Recycled Paper

Subjects: Science, Social Studies, Art
Grades: 2-5
Teaching Time: Two 40-Minute Class Periods
Focus: Learning a Process, Recycling

Rationale

Recycling conserves natural resources and reduces solid waste.

Learning Objective

Students will:

- Recycle used paper into new, usable paper.

Teacher Background

Paper cannot be recycled indefinitely, because the fibers break down eventually. However, many grades of paper can be de-inked, cleaned, and bleached, processes that allow paper to be reused as gameboards, tissue papers, ticket stubs, packaging, covers for hardcover books, insulation, and animal bedding.

Between 1978 and 1980, every American used 580 pounds of paper per year. In comparison, the people of Australia used 295 pounds per person per year and the people of Nigeria, 7 pounds.[1]

Paper constitutes 37 percent of the nation's municipal waste by weight in 1993.[2]

In the State of Washington in 1992, 29.5 percent of the combined residential and commercial waste stream was paper.[3]

In 1986, Washington State recycled 27 percent of total paper produced.[4] In 1994, Washington State recycled 74 percent of corrugated paper, 74 percent of newspaper, and 62 percent of high grade paper. [5]

Materials

- Blender or eggbeater and wide-mouthed container
- Pans
- Large mixing spoons
- Screens
- Cups to scoop pulp onto screens
- Blotters
- Dishwashing detergent
- Sponges or towels for soaking up water
- Scrap paper or newspaper to recycle
- Warm water
- A place to dry the paper
- Iron (to help dry the paper)
- Scale
- Optional: spices, dried flowers, herbs, vanilla, etc.

Pre & Post Test Questions

1. What natural resources are conserved when paper is recycled?

2. What kinds of paper can be recycled?

3. How should you separate paper to take to a recycling center?

4. What are the basic steps in making recycled paper?

1 William U. Chandler. "Materials Recycling: The Virtue of Necessity," Worldwatch Paper 56, Washington, D.C.: Worldwatch Institute, 1983, p. 13.
2 EPA, Characterization of Municipal Solid Waste in the United States, 1994: Update, p. 29.
3 Washington State Department of Ecology, 1992 Washington State Waste Characterization Study,. Vol. 1, July 1993, p. II-27.
4 Ibid., p. 22.
5 Ibid. Solid Waste in Washington, Feb. 1996, p. viii.

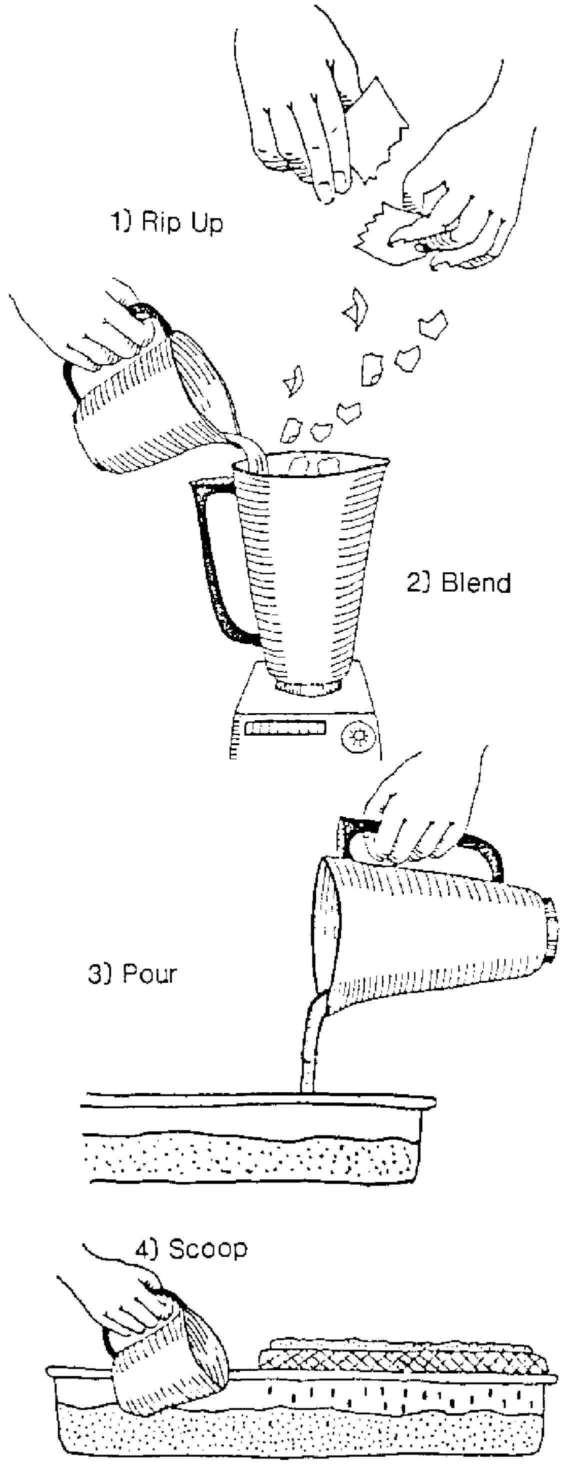
Learning Procedure

(See also diagrams on p. 141)

1 Make recycled paper by using the following procedure:

- Tear sheets of used paper into small strips, about one-inch square. Loosely pack into blender until 1/3 to 1/2 full. Add warm water until blender is 2/3 full.
- Blend (with lid on) until the paper looks like oatmeal mush (5-10 seconds). If you are coloring the paper by using scraps of construction paper, add them now. (If you desire white paper, add a small amount of dishwashing detergent to de-ink the paper.)
- Pour into the pan. When pulp is mush consistency, add about 1/2 inch of water for every blender full of pulp, adding more or less depending on thickness of paper desired.
- Scoop the pulp mixture evenly onto the screen with a cup (hold the frame over 1/2 of the pan). If students want to add things individually to their pulp (colors, paper bits, glitter, spices), they add it to their cupful. Let the pulp drain.
- Place a piece of blotter over the wet sheet of paper on the screen, then flip the screen over so the paper is between the blotter and the screen, with the screen on top.
- Soak up extra water with a sponge. This water can be squeezed out of the sponge back into the pulp mixture.
- Lift off the screen and place the new paper in a safe place to dry. Drying takes one or two days. Exchange blotter and dry paper towels every few hours if you want the paper to dry more quickly. The paper should not be touched or unnecessarily disturbed while drying. You may iron the paper to speed up the drying process. (Place a sheet of paper between the new paper and the iron.)

Special options: You may use deckles such as cookie cutters to create unusual shapes for your paper, or you may add glitter or food coloring to the mixture.



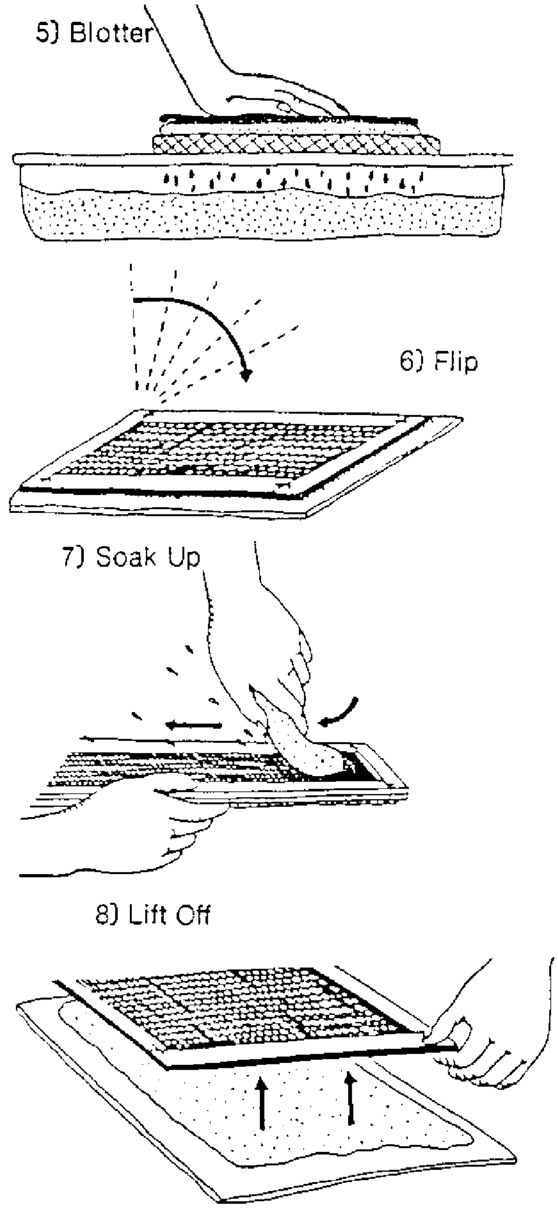
2 As a recycling experiment, you can weight the paper before placing it in the blender, and then weigh the recycled paper after it dries. What conclusions can you make about yield from the original paper? What are the benefits of recycling paper? What are the drawbacks? Can paper be recycled indefinitely? (No, eventually the fibers break down.)

Extended Learning

1 Contact your local recycling center or the Department of Ecology's Recycling Hotline, 1-800-RECYCLE, to learn what types of paper are commercially recycled, the location of the paper recycling centers, and the proper ways to bundle and separate different types of paper.

2 Visit a pulp mill. Find out if the mill uses only virgin timber, a mixture of virgin timber and recycled paper, or only recycled paper.

3 Weigh all the waste paper the class generates in a week. The next week, separate all the paper suitable for recycling. Then weigh again the amount that gets thrown away and determine how much paper the class can save for recycling. Have a contest with another class to see who can recycle the most paper.



Acknowledgment

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Paper From The Urban Forest

Subjects: Science, Social Studies
Grades: 2-5
Teaching Time: 20 Minutes
Focus: Recycling Paper Saves Trees and Energy

Rationale

Fiber from the "urban forest" ---- recyclable paper ---- can be a raw material for making paper just as is fiber directly from trees of the natural forest. As paper from trees becomes more difficult and environmentally costly to obtain, paper from the "urban forest" will become more valuable.

Learning Objective

Students will:

- Understand that paper can be made both from trees and from recycled paper.
- Understand some of the energy and environmental costs of paper production.

Teacher Background

See chart on the following page.[1]

Pre & Post Test Questions

1. What is the "urban forest"?

2. What are some of the raw materials for paper making found in the "urban forest"?

3. What effect does the cutting of forests have on soil, streams, fish, and air?

4. Can you name five different uses of paper?

Learning Procedure

1 Discuss about how long it takes a tree to grow to a size big enough to be harvested. (In Washington State, it used to take 50 to 60 years, but younger and smaller trees are now being processed.)

2 Discuss ways in which energy is used in the making of paper. (Energy to run logging equipment, factory machinery, etc.)

3 Discuss how cutting trees for paper affects the environment. What are the effects on wildlife, fish, soil, and air?

4 Discuss where else we can look for a supply of raw materials with which to make paper, as forests near cities and paper mills get cut down.

5 Put the 1992 paper recycling statistics on the board. (See the chart on the next page.) Which of the four categories needs the most improvement? Point out that 31 percent of the total paper waste stream in Washington State (368,439 tons) was scrap paper. How can this problem be improved? (regulations, recycling, restriction of "slick" paper products).

Extended Learning

Set up five boxes in your home or school for the five categories of paper. For one week, separate all waste paper into the five boxes. Weigh each pile of paper. Rank your categories by weight. Discuss how your home or school paper waste stream compares with the survey.

1 Washington State Department of Ecology

1992, Washington State Paper Recycling

Category	Percent Recycled
Corrugated	62%
High grade paper	58%
Newspaper	58%
Mixed Waste Paper	32%

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As The Worm Churns

Subjects: Science, Woodshop, Home Economics

Grades: K-12

Teaching Time: 30 to 45 Minutes, With Periodic Review

Focus: Household Waste, Waste Reduction, Composting

Rationale

When we throw food scraps into the garbage, we turn a resource into a liability. At significant financial and environmental cost, waste has to be picked up, transported, and buried or burned. Composting our kitchen waste by using worms provides an alternate use for kitchen waste and creates soils.

Learning Objective

Students will:

- Discover a beneficial, low technology way to reduce household waste.
- Understand the natural process of biodegradation and soil production.
- Know how to improve soil through worm composting.
- Learn what a landfill does.
- Learn the benefits of composting.

Teacher Background

Review the lesson "Take A Look In Your Garbage Can!" p. 129.

Redworms, *Eisenia foetida,* are used to process kitchen waste into high quality garden compost. Properly constructed and maintained, the bins do not give off an offensive odor.

Interesting Fact:

In Washington State in 1992, food waste constituted about 12 percent of residential solid waste.[1]

Worm bins provide the following benefits:

- Reduce household waste
- Save garbage disposal costs
- Produce an excellent soil amendment
- Provide worms for fishing
- Demonstrate one of the most important natural processes: biodegradation and soil production

The formula for sizing a worm bin is simple: 1 cu. ft. is needed for each pound of food waste generated each week. If your class has access to about four pounds of food waste each week, you need to build or buy a 4-sq.-ft. worm bin. (Half-size bins are also effective; they require half the amount of food and materials.)

Woodshop classes could make a worm bin as a first project. For a 4-cu.-ft. bin, four 2' x 12" sheets for the sides and two 2' x 12" sheets of plywood for the top and bottom need to be cut. After the sides and bottom are nailed together, the top can be hinged. About nine to twelve holes should be drilled into the bottom and sides of the box. The holes provide air for the worms. A cookie sheet or plastic layer should be placed under the box to catch any debris or water falling through the holes. If your school has no shop class, you can use wood, metal, or other containers, as long as they are not filled deeper than 12 inches. A piece of heavy duty plastic may be used as a cover. For a 4-cu.-ft. worm bin you will need:

- 1 box no deeper than 12 inches (to prevent anaerobic conditions from developing)
- 1 room or space with a temperature between 55°F and 77°F

1 Washington State Department of Ecology, 1992 Washington State Waste Characterization Study, Vol. 1. July 1993.

- 6 pounds of paper for bedding
- 1-2 handfuls of soil (optional)
- Several eggshells
- 1 pound of *Eisenia foetida* (redworms)
- 4 pounds of food waste per week

Shred the paper by tearing it into strips about 2 inches wide. Put the paper in a bucket, and slowly pour water in while fluffing the paper occasionally. Let the paper segments drip until dripping subsides. Put wet strips of paper in the worm box, and sprinkle in several eggshells (for worm reproduction). Gently place the worms in the box, leaving the top open until the worms burrow down. Close the lid or cover with a black plastic sheet. (Since worms do not react to red light, a red plexiglas side panel or lid would allow direct observation of worm activity.) Bury food in the box each week, rotating the burial location.

The general formula for worm bins: for each cubic foot of bin, you need 1.5 pounds of bedding, 4.5 pounds of water, 1 pound of garbage per week, 4.5 ounces of redworms, a bit of soil and calcium carbonate.

To change worm bedding, either dump the contents of the bin under a bright light and brush the layers of compost away (the worms will move away from the light and gather at the bottom of the pile); or pull the compost plus worms to one side of the bin and add new bedding to the vacant side. An alternative is to use only one-half of the box at a time; put your bedding and worms in one side of the worm bin. Continue to bury food into the bedding until it is composted. Then add new bedding to the empty half of the bin. Begin burying food on the new side. Allow one month for the worms to migrate to the new side. Remove the worm castings. Repeat the process. To be certain you have all the worms from the first side, expose the worms to bright light, then wait 20 to 30 minutes. Remove the top layer until worms are exposed. Repeat until the worms are in a mass in the center of the old bedding, then add the mass of worms to new bedding. Use the soil formed by the castings on potted plants or in the garden.

Some of the foods that will work well in the worm bin are apples, apple peelings, baked beans, banana peels, biscuits, cabbage, cake, cantaloupe (a worm favorite), celery, cereal, cheese, coffee filters, coffee grounds, cornbread, cottage cheese, cream cheese, Cream of Wheat cereal, cucumbers, eggshells (good source of calcium carbonate), farina, grapefruit peels, grits, lemon, lettuce, Malto-Meal cereal, molasses, oatmeal, onion peel, pancakes, pears, pineapple, pineapple rind, pizza crust, potatoes, Ralston, tea bags, tea leaves, tomatoes, turnip leaves, and watermelon (another favorite). Avoid putting plastic, bottle caps, rubber bands, sponges, aluminum foil, or glass in the box, and don't allow the box to be used as a cat's litter box. Fruit flies can be avoided by burying the food waste completely.

The worm bins need little routine maintenance. Depending upon the desired outcome, the bedding should be changed every three to six months. After three months, one will find the number of redworms is high; after four months, the number of redworms will still be high, and the quality of compost will be fairly good; after six months, many redworms will have died, but the quality of the compost will be very good. The resulting compost will be primarily worm castings (worm manure).

Materials

- Wooden box (2' X 2' X 12")
- Paper
- Water
- Dirt
- Redworms (*Eisenia foetida*)
- Calcium carbonate
- Food waste

Pre & Post Test Questions

1. What are worm castings?

2. How many ounces or pounds of worms, bedding, water, and food waste do you need for each cubic foot of a worm bin?

Learning Procedure

1 Ask the school's shop class to build a 2'X 2' X 12" wooden bin (see specifications above).

2 Talk about the impact of food wastes on the solid waste stream. Discuss alternative methods of handling food wastes. Introduce the idea of using redworms (*Eisenia foetida)*.

3 You will need one pound of redworms for the bin. Ask the students to look for and collect redworms (not nightcrawlers). Hints for where to look: barn-yards under mulch, in compost piles, under decomposing lumber. You may need to supplement the redworm find by obtaining some from a commercial grower. Consult the resources book for suppliers.

4 Set up your worm bin. For a 4-cu.-ft. bin, bury four pounds of food waste in the bin each week, making sure to rotate the location of the burial (mentally dividing the bin into nine squares would probably be helpful).

Extended Learning

1 (Grades K-12) Study the reactions of worms to different colors of light. Study the food preferences of young versus mature worms. Using four worm bins, study the reactions of the worms to the four food groups.

2 (Grades 4-12) Keep records of the temperature of the compost, room temperature, amount and types of food fed to the worms, and total volume/weight of the compost. Relate these variables to each other and to any variables you identify.

3 (Grades 6-12) Study the worm's life cycle. How do worms reproduce? Do you see any babies? How long do the worms seem to live? Do you see any dead worms?

4 Study the other organisms present in the worm bin. What is the interrelationship of these organisms?

5 Study the effects of various mixtures of vermi-compost, peat moss, soil, and perlite on potted plants.

6 Calculate how much food the households of class members throw away in a day. Base the calculation on the fact that each Washington State resident produces about 7.7 pounds of garbage in the home per day.[2] Of this residential total, about 12 percent of the garbage is food.[3]

7 Discuss: Why, in a hungry world, do we throw away so much food? In the United States in 1993, we threw away 13.8 million tons of food, or 6.7 percent of our total solid waste stream.[4]

2 Ibid. Solid Waste in Washington State, Feb. 1996, p. 54.
3 Ibid. 1992 Washington State Waste Characterization Study, Vol. 1, July 1993.
4 EPA., Characterization of Municipal Solid Waste in the United States, 1994 Update, p. 29.

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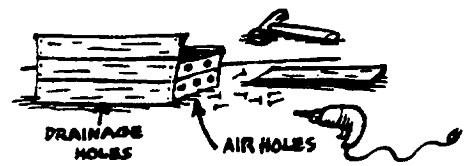
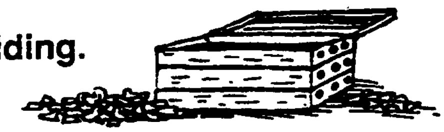
As the Worm Churns

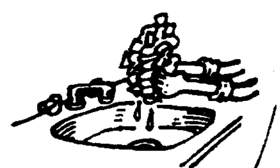
1. Build or obtain a container.
   Drill holes in 2 sides and on the bottom.



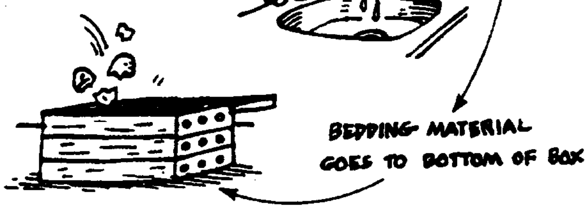
2. Shred paper for bedding.



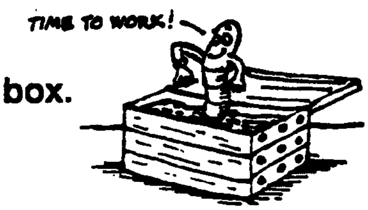
3. Wet the bedding
   and squeeze out excess water in the sink.



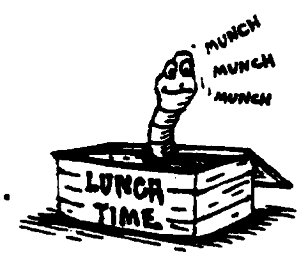
4. Sprinkle in 1 or 2 eggshells.



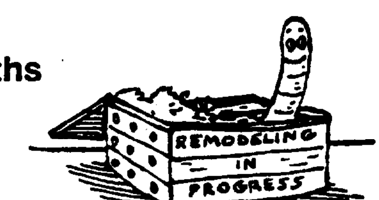
5. Place worms in the box.



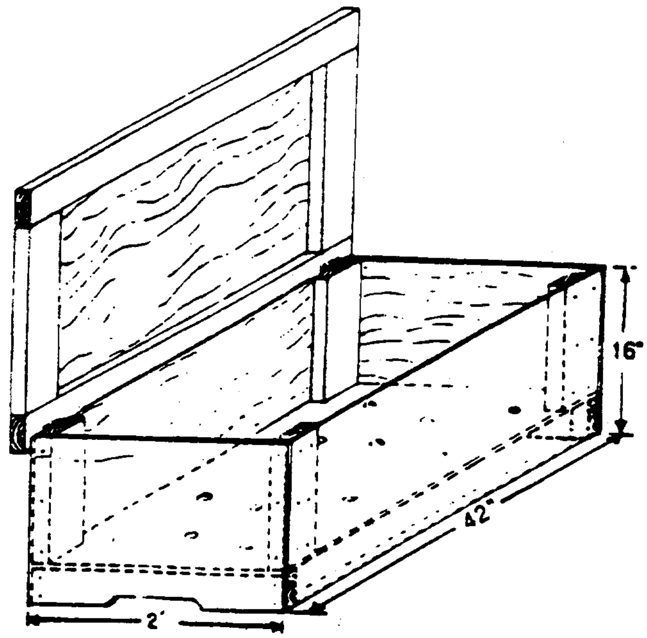
6. Bury garbage for food once a week.
   (Be sure you rotate the placement of the garbage).



7. Change the bedding every 3-6 months
   and remove the newly made soil.



I-2-3 Worm Composting Bin



This system is designed for camposting vegetable food wastes using red worms. Food wastes and worms are "bedded" in shredded and moistened newspaper, cardboard, peat or brown leaves. The worms turn both food wastes and bedding into a highquality compost suitable for use on house plants, seedlings or general garden use.

To maintain this system simply rotate of food wastes throughout the bin. Every 3-6 months compost should be moved to one side of the bin and new bedding added to the empty half. At this time start burying wastes in the new bedding only. Within one month worms will populate the new bedding, finished compost may be harvested and the rest of the bin can be rebedded. During the winter, worm bins should be kept in a cool indoor space such as a basement or warm garage to avoid freezing. A properly maintained worm bin is odorless. Bins may be placed in a shady outdoor space the remainder of the year. Flies may be controlled by placlng a sheet of plastic over the bedding.

This bin can be built for about $25 with new wood and hardware, or less using recycled materials, Worm bins can also be made from wooden boxes or other containers. Any worm bin must have drainage in the bottom and a tight fitting lid to keep moisture ***in*** and pests out. A starter batch of worms can be purchased at a small additional cost, or find some in an old compost pile! For more information see Mary Appelhof's book, Worms Eat My Garbage.

Materials

1 l/2" treated sheet of plywood

1 12 foot 2X4

1 16 foot 2X4

2 lbs. 6d galvanized nails

l/2 lb. 16d galvanized nails

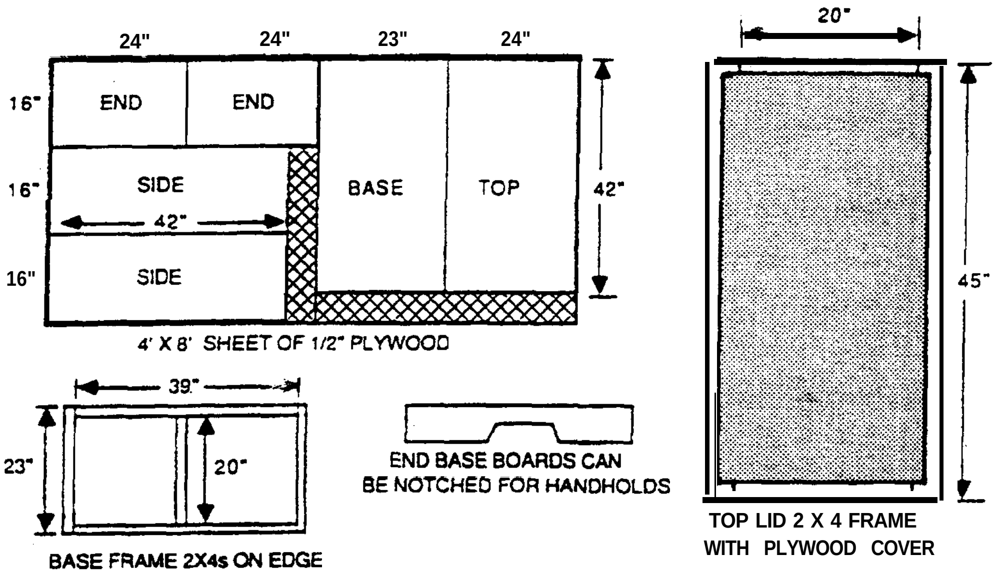
2 galvanized door hinges

Tools

Tape measure, skill saw or rip hand saw, hammer, saw horses, long straight edge or chalk snap line, screwdriver, and drill with l/2" bit.

Use eye and ear protection.

Construction Details



Measure and cut plywood as indicated in drawing above. Cut the 12 foot 2X4 into five pieces: two 39", two 23", and one 20" long. Nail the 2x4s together on edge with two 16d nails at each joint as illustrated in the Base Frame diagram. Nail the plywood base piece onto the 2X4 frame.

Cut four 1 foot lengths out of the 16 foot 2X4. Take each plywood side piece and place a one foot 2X4 under each of it's ends so that the 2X4 is flush with the top and side edges of the plywood, and nail the boards into place. Nail the side pieces onto the base frame. To complete the box, nail the ends onto the base and sides. To reinforce the box and be sure there is a nail staggered at least every 3 inches wherever plywood and 2x4s meet. Drill twelve l/2" holes through the bottom of the box for drainage.

To build the lid, take the remaining 12 foot 2X4 and cut it into two 45" pieces and two 20" pieces and lay them flat, short pieces on the inside as indicated in diagram above, so that the plywood top is inset from the edges of the 2X4 by 1 -l/2" all the way around the perimeter. Nail the plywood onto the 2x4s and on the underside of the 2X4 lid frame, so that the lid will stand upright when opened.

How To Recycle In School

Recycling is part of our daily lives. Recycling programs are being established in communities throughout the state. Schools have an excellent opportunity to reduce and recycle their waste. A school waste reduction and recycling program saves energy, conserves natural resources, preserves landfill space, reduces pollution, and provides a positive, hands-on educational experience for students, teachers, and other school personnel. A school waste reduction and recycling project may provide an important public service by presenting the school in a leadership role in the community.

The "Waste Not in Washington" Bill (ESHB 1671), passed into law in 1989, states in Section 54, "Each public school shall implement a waste reduction and recycling program conforming to guidelines developed by the office." Program guidelines are available in limited quantities from Department of Ecology. Ask for the book, "How to Make Waste Reduction and Recycling Happen in Your School."

The Department of Ecology has developed an awards program for waste reduction and recycling in public schools. Annual monetary awards will be given to schools achieving the greatest levels of waste reduction and recycling. For further information call 360-407-6140.

Goals

Establish attainable goals to ensure continuing success in recycling and waste reduction. Goals may include:

1. Conserve resources and save energy
2. Reduce school waste produced and reduce cost of disposal
3. Educate students and staff in waste management concepts and practices
4. Establish and maintain a successful waste reduction and recycling program in school
5. Participate actively in solutions to environmental land, air, and water pollution problems

Needs Assessment

Waste Reduction

In order to develop a comprehensive waste reduction program, conduct an inventory of current purchases to assess waste reduction possibilities (i.e., what recyclable materials do you purchase? What recycled materials are purchased by your school district?).

Recyclable Materials

Before initiating a recycling program, conduct a waste audit to determine what waste is being generated, what is being throw away, what currently is being recycled, and what could be recycled. Conduct a study of existing disposal practices, including a breakdown of the current waste stream content by kinds of materials and volume per container in yards. Also calculate current disposal costs per container and total disposal cost on a monthly basis.

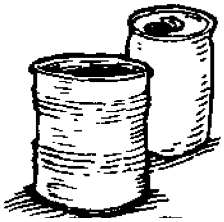
The inventory list below includes example recyclable materials found in schools.

Types of Paper

- White ledger paper
- Computer paper
- Workbooks
- Magazines
- Newsprint
- Construction paper
- Cardboard

Metals

- Aluminum
- Tinned cans
- Steel
- Iron
- Copper

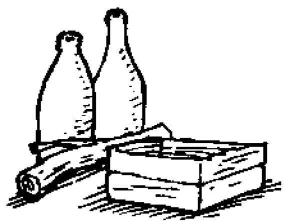


Plastics

- PETE (pop bottles)
- HDPE (Milk jugs)
- LDPE (clear bags)
- Other

Others

- Glass
- Wood products
- Compostables



Market Research

Before initiating a recycling program, a market search should be conducted. Recyclers may collect only certain recyclable materials.

To identify recyclers in your area, contact the Washington State Recycling Hotline 1-800-RECYCLE.

Questions Schools Should Ask The Recycler

What materials will you accept?

Will pay for? (How much?)

Will collect at no cost?

Will collect but for a fee? (What is the fee?)

How should materials be separated and collected and stored?

What will the recycler provide?

Containers?

Promotional materials?

Transportation of recyclables from school?

Frequency of service?

Monitor and report totals of materials being recycled?

How frequently will materials be picked up?

What is the minimum or maximum quantity accepted for collection?

Will the recycler provide a written contract for collection of materials for a specified length of time?

Operations Planning

Waste reduction tips

- Reuse paper
- Purchase recycled paper
- Purchase recyclable/reusable materials

Hints for first-time recycling programs

Form a committee with representatives from all school groups to develop a strategy for education, promotion, collection, storage, transportation, monitoring, evaluating, recording and reporting the results of the waste reduction and recycling program.

Initiate a recycling and waste reduction educational program in your school for students, faculty, clerical staff, administrators, and custodians.

Designate a coordinator to oversee the program.

Initial pilot project

Pick one item (i.e., white paper, aluminum)

Locate a recycler who will accept your source separated materials with the understanding that you may add more recyclable items later. Be certain you have a valid contract with your vendor that meets your needs. See “Questions Schools Should Ask The Recycler.”

Monitor the progress of your project noting successful components and the aspects that need modification.

Measure, record, and report the amount of material being recycled.

After a designated period of successful recycling, add a new recyclable item to the program.

Renew interest in the recycling program with awards, media events, or contests among different groups in school. (The local PTA may be a good resource for promotional campaigns.)

Problems that may arise

- Equipment and storage needs
- Contamination or vandalism of recyclables
- Codes that need to be addressed (i.e., fire, health, safety, etc.)
- Poor participation rates
- Fluctuating markets may affect prices for materials recycled or they may affect recycler participation in the program

Note: Before instituting a waste reduction and recycling program, schools need to contact the local fire marshal. For paper and other flammable materials, fire codes designate policies for storage of materials, preparation of materials, placement of collection receptacles, and types of collection receptacles permitted. Fire codes also address frequency of collection and the types of materials collected.

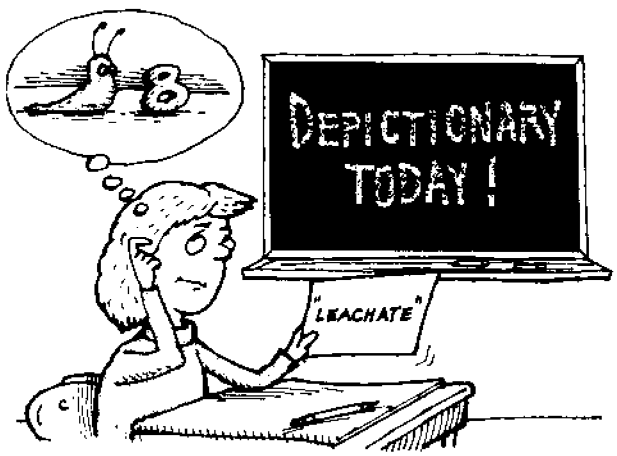
Recycling tips for advanced programs

- Source separate all school materials which are recyclable
- Initiate a composting program in classrooms or on school grounds
- Research possible new markets or vendors before adding materials
- Calculate costs: Include savings from reduced garbage collection fees

The in-school waste reduction and recycling program can be beneficial for students, teachers, and staff in the school and for the community at large.

Depictionary

Subjects: Science, English
Grades: 3-8
Teaching Time: 40 Minutes
Focus: Waste Management, Resource Conservation, Waste Reduction, Recycling Vocabulary



Rationale

Knowledge of the vocabulary of resource conservation is basic to understanding waste reduction and recycling.

Learning Objective

Students will:

- Learn the basic vocabulary of waste reduction and recycling.

Teacher Background

Read the Glossary.

Materials

- Deck of index cards with vocabulary words written on them

Pre & Post Test Question

Ask students for the definitions of any of the attached vocabulary words.

Learning Procedure

1 Divide the class into two teams.

2 One student from each team views the word shown by the teacher and draws illustrations of the word on the board.

3 Teams have 60 seconds to guess the word illustrated by drawing. The first team to guess the word gets a point. That team can earn an additional point by giving the correct definition of the word. If neither team is able to guess the word, reveal the answer. For definition of the word list see the Glossary. You may wish to write the definitions of the vocabulary on the back of the cards and have students read them.

4 New students on each team view and draw the next word and the game continues.

Suggested Vocabulary List

Aluminum - noun

Aquifer - noun

Biodegradable - adjective

Compost - verb

Garbage - noun

Glass - noun

Ground water - noun

Hazardous waste - noun

Landfill - noun

Leachate - noun

Litter - noun

Methane - noun

Paper - noun

Plastic - noun

Pollution - noun

Recycle - verb

Throw away - verb

Wildlife - noun

Difficult Vocabulary List

energy - noun

Environment - noun

Inorganic - adjective

Natural resources - noun

Nonrenewable resource - noun

Organic - adjective

Packaging - noun

Renewable resource - noun

Extended Learning

Add new environmental terms to your list from magazine articles, TV, or newspapers. Define the terms.

Bibliography

Resource Recycling Inc. Glossary of Recycling Terms and Acronyms. Portland, OR: Resource Recycling Inc., 1989.

The Throwaway Three

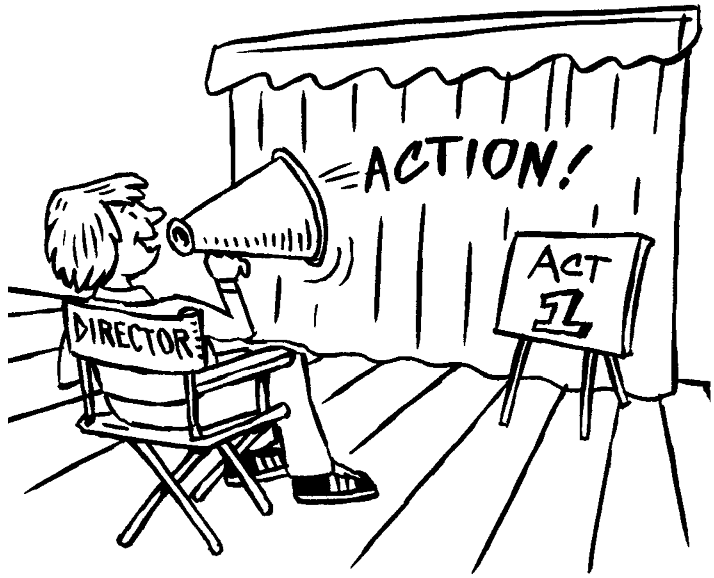
(a skit)

Subjects: Social Studies, Language Arts, Drama

Grades: 4-6

Teaching Time: Two 40-Minute Sessions

Focus: Litter Control, Recycling



Rationale

We can't throw away our trash. There simply is no such place as "away." Care is always required to prevent our trash from having bad effects on our lives.

We can't burn it all. Most of the burning requires expensive and often elaborate controls, to prevent air pollution. There is always ash or something left over which must be buried.

We can't bury it all. Not enough places are available. Besides, plastics and modern synthetics do not rot when buried.

We are literally running out of some natural resources, so that any form of disposal of certain goods is self-defeating.

Learning Objective

Students will:

- Become aware that historical methods of getting rid of solid waste (throw it, bury it, or burn it) won't solve modern urban garbage problems.

Materials

- Skit script
- Props

Pre & Post Test Questions

List three waste disposal problems today's society must solve which did not exist 100 years ago.

Explain how this skit helped you find ways to solve your waste problems.

Who were litter makers in this skit?

Learning Procedure

1 Prepare materials as described in the skit script on the following sheets. Encourage students to make props and costumes from recycled or reused materials.

2 Work with students to develop a production which could be performed for other classes, for parents, or for a group in the community.

Bibliography

Bradley, Fay. "Throwaway Three." Lessons from Litter. Atlanta: Atlanta Clean City Commission, 1979.

U.S. Environmental Protection Agency. Let's Recycle: Lesson Plans for Grades K-6 and 7-12. Washington, D.C.: Office of Waste and Waste Management, 1980.

THE THROWAWAY THREE

PROPS

Person 1

This is the tale of the Throwaway Three,
Of Man and his Garbage throughout his-to-ry:
Now they're very nice people, like you and like me,
Who all have a problem, as you will soon see-
What shall they do with their garbage and trash?

All

Why, throw it! Or bury it! Or burn it to ash!

Person 3 - 50,000 BC (Cave dweller)

I am a cave dweller who lives on the ground. What do I do with old stuff all around? Why, burn it, like meat; burn it up in the fire; Or bury it like bones, in the muck and the mire.	Skins

All

Yes. throw it, or bury it, or burn it to ash!
That's how we always get rid of our trash!

Person 1 - 200 BC (Roman)

I am a Roman who lives in the town. Our laws won't allow me to just throw it down. I have to drag it away for a mile And then I can dump it, forget it, and smile!	Roman Helmet Bag of Trash

Person 2 - 1200 AD (Briton)

I am a Briton, wary and quick; Down on our street it can get pretty thick. When housewives up there want to pitch out their goo, They just leave it out there and yell: "Gardy-loo!" (Person 1 stands on chair and yells, "Gardy-loo!") It will stay there and stay there until the next rain, Or until our fair London should burn down again.	Stack of Trash

All

Oh, what do we do with our garbage and trash:
We throw it. or bury it, or burn it to ash!

Person 3 - 1630 (Settler)

I am the settler. I came without much, But everything else I must make with my hands. So I don't throw out much - I use all I can. Cloth scraps become quilts: I reuse my bent nails	Pilgrim Hat

It will be long time 'fore the next trade ship sails.

Person 1 - 1700 (Colonist)

I am a colonist; now Life's not so tough. We have trade between cities that brings lots of stuff And some things are made by our townfolk today, I could buy a new harness, throw this old one away. We have pigs and hogs running loose in our street, If I toss it out there, they'll eat it up neat! Or I might bury it right over there. Or I might burn it; nobody would care. You see: the New world is the same as the Old! We trashmakers come from the time-honored mold.	Coonskin Hat Leather

All

What are we still doing with garbage and trash?
You guessed it! Throw it away, or bury it, or burn it to ash!

Person 2 - 1890 (Industrialist)

I'm the industrial person and new on the scene, I mass-produce goods with my trusty machine. This sweater, handmade, took a week in days of yore, But now in one hour, I can make forty-four. I make things so cheaply, you can now afford two And throw out twice as much trash as you need to do.	Engineer's Cap 3 Sweaters (One handmade; two machine-made)

Person 3 - 1950 (Scientist)

I am the scientific person in the new post-war age. We've learned a few tricks while the war shortage raged. When we couldn't get natural stuff to process We invented synthetics to replace the rest.	Lab Coat

Person 2 (Industrialist)

Rayons and nylons, acrylics and plastics, For furniture and clothing and even elastics: Forget your old woolens and silks and your cotton; Real wooden toys and washboards are forgotten.	Nylon stockings Plastic Bags & Containers

Person 1 (Scientist)

Our new stuff will last 'til forever, you see Even when it's worn out to you and to me. Permanent pressed, pre-sized and pre-shrunk When dingy and old, it's still permanent "junk" (Person 1 yells, "Junk")	Perma-pressed shirt

Person 2 (Industrialist)

We make instant menus that come in a PACK. You just boil the food in its own plastic sack. Or our TV dinner in its tinfoil tray It's quick; you don't wash it; just throw it away!	Plastic Bag TV Dinner

Person 3 (Scientist)

We make lots of TVs and clothes dryers, too. Don't ask for a trade-in; you're kidding, aren't you?	Broken Small Appliance

Person 2 (Industrialist)

Our new cars all change with each model year, Don't try to repair them, the cost's much too dear. Besides, we don't bother to make last year's parts for Skylarks, or Novas, or Cougars, or Darts.	Toy Car

Person 3 (Scientist)

It's the New Thing, the NEW that America craves.
So out, out with the old stuff, away to its graves.

Person 2 (Industrialist)

So what if there're more of us buying more goods?
So what if they won't rot away as they should?

Person 1 (Indian)

Now wait just a minute! You cannot fail To include me in your historic trash tale. We Indians lived simply, on prairies, in woods, We made no high trash piles, nor mass-produced goods. Let me be your critic, show you where you stand; And tell you just how you're defiling our land. Your new-fangled goods will not rot away. When you throw them all down they remain where they lay Then you say you will bury them deep in the ground: All your urban trash will make quite a mound! So then you would burn it, in smoldering masses And fill up our air with smoke, deadly gases! Oh, all of your answers have faults everywhere: You'll either ruin the water, the land, or the air. What's more, your resources-your lumber, your ore- Get smaller each year than the year before. And what's more-this old earth's not making any more.	Indian Headband

Person 2 (Industrialist)

You're right. Our resources are shrinking away While our garbage problem grows bigger each day. We're always converting resources to refuse Instead of recycling them for reuse!	Throw Out Old Blanket and Cola Bottle

Person 3 (Scientist)

Oh stop it! Don't drop it! We'll think of a way To make food for cows that's much better than hay. Don't burn it, return it--we'll make something new, A vase or your mother, a spyglass for you.	Pick Up Orange Peels Clear Bottle Flower

(Flower in bottle for vase, flower out, bottle held up to eye for spyglass)
Don't bury it, carry it-back to the mill.
We'll make a new blanket to ward off the chill.
(pick up old blanket and wrap around shoulders)

Person 2 (Industrialist)

It's time we progress past the Disposal Age
And make recycling the popular rage!
We'll have to give up old solutions for trash
And all realize that its pure balderdash -to just

All

Throw it, or bury it, or burn it to ash!

DISCUSSION

The skit shows that people have historically gotten rid of solid waste successfully by throwing it out, burying it, or burning it. But none of these methods solves modern urban garbage problems. The discussion should attempt to reinforce this concept. One way this can be done is to discuss the characters in the skit: how they disposed of their garbage or trash and why their method of doing so was either satisfactory or not satisfactory.

Cave dweller:	Threw it, burned if, buried it. These acts still did not cause a problem, for the same reasons.
Roman:	Threw it. Tossing out garbage began to be a problem because of the many people who lived in cities, but if was easily solved by taking the garbage out of the city.
Briton:	Threw it. A problem grew because more and more people moved to the cities, thus producing more trash than they could get rid of in the city.
Settler:	Had virtually no garbage.
Colonist:	Threw it, burned it. buried it. With greater trade came more things to be discarded.
Industrialist:	With a greater concentration of people in cities than ever before, and more buying because machine-made goods were cheaper, much more was thrown out.
Scientist:	The big change to synthetics and the use of enormous amounts of natural resources are causing tremendous problems.

Solid Waste Survey

Subjects: Language Arts, Social Studies, Math

Grades: 4-8

Teaching Time: 30 Minutes, Plus Follow-Up

Focus: Solid Waste Disposal

Rationale

Most people are not aware of the size of the solid waste problem in their community, or the expense required to deal with it.

Learning Objective

Students will:

- Become aware of specific facts to help them understand what happens with solid waste in their community.

Pre & Post Test Questions

1. How is solid waste disposed of in your county?

2. On the average, how much solid waste per day is produced by each citizen of Washington State?

3. In your county, how much does it cost per ton to dispose of solid waste?

Learning Procedure

Step A.

1 Organize the class into six research groups. Have each group find information on one or more of the following questions. Select a representative from each group to work on a committee to compile all information and produce a fact sheet, newsletter, poster, or other publication.

- What is the population of your community? How many families? Check growth over the past ten years by county. (Obtain information from your city hall or the United States Bureau of the Census.)
- How many tons of garbage does your community dispose of each day? (This information may be obtained from the city or county Department of Public Works or the Department of Sanitation).
- How many pounds of garbage are disposed of per person per day? Per year? The average in Washington State is 5.2 pounds per person per day.[1] The average for each person in the U.S. for municipal solid waste is 3.4 lbs.[2]
- How much does it cost to dispose of solid waste per ton?
- How is garbage disposed of in your community? Is it burned or buried? Is any of it subject to resource recovery processes or organized recycling; for example, separate collection of newspapers, cans, and bottles?
- Are there other recycling programs in your town? Are they run by the city or by private citizens?

2 Invite a city or county solid waste manager and a recycler to speak to the class.

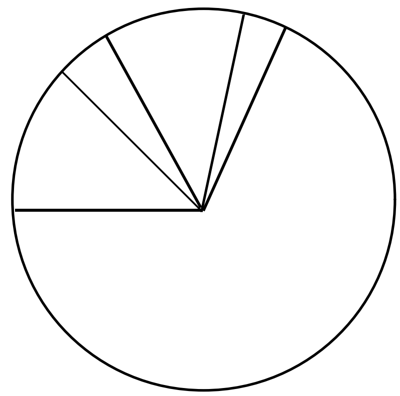
3 **Step B.**

- Have each research group decide upon the best way to present its information. For example:
- Prepare a graph comparing county population growth over the past ten years with growth of the volume of solid waste.
- Prepare a poster depicting the individual's

1 Washington State Department of Ecology, Solid Waste in Washington State, Feb. 1996, p. viii.
2 EPA, Characterization of Municipal Solid Waste in the United States, 1994 Update, p. 3.

daily contribution to the community's solid waste. Divide the population of the community into the tonnage of waste per day. Calculate the annual contribution of each individual.

- Prepare a layout like the one below and compare the costs of these items in your school and community with the costs of solid waste disposal for a year.
- Prepare a pie chart showing the relative costs of the various school and community programs and services, including solid waste disposal.
- Discuss how recycling could reduce your community's solid waste and the expense of its disposal.



Program	Cost Per Year	Cost Per Individual Per Year
Solid Waste Disposal School		
School Basketball Program		
School Band Program		
School Safety Patrol		
Solid Waste Disposal County		

Resources -

Video Tape: Trash Monster. California Solid Waste Management Board. 1980. 12 min.

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Solid Waste: What's My Responsibility?

Subjects: Government, Contemporary Problems, Psychology, Ethics

Grades: 9-12

Teaching Time: One to Two Class Periods

Focus: Solid Waste, Problem Solving, Personal Responsibility

Rationale

People often feel powerless to do anything about enormous economic, political, or social problems. Solid waste is an example of an issue where personal action toward a solution may seem insignificant. Even if individual action by itself cannot solve these large problems, it can be the basis for a positive, personally enriching way of living.

Learning Objective

Students will:

- Examine how their perception of a problem affects their response to that problem by using solid waste as an example.
- Examine the individual's and government's responsibility in solving social problems, and define ways they, acting as individuals or in a group, can take responsibility for solutions.

Teacher Background

See the Solid Waste Fact Sheets, on pp. 5-16, and the Solid Waste Introduction, p. 1.

Pre & Post Test Question

What are two things individuals can do to help solve problems of solid waste?

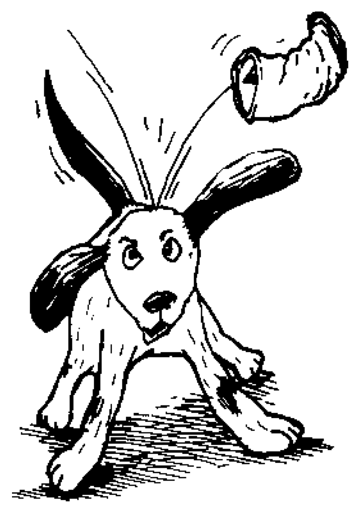
Learning Procedure

Part I: Personal Responsibility And Solid Waste

1 Have students read the following article, "My Twenty Foot Swath," p. 172.

2 Ask students questions about the man in the article:
- What worries this man?
- What does he try to do about it?
- Does he think his response is effective?
- What response do you make when faced with a problem of this kind?
- What is RAO? (Responsibility Assumption Overload) Have you ever felt RAO? In relation to what?

3 Use the problem of solid waste as an example of an area where RAO may have occurred for some people. Have students consider the following facts.
- The average person in Washington State disposes of 5.2 lbs. of garbage per day.[1]
- A thousand tons of uncompacted waste would cover a half-acre of land three feet deep.[2]



1 Washington State Department of Ecology, Solid Waste in Washington State, Feb. 1996, p. viii.
2 John Conroy, Ecology, Northwest Regional Office, Bellevue, 1983.

RAO is a likely response to a problem of this size.

4 Discuss the possible solutions to the problem of waste.

- Who, ultimately, is responsible for solving our solid waste problems —– county, state, or federal government; those we elect; only those who generate the waste; you?
- Should government strictly regulate disposal of all types of household waste? Should government force people to recycle?
- Is it reasonable to expect that individual action has a chance of solving a problem of this size?
- If not, what do you see happening? More and more land used for landfills? Massive contamination problems caused by these landfills? Increased ocean dumping? More resource recovery plants? Use of technology in a yet undiscovered way of handling waste?

Part II: Other Large Issues And Personal Responsibility

1 Ask students to identify other large economic/ political/ social issues they perceive they can do nothing about. Some examples might be:

- Nuclear war
- Hunger
- Industrial pollution
- Overpopulation
- Unemployment
- Inflation

2 Have students pick one of these topics or pick one you are currently studying, and list all possible solutions. Identify individual responses that can help solve this problem. Ask:

- How do individual solutions differ from large organized solutions (i.e., governmental or institutional efforts)?
- How do the benefits differ? Is there any good to be realized from an individual action even when it won't be sufficient to solve the problem?

3 What is the law's role in determining individual response to the problems? Can you think of any laws that demand or encourage personal or corporate responsibility?

- What legal problems might result from a law requiring people to aid accident or rape victims? (The "Good Samaritan" law in Washington State states that you cannot be held liable for civil damages for any action taken in good faith and not for compensation while trying to assist at the scene of an accident.)
- The manufacturers of Agent Orange, the defoliant used in the Vietnam War, were sued to establish responsibility for the alleged subsequent health effects of dioxin on veterans. Should the manufacturers have been held liable? (According to law, the federal government cannot be held liable for injuries sustained in war.)
- As a response to the enormous litter problem, do you think the Washington State law requiring litter bags in every car and a $50 minimum fine and/or litter pickup for persons convicted of littering has been effective?
- What responsibility do companies manufacturing hazardous waste have for its disposal? Should the government regulate disposal? What are the company's responsibilities if the wastes are discovered years later? Regulating businesses can be expensive. Who should pay for regulation —– the government (which eventually means taxpayers), the consumers who use the products, the company itself?
- In terms of managing solid waste, should the state attempt to regulate behavior by laws such as the "Bottle Bill," which attempts to promote recycling by imposing a mandatory surcharge on all beverage containers?
- Should counties and cities enact "flow control" laws that strictly regulate disposal of waste? (Flow control measures are enacted to ensure a steady stream of waste to burn in resource recovery plants.)

4 Ask students to think of a large local problem about which they feel –– "I really should do something about this," (e.g., your reaction to seeing hungry or homeless people in your city).

5 Did students do anything about the problem? Why? or Why not? If not, what keeps people from being the solution? What keeps them from taking that final step of action?

6 Are there any community problems you have helped resolve, even in the smallest way? If you have, what problems were solved? What benefits did you derive from participating in the solution (i.e., made friends, learned something, opened door for employment, gained satisfaction in doing something worthwhile, learned to approach problems in a positive, active way)? Compare your feeling of accomplishment to that of the man in "My Twenty Foot Swath"?

Part III: A Personal Responsibility Activity

1 Have the class identify a waste, litter, or recycling problem as the man in the article did, and determine what to do about it. The solutions may or may not be immediately obvious. Individual action you can take right now:

- Start source separation and recycling at home.
- Be a responsible buyer. Look for products packaged in reusable and recyclable containers.
- Compost waste.
- Speak up against litter! Report litterers to Department of Ecology Hotline, 1-800-LITTERS.

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My Twenty Foot Swath

Kenneth V. Lundberg

[Covenant Companion, Reprinted by permission of the Covenant Press]

‘‘I worried so much about world hunger today, that I went home and ate five cookies.’’ Did personal or global problems ever become so overwhelming that you were immobilized, or driven to some action that actually aggravated the problem? Have you experienced such frustration about the hopelessness of solving the problems of poverty, environmental pollution, or human suffering that you could avoid it only by deciding that you were powerless to do anything about their alleviation? This is called Responsibility Assumption Overload (RAO). Here’s how I dealt with this feeling.

I park my car away from my building at work. That way I get both exercise and a parking space, as everyone else competes for spots next to the entrance. My morning and late afternoon strolls take me on a stretch of lawn between the tennis courts and the soccer field, and across an occasionally used softball diamond. The lawn is twenty feet wide, more or less. Soft and green, it was originally very littered. Tennis players discard tennis ball containers (and their flip-tops), worn out sweat socks, broken shoelaces and energy candy bar wrappers. Soccer game spectators leave behind beer bottles and junk food cellophane.

In my early days it disgusted me, and my thoughts centered on ways of correcting the situation: writing letters to the campus newspaper (no doubt totally ignored); campaigning for anti-litter regulations (who would enforce them?); organizing a ‘‘Zap-Day’’ cleanup (leaving 364 days for littering). All my noble efforts would have demonstrated my indignation, raised my blood pressure, and attracted attention, but they would not have changed the appearance and/or condition of the area.

So, I decided to take ownership. I would be the solution. I did not tell anyone of this; it was probably against some rule or another. I decided that I would be responsible for the environmental quality of this twenty-foot swath. I did not care what other parts of the campus were like. They were someone else’s problem. But each day, going from and to my car, I picked up litter.

At first, it was as much as I could conveniently carry. Then I made a game of it, limiting my picking to ten items each way. It was an exciting day when I realized I was picking faster than ‘‘they’’ were littering. Finally, the great day arrived when I looked back on my twenty feet of lawn - now perfectly clean.

Where did I put the litter? At first, I brought it into a wastebasket in the building, or took it to the car to bring home. Then a curious thing happened. One day, large orange barrels appeared at each end of my swath. Someone in maintenance had become my silent conspirator - periodically emptying and replacing the barrels. He, too, knew the wisdom of keeping a low profile about it all.

I’ve done this for several years now. Has general campus appearance changed? Not much! Have litterers stopped littering? No! Then if nothing has changed, why bother?

Here lies the secret. Something has changed. My twenty-foot swath - and me! That five minute walk is a high spot of the day. Instead of fussing and stewing and storing up negative thoughts, I begin and end my workday in a positive mood. My perspective is brighter. I can enjoy my immediate surroundings - and myself - as I pass through a very special time space.

‘‘It is better because of me. I am better because of ’’it." ‘‘We’’ enjoy the relationship. Maybe, even, ‘‘it’’ looks forward with anticipation to my coming.

With a brighter outlook, I have learned a lot of things that would have gone unnoticed. For instance, I have learned that tennis players grunt a lot. There seems to be some correlation between the quality of the grunt, especially on serve, and the quality of one's game. Maybe I have discovered the secret of the game. I have also learned that soccer players curse a lot, but there does not seem to be any correlation between that ability and soccer skills. I have even learned that most soccer spectators, at least at my college, come to eat, drink, and talk - not to watch the game.

My learning - and the twenty-foot swath - does not stop at the building door. There is an important principle that follows wherever I go. I cannot solve man's inhumanity to man, but I can affirm, with a smile and a word of appreciation, those who feel burdened by the need to work at lowly jobs. I cannot right the imbalances of centuries of discrimination, but I can "lift up" someone who feels the weight of a poor self-image. I can treat women as equals without solving the problems of sex discrimination. I can seek out the social and economic litter in my own "twenty-foot swath" without demanding of myself that I "clean up the whole world."

I now practice a discipline of leaving each time-space capsule of my life a little better than when I entered it. Each personal contact, each event, each room I enter becomes a small challenge. I want to leave it improved, but more important, I am responsible to myself to be improved; and thereby, maybe - just maybe - my having been there will make life better for someone else.

I am becoming more and more disenchanted and suspicious of revolutionaries, crusaders, militants, and do-gooders. Many, if not most, seem to be more concerned about being right than being loving or effectual. The zealot, no matter how well-intentioned, often leaves a trail of wounded people while in pursuit of the cause.

Is this all too myopic - shutting one's eyes to the greater concerns? It does not need to be! I now have a twenty-foot swath. Next year it may be forty, or sixty, or eighty feet wide. Ten talents were not required of him who had been given only one. Too many people stumble by taking on causes too great for their level of discernment and discipline. They need to begin to catch the vision of the important promise, that the meek shall inherit the earth, not the indignant or frustrated.

Deciding What To Do

A Simulation of a Public Hearing: Siting A Solid Waste Disposal Facility

Subjects: Social Studies, Government, Contemporary Problems, Environmental Studies, Science

Grades: 9-12 (Science, Technology, and Society Unit)

Teaching Time: Two or Three Class Periods, Plus Research Over Several Weeks

Focus: Science, Technology and Society, Solid Waste Management, Decision-Making Processes

Rationale

Management of solid waste in general and siting a garbage disposal facility in particular are complex and controversial public decisions. In the decision-making process, a wide range of perspectives and values come into play.

The decision-making process used in managing solid waste is illustrative of the process used to decide other difficult public issues.

Learning Objective

Students will:

- Understand the complexity of managing solid waste.
- Realize the wide range of perspectives and values involved in making decisions about solid waste.
- Understand that there is no one "right" or "correct" answer to most of the serious problems facing our society.
- Learn an interdisciplinary decision-making process through role playing.

Teacher Background

Read and review the "Scenario" and "Roles" included. Review the introduction in the Hazardous Waste section for some of the issues surrounding disposal of both solid and hazardous wastes, p. 197.

See under "Resources for state regulations for the siting of landfills and incinerators. To supplement your materials have students collect information from newspapers, television news shows, and magazines related to siting landfills or incinerators.

Materials

- Scenario and role description
- Sample hearing agenda
- Newspaper and magazine articles from your local area on problems in the management of solid and/or hazardous waste

Learning Procedures

The class will conduct a simulated refuse disposal siting/solid waste management hearing with class members taking the parts (see description) of various participant's roles in the waste management decision-making process. The disposal facility under consideration includes options for an incinerator only, landfill(s) only, or both. Other pertinent issues not explicitly on the hearing agenda, but which have direct or indirect bearing on the waste management problem as a whole, are:

- Waste prevention and reduction and what can be done to encourage it especially in industry.
- Recycling and the role it should play in the overall waste management plan.

- Reducing industrial waste through the establishment of waste exchanges or treatment facilities.

These issues and others are part of the many questions facing communities and government agencies the world over as they grapple with the cumulative effects that result from our "throwaway" culture.

1 Distribute copies of the scenario and a role description to each participating class member in the simulation. For best results, role descriptions should not be shared by different groups. Tell the students that the problem closely parallels the actual situation in a number of Washington State counties. The class's job is to understand and discuss the solid waste problem and come up with solutions. The emphasis should be on possible alternative solutions and not just a single answer to the problem.

2 Choose a student to serve as County Commissioner/Hearing Examiner. Then choose other students to fill the roles described on pp. 178-183. You may wish to assign some roles to more than one student. For example, have two Journalists; one from a large newspaper and one from a smaller weekly publication; or one from the daily paper and one from a magazine. If the class is large enough, let some of the roles be assigned to two or three students who will each study and research a particular aspect of their roles' concerns about the county's disposal strategies. Not all the roles are necessary, but the "hearing" will work best if at least the first six or seven parts are included.

3 An alternative approach is to assign the more technical and science oriented roles, such as Scientist Expert, Toxicologist, Incinerator Vendor, etc., to a Chemistry and/or Biology class, while giving the other roles to a Social Studies class. The final hearing could be held in two sessions, one for each class. Have the Chemistry class do the activity, and "Making Acid Rain," p. 29.

4 Explain to students that this simulation is not meant to represent any actual public hearing or governmental hearing process, but that many public bodies are required by law to solicit input and comment on complex projects that can affect human health and environmental quality.

5 Have students prepare to play their roles realistically and convincingly by having them contact their real counterparts in your county. Encourage students to add substance and appropriate detail to their roles.

6 Hand out the sample hearing agenda or prepare a similar one of your own. Assign a specific date or dates for conducting the hearing. Encourage all the participants to come prepared with either questions or a brief presentation as indicated on the agenda. When the hearing takes place, have that part of the class not playing specific roles serve as the County Council, both questioning the hearing participants and, in the end, reaching a decision about what to do with all that garbage.

Extended Learning

1 Attend a local public hearing or one of the public involvement opportunities sponsored by the Department of Ecology's Information and Education Office. Call 360-407-6488 or write to them at P.O. Box 47600, Olympia, Washington 98504-7600 to learn when the next event near your locality will be held.

2 Invite recyclers, environmental activists, solid waste engineers, garbage haulers, reporters, county commissioners, etc. to your class to describe the role each plays in dealing with your county's solid waste.

Resources - *See the following state regulations for the siting of landfills and incinerators.*

Chapter 173-351 WAC Criteria for Municipal Solid Waste Landfills

Chapter 173-306 WAC Special Incinerator Ash Management Standards

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The Scenario

County population is growing rapidly. The volume of solid waste produced in the county is growing even more quickly. Recent federal and state regulations have outlawed open dumping, so all the old dumps have been closed. To protect human health and the environment, safeguards must be built into any new sanitary landfill, but this makes it very expensive to construct and it must be monitored throughout its use and for many years after. People have been attracted to living in the county because of its beautiful semirural character and thus are very sensitive about environmental degradation or property devaluation that may possibly result from a landfill or large-volume garbage burner being built nearby.

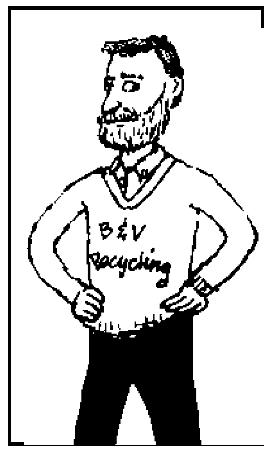
The county public works department, which has responsibility for proper disposal of all municipal waste generated within the county, is increasingly concerned about the growing amount of waste and is considering both a mass burner and/or a new landfill. The existing landfill is filling up fast and, given the long lead time needed to site and build a replacement, a decision about what to do with the county's waste must be made soon.

Roles

Environmental Activist

You feel strongly that more recycling could be done in the county. You think the county should require home source separation of recyclable materials such as aluminum, glass, and newspapers and that private or public garbage haulers should be required to provide separate pickup for recyclables. You'd like the county to institute a county-wide, per-can garbage collection fee schedule that allows as little as one pickup a month. You want the county to fund public education programs in recycling; programs both for citizens' groups and schools.

You oppose the construction of a resource recovery, waste-to-energy incineration plant. As an environmentalist, you are concerned about the effects of incinerator emissions on air quality. You understand that a mass burn incinerator will require huge amounts of refuse to operate efficiently and thus discourage recycling efforts, while at the same time presenting problems in disposing of the toxic fly ash generated. Nevertheless, you are aware that a landfill could cause considerable environmental damage to the land, air, and water.



Recycler

You became involved in recycling a long time before concerns about environmental degradation were first voiced. Profits have never been large and the markets for recyclables have never been particularly stable or reliable. Nevertheless, the satisfaction of knowing that your job is part of the solution and not part of the problem has always made the hard work and long hours necessary to survive more than worth it. After 20 years, you have carved out a secure market for your business and you are looking forward to relaxing a little, while letting the younger generation carry on the day-to-day work.

You are worried that a mass burn, waste-to-energy type incinerator will cut the bottom out of the recycling market. Although you would like to see the city institute mandatory recycling and source separation, you recognize that your own business is probably too small to compete with the large waste management firms that the city would most likely end up contracting with for such a mandatory program. You are gratified that at last recycling is becoming a "big business" and thus respectable, but you are angry and a little bit frightened that you and your hard-earned business will get lost in the shuffle.

Garbage Hauler

You own a garbage collection company. Your company is licensed by the state and franchised by the county. Your prime concerns are providing good service to a rapidly growing number of customers and keeping costs down. You are also concerned about county and state regulations of your business. In recent years, more of the task of running your business has been taken up with government forms and "red tape." You are concerned about the prospect of the county telling you how to set your collection fees, how the garbage itself must be picked up, and where you have to take it once it's been collected.

Spokesperson, Homeowners' Group

You are worried that the county/city may be planning to build a landfill or an incinerator near your home. You are worried about the roadway litter you're afraid would result. You are also concerned about the increase in the rat, crow, seagull, and wild dog population that a landfill may bring. You are also worried that household hazardous wastes dumped into the landfill will generate toxic leachate that could contaminate your drinking water. You are angry when you think that a landfill or large-volume garbage burner may decrease the value of the house and land you've worked so hard to own.

As the cofounder of the Ratepayers Against Incinerators/Landfills (RAIL) you have been asked by the organization to present RAIL's concerns at the upcoming hearing. You realize, however, that it is not enough to protest a specific site, but that appealing and feasible alternatives must be presented. For this reason your organization has come out in favor of increased recycling.

County Public Works Engineer

Your county department has responsibility for disposing of all waste generated within the county. You also have responsibility for meeting federal and state regulations governing the disposal of waste. Part of your job is to design and build waste facilities such as landfills and mass burners. At the same time, you are required to ensure that these disposal facilities do not create hazards for the environment or human health. A great deal of your energy goes into selecting and evaluating possible disposal sites and advising county commissioners/council members on technical aspects of solid waste management. You are becoming alarmed at the rate of growth of the county's volume of solid waste and, probably most acutely, realize the enormity of the county's solid waste problem. You ask yourself: "Where is all this stuff going to go?"

Lately, however, much more of your time has been taken up with public relations, dealing with the concerns and sometimes anger of citizens who question or challenge county solid waste policy or decisions. You believe that citizens need to be better informed about some of the scientific and technical issues that are part of deciding what's the best option. You are especially concerned that the press is playing up some of the more sensational but remote dangers associated with incinerators and landfills. It seems that no matter how well you document the safety of a waste-to-energy incinerator or a landfill site, the papers always play up the negative aspects.

County Commissioner/Council Members

Your job is to make the final decision about how to deal with the county's growing volume of solid waste, while taking into account the needs and interests of a broad range of county citizens and businesses. You have to understand both the technical information provided you by the public works director and the anxiety of homeowners who feel threatened by the possibility of a landfill or mass burner in their area. You try to be pragmatic and fair. You also want to get reelected to office.

Your role in the hearing is to conduct a landfill siting/solid waste management discussion by calling on and questioning the other role players. It is also your responsibility to seek the input of other county commissioners/council members and interested citizens. It is your responsibility to conduct an orderly and productive meeting. This means that each participant should be treated equally and that all viewpoints are given a fair hearing.

County Citizen
You lead a busy life. You like the convenience that some packaged and processed foods give you, though you are sometimes bothered by the amount of packaging left over. You know your county is growing rapidly but have been more concerned about other consequences of growth such as crime, crowded highways, and air pollution than you have been about an increase in garbage. Frankly, you'd like to throw your trash in the garbage can and forget about it, even though you know in the long run that your children or grandchildren may end up paying for it with a less healthy environment.

You're paying the garbage hauler and the county taxes to take care of trash for you. You don't feel you have enough time in your day to fool around with the trash, separating it for recycling.

Journalist
Your job is to ask hard questions, understand the important issues, and report accurately the decision-making process. Time and time again you've been assured by elected officials that the city has its garbage problem under control, only to learn later, after careful digging, that the plans made have proved to be inadequate for the mounting garbage generated daily through expanded growth. When you ask about safeguards for environmental and human health, the engineers and planners present seemingly endless numbers and graphs all purporting to establish the safety of the sites being proposed for the disposal facility.

Just this past week you received a tip that the father-in-law of one of the county commissioners has a substantial investment in the company that is proposing to build and manage a mass burner, waste-to-energy incinerator. Before going public with this information, you will have to spend considerable time verifying its accuracy – time you would much prefer spending on researching substantive issues.

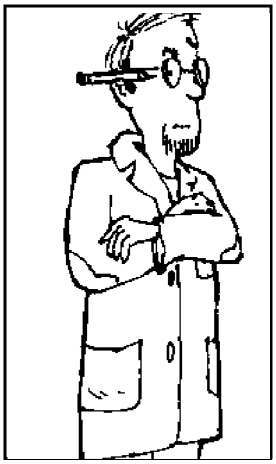
Incinerator Plant Vendor
You believe that incineration is the best solid waste management method available. As an engineer with many years of experience in waste management and chemical processes, you know that the technology for safe incineration is already available and you don't understand why some citizens are fearful and unwilling to trust your professional judgment. If asked, you would have no qualms about having an incinerator site next to your property.

You want your company to be selected for this county's contract. Your boss has promised you an especially attractive bonus if you can "land" this one. You also know that waste incinerators, under the right conditions, are good opportunities for investors.

Regulatory Agency Official
You have been assigned by your agency to carry out state law as mandated by the State Legislature. Your responsibility is to write enforcing regulations that will protect public health and the environment yet still provide practical and economically feasible waste management facilities. You are sensitive to the public's view of you, yet you know that there is no perfect set of regulations that will please all the parties. From your past experience as a field inspector, you know that strict enforcement of the law doesn't always lead to the desired result of a safer environment. You are sometimes as frustrated as the public by the legal requirements built into the regulations as safeguards against unjust government actions, but which are all too often exploited by a few "bad eggs" at the expense of the many. It is sometimes hard to remember that most

individuals and businesses are honest and want to comply with the law, especially as it relates to the environment.

You have been asked to attend this hearing to explain the current state and federal regulations and how they affect the county's proposal for siting a disposal facility. You expect to be questioned closely by both citizen and industry groups.



Scientist-Expert
You are a professor of geology at a nearby university specializing in hydrology, the study of water movement in the earth. Your research has focused on groundwater flow and the scientific study of the problems associated with contamination from human activities. Your publications have appeared in numerous journals and your scholarly expertise has been acknowledged by many professional organizations throughout the world. As your reputation as an expert has grown, you have been called on to speak at a growing number of public hearings and workshops throughout the state, including testimony at legal trials on the safety of various disposal options with respect to potential and actual groundwater contamination. You know as a scientist that there is no such thing as certainty, especially in a field like geology where most events are measured in millions of years, and actual experimental verification is possible only on a limited basis. Nevertheless you find yourself being asked to give "yes" or "no" answers to questions that scientific and technical knowledge can never provide.

The county commissioner has asked you (for a fee) to examine the county's plans for disposal and to provide a brief report discussing the impacts that each option might have on the water supply now and in the future. At present the data available and current scientific models can only suggest in a most sketchy fashion what these impacts might be. You are worried that, because of this, each faction will seize upon those parts of your presentation that most closely support its position and then point to you as proof of the "truth" of its claims.

County Attorney
The district attorney's office reviews all the county plans to ensure that the county does not violate any of the many governmental regulations that inevitably cover any large-scale plan. Projects with the potential for environmental harm and/or human health effects are especially complex, involving as they do both technical and political issues. You have been assigned the job of monitoring the legal aspects of the county's waste management plans.

As a recently graduated law student from a prestigious university, you have been on the job for about a year. You feel you are ready to tackle a "real" assignment instead of all the routine jobs you've been handed during the past year. Anxious to establish yourself as a top-notch lawyer, you welcome this assignment as the first step in your career as a public official. Like many other young lawyers you have political ambitions, and you know how crucial it is to perform well on this, your first big assignment.

Your boss, the district attorney, is particularly concerned about the threat of lawsuits and other legal actions from various special interest groups, such as nearby homeowners, industry organizations, and environmental activists.

Private Consultant
The county hired the firm you work for to study the various options for a garbage disposal facility. You have been part of the team that carried out the necessary research and your particular expertise is in the area of stack emissions in incinerators and other industrial combustion facilities. Your supervisor is out of town this week and you have been tapped to represent the firm if any questions arise concerning the recommendations that were

made to the county as part of your firm's final report. Since a mass burner was included as part of the recommendation, you expect to be sharply questioned on this aspect of the overall strategy your company proposed.

Toxicologist

You work at a federal government laboratory studying the effects of chemicals on mice and rats. Most of your research is directed toward determining whether certain chemicals can cause cancer in humans and animals. The main research tool for doing this is to expose special strains of rats and mice to substances and observe whether, or at what dosages, tumors develop. You know that many people are doubtful about relating results from mice to humans. Skeptics point out that experimental animals are exposed to high doses of substances at levels not commonly found in a normal living environment. You, however, know that in order to extrapolate to the low dose exposures that are typical of human environments, the 50 to 100 rats and mice must ingest enough toxin to produce a statistically significant number of cancers. Estimates of a substance's cancer-causing potency are based on the extrapolation of the experimental animal results to low doses.

Several environmental organizations have expressed concern about production of dioxins by the incinerator, either as smokestack emissions in the air or as part of the fly ash that must be disposed of. Dioxins are a class of chlorinated organic compounds produced as by-products in the production of herbicides and other industrial products. At least one dioxin, TCDD, is the most potent carcinogen (cancer-causing substance) known in mice and rats. The evidence for its cancer production in humans is not, however, established, and scientists disagree as to what exposure levels are safe.

Farmer/Agriculture Representative

Your family has roots in the area that stretch back to the early pioneer days more than a hundred years ago. You have watched the county seat grow from a small town to a medium sized city. You are concerned about the rapid growth and its effects on prime agricultural land. In your view, building a mass burner will encourage more growth and you know that your family farm may ultimately be threatened by this growth. Taxes continue to increase and you have farmer colleagues who have been forced to sell their acreage due, in part, to rising property taxes. You feel strongly about your stewardship of the land and are worried that your family's long-time ties to the land may be broken.

Real Estate Developer

You believe that progress must necessarily include some environmental disruption, but that the economic growth for the area far outweighs the short-term pollution of a "few" streams or the conversion of some prime agricultural land for suburban housing and shopping centers. If most environmentalists had their way, the county would soon stagnate from the many regulations and restrictions that stifle growth. You are convinced that the expansion now under way must not be interrupted and that desirable "high tech" industries can be attracted to the area only if they can be assured that there are adequate waste disposal facilities.

You believe that growth is inevitable and that, even if there are some minor problems now, scientists and engineers will come up with the necessary technology in the future to solve them. Sure, in the past, some mistakes were made, but there are plenty of safeguards built into the law now and, besides, it's always been necessary to "break a few eggs to make an omelet." You believe that a waste-to-energy incinerator, with its capability to generate electricity, is necessary for the continued economic health of the county.

Chamber of Commerce Representative

You have been a member of the local business community for 20 years. Your business has been slowly growing after a struggle to make ends meet for the first 10 years. However, the recent recession has caused you great concern: will you be able to meet the costs of college education for your two teenage children? A waste-to-energy plant would bring cheaper electrical power rates and build an economic base in the county. Recycling efforts could bring in a few jobs, but larger companies outside the area are already prepared to initiate large-scale recycling efforts. A new landfill might cause a reduction in business opportunities, tourism, and residential growth.

Public Hearing On Proposed Municipal Refuse Disposal Facilities

Agenda

I. Opening Statement - *County Commissioner*

II. County Proposals - *Public Works Engineer*

- **A.** Combination Incinerator and Sanitary Landfill
- **B**. Waste Reduction/Recycling with Smaller Landfill and Incinerator
- **C**. Long Distance Hauling to Eastern Washington or Eastern Oregon
- **D**. Question Period

III. Expert Reports

IV. Citizen Testimony

- **A.** RAIL
- **B.** Organizations

V. Industry/Business Testimony

VI. Final Summarization and Questions

VII. Conclusion and Vote - Commission Members

VIII. Report of Proceedings by the Two Journalists

Landfills Then And Now

Landfills Then

Prior to 1969, no solid waste statute existed in Washington State. A hole was dug, and garbage was placed in the open pit or dump. The traditional sanitary landfill designs which were initiated in 1969 in Washington State placed refuse no deeper than 5 feet above the high ground water level to prevent water leaching into the landfill. To prevent water percolation down through the refuse, a fairly impermeable cover material was used and the surface was kept fairly level. The most suitable cover material was a sandy loam about half sand and the rest equal parts of silt and clay. Refuse was spread in two-foot layers and immediately compacted. Each day's layer of refuse was covered by a six-inch layer of earth. When a section of the landfill was filled to capacity, a final two-foot compacted layer of earth covered the area. Grass was planted in the area to prevent erosion.

Methods developed to avoid pollution of surface water and ground water were a gradual sloping of the landscape, constructing diversion ditches, and installing collection pipes. Landfill operators used graders, bulldozer tractors, and landfill compactors for sloping, filling, compacting, and covering the refuse. Most older landfills had no leachate collection system, no methane gas collection system, no ground water monitoring wells, and no protective liner at the bottom of the landfill.

Landfills Now

Landfilling standards as identified in WAC 173-304-460 were established in 1985. The following major standards apply to facilities which dispose of solid waste in landfills except for inert and demolition wastes. The minimum functional standards guide performance, design, maintenance and operation, and closure and postclosure.

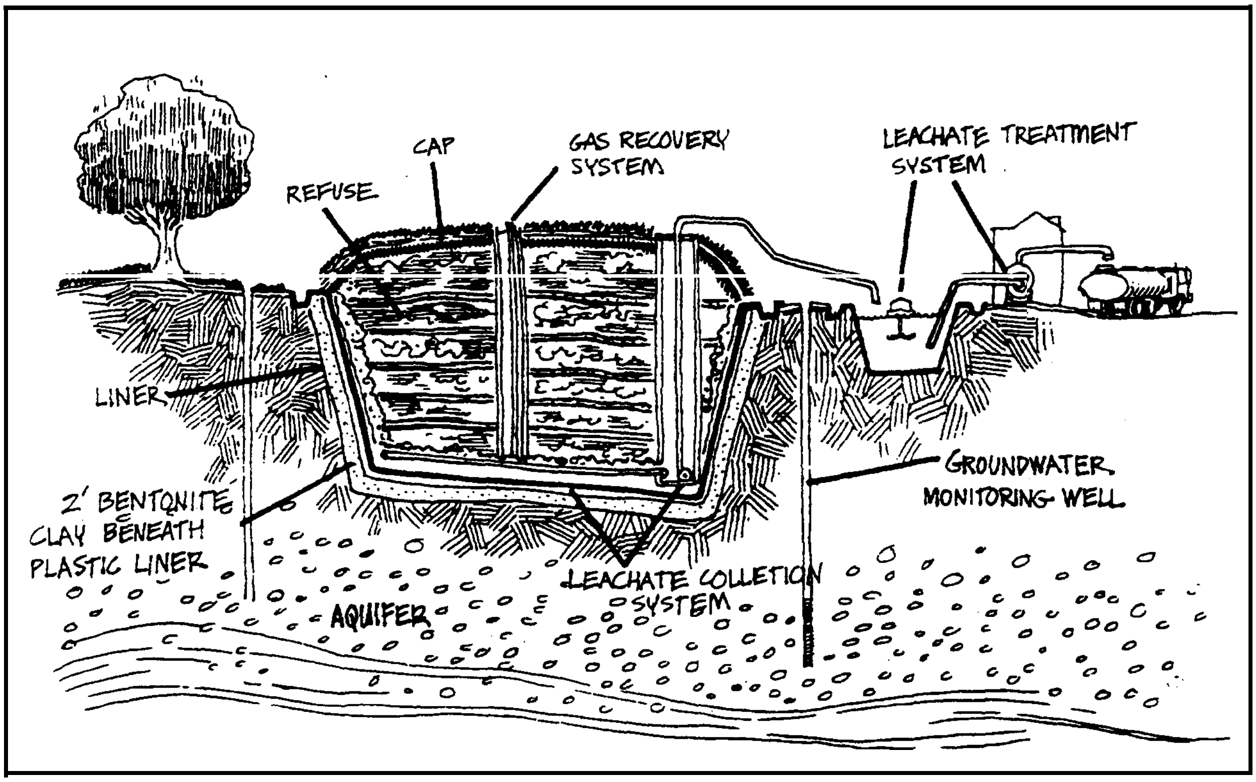
Performance standards protect ground water, air quality, and surface waters. Design standards minimize liquids admitted to the active areas of landfills, provide leachate collection systems, and install liners or an equivalent design alternative. Arid areas (less than 12" annual precipitation) use a vadose zone moisture monitor. The vadose zone is the area in the earth's crust above the ground water level but below the surface. The design standards also include a 100 year floodplain location for the landfill (designed for anticipation of the worst storm each 100 years). Some other requirements are adequate access roads, fencing around the site, and a series of ground water monitoring wells checking for leachate in the water or for subsurface gas movement.

Maintenance and operating standards require dust control, no open burning of garbage, litter collection, compaction, and daily cover (with some local health department exceptions). They also provide facilities for recycling by the general public, and maintenance of the ground water monitoring system.

Closure standards require written estimates of the cost of closure and postclosure monitoring and maintenance in accordance with the closure and postclosure plan(s).

The drawing on p. 296 is based on the design for the new section at Cedar Hills Landfill in King County. The landfill at Cedar Hills has over 40 gas and ground water monitoring wells. It has two holding ponds for collection and treatment of leachate. A successful seagull control program has been implemented by stringing wires on poles around the landfill site. The Cedar Hills design exceeds the standards required by law.

A Modern Landfill



Making A Mini Landfill

Subjects: Science, Social Studies
Grades: 3-10
Teaching Time: Step A - 20 Minutes; Step B - 20 Minutes; Step C - 20 Minutes
Focus:

Rationale

Products that end up as waste are made from a variety of natural resources. Because of differences in composition and biodegradability, much of what we now throw away could be composted or recycled.

Learning Objective

Students will:

- Understand the meaning of the terms “organic,” “biodegradable,” “renewable,” and “nonrenewable resource” and why each kind of waste should be handled in a particular way.

Teacher Background

See the Solid Waste Introduction for landfill information, p. 79.

For examples of model landfills, see the activities “Waste And Water,” p. 213, and “Landfills Then And Now,” p. 185.

Materials

- Four large clear glass jars
- Soil
- Wooden spoon
- Four sample garbage pieces
- Labels
- Enduring litter poster

Pre & Post Test Questions

1. What does “biodegradable” mean?

2. What is the difference between a dump and a sanitary landfill?

3. Which natural resources are renewable? Which are not? Why?

4. What are four items you use everyday you could recycle?

Learning Procedure

Step A.

1 Ask students how garbage is disposed of. Discuss: The proper disposal method for each component of garbage should be determined by its natural resource content.

2 Show examples to students and outline four basic categories of solid waste:

- Organic (e.g., potato peelings)
- Renewable resource/recyclable (e.g., newspaper)
- Nonrenewable resource/recyclable (e.g., aluminum can)
- Nonrenewable resource/hard to recycle (e.g., styrofoam cup)

3 Have students draw the life cycle of these items from raw material to disposal in a landfill.

4 To save natural resources and to reduce solid waste, from which of these four categories would you try to buy products? Which category of products would you avoid? Taking each of the examples listed (potato peelings, newspaper, aluminum can, styrofoam cup), think of ways to avoid disposing of them in a landfill.

Step B.

1 Ask students to: Fill four glass jars with the same amount of soil. Each student may wish to have a jar.

2 Label each jar with one of the four category headings.

- Organic
- Renewable/recyclable
- Nonrenewable/recyclable
- Nonrenewable/hard to recycle

3 Put an appropriate small sample in each jar. Cover with soil and dampen with water. Leave the lids off.

4 Observe and chart what happens over two to three weeks. Discuss the condition of the various kinds of waste. Discuss biodegradability. Compare the mini landfill to real landfills. From your observations, discuss the potential environmental problems associated with waste in landfills (leachate contamination of water, smell, methane gas, garbage truck traffic, litter, scavenging birds and animals scarcity of landfill sites, cost, loss of natural resources and energy, etc.).

Step C.

1 At the grocery store, while purchasing the family's groceries, have each student keep a record of the purchases by dividing them into the four solid waste categories.

2 In class, have students discuss which items they should eliminate from their shopping list or how they can substitute nonrenewable and nonrecyclable items with items that use renewable resources and generate less trash for the landfill.

Step D.

1 Make a model landfill; see activity "Waste and Water," p. 313.

2 Place examples of photodegradable, biodegradable, and nondegradable plastics in the landfill.

3 Monitor the degradation changes in the plastics for three months.

4 After monitoring the results for plastics, repeat the experiment with various grades of paper or other organic materials.

Extended Learning

Take a field trip to your county's landfill, or invite your county's solid waste manager to speak to the class.

Resources -

Video Tapes: Trash Monster. California Solid Waste Management Board. 1980. 12 min.

Wizard of Waste. California Solid Waste Management Board. 1980. 12 min.

Bibliography

Beck, R.W. and Associates. Waste Reduction and Recycling: Practical Planning. Olympia: Washington State Department of Ecology, November 1987.

Dart, R. K. and R. J. Stretton. Microbiological Aspects of Pollution Control. Amsterdam, N.Y.: Elsevier Scientific Publishing Co., 1980.

Columbus Clean Community. Biodegradable. Columbus, OH: Columbus Health Department, Office of Litter Control, 1987.

Washington State Department of Ecology. Best Management Practices Analysis for Solid Waste. Vol. 2: Eight Waste Generation Areas Findings. Olympia: Office of Waste Reduction and Recycling, 1988, pp. B79-89.

CHART FOR "MAKING A MINI-LANDFILL"

— Example —

Product	Chart for "Making A Mini-Landfill" Step B. What type of resources were used for the packaging?				Is this product necessary?	Is there an alternative?	How could this product be better packaged to save resources and energy?
	Organic	Renewable/ Recyclable	Nonrenewable/ Recyclable	Nonrenewable/ Nonrecyclable			
Plastic Milk Jug					Yes	Yes	In glass or waxed cardboard.
Chewing Gum		Part	Part	Part	No	Yes	Package in biodegradable paper
Vegetable in Tinned Can			Where a market exists		Yes	Yes	Can the vegetables yourself in reusable jars. Biodegradable paper package for frozen foods.
Pop Aluminum Can					No	Yes	Glass, also returnable glass.

CHART FOR “MAKING A MINI-LANDFILL”

Product	Chart for “Making A Mini-Landfill” Step B. What type of resources were used for the packaging?				Is this product necessary?	Is there an alternative?	How could this product be better packaged to save resources and energy?
	Organic	Renewable/ Recyclable	Nonrenewable/ Recyclable	Nonrenewable/ Nonrecyclable			

Analyzing Ash

Subject: Chemistry
Grades: 9-12
Teaching Time: 40 Minutes
Focus: Incineration, Hazardous Waste

Rationale

Incineration solves some of the environmental problems of garbage but poses others; in particular, what to do with toxic fly ash.

Learning Objective

Students will:

- Learn where metals go in the process of waste incineration.
- Learn how relationships of mass and volume change as paper is burned.

Teacher Background

Review the background material on the student lab sheets. In this demonstration, the total mass and volume of the paper will decrease because much of the paper is converted to gases (CO_2 and H_2O vapor), which are released into the atmosphere.

Warning: It is necessary for the safety of the class to have a lab with a hood and a fan to preserve the quality of the air.

Materials

- The materials and equipment needed are listed on the Student Lab Sheet, p. 193.

Pre and Post Test Questions

See the questions at the end of the Student Lab Sheet.

Learning Procedures

1 Tell students that this experiment will investigate what happens to metals when they are mixed with other materials and burned.

2 Have students work in pairs. Hand out Student Lab Sheets to each pair.

3 Go over the laboratory procedure with the students as given in the Student Lab Sheet instructions.

4 Have students do the experiment and fill in the blanks on their Lab Sheet.

5 When all the students have finished, **Ask:** "Where did the iron metal go when the paper was burned?" (It's in the ash.) Discuss with students the implications of the metal remaining in the ash as detailed in the background material in the Student Lab Sheet. Use the questions at the end of the sheet.

Extended Learning

1 Test for the presence of iron in raisins, by repeating this experiment. Use raisins and a crucible; no need to add $FeCl_3$. (Be sure to flatten the raisins.)

2 Develop demonstrations to test for the presence in ash of the hazardous heavy metals listed in the background material in the student handout. Or, assign groups of students a different heavy metal and have them research the methods used to test for these metals.

3 Have students determine differences in the solubilities of heavy metal oxides when changing the pH.

4 Invite a speaker from the Department of Ecology or your municipal engineering or waste disposal department to speak on the chemistry involved in the incineration of solid and hazardous waste.

Bibliography

American Chemical Society. ChemCom: Chemistry in the Community. Dubuque, IA: Kendall-Hunt Publishing Co., 1988.

Case, Frederick. "A Burning Issue." Seattle Times. January 4, 1987.

Hershkowitz, Allen. "Burning Trash: How It Could Work." Technology Review. July 1987, pp. 26-34.

Knudson, James V. Study of Municipal Incineration Residue and Its Designation as a Dangerous Waste. Olympia: Washington State Department of Ecology, 1986.

Washington State Department of Ecology, Solid Waste in Washington State, Fourth Annual Status Report, Including the 1994 Recycling Survey, Feb. 1996, Publ. # 96-500.

Analyzing Ash - Student Lab Sheet

Name_____________________ **Date**___________

Experimental Objectives

1. Demonstrate where metals go in the process of incineration.
2. Demonstrate how the relationships of mass and volume change as paper is burned.

Background

Incinerating waste reduces input waste volumes 70 to 90 percent depending on how much source separation has been done and the type of incineration (i.e., mass burn, sludge only, etc.). The resulting ash is of two types: bottom ash and fly ash. Bottom ash is relatively inert and harmless. But toxic heavy metals in waste concentrate in fly ash. Thus, fly ash disposal becomes an environmental and public health concern.

During high temperature incineration, metals in garbage form particulates that may be trapped by pollution control devices and end up in fly ash residue. Some heavy metals may cause cancer if ingested in particulate form in sufficient concentrations. They may also leach into water and poison aquatic organisms. These metals are: arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver.

Garbage contains some of these heavy metals. Thus, effective pollution control to capture heavy metal particulates and safe disposal of fly ash become important environmental and public health concerns.

In 1994, five waste-to-energy facilities/incinerators in Washington State burned 421,626 tons of solid waste. Of that amount, 7,134 tons was identified as woodwaste at the Inland Empire Paper facility in Spokane. This is the only incinerator that does not burn municipal solid waste. The amount of solid waste statewide that was incinerated has remained stable (10 percent) for the past three years. One of the municipal solid waste incinerators in Skagit County closed in 1994.

For waste-to-energy facilities or incinerators that meet both the chapter 173-304 WAC and chapter 173-306 WAC, the ash generated from the facilities must be disposed in a properly constructed ash monofill. There are four remaining energy recovery/incinerators that meet these criteria. All of the ash (113, 271 tons) from those facilities is disposed at the ash monofill at the Roosevelt Regional Landfill in Klickitat County.[1]

Materials

- Ruler
- Balance
- 250 or 400 ml beaker
- Glass stirring rod
- Paper and matches
- Small paint brush
- KSCN (0.1 M) solution
- $FeCl_3$ (0.1 M) solution
- HCl (0.002 M) solution

1. Washington State Department of Ecology, Solid Waste in Washington State, Feb. 1996.

Laboratory Procedure

1 Using one full sheet of used notebook or typing paper, crumple the paper as tightly as possible. Weigh and record the following:

a. Mass of beaker________________________________

b. Mass of paper _________________________________

c. Mass of beaker and paper ______________________

d. Measure the diameter, d, of the crumpled paper ___________________________ cm.

e. Calculate the volume of the paper ($\pi d^3/6$) __________________ cm^3.

2 Unfold the paper enough to paint on several stripes of $FeCl_3$ solution. The "Fe" in the $FeCl_3$ represents the metal (iron) in this garbage.

3 When the solution is dry, recrumple the paper and burn it in the beaker.

4 Use a glass stirring rod to reduce the ash to its smallest volume. Spread the ash evenly on the bottom of the beaker.

a. Measure the depth of the ash ___________________cm.

b. Calculate the volume of the ash (πr^2 x depth) ________________cm^3. (where r is the radius of the beaker)

c. Calculate the percentage reduction in volume _____________________________

5 Weigh the beaker and ash again.

a. Mass of unburned paper and beaker ____________________________________

b. Mass of ash and beaker ___________________________

c. Change in mass ___________________________________

d. Calculate the percentage change in mass _______________________________

6 Add 2 ml of dilute HCl (0.002 M) to the ash.

7 Add 2 to 4 drops of KSCN (0.1 M) solution to the acidified ash. The resulting deep red color indicates that the metal iron has remained in the ash.

Preparation of Solutions - Procedures

1. Ferric chloride($FeCl_3$) - 0.1 M solution
   a. Weigh out 2.7 grams (g) of $FeCl_3$.

   b. Dissolve the $FeCl_3$ in 100 ml of distilled water.

2. Potassium thiocyanate(KSCN) - 0.1 M solution
   a. Weight out 0.97 g of KSCN.

   b. Dissolve this in 100 ml of distilled water.

   c. WARNING! Potassium thiocyanate is poisonous. Students should wash their hands thoroughly after use. Call poison control or physician if taken internally.

3. Hydrochloric acid(HCl) - 0.002 M solution
   a. Using stock solution of HCl, add 20 ml of HCl to 80 ml of distilled water. This results in 100 ml of 0.02 M HCl.

   b. Use 10 ml of 0.02 M HCl made above and add this to 90 ml of distilled water. This will produce 100 ml of the desired 0.002 M HCl.

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

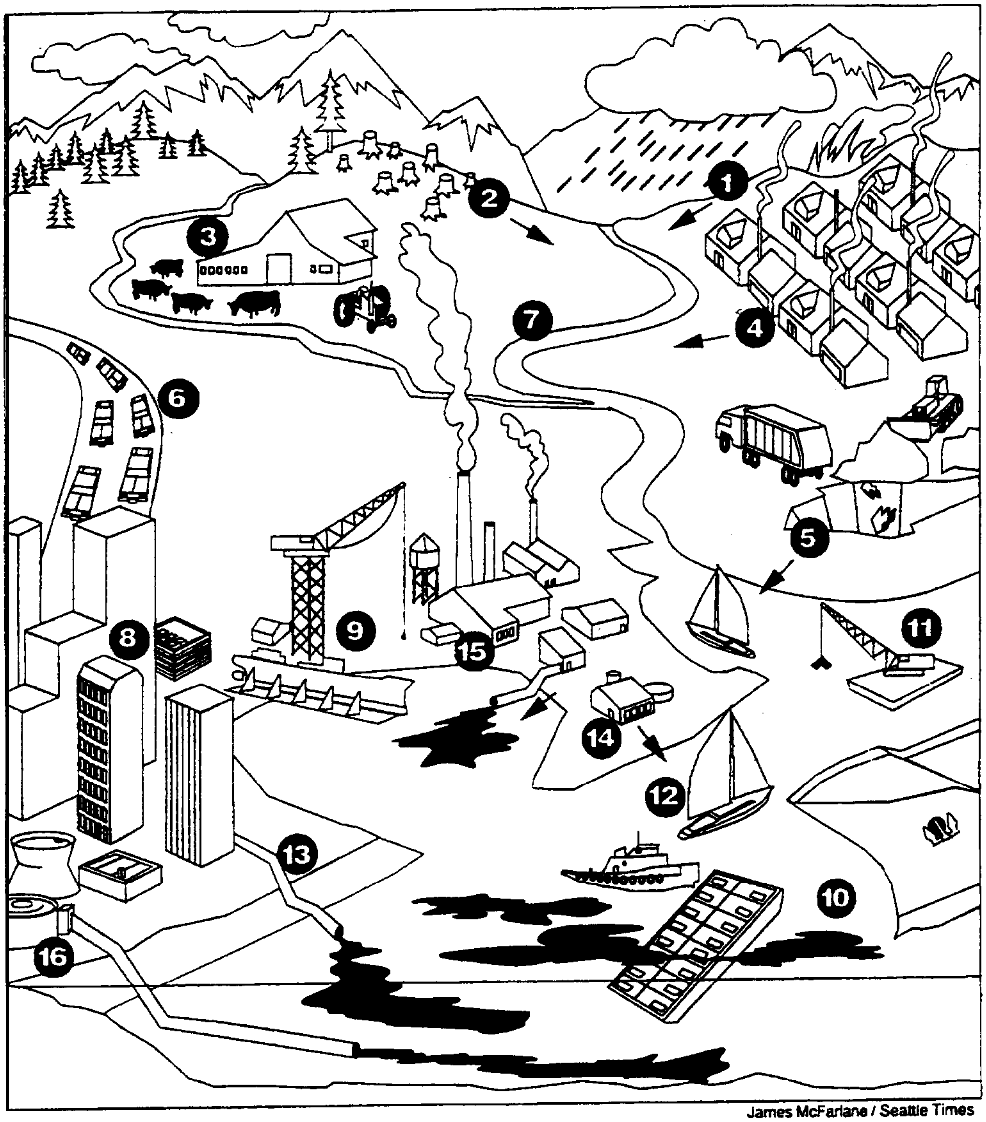
2. World Resources Institute, Houghton Mifflin Co., The 1994 Information Please Environmental Almanac, Boston, New York, 1994

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



James McFarlane / Seattle Times

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.

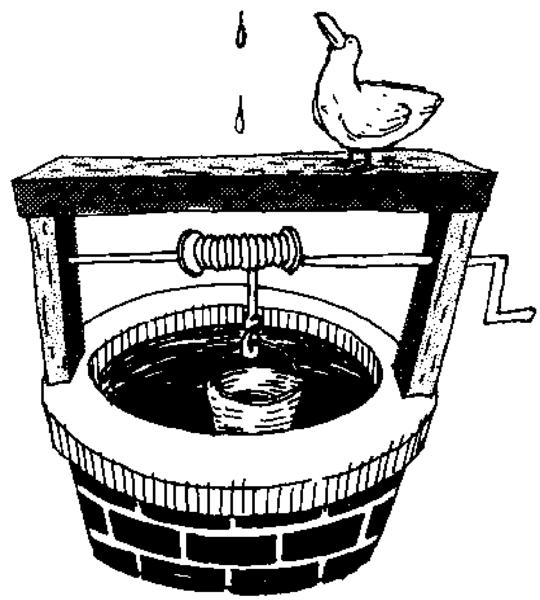
Materials

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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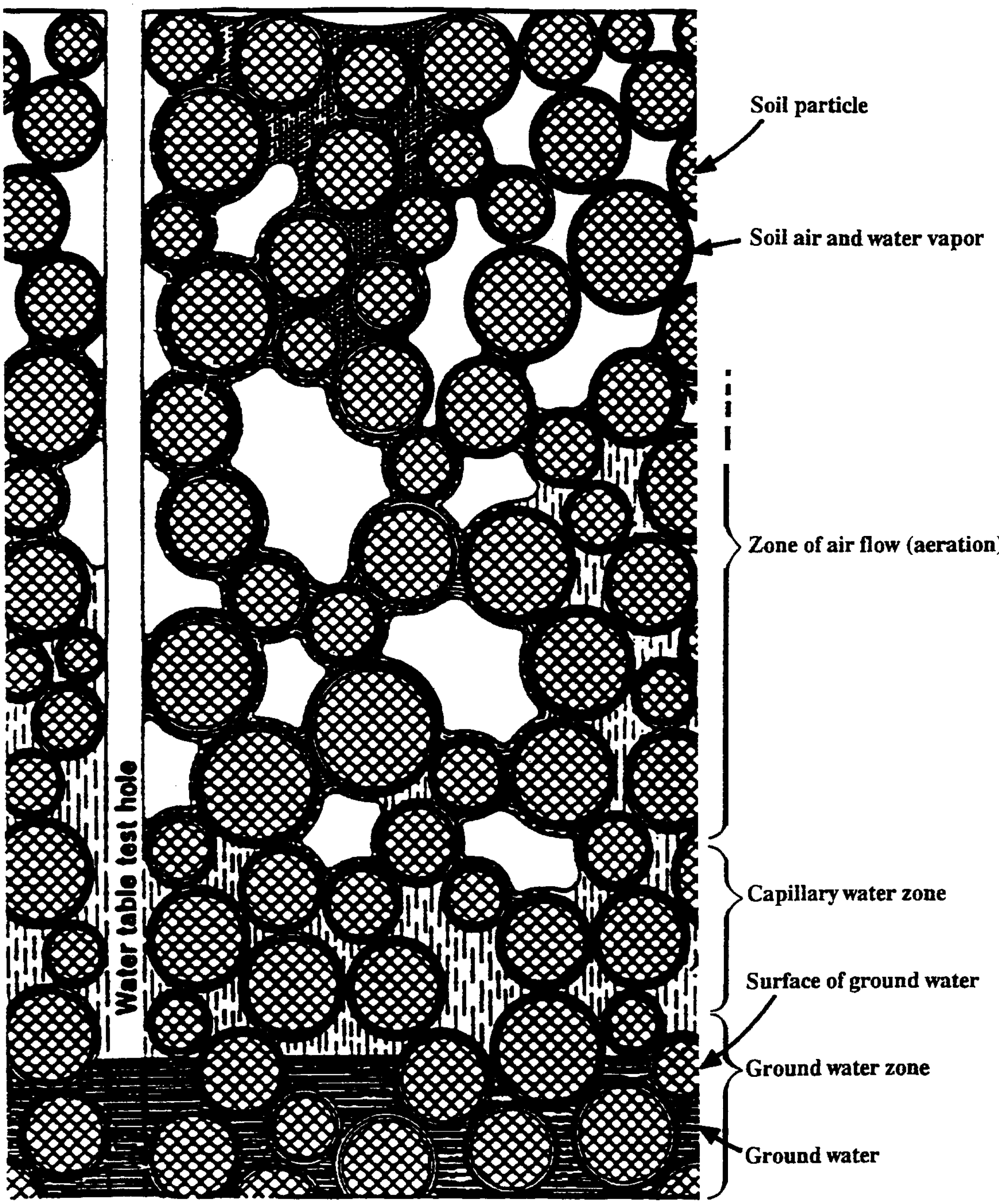
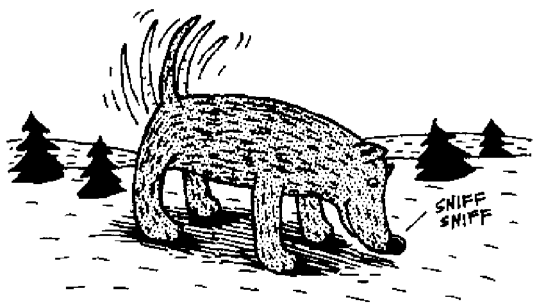
Water In Soil



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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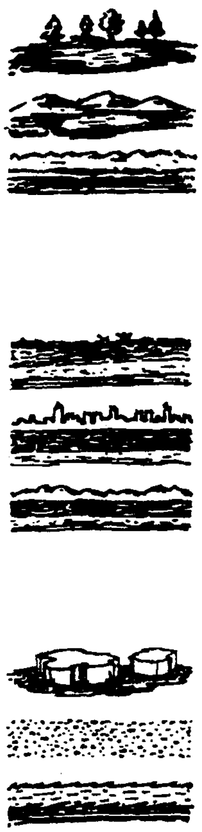
Distribution of the World's Estimated Water Supply



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.

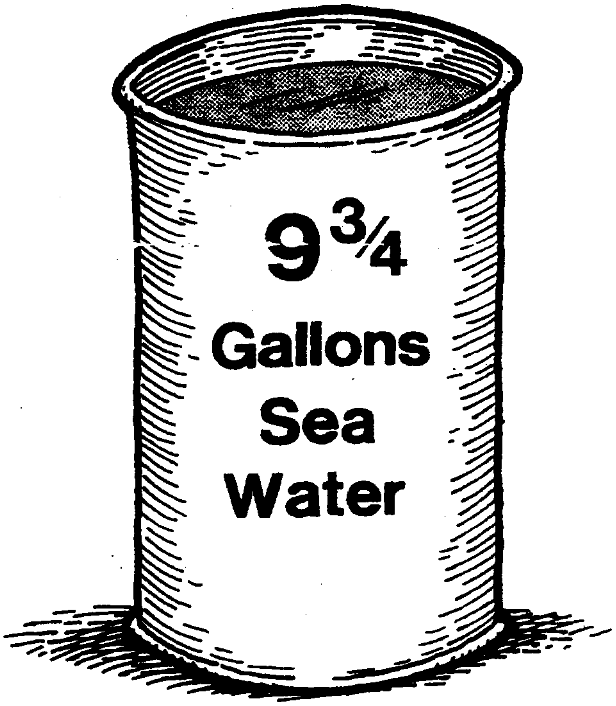
New words by Barb Russell

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?

4 1/2 Cups
Total Fresh Water

1/2 Cup
Accessible Fresh Water



8 1/2 Drops
Available and Drinkable
in Ground Water

Half a Drop

Available in Unpolluted
Lakes, Resevoirs, Etc.

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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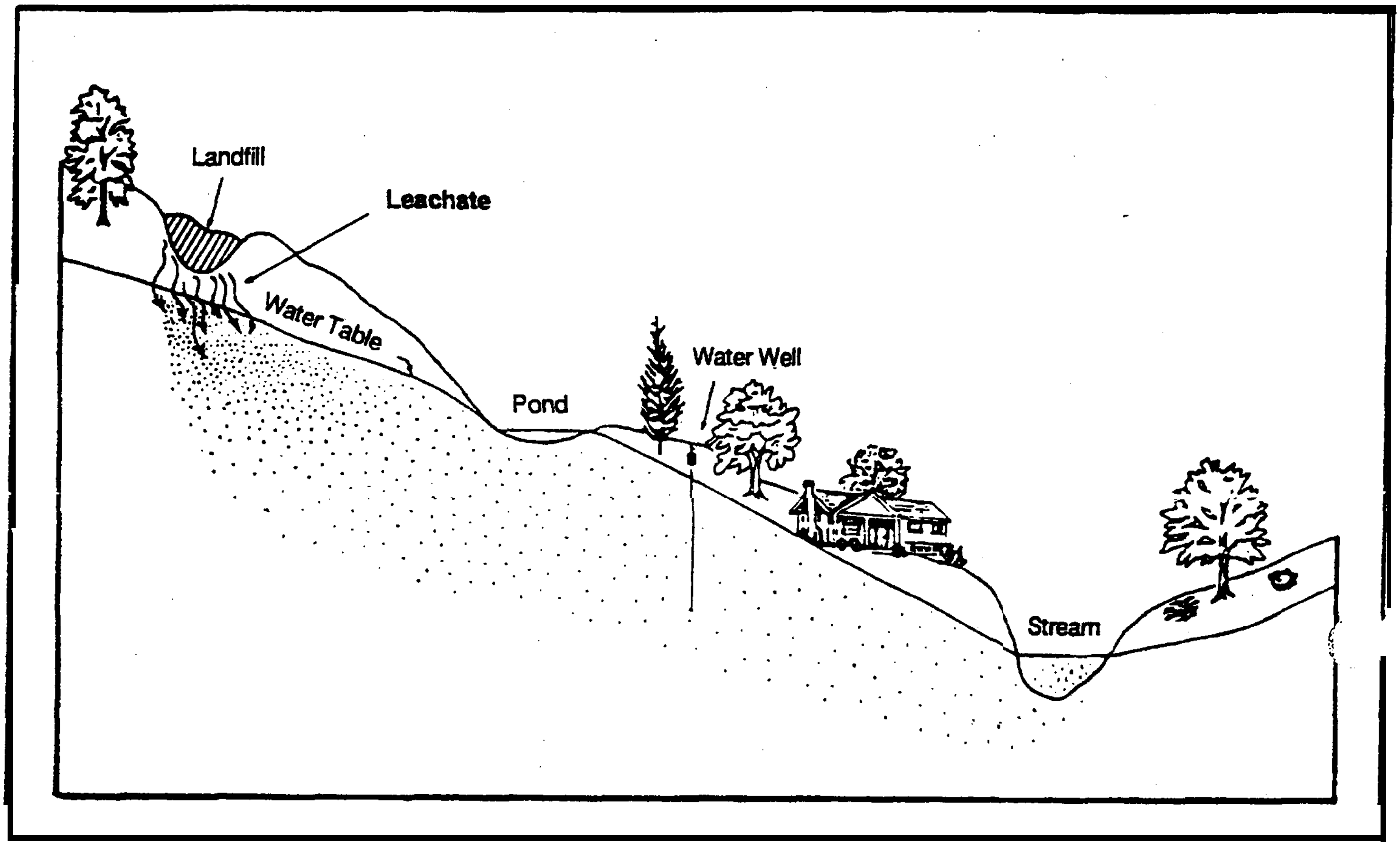
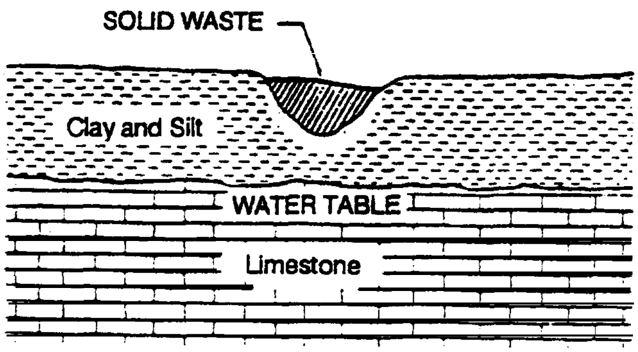
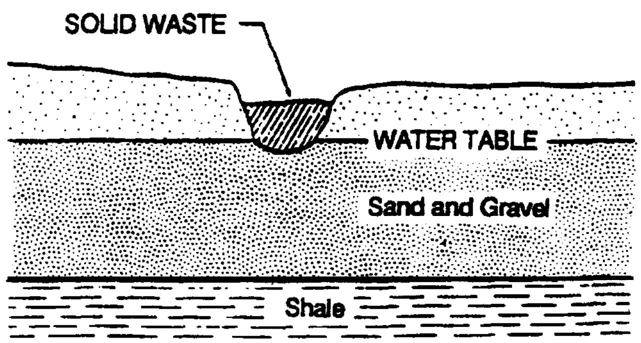
Soil Types and Ground Water Pollution

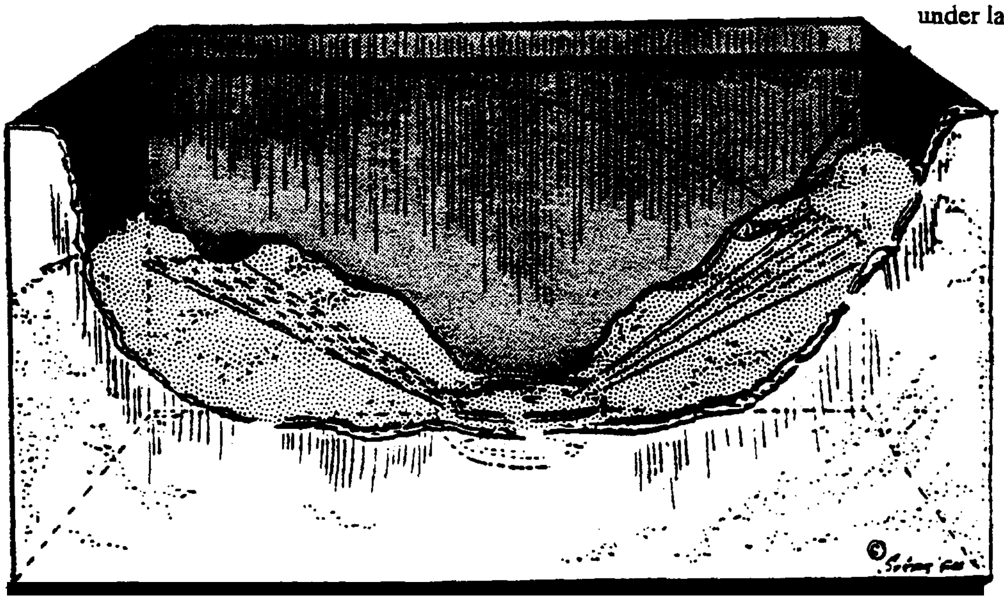






Relatively Safe

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

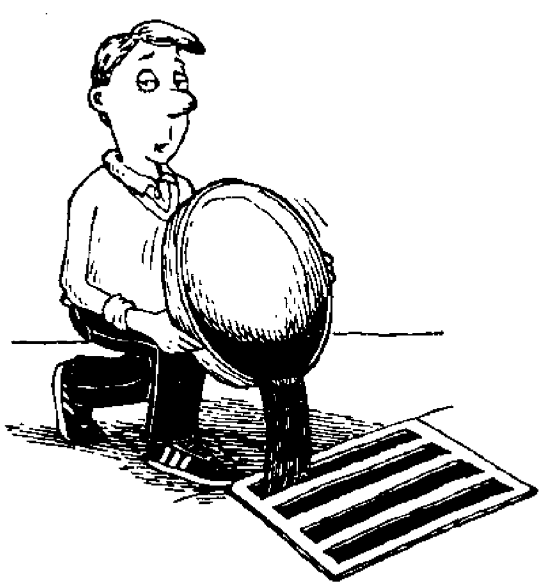
Rationale

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

Bibliography and Resources for Water Section

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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.

Hazardous Waste Introduction

What are the implications of hazardous waste generation and disposal and why do we have to worry about them? We are not the first generation to consider this question, nor will we be the last. The activities in the Hazardous Waste Section of A-Way With Waste are designed to promote awareness of issues surrounding hazardous waste generation and management so that the teacher and the student will develop a base of knowledge upon which to make sound decisions in response to the problems, thereby becoming part of the solutions.

The primary goals of the activities are:

- To promote an awareness of the problems our society faces due to past hazardous waste disposal practices.
- To promote an understanding of how government in the state of Washington is working to deal with the problems of hazardous waste management.
- To help students understand their role in the problem and to give students some positive ways they can be a part of the solution.

Hazardous wastes, those waste that pose a danger to human health and the environment, have received considerable attention in recent years as our indiscriminate disposal practices of the past come back to haunt us. It was assumed that we would always find some place to “get rid” of our waste or that technological advances would lead to solutions of the mounting problems. Today, past assumptions are overshadowed by the realities of contaminated drinking water, acidified lakes, smog alerts, and the threats of global warming. Increasing awareness of the problems associated with improper management of hazardous waste has prompted public officials and private citizens to demand that regulation be implemented to manage hazardous waste disposal.

By the time we learned hazardous waste management was needed, we had already released millions of tons of dangerous chemicals into our water and air, and onto our land. Contaminated sites have been identified all across the state. One of the most notable is the contamination of our drinking water. Already, households throughout the state must use bottled water. In Spokane the sole source aquifer that provides drinking water is threatened by hazardous chemical contamination. There are 625 hazardous waste sites in Washington State.[1] Table 1 on p. 236 lists the sites that have been designated by EPA as Superfund Sites.

Hazardous wastes come in many different forms and pose a variety of health risks. Some chemicals are toxic if ingested, inhaled, and/or absorbed through the skin. The effects of exposure can take many different forms. Generally, hazards can be considered either chronic or acute. Acute hazards are those that cause harm immediately. Thus accidentally swallowing drain cleaner leads to an immediate life threatening situation, the danger depending upon the amount ingested. Chronic hazards are those that can cause harm through long-term, low level exposure. The health or environmental effects may take years to appear. Pesticides such a DDT and many industrial wastes fall into this category.

Assessing the risks to human health from exposure to the various chemical products and wastes in our environment is difficult. Much of our knowledge is not based on observation of human exposure but on studies of animal exposure. Often the chronic hazards and the combined effect of different chemicals are unknown.

1 Washington State Department of Ecology, Model Toxics Control Act, 1995 Annual Report, 1995, p. 20.

Washington State Superfund Sites

There are currently 53 sites in Washington State.

Clark County	Alcoa (Vancouver Smelter)	Vancouver
	Boomsnub/BOC Gases	Vancouver
	BPA - Ross Complex*	Vancouver
	Frontier Hard Chrome	Vancouver
	Vancouver Water Station # 4	Vancouver
Franklin County	Pasco Sanitary Landfill	Pasco
Grant County	Moses Lake WF	Moses Lake
Island County	USN Whidbey	Oak Harbor
King County	Harbor Island	Seattle
	Kent Highlands Landfill	Kent
	Midway Landfill	Kent
	PACCAR	Renton
	Queen City Farms (2 sites)	Maple Valley
	Western Processing	Kent
Kitsap County	Wyckoff	Bainbridge Island
Lewis County	American Crossarm and Conduit Company	Chehalis
Okanogan County	Silver Mountain Mine	Loomis
Pierce County	Asarco	Tacoma
	Commencement Bay Nearshore/Tideflats (11 sites)	Tacoma
	Fort Lewis (3 sites)	Fort Lewis
	Hidden Valley Landfill (Thun Field)	Puyallup
	Ponders Corner	Lakewood
	Ruston/North Tacoma	Tacoma
	South Tacoma Field	Tacoma
	Tacoma Tar Pits	Tacoma
	Well 12A	Tacoma
Snohomish County	Tulalip Landfill	Marysville
Spokane County	Geiger Electric	Spokane
	Greenacres Landfill	Greenacres
	Kaiser Aluminum	Mead
	Mica Landfill	Mica
	North Market Street	Spokane
	Northside Landfill	Spokane
	Old Inland Pit	Spokane
	Spokane Junk Yard	Spokane
Whatcom County	Northwest Transformer (2 sites)	Everson
Yakima County	FMC Corporation	Yakima

*Denotes Federal Facility

Washington State Department of Ecology, Model Toxics Control Act, 1995 Annual Report, 1995, Publ. # 95-611.

Table 1

Identifying, investigating, and cleaning up contaminated sites to minimize exposure is a long, complicated, and expensive process. In some cases, responsible parties can be identified and are required to pay the cleanup cost. Often the cleanup cost must be funded by the state or by the federal Superfund program. It is, of course, more effective to change old habits and control the way waste is managed in the future than to clean up the mistakes of the past.

Essentially all of our activities generate waste and almost all wastes have some potential for hazard. In 1993, Washington's businesses released about 24.6 million pounds of toxic chemicals.[2] This amount represents the companies that have reported to Washington State Department of Ecology and includes releases to air, land, and water.

Many businesses, such as dry cleaners, printing shops and auto body shops, commonly generate hazardous waste but are not required to report to the Department because they generate under the threshold set by the Dangerous Waste Regulations (WAC 173-303). In order to avoid the reporting requirements, small quantity generators, as these businesses are known, must generate less than 220 pounds of hazardous waste per month and accumulate less than 2220 pounds prior to disposal. Some waste, called acutely hazardous waste, must be reported if generated in quantities as small as 2.2 pounds. Although not required by the Dangerous Waste Regulations to report, small quantity generators are required to dispose of their waste as outlined in the regulations. In 1994 Washington residents, not regulated by the Dangerous Waste Regulations, sent an estimated 11.8 million pounds of household hazardous waste to solid waste landfills and incinerators.[3]

1994 Hazardous Waste Generation[4]

Each year, all businesses in Washington that generate regulated quantities of hazardous waste are required to submit an Annual Dangerous Waste Report to the Department of Ecology. These reports are required under the state's Dangerous Waste Regulations. These reports are a detailed summary of the hazardous waste activity that occurred at each individual generation site. On the report, generators of hazardous waste give information as to the volume and types of hazardous waste they generated and how their waste was managed (either on-site or off-site) and its final destination.

The annual report data Ecology receives from generators serves as the basis for decision making throughout the Hazardous Waste Toxic Reduction Program. State planners use the data for projecting the state's future generation and management capacity needs. In the area of toxic reduction, the annual report data is used to assign hazardous waste generator fees which fund waste minimization technical assistance. In day to day program operations, such as regulatory development and enforcement action, the data is used to analyze waste activities.

The waste data reported to Ecology in the Annual Reports is analyzed in the following four primary categories of generation type:

- **Recurrent waste** is derived from a generator's on-going production process. This type of waste includes those that have been recycled and burned on-site.
- **Permit-by-Rule** waste waters are those waters discharged under National Pollution Discharge Elimination System (NPDES), state water quality, or local discharge permits that designate as dangerous waste prior to on-site treatment by the generator. In most cases, this waste type meets the definition of

2 Washington State Department of Ecology, Washington State Toxic Release Inventory, Summary Report: 1993, July 1995, Publ. # 95-417.
3 Ibid, Solid Waste in Washington State, Fourth Annual Status Report, Including the 1994 Recycling Survey, Feb. 1996, Publ. # 96-500.
4 Hazardous Waste updated information from Jean Rushing, Department of Ecology, Olympia, Washington.

Waste Generation (in tons)

COUNTY	NO. OF GENERATORS	RECURRENT	NON-RECURRENT	PERMIT-BY-RULE	MIXED RADIOACTIVE	TOTAL
ADAMS	19	4.33	12.13			16.46
ASOTIN	10	1.32	1.93			3.25
BENTON	126	682.78	3,471.13	18,152.89	119,744.32	142,051.12
CHELAN	89	2,419.79	77.86			2,497.65
CLALLAM	73	33.70	26.80	4.28		64.78
CLARK	250	12,513.64	317.72	274,281.66		287,113.02
COLUMBIA	11	2.31	5.56			7.87
COWLITZ	114	45,992.80	7.97			46,000.77
DOUGLAS	21	6.18	120.00			126.18
FERRY	7	5.06				5.06
FRANKLIN	75	1,193.13	9.64			1,202.77
GARFIELD	5	1.27				1.27
GRANT	97	143.54	1.87	100,305.37		100,450.78
GRAYS HARBOR	78	35.52	113.39			148.91
ISLAND	28	509.87	1.29			511.16
JEFFERSON	34	58.44	6.38			64.82
KING	2,686	69,827.14	10,742.99	1,495,961.14	8.52	1.586,539.79
KITSAP	195	8,890.10	25,957.42	15,488.19	9,202.55	59,538.26
KITTITAS	28	13.42				13.42
KLICKITAT	16	10,509.54				10,509.54
LEWIS	109	148.69	1,057.99	15,137.61		16,344.29
LINCOLN	16	0.13				0.13
MASON	37	25.01	2.37			27.38
OKANOGAN	45	37.32	3.87			41.19
PACIFIC	21	11.07	0.91			11.98
PEND OREILLE	9	1.69				1.69
Pierce	865	26,125.46	54,476.31	653,359.84		733,961.61
SAN JUAN	4	0.64	0.03			0.67
SKAGIT	122	19,014.19	812.43	3,600,000.00		3,619,826.62
SKAMANIA	6					—
SNOHOMISH	613	4,546.58	102.86	48,265.58		52,915.02
SPOKANE	482	4,116.76	610.87	21,465.40		26,193.03
STEVENS	25	9,908.34				9,908.34
THURSTON	214	338.66	7.73			346.39
WALLA WALLA	50	160.90	1.55			162.45
WHATCOM	185	7,636.85	138.70	321,000.00		328,775.55
WHITMAN	45	27.98	87.60	15.09	4.72	135.39
YAKIMA	215	356.56	95.76			452.32
TOTAL	**7,025**	**225,300.71**	**98,273.06**	**6,563,437.05**	**128,960.11**	**7,015,970.93**

"recurrent." Due to the tremendous volume of waste waters generated by a small percentage of sites, this waste type is analyzed separately as not to overwhelm all other sources of waste.

- **Non-Recurrent** waste are those not normally associated with a site's ongoing operations. Demolition or clean-up debris, contaminated soils, or spill materials that are accidentally or infrequently generated are a few examples.

- **Radioactive Mixed** waste streams originate almost exclusively from the United States Department of Energy's Hanford Nuclear Reservation. These radioactive mixed waste streams consist of designated hazardous waste that exhibit low level radioactivity. High level radioactive waste is regulated by Ecology's Nuclear and Mixed Waste Program. In most cases, radioactive waste will meet the definition of either "recurrent" or "non-recurrent" wastes. Since this waste comes from only a few sources, combined with the large quantities generated, this waste type is analyzed separately as not to overwhelm all other wastes sources.

In 1994, Washington State generated just over 7 million tons of hazardous waste. Table 2 on p. 238 shows the volume of wastes generated and number of generators in each county. By looking at the table, it's easy to see a few of the relationships between counties and types of waste generated. For example, only three counties in Washington reported the generation of mixed radioactive waste. The US Department of Energy's Hanford Reservation, located in Benton county, is the primary generator of this waste stream followed by Puget Sound Naval shipyard in Kitsap county from the repair of nuclear powered ships and submarines. A few counties, such as Skagit and Whatcom, reported very large quantities of Permit-by-Rule waste waters. In this case, the large waste water volumes were generated by just a few petroleum refineries located. With recurrent waste, a strong correlation can be made between the counties with high urban density (such as King and Pierce) and the amount of recurrent waste generated there.

1994 Hazardous Waste Management

In 1994, 6,822,448 tons of hazardous waste were managed in Washington State by both commercial Treatment Storage Disposal Recycling facilities (TSDRs - businesses that specialize in the treating, storing, disposal and/or recycling of hazardous wastes) and captive facilities (those who either generate and manage their own waste on-site or receive waste from a select group of generators usually having the same ownership). Examples of commercial TSDRs in Washington State include Phillip Environmental, Safety Kleen and Sol-Pro. Examples of captive facilities include Boeing and the Federal Government's Defense Reutilization and Mobilization Organization (DRMO) at Fort Lewis.

For purposes of summarizing hazardous waste management, the Department of Ecology has defined and analyzed the following three primary categories of management type:

- **Treatment** means the physical, or biological processing of hazardous waste to make such waste non hazardous or less hazardous, safer for transport, amenable for energy or material resource recovery, or amenable for storage or reduced in volume.
- **Storage** means the holding of a hazardous waste for a temporary period.
- **Disposal** means the discharge, discarding or abandoning of hazardous waste, or the treatment, decontamination, or recycling of such wastes once they have been discarded or abandoned. This includes the discharge of hazardous waste into or on any land, air or water.

Waste Management - 1994 (in tons)

	TREATMENT	STORAGE	DISPOSAL	TOTAL
TOTAL	6,689,668	119,484	13,296	6,822,448

As you can see in the table on p. 238, the dominant waste management type is Permit-by-Rule. Waste waters account for nearly 97 percent of the waste managed within the state. In almost all cases, these waste waters are treated at the same site of generation. Following treatment, Permit-by-Rule waste waters are discharged to local sewers under special permits. Radioactive mixed waste accounted for less than 2 percent and was managed. These waste were generated and managed almost exclusively by the Department of Energy-Hanford. The Other category of waste is made up of waste types that did not classify as either Permit-by-Rule or Radioactive mixed. This accounts for 1 percent of the waste managed and includes both recurrent and non-recurrent waste types as defined by the individual generators.

Hazardous Waste Exports

Since Washington State does not have a hazardous waste landfill or incinerator, a large proportion of waste is exported out of state to specialized facilitates in other states or countries. In 1994, 167,833 tons of hazardous waste were exported out of Washington for treatment, management and/or disposal elsewhere. Due to its close proximity and available hazardous waste landfill, the state of Oregon received 70 percent of this exported waste.

Hazardous Waste Fact Sheets

Hazardous Waste Management

Washington State Facts

In 1994, Washington State industries and commercial operations generated just over 7 million tons of hazardous waste. Source: Jean Rushing, Department of Ecology, Olympia, Washington.

In 1994, 6,689,668 tons of hazardous wastes were treated, 119,484 tons were stored and 13,296 tons were disposed. Source: Jean Rushing, Ecology.

Washington State does not have a final disposal facility for hazardous waste, such as a specially built landfill or high temperature incinerator. As a result, in 1994, 167,833 tons were sent out of state for final disposal. Source: Jean Rushing, Ecology.

In 1994, Washington residents sent about 11.8 million pounds of household hazardous waste to landfills and incinerators. Source: Washington State Department of Ecology, Solid Waste in Washington State, Fourth Annual Status Report, Including the 1994 Recycling Survey, Feb. 1996, Publ. # 96-500..

Hazardous Waste: Pesticides

International Facts

Many chemicals that have been banned or restricted by industrial countries are still widely used by farmers in the Third World. DDT and benzene hexachloride (BHC) are examples of chemicals banned from use in the U.S. and much of Europe, yet they account for about three-quarters of pesticide use in India. Source: Sandra Postel, "Defusing the Toxics Threat: Controlling Pesticides and Industrial Waste," Worldwatch Paper 79, Washington, D.C. Worldwatch Institute, 1987, p. 16.

Consumers in industrial countries are still exposed to these chemicals through imported foods, even though their own governments may have restricted or banned them from domestic use. Source: Postel, p. 16.

Although a monitoring program exists in the United States, the General Accounting Office (GAO) estimates that less than 1 percent of imported fruits and vegetables are inspected for banned pesticides. Source: Postel, p. 16.

U.S. Facts

U.S. pesticide facts source: Sandra Postel, "Defusing the Toxics Threat" Worldwatch Paper 79, Washington D.C.: Worldwatch Institute, 1987.

Pests have evolved mechanisms of detoxifying and resisting the action of chemicals designed to kill them. In fact, chemicals have killed natural enemies that help control the pest population. Therefore, chemicals no longer provide the effective means of crop protection they once did. In 1938, scientists knew of just seven insect and mite species that had acquired resistance to pesticides. By 1984, 447 species, including most of the world's major pests, had acquired resistance of pesticides. Source: Postel, p. 19.

Integrated Pest Management (IPM) is an alternative approach to using pesticides as a corrective means of pest control and instead focuses on prevention as a strategy to reduce pesticide use. Source: Postel, p. 26.

IPM looks at the ecosystem as a whole, utilizing biological controls (e.g., natural predators), cultural practices (e.g., planting patterns), genetic manipulations (e.g., pest resistant crop varieties), and use of chemicals selectively and only when necessary. Source: Postel, p. 26.

Nearly 40 crops and collectively 11 million hectares, about 8 percent of the nation's harvested cropland area, have been utilizing IPM programs since 1984. Source: Postel, p.29.

Waste Reduction Information

Reducing waste at the source, rather than having to properly manage it, can save resources, and save money. If reducing or reusing a waste is not possible, recycling is the next best option. Consider the following:

It takes 42 gallons of crude oil to produce 2 1/2 quarts of new 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. Source: Washington State Department of Ecology, The Used Oil Problem (pamphlet), Olympia: Waste Reduction, Recycling and Litter Control Program, 1990.

Recycling used crude oil could reduce national petroleum imports by 25.5 million barrels of oil per year, and save much of the energy to process it. Source: The Used Oil Problem.

One manufacturing facility in Southwest Washington found that they could recover methylene chloride, formerly handled as a hazardous waste, and sell it to a local solvent supplier for reuse in the paint industry. Now, each drum of methylene chloride recovered brings in revenue rather than costing money for disposal. Source: Success Through Waste Reduction, Volume II, 1992.

Benefits aren't just realized in direct costs savings either. Reduced regulatory burden, increases in production efficiency and improved competitiveness and improved worker safety are all benefits that facilities have experienced through reducing their use of hazardous chemicals. For example, the owner of a wood products manufacturing facility found that his waste reduction program cut worker exposure to paints and solvent vapors. He discovered that a cleaner, safer workplace brought a decrease in worker absenteeism and injury and an increase in production rates and quality. These changes have provided an economic edge over his competitors. Source: Success Through Waste Reduction, Volume II, 1992.

Using technologies and methods now available, pesticide use could probably be reduced by 50 percent and reduce the generation of industrial waste by a third or more over the next decade. Efforts to date suggest that farmers and manufacturers would benefit economically, while people and the environment would benefit through decreased risk. Source: Postel, p. 6

Hazardous Waste Cleanup

Washington State Facts

The Washington State Legislature passed the Hazardous Waste Cleanup Act (Ch. 70.105b RCW) in October 1987. It created a program that will help this state clean up and manage its solid and hazardous waste. In November 1988, Washington voters enacted Initiative 97, the Model Toxics Control Act, which became effective March 1, 1989, and replaces the Hazardous Waste Cleanup Act. Programs defined in Initiative 97 are funded by a tax on hazardous substances. Source: Washington State Department of Ecology, Hazardous Waste Cleanup Program: 1988 Annual Report, Olympia, 1989, p. 5.

It is estimated that there are about 625 hazardous waste sites in Washington State. Source: Washington State Department of Ecology, Model Toxics Control Act, 1995 Annual Report, p. 20.

In 1995 more than 816 spills of oil or hazardous substances demanded the State Department of Ecology's quick response. Source: 1995 Annual Report, p. 16.

Bikes And By-products

Subjects: Science, Social Studies
Grades: 3-8
Teaching Time: One Class Period
Focus: Hazardous Waste, Natural Resources, Manufacturing By-Products

Rationale

Sometimes making the things we do want creates things we don't want, such as hazardous waste.

Learning Objective

Students will:

- Learn what the term "hazardous waste" means.
- Learn some of the hazardous wastes created by the manufacturing of a bicycle.

Materials

- Bicycle (select a student to bring one to class)
- Diagram "Bicycle Materials, Wastes, and By-products"

Pre & Post Test Questions

1. What raw material is plastic and synthetic rubber made from?

2. What happens to hazardous industrial wastes?

3. (Grades 3-4) What is a natural resource? Name two.

Learning Procedure

1 **Ask:** "How many of you have bicycles?" "Of what are they made?" "What are the frames made of?" "How about the tires?" "The handle bar grips?" "Where are the metal and rubber and plastic that go into bicycles made?" (In mills and factories that transform raw materials such as petroleum, bauxite, and iron ore into bicycle components.) **Ask:** "What makes your bike special - different from others?" "How many different colors of bikes do we have?" "Whose bike is shiny?" "What is the shiny metal on bikes called?" **Ask:** "Which natural resources are used in the making of bikes?" (iron andpetroleum for plastics, synthetic fibers, and synthetic rubber; petroleum distillates for paint and paint solvents; bauxite for aluminum; chrome, coal for coke to smelt the iron ore into steel; and others.) **Ask:** "What had to happen to the natural resources before they could be used to build your bike?" (They had to be processed in factories.) Direct the discussion from here with the aim of having students realize that when natural raw materials are processed, by-products and waste, some of which may be harmful, are produced. **Ask:** "What are by-products?" "For example, what by-products are produced when you burn wood and paper in your fireplace or woodstove at home?" "Are some of these by-products harmful?" "What kinds of things might be by-products of the manufacturing of your bicycle?"

2 Distribute: "Bicycle Materials, Wastes, and By-products" (A diagram of a bicycle that lists some of the materials and by-products associated with the manufacturing of bikes) or ask a student to bring his or her bike to class. In the latter case, have students make their own diagrams of the bike. Guide students in identifying the bike's component materials (steel, synthetic rubber, plastic, chrome, synthetic fibers, aluminum, paint, etc.). Then, by referring to the diagram, point out some of the by-products and wastes resulting from the manufacturing of these components.

3 Explain: Some of the by-products and wastes from making a bike are hazardous. Discuss what hazardous means. NOTE: Hazardous means dangerous. Hazardous wastes are likely to cause harm to the environment or humans because they are either toxic (poisonous), flammable (ignitable, highly burnable), reactive (explosive), or corrosive (substances that rapidly eat into and/or dissolve what they touch).

Ask: "Does this mean that you will get sick from handling or riding your bike?" "Why not?" "What happened to the hazardous by-products and wastes produced when your bike was made?" (NOTE: Some are captured and recycled for industrial reuse. Some are captured and disposed of in hazardous waste disposal sites, such as the one in Arlington, Oregon. Some escape into the air and water, such as into Tacoma's Commencement Bay. Some are dumped illegally.)

Ask: "How should hazardous wastes and by-products be managed?" "Why is it important to use great care in disposing of these wastes and by-products?"

Ask: "Because hazardous wastes and by-products are made when bikes are built, should we stop making bikes?" " What should we do that makes more sense?" "What are some other things you use that might also have produced hazardous by-products when they were made?"

4 Discuss why there has been so much news about hazardous waste lately.

Acknowledgment

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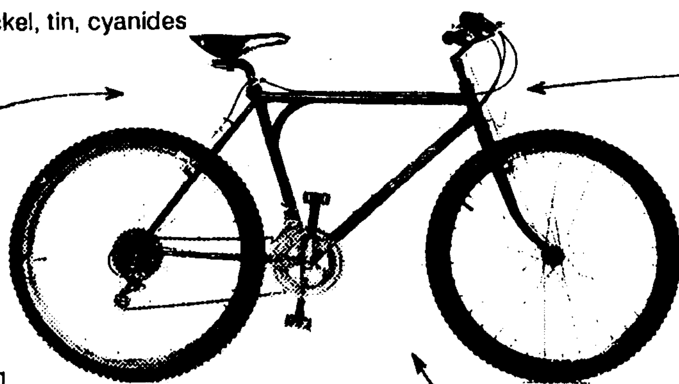
Bicycle Materials, Wastes, and By-Products



Chromed and Plated Metal Parts

Materials

Chrome, nickel, copper, zink

By-Products and Waste

(Highly toxic liquid wastes) Acids, chromium, zinc, copper, nickel, tin, cyanides

Handle Bar Grips, Plastic Seat Cover, Paint, Synthetic Fibers, Synthetic Rubber Tires

Materials

Petroleum and petroleum distillates

By Products and Waste

Waste oil from leaks, caustic and acid sludge, alkaline and acid waters, acid gases and filtering clays

Paints and Coatings

Materials

Pigment, sovents, resins,cleaner

Wastes

paints, solvents, cleaners

Frame and Other Metal Parts

Materials

Iron ore and coal to make steel

By Products and Wastes

Ammonia, tar, acids (pickling liquor) waste), blast furnace flue dust

Fenders and Other Metal Parts

Materials

Aluminum (from bauxite)

By-Products and Wastes

Large volumes of "Red Mud" consisting of iron, titanium and silica

Hazardous Waste in My Home Town?

Subjects: Social Studies: Geography, Economics, Environmental Studies

Grades: 7-12

Teaching Time: This Activity Can Be Spread Over One to Four Class Periods

Focus: Hazardous Waste Generation, Hazardous Substances, Community Right to Know

Rationale

Hazardous waste is produced in almost every community in Washington. Industry, government, and citizens share responsibility for managing hazardous waste. To deal with this complex and controversial issue, we need informed citizens.

Learning Objective

Students will:

- Identify the number and kinds of local commercial and industrial waste generators.
- Identify ways they benefit from products or services that produce hazardous waste.
- Learn where they can get information about hazardous waste.

Teacher Background

All businesses, large and small, generate waste. Some of this waste is hazardous. The toxic wastes produced by large firms in the chemical, pulp and paper, and steel and aluminum industries are obvious, but many small businesses that are found in every community also generate hazardous wastes. These include such operations as auto body repair shops and dry cleaners. "High-tech" companies that manufacture computer chips and electronic circuits are often thought of as "clean" industries. However, they, too, produce sometimes large quantities of hazardous by-products.

Materials

Teacher/Classroom materials

- Local telephone yellow pages
- Washington Manufacturers Guide (Available in most public libraries. Call the Department of Ecology Hazardous Substance Hotline - 1-800-633-7585. If you can't locate a copy; the Hotline will send you information about your county.)
- Overhead: "Hazardous Substance Characteristics," p. 299
- Overhead or handout: "Some Industrial and Commercial Hazardous Waste Categories" (Answer key)
- EPA brochure Protecting Our Ground Water (See Bibliography)

Student materials

- Map of your community or county—contact the city or county planning office (optional)
- Handout: " Businesses Generating Hazardous Waste"
- Handout: "Some Industrial and Commercial Hazardous Waste Categories" (blank worksheet)
- "It's Your Right to Know" pamphlet available from the Hazardous Substance Hotline 1-800-633-7585 (optional)

Pre & Post Test Questions

1. What characteristics make waste hazardous?

2. What are three types of small businesses that generate hazardous waste?

3. From whom can you learn more about hazardous waste?

4. Why are heavy metals hazardous?

Learning Procedure

1 Ask students to think of as many different kinds of businesses and industries in their area as possible. Use the yellow pages, the Washington Manufacturers Guide, or ask your Chamber of Commerce for information. Make sure that both large and small businesses are included.
As local businesses and industries are identified, have students describe what products or services these enterprises provide. Tabulate the number and kind of industries on the board.

Discuss how these products or services benefit us. (For example: dry cleaners clean our sweaters, suits; automotive body shops repair or customize our cars; printing shops prepare brochures, flyers, newspapers, etc. that keep us informed.)

2 **Ask:** "What wastes might be produced by these local businesses and industries?" "How are these wastes managed?" (They're either recycled, go to a landfill, or are released into the sewage system for treatment. If they are hazardous, they may be reused, recycled, stored, treated, or disposed of by way of a hazardous waste landfill or incinerator.)

3 **Ask:** "What qualities might be characteristic of a hazardous waste?" Show and discuss the overhead "Hazardous Substance Characteristics," p. 299, so that students understand the five basic characteristics of hazardous waste.
Ask: "Under what conditions can a hazardous waste pose a threat to human or animal life?" (For example: persistent substances lasting a long time in the environment before being broken down into something less hazardous; long-term exposure to certain substances at low levels; bioaccumulation of substances; reactive or synergistic effects [See the Glossary for definition of terms]; heightened sensitivity of certain groups of people to specific substances, such as young children to lead, a heavy metal.)

4 Distribute copies of the handout "Businesses Generating Hazardous Waste." **Ask:** "Did we find any of these kinds of businesses in our community?"

5 Pass out copies of the blank "Some Industrial and Commercial Hazardous Waste Categories" sheet. Ask students to match the categories with the hazard characteristics discussed above, by filling in the "blank" column. Explain that any category may have more than one characteristic, be persistent, or affect certain subgroups of people. Ask students to think of ways wastes might cause harm. This can be done individually or in groups using brainstorming techniques. Give students ten minutes or so to work on their answers.
Using the "Some Industrial and Commercial Hazardous Waste Categories" answer key, go over students' answers. **Ask:** "How can we find out more about the hazardous wastes generated in our community?"

6 Identify the Department of Ecology's Hazardous Substance Hotline as a good source of information about hazardous substances and hazardous waste. Local city and county offices of water quality and environmental health often have specific information on small businesses producing hazardous waste. Tell students that a hazardous product is termed a hazardous waste when it is no longer wanted or useful and is destined for disposal. While the product is still considered useful, it is termed a hazardous substance.
If you wish, pass out "Your Right to Know" pamphlets. Explain to the students that although you have focused on hazardous waste and its potential for harm when disposed of, it is important to recognize that chemical substances pose potential danger during use and when they are stored prior to use — in other words, prior to their becoming hazardous waste. Discuss the principle that all citizens have a right to know about hazardous substances in their community.

7 Distribute the brochure “Protecting Our Ground Water.” **Ask:** “What are some of the ways wastes can enter the environment?”
Distribute maps of your town or county, or have students draw maps. Have students locate and mark the local landfill and sewage treatment plant. Have them highlight streams, lakes, and salt water. Discuss the significance of these locations.

Ask: “Is hazardous waste generated near any of these sensitive areas?” “Have we identified all the hazardous waste generators in our area?” “How can we find out?” “How can we get more information about hazardous waste?” Remind students that the Hazardous Substance Hotline has information on all these topics.

8 Using the list of businesses, have students mark the locations where hazardous wastes might be produced on their maps. When maps are complete, **Ask:** “Which areas in our town or county are most vulnerable or sensitive to pollution?” (Aquifers and wetlands, for example)

9 **Ask:** “What can we do to prevent pollution?” “How can we ensure that our environment and human or animal health is not endangered due to hazardous wastes in our communities?”
Explain to students that to protect public health and the environment, hazardous waste is managed by a system much stricter than for nonhazardous waste.

Explain that the Department of Ecology is responsible for regulating hazardous waste and that one part of this responsibility is the monitoring of businesses that produce hazardous waste. But, local governments are responsible for small quantity generators—those producing less than 220 pounds (about 27 gallons, or half of a 55 gallon drum) of hazardous waste per month. (To introduce students to the career opportunities in environmental protection, do the activity “Investigating Environmental Professions,” p. 279.)

Extended Learning

1 Have students call the Hazardous Substance Hotline with questions about the wastes that may be generated or the hazardous substances stored in their community. Have them ask for a free brochure describing their right to know about hazardous substances.

2 Assign a particular waste to a group of students to research. For example, a group (or individual) might try to find out what are the specific hazards associated with the wastes generated by auto detailing shops, print shops, or dry cleaners.

3 Have students investigate the hazardous wastes generated by the school in chemistry labs and shop classes.

4 Check with local county government to find out what programs exist in your community for small business hazardous waste.

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Businesses Generating Hazardous Wastes

Type of Business	Hazardous Wastes Generated
Auto Repair and Maintenance	Lead-Acid Batteries Heavy Metals Solvents Acids/Bases Used Oils
Building Cleaning and Maintenance	Acids/Bases Solvents
Cleaning Agents and Cosmetics	Acid/Bases Heavy Metal/Inorganics Solvents
Construction	Acids/Bases Solvents Preserving Agents
Electric and Computer Chip Manufacturers	Acids/Bases Spent Plating Wastes
Farmers and Agricultural Service Shops	Pesticides Solvents Used Oils
Furniture/Wood Manufacturing/ Refinishing	Solvents
Laundries and Dry Cleaners	Dry Cleaning Filtration Residues Solvents
Motor Freight Terminals and Rail Transport	Acids/Bases Lead-Acid Batteries Heavy Metals/Inorganics Solvents Used Oils
Printing Industries	Acids/Bases Heavy Metals/Inorganics Ink Sludges Spent Plating Wastes
Schools, Labs, and Vocational Shops	Acids/Bases Solvents Heavy Metals/Inorganics
Wood Working (Boat builders, lumber mills, etc.)	Preserving Agents

Some Industrial and Commercial Hazardous Waste Categories - Answer Key

Waste Category	Hazard Characteristic(s)	Other Considerations
Acids/Bases	Corrosive, Reactive	Can sometimes react violently with water
Cyanide Wastes	Toxic	
Filtration Residues	Corrosive, Reactive, Toxic	
Formaldehyde	Toxic	Sensitive populations - (1)
Heavy Metals and Inorganics	Toxic	Persistent; sensitive populations - (2)
Ink Sludges	Toxic	Persistent; sensitive populations - (2)
Oils (used)	Toxic	Persistent; sensitive populations
Pesticides	Toxic	Persistent - (3)
Preserving Agents	Toxic, Corrosive	
Solvents/ Degreasers	Corrosive, Reactive, Ignitable, Toxic	Sensitive populations - (1)
Spent Plating Wastes	Corrosive, Toxic	

1. Some individuals are especially sensitive.
2. Children are especially at risk to lead exposure.
3. Chlorinated pesticides can bioaccumulate.

Some Industrial & Commercial Hazardous Waste Categories - Worksheet

Waste Category	Hazard Characteristic(s)	Other Considerations
Acids/Bases		
Cyanide Wastes		
Filtration Residues		
Formaldehyde		
Heavy Metals and Inorganics		
Ink Sludges		
Oils (used)		
Pesticides		
Preserving Agents		
Solvents/ Degreasers		
Spent Plating Wastes		

What Waste Went Where?

Subjects: Social Studies: Washington State History, Contemporary Problems, Biology, Chemistry, Geography, Health and Safety

Grades: 9 -12

Teaching Time: One to Three Class Sessions

Focus: Hazardous Waste Management, Environmental Contamination, Health and Environmental Threats, Group Cooperation

Rationale

Unsafe and illegal handling of hazardous wastes has created many health and environmental problems in the state of Washington.

Learning Objective

Students will:

- Use information about Washington State to identify where, why, and which hazardous wastes have created environmental and health problems in our state.
- Work cooperatively to solve problems.

Teacher Background

There are hundreds of locations in Washington State where hazardous wastes have contaminated the environment. Some of these hazardous wastes continue to threaten the health of humans and wildlife. Others have been treated or removed.

This activity is designed to give students the "facts" about 14 of the hundreds of sites where hazardous wastes have been unsafely disposed of or spilled. Working cooperatively, groups of students will piece together the various "clues" about where, how, and what hazardous wastes have entered the environment in Washington.

Read the "What Waste Went Where" direction sheet that explains how the members of each group work together. In the "full" version of this activity, students identify 14 locations throughout the state. Shortened versions of the "game" can be "played" by using only three, six, or eight locations out of the fourteen.

Please see the items listed below under Teacher Resource and Background Materials for detailed information on the locations and hazardous substances described in this activity.

Materials

Game Materials

Each student group should have its own copies of the following:

- "What Waste Went Where" directions
- Map(s) of Washington State with numbered locations
- Clue cards—in the full game, there are 14 WHERE cards; 14 CONNECTION cards; 14 WHAT cards; and 6 FOLLOW-UP cards. Separate and shuffle the cards prior to starting the activity. (Shorter versions may have fewer cards.)
- Number line—for placing clue cards when the hazardous waste in that location is identified. Use the template provided or prepare your own.
- "What Waste Went Where" worksheet (optional)
- Group Evaluation Sheet

Teacher Resource and Background Materials

- "A Sampling of Locations in Washington Where Hazardous Wastes Have Entered the Environment"
- "Selected Hazardous Wastes - Their Health or Environmental Effects"
- Answer Key for worksheet, pp. 265-267

Participants Reference Materials

These items should be available to students for consultation.

- Road map of Washington
- Dictionary

Pre & Post Test Questions

1. Can you list at least six ways that hazardous substances get into the environment?

2. Can you list at least six problems that have been caused by hazardous substances being released into the environment?

3. Can you explain why the Department of Ecology and the Environmental Protection Agency must know exactly what hazardous substances are involved before they attempt to clean up a hazardous waste location?

4. What human activities contribute to the hazardous waste problem?

Learning Procedure

1 Introduce this activity by telling students that, in 1993 about 24.6 million pounds of toxic chemicals were released by industry in Washington State.[1] Many of these hazardous wastes are by-products from the manufacture of consumer products ranging from aluminum soda pop cans to chrome plated automobile ornaments.

Explain that the unsafe handling, storage, and disposal of hazardous wastes have caused serious problems in this country and in our state.

2 Start the "game" by dividing students into groups of three. The activity will progress faster if at least one member of each group is good at solving puzzles. Explain that this is a cooperative activity. Members in each group will work together to figure out what waste went where.

3 Pass out a copy of one or both of the maps of Washington to each of the groups. Tell students that the circles on the maps represent some of the many hundreds of places in Washington where hazardous waste has escaped into the environment.

4 Point out the numbered locations marked on the map(s). Pass out the clue cards and tell students that each type of clue card (WHERE, WHAT, CONNECTION, AND FOLLOW-UP) contains certain key words and phrases that link them to a specific numbered location or to another card. Together, the cards contain all the clues needed to help group members figure out one hazardous waste that got into the environment in these particular locations.

5 Hand out and go over the directions with the students. Note that the WHERE cards are placed first. Tell students to use a road map if necessary. After the WHERE cards have been placed under the numbers, the CONNECTION cards are next, followed by the WHAT cards. The FOLLOW-UP cards are played last.

6 Circulate among the groups as they proceed, to make sure that each group is focusing on the proper key words and phrases in the cards. If necessary tell them when their cards are improperly placed, so they can see how the key words link up the different WHERE, CONNECTION, and WHAT cards to a given location. (Teacher: Refer to the answer key as you circulate.)

Continue until all groups have matched the hazardous wastes to the numbered locations or until sufficient matches have been made to accomplish the learning objectives.

7 Depending on the problem-solving abilities of the students involved, the activity using all 14 locations could take two to three class periods to complete. If necessary use the "What Waste Went Where" worksheet to record each day's results. The following steps outline several ways to shorten the activity.

1 Washington State Department of Ecology, Washington State Toxic Release Inventory, Summary Report: 1993, July 1995.

One Period Version

With the class, go through the WHERE cards together. Then tell the groups the answers for the CONNECTION cards. Let the groups complete the matching on their own with the WHAT and FOLLOW-UP cards.

One or Two Period Versions

Prior to class, use the answer key to separate the cards that go with the first six and the last eight locations. Hand out either one or the other of these subgroups and the appropriate number line sections.

Tell students they are going to examine either Puget Sound (locations 1-6) or the state outside of Puget Sound (locations 7- 14). Proceed as in Step 6. Do one area the first day and the other area the next.

8 After all the groups have finished you may wish to hand out the answer key and any other teacher material as needed. Generate class discussion by asking the following questions:

- What actions of group members were most helpful in solving the puzzle and completing the activity?
- What did you learn about hazardous waste in Washington?
- How could the hazardous waste problems described in this game have been prevented? (government regulation of waste treatment, storage, and disposal; development of alternate manufacturing processes; changing consumer habits; waste exchanges and recycling, etc.)

Extended Learning

1 When the groups have completed the matching part of the activity, give each group the "Evaluation of Group Participation," p. 278. This evaluation may be changed to meet the teacher's group interaction objectives.

2 Show the overhead "Hazardous Substance Characteristics," on p. 299. Ask students to identify the hazard characteristics that some or all of the chemicals in this activity have.

3 Have students identify and research a hazardous waste location near where they live by calling a hazardous waste inspector at the nearest Department of Ecology office or the Hazardous Substance Information Hotline 1-800-633-7585. (Teacher, please call in advance to prepare the Department and the Hotline for calls.)

4 Have students find out what was done or is being done at this site to reduce damage to human health and the environment.

5 Have students research what has been done to clean up hazardous wastes at the locations described in this activity.

Acknowledgment

Honors to Mary Porter for many hours spent developing, writing, and field-testing this activity. The following people in the Washington State Department of Ecology very kindly took the time to provide detailed information about each of the hazardous waste sites used in this activity: Dennis Bowhay, Yakima; Lynn Bernstein, Olympia; John Conroy, Redmond; Jim Malm, Spokane.

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A Sampling Of Locations In Washington Where Hazardous Wastes Have Entered The Environment

This is background information for the teacher. Do not share this information with students until they have completed the "What Waste Went Where" activity.

There are hundreds of locations in Washington State where hazardous wastes have entered the environment from manufacturing, storage, or spills. The following is a sampling to show a range of hazardous waste locations around the state and reasons the hazardous wastes are there.

1. Purdy Junkyard Site, Kitsap County
Eight Northwest public utilities stored electrical transformers in a junkyard in Purdy, south of Bremerton. The transformer cooling oil contained polychlorinated biphenyls - PCBs. In the process of salvaging the copper wire in the transformers, PCBs drained onto and contaminated the soil. Rainwater carried the hazardous chemicals toward a saltwater lagoon downhill from the junkyard. Organisms in the lagoon now have PCBs in their systems.

In addition, some of the PCB-contaminated transformer oil was used for dust suppression and some was burned. When PCBs burn, another extremely hazardous chemical forms. This chemical is 2,3,7,8-TCDD, the most toxic form of dioxin.

The junkyard owner voluntarily assisted in the site's cleanup.

2. Western Processing, King County
This chemical processing and storage plant operated in Kent from 1960 to 1983. Western Processing accepted hazardous wastes from over 300 companies, including Boeing and other industrial manufacturers.

The wastes, however, were not properly managed. About 100 chemicals with proven levels of toxicity have contaminated soil at the site and are threatening ground water and nearby Mill Creek.

Nitrobenzene is one of the hazardous chemicals that leaked from drums at Western Processing. Others include the most toxic form of dioxin - 2,3,7,8- TCDD, which was found in 2,500 gallons of kerosene at levels of 200-300 parts per million (ppm) and dichloroethylene, a solvent that leached into the ground water.

Some of the hazardous wastes may be entering an aquifer that was to be a future source of drinking water for the city of Kent.

3. Midway Landfill, King County
Located between Seattle and Tacoma, this landfill was opened in the 1960s to receive demolition debris from road construction. The landfill, operated by the City of Seattle, was sited in a gravel pit surrounded by wetlands. The people living near the site were strongly opposed to the location of the landfill but were promised it would handle harmless wastes.

All kinds of wastes, however, were dumped. Over 20 years, the decomposing garbage produced large volumes of methane gas. This gas, which is explosive when mixed at 5 to 13 percent concentration with air,[2] migrated in some directions over a quarter of a mile through the porous, gravelly soils, finally moving into the basements of homes and businesses.

Eleven families were evacuated because of the potential danger of explosion and because other landfill gases also threatened health.

Benzene, vinyl chloride, and hydrogen sulfide

2 Douglas M. Considine and Glenn D. Considine, Van Nostrand Reinhold Encyclopedia of Chemistry., New York, N.Y.: Van Nostrand Reinhold Company, Inc., 1984, p. 570.

produced by the landfill have also contaminated ground water.

"For Sale" signs were everywhere in nearby neighborhoods. The City of Seattle has purchased 122 houses and has spent nearly $100 million on this landfill and another nearby dump at Kent Highlands.[3] Seattle now has one of the highest garbage disposal rates in the country and this enormously expensive remediation is a major contributing factor.

4. ASARCO Copper Smelter, Tacoma, Pierce County

This copper smelter near Commencement Bay in Tacoma closed down in 1985. During the years of its operation, arsenic, cadmium, lead, and impurities removed from the copper ore were spread for miles by the lift of hot gases from the smelter stack. Heavy metal-contaminated smelter slag ended up in building foundations all over Tacoma.

Studies with honey bees in the Puget Sound region have revealed the wide extent of the arsenic and cadmium pollution and have shown that these metals contributed to bee mortality. In addition, gardeners in parts of Vashon Island downwind of the smelter were advised not to eat their homegrown vegetables.

The dismantlement of the smelter is now largely complete. The U.S. Environmental Protection Agency has designated the smelter grounds as a hazardous waste Superfund site. The Washington State Department of Ecology hazardous waste staff estimate that complete cleanup could take 20 years.

5. Buffalo Don Murphy Junkyard, Pierce County

During the 1970s, Buffalo Don Murphy stored waste from Reichold Chemical Company on his five-acre rural property. Over 1000 drums of different wastes generated in the manufacture of industrial disinfectants were stored at the junkyard. Hazardous compounds such as pentachlorophenol (a wood preservative), phenanthrene, and anthracene (by-products of the burning of carbon compounds) leaked out of these drums and into the soil.

The property is a filled wetland and is near a creek used for irrigation and stock watering. Several schools are nearby.

Some of the wastes were sold as wood preservatives and weed killers.

Buffalo Don died in 1975.

6. Strawberry farm, Thurston County

A pesticide, Terr-o-cide, which is 54 percent EDB (ethylene dibromide, a now illegal compound) was applied for three years at the rate of 18-20 gallons per acre on this 12-acre farm near Olympia.

EDB and DCP(1,2-dichloropropane), a chemical used to kill nematodes, polluted nearby wells that provided water for 22 homes. The residents were drinking bottled water until a new source of clean water could be provided.

7. Weyerhaeuser Company Chloralkali Plant, Cowlitz County

From 1956 to 1975, this plant in Longview used a mercury process to produce chlorine gas and caustic soda for an adjacent pulp mill. The waste mercury and zinc have contaminated soils and ground water at the site and, possibly, sediments and resident fish in the Columbia River.

8. Frontier Hard Chrome, Clark County

This chromeplating company operated from 1970 to 1983 in Vancouver, half a mile north of the Columbia River. The waste hexavalent chromium was discharged into a dry well and has entered ground water. A study shows that the contaminated ground water is flowing toward the Columbia River.

3 David Schaefer, "City, Homeowners Settle in Suit over Landfill," Seattle Times, April 20, 1988.

9. Train derailment, Klickitat County

Many train derailments have spilled hazardous materials ranging from sodium hydroxide to oil. A derailment near White Salmon spilled antifreeze and hydraulic fluid on the banks of the Columbia River.

10. Jet fighter emergency landing, Yakima County

In 1983, a jet fighter was forced by a malfunction to land at Yakima airport. Hydrazine, an extremely reactive and toxic fuel used in the jet's backup generator system, leaked onto the ground. Airport workers wanted to clean up the spill, but the Department of Ecology secured the area and a spill response team from McChord Air Force Base, wearing protective suits and breathing gear, removed the fuel.

11. Crop King Chemical, Yakima County

This company in Yakima manufactured and formulated pesticides between 1940 and 1985. Leftover pesticides, including DDT, have contaminated soil and possibly ground water at the site.

12. Turner Dump Site, Okanogan County

An individual who was moving cleaned all the stored pesticides out of a shed at his place south of Okanogan and dumped them on the bank of the Okanogan River. A neighbor alerted the Department of Ecology and an emergency cleanup was conducted. Among the discarded pesticides were: 14 gallons of parathion, 13 pounds of lindane, 50 pounds of strychnine, and 2 gallons of endrin. (Because of the risks they pose to public health and the environment, endrin is now illegal in Washington State, and the use of parathion and lindane is restricted. Endrin and lindane are no longer being manufactured. The trend is to not manufacture these persistent chlorinated hydrocarbons for use as pesticides.)[4]

A total of 24 identifiable pesticides were recovered. It took six people three days, working 16 hours a day to collect 25 drums of hazardous waste from the riverbank.

The individual was indicted for endangering public health, but a jury in Spokane cleared him because they thought his actions did not make him a criminal.

13. Colbert Landfill, Spokane County

This landfill, eight miles north of Spokane, was operated by the Spokane County Utilities Department from 1968 until 1986. Between 1975 and 1980 Key Tronic Corporation dumped tons of chemical solvents into the landfill. Three of the hazardous chemicals were–1,1–dichloroethane, 1,1–dichloroethylene, and 1,1,1–trichloroethane.[5]

The chemicals seeped into the ground water and contaminated the wells of families living nearby. Their well water contained levels of 1,1,1–trichloroethane up to ten times the levels considered safe. The plume of contamination is spreading south and west in the aquifer under the landfill.

14. North Market Street, Spokane County

Petroleum by-products have contaminated the wells in an area a mile north of Spokane. Discovered in 1984, a huge underground pool of petroleum waste containing benzene, toluene, and xylene caused problems for a nursery watering its trees from a well. The chain-link fence and paving around the nursery turned oily brown, and $10,000 worth of maples, spruces, and other trees died. The nursery had to be moved.

The hazardous petroleum by-products are slowly leaching and spreading in the Spokane aquifer.[6]

The area has a long history of use as a site for oil refineries, tank farms, pipeline terminals, and retail oil sales outlets. At one location, waste oil was pumped into unlined lagoons that may have been as large as four acres. There have been 16 potentially responsible parties identified.

4 Mary Touhy, Department of Agriculture.

5 Jeff Sher, "Trichloroethane in Our Water," Spokesman Review, May 14, 1982.

6 Lonnie Rosenwald, "$500 Million Sought for Cleanup," Spokesman Review, November 10, 1985. Jeff Sher, "Pollution Spreading in Aquifers," Spokesman Review, December 22, 1985.

Selected Hazardous Chemicals And Compounds – Their Characteristics And Health Or Environmental Effects

Please note: The health effects of intense, acute exposure and low-level, long-term exposure to hazardous material are not the same. In some cases the effects of chronic, low-level exposure are not known.

Hazardous Material	Characteristic	Health or Environmental Effects
Arsenic	Gray solid. Water insoluble. Highly toxic if ingested or inhaled.	Birth defects in animals after long-term exposure. Skin and lung cancer in humans.
Benzene	Colorless liquid slightly water soluble. Very ignitable. Highly toxic if ingested, inhaled, or if in contact with skin.	Interferes with red and white blood cell production; causes anemia. Damages chromosomes in bone cells; results in leukemia. Causes headaches, nausea, and poor concentration.
DDT	Colorless crystal or white powder. Water insoluble. Toxic.	Interferes with animal reproduction. Bioaccumulates. Highly toxic to fish.
EDB	Colorless liquid. Slightly water soluble.	Causes cancer and birth defects in animals. Toxic if ingested, inhaled, or if in contact with skin.
Endrin	White powder. Insoluble in water. Very toxic if inhaled or absorbed through skin.	Poisonous. Can produce convulsions, temporary deafness, mental confusion, nausea, and unconsciousness. Causes cancer and birth defects. Bioaccumulates. Kills not only target animals but those further up the food chain.
Ethylene glycol (active ingredient of antifreeze)	Liquid. Low corrosivity and ignitability. Toxic when ingested.	Affects kidneys and liver. Kills fish. Animals attracted to its sweet taste.
Hexavalent chromium	Purple crystals. Exists in solution as acid or salt. Reactive. Toxic.	Causes lung damage. Chronic exposure leads to liver and nerve damage. Toxic to aquatic organisms.
Hydrazine	Colorless liquid. Reactive. Ignitable.	Eye irritant. Toxic if ingested, inhaled, or in contact with skin.

Hazardous Material	Characteristic	Health or Environmental Effects
Mercury	Liquid metal. Water insoluble. Conducts electricity. Highly toxic if inhaled, ingested, or absorbed through skin.	Causes brain and nerve damage, mental retardation. (The term “mad as a hatter” comes from the bizarre behavior of hatters who used mercury in making felt and suffered brain damage as a result.) Causes birth defects and deformities.
Nitrobenzene	Greenish yellow crystals or oily yellow liquid. Slightly water soluble. Highly toxic if ingested, inhaled, or absorbed through skin.	High concentrations are poisonous. The effects of long-term, low-level exposure are not known. Effects can take several hours to show. Causes weakness, headaches, and interferes with production of red and white blood cells.
PCBs	Both colored and colorless liquids and solids. Toxic, prolonged exposure can cause death.	Causes liver and skin irritations (chloracne). Causes cancer.
Pentachlorophenol	Dark colored solid with a characteristic odor. Insoluble in water. Highly toxic if ingested or inhaled.	Skin irritant. Prolonged exposure causes dermatitis (skin irritations). Production process contaminates pentachlorophenol with dioxins.
Toluene	Colorless liquid. Insoluble in water. Ignitable. Reactive. Moderate toxicity.	Produces mild anemia. May produce liver or kidney damage or cause menstrual disorders.
1,1,1–Trichloroethane	Colorless liquid insoluble in water. Toxic and highly reactive with certain substances.	Suspected carcinogen. Effects of long-term, low-level exposure unknown. Can cause heart damage and affect mental functioning.

“What Waste Went Where”

Game Directions

1. Make sure that you have:
    - A map showing some of the hazardous waste sites in Washington State. The numbered locations are the ones that are part of this activity.
    - A number line.
    - Clue cards for your number line.
    - Worksheet for recording your answers. (Optional)

2. Place the map(s) and the number line face up in front of the group.

3. Shuffle the cards and then deal the cards face down so that each person in the group has about the same number of cards.

4. Sort your cards according to the categories WHAT, CONNECTION, WHERE, and FOLLOW-UP. There are less FOLLOW-UP cards than the others. Lay the sorted piles in front of you face up.

5. The person with the WHERE card “A” begins by reading this card out loud. With the help of the rest of the group, decide which numbered location is being described. Feel free to consult a Washington State road map or almanac, if necessary. Place the WHERE card face up under that number on the number line.

6 The person to the left of the person who started chooses a WHERE card from his own hand and, with other group members, tries to place it on the number line. If the location cannot be determined, return the card to the bottom of its pile. If the person to the left has no WHERE card, the next person to the left continues.

7. When all the WHERE cards have been placed under the number line, proceed to place the CONNECTION cards on their correct numbered locations. Keep in mind that each card is linked to a card in the other categories through key words or phrases. For example, one card might refer to ground water contamination and another card might mention drinking water pollution, or one card might describe the geography as a wet region and another card might refer to a city in a part of the state with a heavy rainfall. After the CONNECTION cards have been placed face up on the number line, continue with the WHAT and, if desired, the FOLLOW-UP cards.

8. Record your answers on the “What Waste Went Where” worksheet, especially if you are taking more than one day to complete this activity.

Answer Key to "What Waste Went Where"

LOCATION	WHERE	CONNECTION	WHAT	FOLLOW-UP
Number	Nearest City	Key Words That Connect Waste With Location	Hazardous Waste	How Or Why The Waste Got To This Location
1	Purdy (Port Orchard)	Transformers, PCBs, rain	PCBs	Utilities stored electrical transformers which contained PCBs
	G	D	J	
2	Kent	Yellow liquid, many different wastes	Nibrobenzene	Western Processing Plant stored and treated wastes for other companies
	M	H	A	B
3	Between Seattle and Tacoma (Midway)	Landfill, methane, leukemia	Benzene	Midway landfill is in a gravel pit. Methane gas migrated through porous soils
	K	K	B	A
4	Tacoma	Copper, ore, arsenic, Puget Sound	Arsenic and Cadmium	ASARCO Copper Smelter had metal-contaminated slag and released arsenic and cadmium from its smoke stacks before it was shut down
	L	F	E	D
5	Tacoma	Junkyard, drums, skin disease	Pentachoro-phenol	Buffalo Don Murphy stored waste from a chemical company in his junkyard
	N	E	G	

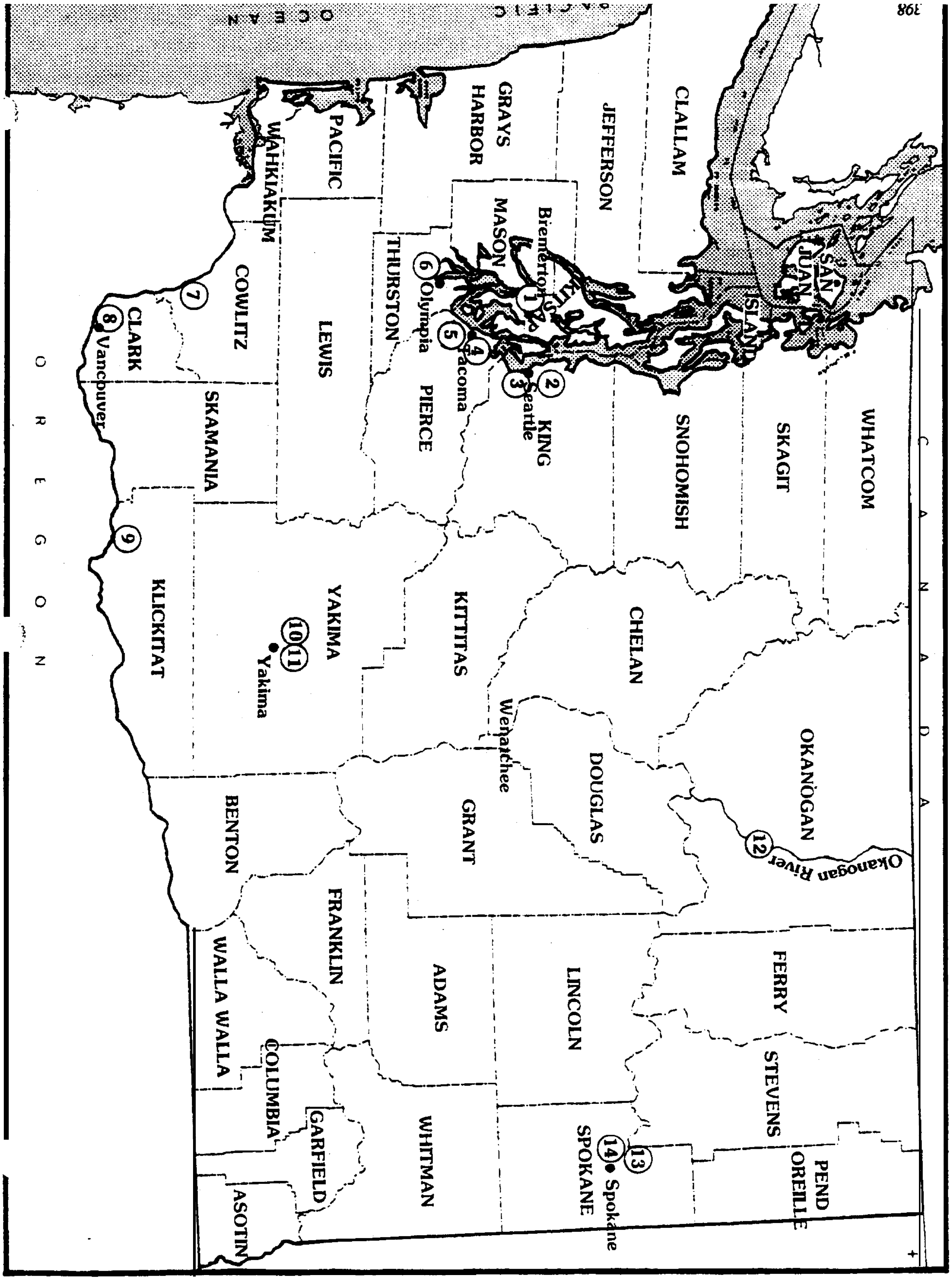
NOTE: Capital letters refer to the "What Waste Went Where" cards.

Answer Key to "What Waste Went Where"

LOCATION	WHERE	CONNECTION	WHAT	FOLLOW-UP
Number	Nearest City	Key Words That Connect Waste With Location	Hazardous Waste	How Or Why The Waste Got To This Location
6	Olympia	Wells, ground water, mutations, strawberry farm	EDB	The pesticide EDB was applied in heavy doses and leached into ground water
	A	A	D	
7	Longview	Metal wastes, Columbia River	Mercury	Mercury waste from a chemical plant contaminated ground water
	B	C	F	
8	Vancouver	Chromium, Vancouver, Columbia River	Hexavalent Chromium	Waste from chromeplating was put in a dry well and entered the ground water
	E	N	C	
9	White Salmon	Hazardous Waste (antifreeze is not a serious hazardous waste)	Ethylene Glycol (antifreeze)	A train derailed and spilled antifreeze
	J	L	N	

Answer Key to "What Waste Went Where"

LOCATION	WHERE	CONNECTION	WHAT	FOLLOW-UP
Number	Nearest City	Key Words That Connect Waste With Location	Hazardous Waste	How Or Why The Waste Got To This Location
10	Yakima	Jet airplane fuel, ignitable	Hydrazine	An Air Force jet, forced to make an emergency landing, spilled fuel
	D	I	L	E
11	Yakima	Pesticides and food chain	DDT	Crop King Chemical Company manufactured pesticides, some of which reached ground water
	H	M	M	
12	Okanogan	Riverbank, pesticides dumped	Endrin (Pesticide)	A man cleaned pesticides out of his shed and dumped them on the bank of a river
	F	B	H	C
13	Spokane	Landfill, hazardous waste, nerve damage	1,1,1-Tri-chloroethane	Key Tronic Corporation dumped chemical degreaser into Colbert Landfill
	C	G	K	F
14	Spokane	Aquifer petroleum by-products	Toluene	Petroleum by products have been stored or spilled and are reaching ground water
	I	J	I	



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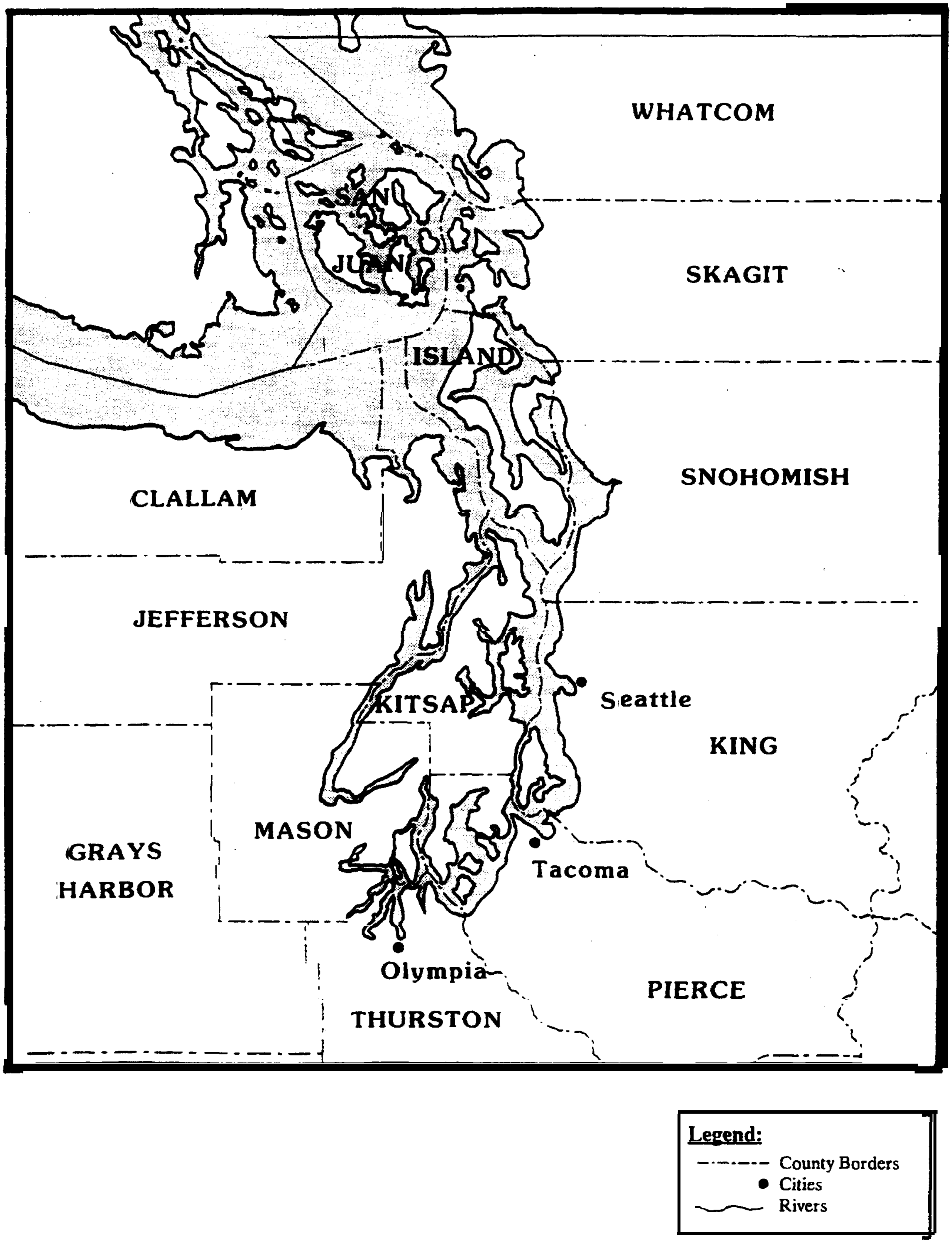
PUGET SOUND Enlargement



DDT is a colorless crystal or white powder that is water insoluble and very toxic to fish. When DDT gets into a food chain, the top cqarnivores, such as bald eagles, may accumulate dangerous concentrations. Birds with high levels of DDT lay thin-shelled eggs that get smashed instead of hatching. What M	Ethylene glycol is slightly corrosive, moderately ignitable and toxic if ingested. Most antifreeze is made of ethylene glycol. What N	For Sale signs were everywhere. The City of Seattle has spent millions of dollars closing the nearby landfill and venting the methane. As a result of this enormously expensive remediation, Seattle now has among the highest garbage disposal rates in the country. Follow-up A	Western Processing was a chemical processing plant that operated from 1960 to 1983 in Kent. Environmental cleanup of this plant is costing millions of dollars. Follow-up B
An emergency cleanup of 24 identifiable pesticides took place along the bank of the Okanogan River. Six people worked 16 hours a day for three days to remove a total of 25 55-gallon drums of hazardous waste pesticides. The man who dumped the pesticides was located and indicated for endangering public health. A jury in Spokane cleared him of criminal charges because a majority of jurors thought that the man's actions did not make him a criminal. Follow-up C	A smelter in Tacoma has been closed. The dismantlement of this smelter is regarded as a Department of Ecology hazardous waste site and will cost millions of dollars to clean up. Heavy metal-contaminated smelter slag was used in building foundations all over Tacoma and is a serious health risk. Follow-up D	Airport personnel wanted to clean up fuel that spilled but a Department of Ecology official knew that the fuel was toxic and dangerous. If it touched anyone's skin or eyes. Experts from McChord Airforce Base, wearing protective suits and breathing apparatus, were called in and removed the fuel Follow-up E	The City of Spokane faces a $62.8 million lawsuit because it gave approval for a company to dump chemical degreaser into one of the city's landfills. Follow-up F

Over 20 years, decompsoing garbage produce large volumes of methane gas. This gas migrated over a quarter of a mile though porous, gravelly soils. Some entered basements of homes and businesses. Families had to leave their homes. Other hazardous liquids were produced from the garbage and have contaminated ground water. One of these is a liquid that can burn explosively and may cause leukemia. Connection K	Many train derailments have spilled hazardous materials ranging from sodium hydroxide to oil. One example is a train that derailed and spilled antifreeze along a riverbank. Connection L	A pesticide that was used extensively for killing insects is now banned in the United States. It was getting into food chains and interferring with the reproduction of large birds including bald eagles, ospreys, and brown pelicans. This pesticide used to be manufactured in Washington State and has been released into the environment in these locations. Connection M	Industrial waste was discharged into a dry well and has entered groundwater. The water soluble acidic hazardous waste may threaten the City of Vancouver's well field. If the waste gets into the ground water, it could cause serious health problems. Connection N
Nitrobenzene is an oily, yellow liquid that is highly toxic if drunk, inhaled or absorbed through the skin. Effects, which show up several hours after exposure, are weakness, headaches and reduced blood cell production. What A	Benzene is a colorless liquid that is ignitable and highly toxic. It interferes with red and white blood cell production and, at certain levels, can cause bone marrow damage and leukemia. What A	Hexavalent chromium is reactive, toxic and corrosive to skin. It is water soluble. Chronic exposure can lead to liver, nerve and lung damage. It is toxic to aquatic organisms. Hexavalent chromium forms chromic acid (H_2CRO_4) when it dissolves in water. What C	EDB (Ethylene Dibromide) is a colorless liquid pesticide, the use of which is now illegal. Used primarily on strawberry fields, EDB is toxic if inhaled, ingested or absorbed through the skin. At certain accumulations, it causes cancer and mutations (carcinogenic and teratogenic). What D

Arsenic is a brittle, grey, highly toxic solid. Its health effects, given intense or long-term exposure, may include cancer and birth defects. What E	Mercury is a liquid metal not soluble in water. It is highly toxic, causing, at certain concentrations, brain and nerve damage, mental retardation and birth defects. In the past, mercury was used in the making of felt. Hat makers, who produced the felt, were exposed to very high levels of mercury. Consequently, they often suffered mercury poisoning and brain damage and their resulting bizarre behavior lead to the expression ‘Mad as a Hatter.’ ’ What F	Pentachlorophenol is toxic and slightly water soluble. Pentachlorophenolis usually contaminated with small amounts of dioxin. Prolonged exposure can cause a skin inflammation called dermatitis. What G	Endrin is an acutely toxic white powder. One quarter ounce can kill an adult human. Exposure can produce convulsions, nausea, temporary deafness, mental confusion and unconsciousness. It has been used to kill mice that gnaw on the bark and roots of fruit trees during the winter. What H
Toluene is a colorless liquid that is ignitable and moderately toxic. If ingested, inhaled or absorbed through the skin, it produces mild anemia and may cause liver or kidney damage. Toluene is produced from petroleum. What I	PCBs occur in a range of colors and in liquid or solid forms. PCBs can cause cancer and kidney damage. What J	1,1,1-Trichloroethane is a colorless solvent that may cause nerve, liver or heart damage in humans. The health effects of long-term, low-level exposure is not known. What K	Hydrazine is a colorless liquid that is ignitable and very reactive. Hydrazine is toxic if breathed, eaten or absorbed through skin and it irritates eyes. What L

Liquid metal wastes from a plant operated by Weyerhaeuser, a wood products company, have contaminated soil and groundwater as well as sediments and fish in the Columbia River. Connection C	Old electrical transformers often contain PCBs. If the transformers are opened, PCBs can contaminate soil and water. When PCBs are burned, Connection C	The owner of a junkyard sold hazardous wastes as wood preservatives and insecticides. The chemical he sold as a preservative can cause a skin disease. This chemical and others leaked out of drums that he had stored in his junkyard. The chemicals have contaminated the soil. Connection E	Honeybees around southern Puget Sound were tested and found to contain high levels of the metals arsenic and cadmium. The bees pick up the metals as they forage. The honey they produced was not affected but survival of bees in some locations was not affected but survival of bees in some locations was reduced. Gardeners in these areas were advised not to eat their homegrown vegetables because of an increased risk of cancer or birth defects. The metals, found as impurities in copper ore, were carried for miles by hot gases from a smokestack. Connection F
Residents near a landfill must drink bottled water because their wells contain a hazardous waste that may cause nerve damage. The waste came from tons of chemical solvent that was dumped in the landfill between 1975 and 1980 by Key Tronic Corporation, a manufacturer of parts for computers. Connection G	A Spokane paint company was among 300 companies that sent their wastes to a chemical processing plant. The chemical processing plant handled a large variety of hazardous chemicals. Many of these hazardous wastes were unsafely handled and extensive environmental contamination has occurred. Connection H	A very reactive fuel used in a jet's backup generator system leaked onto the ground. Connection I	A nursery watered its trees with contaminated well water. The chain-link fence and concrete around the nursery turned an oily brown from the water and $10,000 worth of uninsured trees were killed. The water contained petroleum by-products. Connection J

Hazardous petroleum by-products are leaching into the aquifer in an area a mile north of a city in Eastern Washington. The area on North Market Street has a long history of petroleum industries, tank farms, oil refineries and oil sales outlets dating back to 1938. Sixteen potentially responsible parties have been identified. Where I	A chemical that is not a serious hazardous waste was quickly removed from the environment before it could get into the Columbia River. The location was away from any large cities. Where J	Located between Seattle and Tacoma, a landfill was opened in the 1960s to receive demolition debris from road construction. The landfill, operated by the City of Seattle, was sited in a gravel pit surrounded by wetlands. The people living near the site were strongly opposed to the location, but were promised it would handle harmless wastes. However, all kinds of wastes were dumped there. Some wastes decomposed and released hazardous gases and liquids. Where K	The ASARCO Copper Smelter is located on peninsula in a large city on Puget Sound. Where L
A very toxic yellow liquid is just one of 90 different hazardous wastes that have contaminated the soil and are entering an aquifer. This aquifer was to be a future source of water for a city of about 28,000 people in densely populated King County. Imagine! How could so many different hazardous wastes end up in the same place? Where M	During the 1970s, Buffalo Don Murphy stored waste from Reichholz Chemical Company on his 5-acre rural property south of Tacoma. The property is located on a filled wetland near a creek used for irrigation and watering livestock. Over 1000 drums of different wastes generated from the manufacture of industrial disinfectants were stored at Buffalo Don's junkyard. Where N	For 3 years, the pesticide terrocide, which is 54% EDB, was applied to a 12-acre Western Washington strawberrry farm at a rate of 18-20 gallons per acre. EDB polluted nearby groundwater. Connection A	Among discarded pesticides were 14 gallons of parathion, 13 pounds of lindane and 2 gallons of endrin. Because of the risks they pose to public health and environment, all of these pesticides are illegal to use in Washington State. Connection B

Residents of 22 homes have to drink bottled water until a new source of drinking water is provided. Although their well water looks and smells fine, a hazardous waste that it contains could cause cancer or mutations. The hazardous substance reached the water table underneath a farm near Olympia. Where A	From 1956 to 1975 a Chloralkili Plant in Longview produced chlorine gas and caustic soda for an adjacent pulp mill. Metal wastes from the process present serious potential health problems. Where B	The levels of a hazardous waste in some wells near the Colbert Landfill, 8 miles north of Spokane, exceeds 9600 parts per billion. A level of 200 parts per billion is considered safe. A Spokane company dumped a hazardous waste in the Colbert Landfill. The plume of contamination is spreading south and west in the aquifer under the landfill. Where C	A jet fighter was forced to make an emergency landing at Yakima Airport on the city's westside. Where D
A chromeplating company named Frontier Hard Chrome operated from 1970 to 1983 half a mile north of the Columbia River. Industrial waste from the company was discharged in a dry well and has entered groundwater. Where E	An individual, who was moving, dumped his stored pesticides on the bank of a river in central Washington. Where F	Seattle City Light and other utilities stored their old elecgrical transformers in a junkyard in Purdy south of Bremerton. When it rained, the hazardous waste from the transformers was carried to a salwater lagoon. Small animals in the lagoon have the hazardous waste in their systems. Where G	Crop King Chemical Company manufactured pesticides in a major orchard fruit-producing area in central Washington. Many of the leftover pesticides at the company's location have contaminated the soil and maybe the groundwater. Where H

NUMBER LINE FOR ACTIVITY "WHAT WASTE WENT WHERE

First, cut along dashed lines. Then apply glue to gray-shaded areas to make one continuous strip (1-14).

1 2 3

4 5 6

7 8 9

10 11 12

13 14

What Waste Went Where Worksheet?

Location Number	WHERE Nearest City	CONNECTION Key Words That Connect Waste with Location	WHAT Hazardous Waste	FOLLOW-UP How Or Why The Waste Got To This Location
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				

Evaluation Of Group Participation In Cooperative Learning Activity

Circle one number for each statement.

1 = poor

5 = super

1. Everyone in the group participated.

   1 2 3 4 5

2. People in the group explained things to other people in the group.

   1 2 3 4 5

3. People in the group did not "put down" other people in the group.

   1 2 3 4 5

4. People in the group listened to each other.

   1 2 3 4 5

Total group participation score = ____________________

Investigating Environmental Professions

Subjects: Career Education, Chemistry, Biology, Earth Sciences

Grades: 9-12

Teaching Time: 30 Minutes Initially, Followed By Research and Reporting

Focus: Environmental Protection, Waste management, Environmental Careers

Rationale

Career opportunities in environmental management and protection, particularly in solid and hazardous waste management, are expanding.

Learning Objective

Students will:

- Discover career opportunities in environmental management and protection.
- Identify trade magazines and professional publications as sources of information about careers.
- Develop skills in using libraries.

Teacher Background

As our awareness and knowledge about environmental degradation resulting from past toxic waste disposal practices have increased, both federal and state legislatures have passed so-called Superfund bills mandating the cleanup of hazardous dumpsites. Cleanup costs for the more than 600,000 toxic sites scattered across our country have been estimated at more than $300 billion over the next 50 years.[1]

Washington State emphasizes the waste management processes of reduction and prevention. Thus, solid and hazardous waste management today is much needed service, offering a range of employment opportunities. Students can learn about these opportunities by researching trade and professional publications dealing with waste management and environmental protection.

Materials

Two handouts:

- List of professions concerned with solid and hazardous wastes and environmental management and protection
- List of trade journals and professional publications

Pre & Post Test Questions

1. Can you name three jobs/careers in environmental management and protection?

2. Can you name three publications offering information about careers in environmental management and protection?

3. Can you list three school classes that environmental protection professionals need?

Learning Procedure

1 Write the number $300,000,000,000 on the board. Tell students this is the estimated cost of cleaning up hazardous dumpsites over the next 50 years. **Say:** "Jobs related to cleanup activities are expected to increase sevenfold in the next ten years." Discuss the Washington State waste management priorities of reduction, recycling, treatment, incineration, and landfills. **Say:** "Disposal of solid and hazardous waste is now the least preferred waste management." (For more background on the management priorities, see the activity "Hazardous

1 Michael Stanton, "Hazardous Wastes: Who's Cleaning Up?" Occupational Outlook Quarterly, Winter 1987, Vol. 31, No. 4, p. 3.

Waste in My Home Town?" p. 247.) Tell students that as industries work to implement these priorities many new jobs are expected to open up.

2 Have the class brainstorm a list of environmental management and protection occupations: for example, toxicologist, hydrologist, environmental attorney, natural resource manager for a government agency, environmental chemist, and spill engineer.

3 Distribute the handout listing the environmental management and protection occupations. Combine this list with the one just generated by the class.

Have each student choose an occupation of interest.

4 Provide students with the publications listed on other handouts or give students the assignment of finding as many of these publications as possible in the nearest large library. (Teacher: You may want to alert your School Librarian prior to doing this activity.) If your school or local library does not have or cannot obtain any of these publications, other sources are:

- State Departments (Ecology, Natural Resources, Fish and Wildlife, etc.)
- Municipal (City or County) Engineering Department
- Private or public waste haulers or recyclers
- Private waste management companies.

Look in the yellow pages of your local telephone book.

5 Have students research a specific environmental career using the listed publications and other appropriate sources, such as the classified ads in the Sunday newspapers of any large city.

Have students prepare a report on their research that includes information on the following:

1. What do people in this profession do? Why is their work important?
2. How do people begin careers in this field?
3. What are the educational requirements for entering this field?
4. In what kinds of companies and organizations are professionals in this field employed?
5. How much money do professionals in these occupations make?
6. How do these occupations work to protect the environment?
7. What is the future outlook for this occupation?

Extended Learning

1 Have students identify companies and organizations in your area where environmental professionals are employed. Research the descriptions of the environmental jobs these companies offer.

2 Invite an environmental professional to speak to your class. Call the Department of Ecology Regional Office in your area to arrange for a speaker.

3 Follow a waste from its creation to its ultimate disposal and describe the jobs associated with this process. For example, chemists create a hazardous substance, chemical engineers and technicians design the processes which generate it. A toxicologist will test it to determine its potential for long-term harm to humans and animals. Transporting it will entail certain jobs. A sanitary engineer or a biochemist might be concerned with its disposal.

Bibliography

Stanton, Michael. "Hazardous Wastes: Who's Cleaning Up?" Occupational Outlook Quarterly. Winter 1987, Vol. 31, No. 4, pp. 3-14.

"Two States to Hire 500+ Hazardous Waste Officials." Waste Age. June 1988, p. 28.

Watson, Tom. "The Job Explosion." Resource Recycling. May-June 1988, p. 24.

"Which Niche?" Project Wild. Boulder, CO: Western Regional Environmental Education Council, 1985.

Environmental Management, Protection, and Information Publications

Chemical Week

Waste Management

EPA Journal

Science

Environmental Progress

Chemical and Engineering News

Resources and Conservation

Environmental Management

Hazardous Wastes

Public Affairs

Waste Age

Resources Recycling

Scientific American

Nature

Amicus Journal

Earthcare Northwest

National Wildlife

Northwest Energy News

(List others you found here.)

Environmental Management and Protection Professions

Attorney - environmental issues specialization

Biologist - hazardous waste inspection

Chemical Engineer - toxic waste management

Chemist - hazardous waste inspection

Civil Engineer - hazardous waste inspection

City/County Planner - waste reduction and recycling management

City/County Recycling Education Coordinator - recycling education

Consultant - solid and hazardous waste management

Environmental Educator - waste management and recycling

Environmental Engineer - solid waste management

Environmentalist - spill response

Environmental Planner - waste reduction, recycling, environmental assessment, shorelines management

Environmental Technician - permit data processing, field investigation

Fisheries Manager - spill response

Hydrologist - solid waste reduction

Legal Assistant - solid waste management practices

Recycler - private business and industry

Research Assistant - recycling programs, waste management

Resource Geographer - hazardous waste inspection

Sanitary Engineer - solid waste management

Technical Writer - environmental impact assessment

Wastewater Treatment Plant Operator/Technician - solid waste management

How Very Little It Must Be

Subjects: Math, Chemistry
Grade: 11-12
Teaching Time: One Class Period
Focus: Drinking Water and Ground Water Contamination, Chemical Concentrations, Drinking Water Standards, Parts Per Million (ppm), Parts Per Billion (ppb)

Rationale

While the measurements parts per million (ppm) and parts per billion (ppb) are widely used in studying environmental contamination, the relative size of these measurements can be difficult to visualize.

Learning Objective

Students will:

- Working from data, gain experience calculating ppm and ppb.
- Understand how proportionally small a ppm and a ppb are.
- Understand that a very little of some contaminants goes a very long way.

Materials

Student Handout:

- How Very Little It Must Be - Problem Worksheet

Pre & Post Test Questions

1. What is a part per million? How is it abbreviated?

2. Name two units that describe volume.

Learning Procedure

1 Some environmental contaminants are so hazardous that we need to measure them in terms of ppm or even ppb. What do these terms mean?
(A ppm is a proportion in which one unit of a substance is found in a million units of surrounding material such as air, soil, or water. One ppm is proportional to one second in twelve and a half days (300 hours). A ppb is a proportion in which one unit per billion is measured. One part per billion is proportional to one second in 32 years.)

2 Provide students with the following information:

- Clear Lake is a 100-acre lake, with an average depth of 25 feet.
- Swimming Pond covers one acre, with an average depth of 10 feet.
- Deep Rock Aquifer extends over 50 square miles, with an average depth of six feet.

Drinking Water Standards
Listed on the next page are some of the chemicals or compounds that can contaminate our drinking water, along with the federal standards for the maximum acceptable levels allowed in both ppm and ppb.[1]

Benzene - 0.005 ppm = 5 ppb

Arsenic - 0.05 ppm = 50 ppb

2,4-D - 0.07 ppm = 70 ppb

1,1,1-Trichloroethane (TCE) - 0.2 ppm = 200 ppb

Fluoride - 4 ppm = 4000 ppb

1 Code of Federal Regulations, Title 40, Part 141.

Conversion Table

1 cubic foot	=	7.48 gallons
1 gallon	=	.1337 cubic feet
1 acre	=	43,560 square feet
1 square mile	=	27,878,400 square feet

3 Using the information above, have students solve the following problems (Answers are given in parenthesis):

- The EPA Criminal Investigations unit is attempting to track down the parties responsible for dumping five gallons of the herbicide 2,4-D in Swimming Pond. If the chemical becomes evenly dispersed, what would be its concentration in ppm? (1.534) In ppb? (1,534) Should the EPA restrict access to Swimming Pond? Why?
- The State Highway Patrol has notified the Department of Ecology that six gallons of benzene were accidentally spilled into Clear Lake. If it is evenly dispersed, what would its concentration be in ppm? (0.00738). In ppb? (7.38) **Ask:** "Should the residents who depend on the lake for drinking water be notified? Why?"
- An old rusted, unmarked 55-gallon drum was discovered on the property of a resort near Clear Lake. Although the manager suspects it may contain a hazardous chemical, he asks his assistant to get rid of it any way he can. Calculate the concentration of contaminant in ground water if a 55-gallon drum of the chemical were illegally disposed of in an old well and dispersed evenly throughout Deep Rock Aquifer. (0.000879 ppm or 0.879 ppb) What if the same quantity of the chemical were illegally disposed of in Clear Lake? (.0675 ppm or 67.5 ppb). In Swimming Pond? (16.9 ppm or 16,900 ppb)
- Suppose a 5,000-gallon tank truck loaded with the chemical arsenic ran off the highway and all the chemical spilled into Clear Lake. What would be the concentration of chemical in the lake? (6.138 ppm or 6,138 ppb) Does this violate federal standards?

4 Have students compare their calculations to the federal drinking water standards for all the chemicals listed above.

Ask: "Which 'incident' was the worst in terms of contamination?" " Which scenario(s) didn't violate any of the standards?" "How many of the cases violated the benzene standards? The TCE standard?"

5 Discuss possible ways of dealing with each of these problems. (Calling the Department of Ecology's Emergency Spill Response Section; determining civil or criminal penalties for violators; educating the public as to potential threats to human health and to fish and wildlife; restricting access to contaminated waters; developing plans to prevent similar contaminations in the future, etc.)

Extended Learning

1 To illustrate the large volumes of water that can be contaminated by a small amount of pollutant, do the red dye demonstration in "A Little Can Go A Long Way," p. 225.

2 Have students research the chemicals used above as to their industrial or household uses and potential health hazards.

3 If you have access to a computer, have students use a spreadsheet or write a short computer program that would calculate the answers to the problems above.

Bibliography

American Chemical Society. ChemCom: Chemicals in the Community. Dubuque, IA: Kendall-Hunt Publishing Co., 1988.

Gordon, Wendy. A Citizens Handbook on Groundwater Protection. New York, N.Y.: Natural Resources Defense Council, 1984.

National Archives and Records Administration. Code of Federal Regulations, Washington, D.C.: Office of the Federal Register, 1995, Part 141.

Ontario Waste Management Corporation. Hazardous Waste Education Resource Kit. Toronto, 1985.

Ontario Waste Management Corporation. "Units of Measure Chart." Hazardous Waste in Ontario. Toronto, 1986, p. 19.

"How Very Little It Must Be"
Problem Worksheet

Student Handout

1. The EPA Criminal Investigations unit is attempting to track down the parties responsible for dumping five gallons of the herbicide 2, 4-D in Swimming Pond. If the chemical becomes evenly dispersed, what would be its concentration in ppm? In ppb? Should the EPA restrict access to Swimming Pond? Why?

2. The State Highway Patrol has notified the Department of Ecology that six gallons of benzene were accidentally spilled into Clear Lake. If it is evenly dispersed, what would its concentration be in ppm? In ppb? Should the residents who depend on the lake for drinking water be notified? Why?

3. An old rusted, unmarked 55-gallon drum was discovered on the property of a resort near Clear Lake. Although the manager suspects it may contain a hazardous chemical, he asks his assistant to get rid of it any way he can. Calculate the concentration of contaminant in the ground water if a 55-gallon drum of the chemical were illegally disposed of in an old well and dispersed evenly throughout Deep Rock Aquifer.

   What if the same quantity of the chemical were illegally disposed of in Clear Lake? In Swimming Pond?

4. Suppose a 5,000-gallon truck loaded with the chemical arsenic ran off the highway and all the chemical spilled into Clear Lake. What would be the concentration of chemical in the lake? Does this violate federal standards?

Drinking Water Standards

Listed below are some of the chemicals or compounds that can contaminate our drinking water, along with the federal standards for the maximum acceptable levels allowed in both ppm and ppb.

Benzene - 0.005 ppm = 5 ppb

Arsenic - 0.05 ppm = 50 ppb

2,4-D - 0.07 ppm = 70 ppb

1,1,1, - Trichloroethane (TCE) - 0.2 ppm = 200 ppb

Fluoride - 4 ppm = 4000 ppb

Conversion Table

1 cubic foot	=	7.48 gallons
1 gallon	=	.1337 cubic feet
1 acre	=	43,560 square feet
1 square mile	=	27,878,400 square feet

Water Body Dimensions

Clear Lake - 100-acre lake, 25 feet deep
Swimming Pond - 1 acre, 10 feet deep
Deep Rock Aquifer - 50 square miles, 6 feet deep

What's Hazardous At Home?

or Meet Mr. Yuk

Subjects: Science, Social Studies, Health
Grades: 2-6
Teaching Time: One Class Period
Focus: Household Hazardous Substance Storage and Disposal, Health and Safety, Map Skills

Rationale

Some household products may be harmful if handled improperly.

Learning Objective

Students will:

- Learn about some common household products that may be hazardous if not used and disposed of carefully.
- Identify places in their homes where these potentially hazardous materials may be found.
- Learn about Mr. Yuk and how he can prevent them or their younger brothers and sisters from swallowing something harmful.

Teacher Background

People have become concerned about the health effects of hazardous materials stored, used, or disposed of in their houses and communities. Consumers generally have little information about the long-term effects of chemicals contained in common home and garden products. Many products and chemicals that were once considered "harmless" have now been linked to health problems, due to exposures over long periods. These health effects can be as mild as fatigue and headaches or as serious as cancer. Often products combine with other substances in the environment, creating a reaction which is more hazardous than the individual chemical effects.

A substance that is classified as hazardous is required to bear labeling with warning statements and safety information if it is packaged for, or intended for, use in or around the home. The U.S. Consumer Product Safety Commission has established specific labeling requirements; however, labels required for various hazardous substances differ. This, in addition to the considerable amount of label information required, can make it very difficult to determine how to use, store, and dispose of a product safely.

Materials

- Packages and labels from potentially hazardous household products. (See accompanying list entitled "What's In Your House?") Make sure any packages are well sealed, not leaking, and are stored in a secure cupboard when not in use.
- Mr. Yuk stickers (See Resources)

Pre & Post Test Questions

1. What are the four categories of hazardous substances?

2. What can you do if you have pesticides in your home that you want to dispose of?

3. Where should you look first to find out if a household product is potentially harmful?

4. When you see Mr. Yuk's face on a bottle or can, what does this mean?

5. What should you do if you find someone eating or drinking something harmful or poisonous?

6. (Grades 5-6) What is an antidote?

Learning Procedure

1 Explain to students that there are products we use at home that may be hazardous if not handled and disposed of carefully. Explain that

hazardous means dangerous and that hazardous substances are likely to cause harm to the environment or to humans because they are either toxic (poisonous), flammable (quickly burnable), reactive (explosive), or corrosive (substances that rapidly eat into or dissolve away what they touch).
Ask: "Where at home might we look to find some of these products that require careful handling?" Let's draw a map — called a floor plan — of our houses and find out.

2 Have each students draw a floor plan of his or her house and garage.

3 Project and hand out copies of the following overhead entitled "What's In Your House?" (NOTE: This overhead and other hazardous waste activities for schools are from SLEUTH: Educational Activities on the Disposal of Household Hazardous Waste, available from Metro, Water Quality Divison, Municipality of Metropolitan Seattle.) Go over the list with students, identifying and describing the less familiar products such as antifreeze, paint strippers, varnishes, and drain cleaners. Students may be more familiar with brand names of particular products.

4 Using the previously drawn floor plans, have students mark where in their houses the listed products might be found.

5 Show students packages and labels from a number of products on the list.
Ask: "Where on a label or package can you look to find out if the product might be harmful?" "What will the package or label say?" (Package or label may say "Danger/Poison," "Warning," "Caution," or "Keep out of the reach of children," and then will list the possible harmful effects of the product.)

Ask: "How and where should products such as these be stored?" Draw an arrow on your floor plan showing where hazardous waste materials should be moved to a new location for safety.

Ask: "How can you get rid of potentially harmful products you no longer need without damaging the environment or other people?" (For answers, refer to the accompanying "Product Disposal Recommendations," pp. 290-291.)

Ask: "How many of you know about Mr. Yuk?" "When you see Mr. Yuk's scowling face, what does that mean?" (Mr. Yuk is the warning symbol of Children's Orthopedic Hospital's Poison Control Center. Children should know that anything with a Mr. Yuk symbol on it is poisonous.) Draw a big Mr. Yuk symbol on the board or show Mr. Yuk stickers.

Ask: "How many of you have younger brothers and sisters?" "How could Mr. Yuk help if you found your little brother or sister eating or drinking something from the list we've been talking about?" (By calling the Poison Control Center listed in your phone book, you can find out exactly what is in any of the products so you can tell the doctor. The doctor can then prescribe the correct antidote.)

Ask: "How and where should the products on the list be stored so small children can't get them?"

6 Have students take home the marked floor plans, the list of potentially harmful household products, and the information about Mr. Yuk to share with their families. Ask students to put a Mr. Yuk sticker on the phone at home.

Product Disposal Recommendations

1. General Precautions:
   - Keep all chemical wastes out of the reach of children.

- Read the label before handling any household chemicals.
- Household wastes should not be mixed together.

2. Pesticides and Wood Preservatives: Pesticides should not be disposed of in the trash can or down the drain. Call your local health department district office for recommendations, or the Washington State Department of Ecology Recycling Hotline 1-800-RECYCLE.

3. Automobile Oil: Recycle at local gas station or call the Department of Ecology Recycling Hotline, 1-800-RECYCLE, for the location of the nearest oil recycler.

4. Antifreeze: Do not pour antifreeze into storm drains or sewers, as these may be directly connected to streams.

5. Paint Solvents: When possible, reuse paint solvents by letting the paint sludge settle and reusing the solvent. If solvent is not reusable, call the Department of Ecology Recycling Hotline, 1-800-RECYCLE.

6. Paint: Some charities accept excess paint. Small amounts of latex (water base) paint can be left open to dry in a safe place. The paint can and its dry contents can be disposed of in the trash.

7. Contact Department of Ecology Recycling Hotline, 1-800-RECYCLE, for information regarding all the above products.

Extended Learning

1 Do the activity "Hazardous Waste Hot Potato" on pp. 293.

Acknowledgment

Special thanks to Julie Sellick and John Conroy, Washington State Department of Ecology, for help with this activity.

Resources -

Mr. Yuk stickers are available at your local Poison Control Center. Your local Poison Control Center is listed inside the front cover of your telephone directory.

Washington Poison Center, 155 NE 100th, Suite 400, Seattle WA 98125

King County Solid Waste Division curriculum, "Hazards on the Homefront," 4th-12th grades, January 1995.

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Dyckman, Claire, et al. Sleuth: Educational Activities on the Disposal of Household Hazardous Waste. Seattle: Toxicant Program, Report No. 10, Water Quality Division, Municipality of Metropolitan Seattle (Metro), August 1982.

Schwartz, Anne. "Poisons In Your Home: A Disposal Dilemma." Audubon. May 1987, pp. 12-16.

Seymour, John and Herbert Girardet. Blueprint for a Green Planet. Englewood-Cliffs, N.J., Prentice-Hall, 1987.

Toteff, Sally and Cheri Zehner. Toward Hazardless Waste. Seattle: Seattle-King County Department of Public Health, 1985.

*For more updated bibliography, see "Hazards on the Homefront" under Resource curriculum listed above.

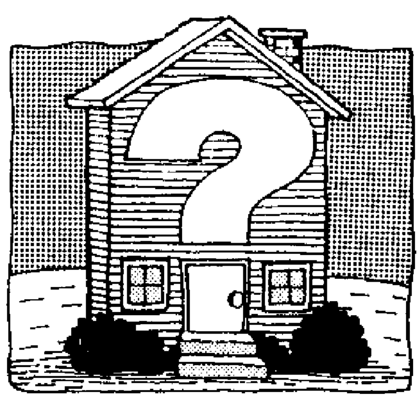
What's In Your House?

Potentially dangerous household wastes might be found in many places in the home.

All of us who use these products know how beneficial they are,
but might they also harm us? or others?

PET FLEA COLLARS
FLOOR POLISH
TOILET BOWL CLEANERS
ROACH SPRAY
SLUG BAIT
PAINT THINNER
LAUNDRY SOAP
MILDEW PROOFING
WEED KILLERS
LACQUER THINNER
OIL
WOOD PRESERVATIVES
ANTIFREEZE
RAT POISON
BRAKE FLUID

NO-PEST STRIPS
OIL BASED PAINT
BATTERIES
DRAIN OPENERS
STAINS/VARNISHES
ENAMEL PAINTS
FURNITURE POLISH
PAINT STRIPPERS
MOTHBALLS
ROOM DEODORIZERS
DISINFECTANT CLEANERS
OVEN CLEANERS
POWDERED BLEACHES
GLASS AND WINDOW CLEANERS
SCOURING POWDER



Hazardous Waste Hot Potato

Subjects: Science, Social Studies
Grades: 4-6
Teaching Time: One Class Period
Focus: Household Hazardous Wastes, Warning Words and Terms, Hazardous Characteristics

Rationale

Many useful products are hazardous. The typical household stores about 60 products with hazardous properties. These products, when handled or disposed of improperly, can endanger human health and harm our environment. We should consider how each of us generates hazardous waste and our responsibility for its safe management and disposal.

Learning Objective

Students will:

- Learn what characteristics make a substance hazardous.
- Learn the signal words for hazardous substances.
- Learn the definitions for terms related to household hazardous waste.
- Recognize their responsibility for safe disposal of household hazardous waste.

Teacher Background

Many common household products contain hazardous substances. Washington citizens dumped 11.8 million pounds of household hazardous wastes in landfills in 1994.[1] When these wastes are discarded in landfills, the unused portions can accumulate and, over time, contaminate water supplies or emit harmful vapors. Because of tightening hazardous waste disposal regulations, the closure of landfills, and the realization that these wastes present health and environmental problems, our public officials are faced with the problem of what to do with wastes from a variety of sources that in the past were assumed to be harmless. This activity introduces the many problems associated with hazardous wastes and looks at how we might manage hazardous wastes for the benefit of people and the environment.

Study the three overheads before teaching this lesson to familiarize yourself with the terms used to describe hazardous substance characteristics and toxicity ratings.

The four disposal options and products in the game are:

Recycle: (motor oil, auto battery, transmission fluid, etc.)

Trash for the landfill: (empty aerosol can, empty cleanser, etc.)

Hazardous waste collection: (rat poison, 1/2 full drain opener, etc.)

Flush down drain: (ammonia household cleaner, dish detergent, etc.)

You should be able to explain why a sewer line can take certain items that a septic tank can't. (The bacteria in the septic tank may be killed by these toxic household items or they may be released to the ground water by failing septic systems; whereas the sewage treatment plant chemically breaks down the toxics.) This is one reason not to dump things in the sink. Ask the class for others. Be prepared to explain to the class what a sanitary landfill is. Household hazardous waste collection programs

1 Washington State Department of Ecology, Solid Waste in Washington State, Fourth Annual Status Report, Including the 1994 Recycling Survey, February 1996, publ. # 96-500.

safely store, reuse, treat, or dispose of a community's household hazardous wastes.

Materials

Teacher:

- Four examples of hazardous household products as overheads or handouts. Choose one from each of those listed with disposal options shown above.

For Each Team:

- ten "hot potatoes" (these may be potatoes, eggs, wood blocks, or plastic containers, etc.)
- ten household product sticker labels for the ten household products
- ten toxic warning stickers
- five corrosive warning stickers
- five flammable warning stickers
- two irritant warning stickers (sample warning stickers), on p. 295

Four depositories marked with different disposal option for each team: boxes, bags, wastebaskets, or designated areas.

Overheads: "Hazardous Substance Warnings," "Hazardous Substance Toxicity Chart," and "Hazardous Substance Characteristics."

Pre & Post Test Questions

1. (Grades 3-4) What are six household "why hazardous" words? (Grades 5-6 - define the words).

2. What is toxicity? What are the three warning words for the degrees of toxicity?

3. What are four common disposal methods for household hazardous wastes?

Learning Procedure

1 Explain the dangers of household hazardous substances to the class. Tell them, for example, that 125 people a day in the U.S. are poisoned by pesticides.[2]

2 Show each of the four household hazardous product examples to the class. (Be certain that your containers are empty and safe for display in the classroom.)

3 Read aloud to the class any warnings on the labels.

4 Show the overhead "Hazardous Substance Toxicity Chart." Explain the three degrees of toxicity. Ask the class if they have items in their homes that meet the different degrees of toxicity.

5 Show the overhead "Hazardous Substance Characteristics." Carefully go over the definitions.

6 Ask the students to make a list of five hazardous items in their own homes. Ask how the items are stored. Discuss which hazardous signal words you would find on these items. Discuss what you would do with these items when you are finished with them. (Examples might be to throw in trash, dump on ground—almost never, flush down drain—rarely, store in basement or garage, share usable products with neighbors.)

7 Show the overhead "Hazardous Substance Warnings." Outline to the class each of the four disposal methods on the overhead (recycle, hazardous waste collection, trash for landfill, and flushing down a toilet). Explain here the difference between a septic tank and a sewer line system to a treatment plant.

8 Now, cover the overhead. Ask the class which of the four disposal methods they think is appropriate for each of the display items.

2 Tom Parker, In One Day, Detroit: Gale Research Col, 1984, p. 45.

9 Tell the class that they will be given an opportunity to work as teams to decide the proper disposal of ten household hazardous waste items. Then explain the rules of the game from the attached sheet. They may consult one another for advice, and each team may be given a copy of the "Hazardous Substance Warnings" overhead. Play the "Household Hazardous Waste Disposal Game."

Extended Learning

1 Have the class make an inventory of the household hazards in their home, and bring the list to class.

2 Call the Department of Ecology Recycling Hotline, 1-800-RECYCLE, and find out when they have hazardous waste collection days in your area.

3 If your city or county has a permanent hazardous waste collection site, arrange a visit.

Resources -

King County Solid Waste Division curriculum, "Hazards on the Homefront," 4th-12th grade, January 1995.

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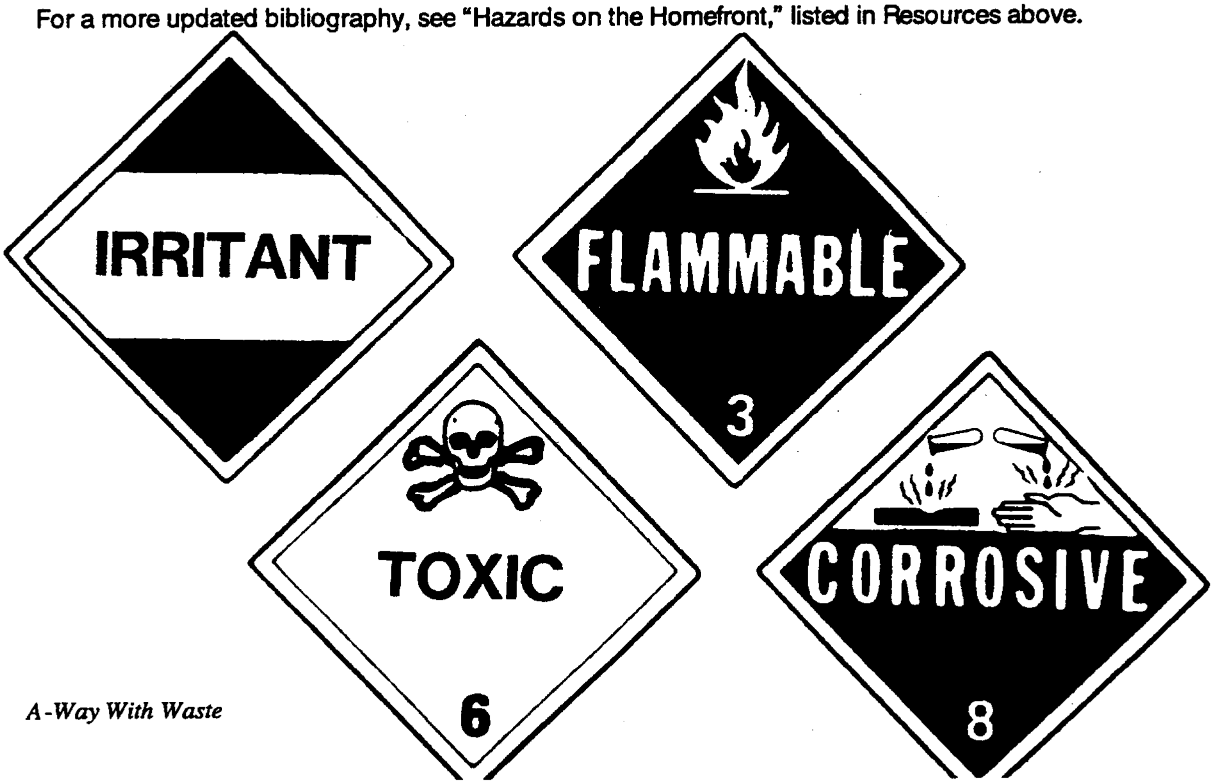
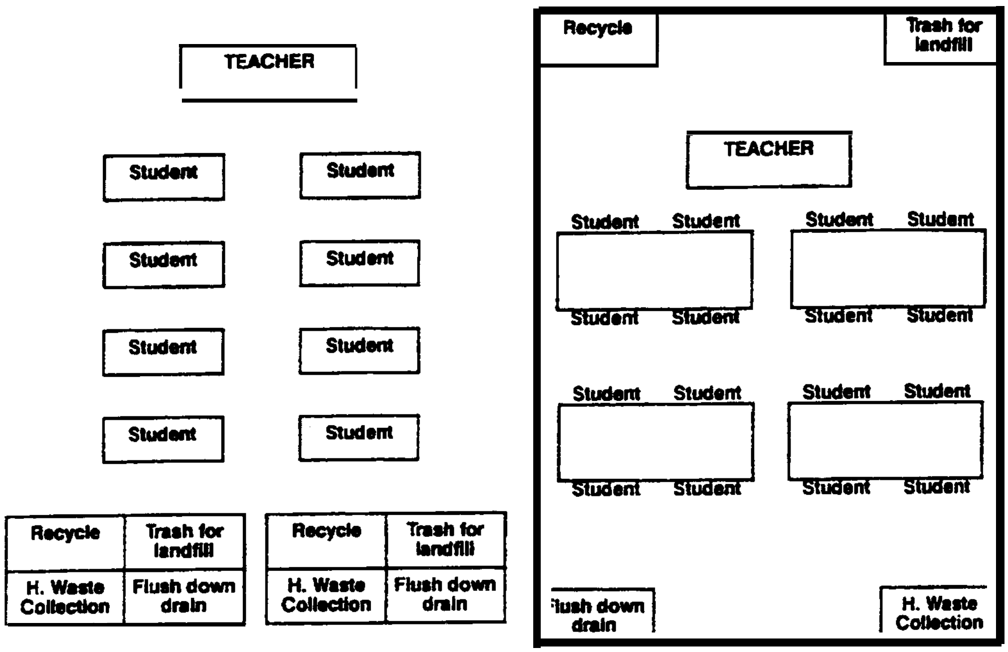
For a more updated bibliography, see "Hazards on the Homefront," listed in Resources above.



Household Hazardous Waste Disposal Game

Class arrangement options for game



Rules

1. Each team has ten hot potatoes, ten household product name stickers, and a pile of warning word stickers to attach to the potatoes.

2. The team has a twenty-five second time limit to place the product name on the potato, apply the proper warning stickers, and place the potato in the proper depository.

3. A designated team member applies the household product name sticker and the appropriate warning label(s).

4. If the potato is not in the depository at the end of the time limit, the person holding the potato must keep it at his or her desk. (This represents littering.)

Keeping Score

1. One point for each proper warning sticker for each product.
2. Two points for placing the potato in the proper depository.
3. Two points are deducted for placing the potato in the wrong depository.
4. Two points are deducted for littering.
5. One point is deducted for applying an incorrect label.
6. The team with the most points after the disposal of all ten potatoes wins.

Depositories can be boxes, bags, baskets, or designated areas of the classroom.

Hazardous Substance Warnings

Item	Why Hazardous	Disposal
Auto battery	Corrosive, toxic	Recycle
Drain cleaner	Corrosive, toxic	Give to someone to use up or Hazardous Waste Collection
Empty aerosol can	Flammable, toxic	Place in trash for landfill
Household cleaners with ammonia	Corrosive, toxic, irritant	Give to someone to use up or flush down drain
Oil based paint	Flammable, toxic	Give to someone to use up or Hazardous Waste Collection
Oven cleaner	Corrosive, toxic	Give to someone to use up or Hazardous Waste Collection
Rat poison	Toxic	Hazardous Waste Collection
Roach and ant killer	Toxic	Hazardous Waste Collection
Transmission fluid	Flammable, toxic	Recycle
Used motor oil	Flammable, toxic	Recycle

Household hazardous waste disposal method recommendations are subject to change as new information is obtained about chemical products. For current disposal recommendations, contact Washington State Department of Ecology's Recycling Hotline toll-free at 1-800-RECYCLE.

Hazardous Substance Toxicity Chart

Warning Word	Toxicity*	Examples
CAUTION OR WARNING	Moderately to very Toxic Lethal dose: A teaspoon to a pint	Ammonia Most paints Floor polishes Antifreeze Bleach Some fertilizers Many pesticides
DANGER	Extremely Toxic, Flammable or Corrosive Lethal dose: A taste to a teaspoon	Rat poison Mercury batteries Some pesticides and weed killers Paint thinner Drain opener Some oven cleaners
POISON	Highly Toxic	

*Robert E. Gosselin et al., Clinical Toxicology of Commercial Products, Baltimore: Williams and Wilkins, 1984, pp. 1-2.

Hazardous Substance Characteristics

Signal Word	Characteristics	Examples
Ignitable (Flammable)	Catches fire readily; explodes easily	Fuels Some cleaning fluids Some furniture polishes
Corrosive	Eats away what it touches	Battery acid Bathroom cleaners Pool chemicals
Reactive	Undergoes an unwanted reaction when exposed to other substances	Bleach Ammonia
Irritant	Causes soreness or inflammation	Ammonia
Toxic	Poisonous	Lead Mercury Pesticides

Washington State also identifies some hazardous wastes as persistent and some hazardous waste as carcinogenic. Persistent waste and materials such as pesticide DDT last a long time in the environment. Carcinogenic waste and materials such as chlordane are cancer causing. The signal word, Irritant, is not part of the official terminology used by most government bodies.

Safer Subs

Subjects: Science, Home Economics, Consumer Education

Grades: 5-10

Teaching Time: One to Two Class Periods, Plus Extended Learning

Focus: Household Hazardous Products, Waste Reduction, Safer Substitutes, Consumer Awareness

Rationale

Hazardous household products, if improperly used and disposed of, may harm human health and the environment. Safer substitutes are available.

Learning Objective

Students will:

- Learn substitutes for common potentially hazardous household products.

Teacher Background

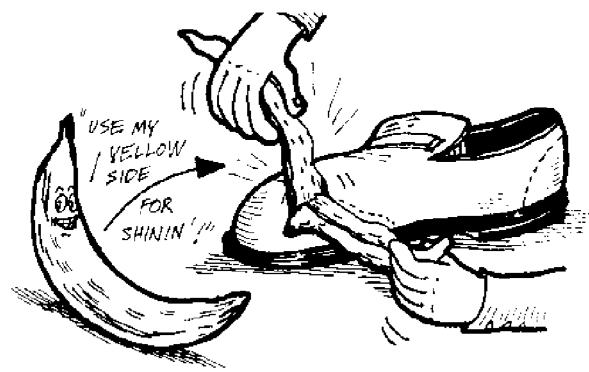
People have become concerned about the health and environmental effects of hazardous materials stored, used, or disposed of in their homes and communities. Consumers generally have little information about the long-term effects of chemicals contained in common home and garden products, or the proper management of these products once they are no longer needed. Many products and chemicals once considered "harmless" have now been linked to health problems due to exposure over long periods of time. These health effects can be as mild as fatigue and headaches or as serious as cancer.

Many hazardous products people buy are not only potentially dangerous to human health and the environment but are often unnecessary and quite expensive. Alternatives to many potentially hazardous household products are available at most grocery stores, and one alternative can often be used for several jobs.

Materials

Teacher Materials

- Magazine and newspaper advertisements for potentially hazardous products, such as drain cleaners, furniture polish, bug killer, etc. (Make sure the ads show at least some products with hazard warning labels.
- Four or five examples of safer substitutes. (Optional) For example:
  —Banana peel as a substitute for a shoe shiner product
  —Vinegar as a substitute for window cleaner



  —Salt as a substitute for coffee cup stain cleaner
  —White chalk as a substitute for spot cleaners that remove oil stains
  —Baking soda as a substitute for general household cleaners

See the sheet, "Potentially Hazardous Household Products - Some Safer Substitutes," for other examples.

Student Materials

- Game cards, pp. 306-310. One set of cards for each group of four to five students. Cards will need to be copied and cut. Some cards are duplicates. This will not interfere with the game's objective, which is to link a hazardous product with a safer substitute.

- "Potentially Hazardous Household Products - Some Safer Substitutes," p. 304. (One copy for each student)
- "Safer Subs - Alternatives for Potentially Hazardous Household Products," p. 305. (One copy for each student)

Pre & Post Test Questions

1. What are two reasons why safer substitutes for household hazardous products should be used?

2. What are two uses for baking soda?

3. Can you name one way to get rid of insects on plants?

4. What fruit can be used to shine shoes?

Learning Procedure

1 Hand out ads for potentially hazardous household products from magazines and newspapers. Make sure that each student has at least one ad.

2 Discuss with students how these products are advertised. **Ask:**

- Which of these products have you seen advertised on TV or heard about on the radio?
- What other similar products have you seen advertised? List responses on the board.
- What do the advertisers say these products will do for you? (For example, remove spots; kill bugs and germs, etc.)
- How do they try to convince you that their product is best? (e.g., new and improved; attractive packaging; the only one with enzyme action; easy to use; pleasant odor, etc.)
- Do the advertisers mention any potential hazards to human health and the environment?

3 **Ask:** "Why do people need these products?" "What purposes or function do they serve?" (Possible answers: to get rid of odors, to keep bugs from damaging plants or getting into food, to unclog drains, to stop fleas from bothering pets, to polish furniture, cars, etc.) List responses on the board.

4 **Ask:** "How do these products accomplish the purposes they serve?" (Possible answers: Cover up a bad odor with a sweet smell; kill bugs and fleas; dissolve or break down substances, etc.) Write down student responses on the board.
Ask: "Is there any other way to accomplish our purpose?" "Do we have to use these products?"

5 Explain that many of the potentially hazardous products people buy are not only unnecessary but may damage the environment and are often quite expensive. The packaging and advertising of a product is eventually paid for by the consumer. Safer substitutes are available at most grocery stores, and one safer substitute can often be used for several jobs.

6 Pass out the "Potentially Hazardous Household Products - Safer Substitutes" sheet. Read aloud. If possible, display some of these substitutes as you read about their uses.
Ask: "Are any of these substitutes used in your home already?" "Do your grandparents use any of these products?" "Do you think your family would be willing to use these substitutes? Why or why not?"

7 Explain to the class that they are now going to play a card game to help them identify safer substitutes for potentially hazardous household products. (Teacher: This game is similar to the card game, Go Fish.) Distribute the handout, "Safer Subs - Alternatives for Potentially Hazardous Household Products." Tell students that they will use the two lists to help them play the game.

Object of the game:
Students will try to make pairs of cards by matching a Hazardous Product card (marked HP) with a corresponding Safer Substitute card (marked SS). Students may refer to the Safer Substitute lists to make a correct match.

How to Play:

- Divide the class into groups of either four or five.
- Distribute a set of cards for each group.
- The Dealer passes out six cards to each player and himself. The remaining cards are placed face down on the table and become the DRAW pile. Play starts with the person to the left of the dealer. The person whose turn it is, is called the "Shopper."
- Each player attempts to make as many matches as possible while "Shopping" (i.e., during his or her turn). Remember a pair is a Hazardous Product (HP) card matched with an appropriate Safer Substitute(SS) card as shown on the lists. During a turn, the Shopper is allowed to "Go Shopping" for as many times as matches can be made. "Going Shopping" means the player may ask another player (by name) for a specific SS or HP card that will make a match with a card in the player's hand. Players must give up a card if asked. If the "Shopping Trip" fails (i.e., the player asked does not have the requested card), the "Shopper" takes a card from the DRAW pile. Shoppers may use their lists to determine what cards to "Go Shop" for.
- If a match is made, the Shopper lays it face up on the table in front of him or her, while stating out loud what the match is. Any other player may challenge a match, and an incorrect match will cause the turn to be passed immediately to the next player. The Shopper may continue to "Go Shop" as long as matches are made. Each time a "Shopping Trip" is successful, the two players draw a replacement card from the DRAW pile. The Shopper may also use this card to make a match. When no more matches can be made, then the player to the left becomes the new Shopper.
- When the teacher calls time (15 to 20 minutes) or the DRAW pile is used up, the player with the most matches is declared the winner. The winner in each group gets to demonstrate a safer substitute. (Optional)

8 Disband the groups and ask the demonstrators to report to class the results of using the safer substitute. Have the class question the demonstrators as to the effectiveness of the substitute. Discuss what the advantages and disadvantages are of using less or nonhazardous substitutes. Discuss how easy it would be to use safer subs at home.

Extended Learning

1 Create a slogan or poster warning against the use of potentially hazardous household products. (The Puget Sound Water Quality Authority's "Don't Pollute My Food" poster, displayed around Puget Sound, was designed by students.)

Acknowledgment: Adapted from Toxics in My Home? You Bet! Golden Empire Health Planning Center. Sacramento, CA .,1984.

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Schwartz, Anne. "Poisons in Your Home: A Disposal Dilemma." Audubon. May 1987, Vol. 89, No. 3, pp. 12-16.

Potentially Hazardous Household Products - Some Safer Substitutes

For This Potentially Hazardous Product	Try This Safer Substitute
Air Freshener	Cinnamon and cloves (simmered)
Bathtub and tile cleaner	Baking soda; vinegar and water
Burn mark remover	Grated onion
Coffee cup stain cleaner	Salt (moist)
Decal remover	Vinegar (soak in white vinegar)
Drain cleaner	Plunger; baking soda and hot water; vinegar and hot water
Furniture polish	Lemon oil (or juice) and mineral oil
General household cleaner	Baking soda
Hand cleaner for paint/grease	Baby oil
Ink spot remover	Cream of tartar and lemon juice and cold water
Insects (on plants) repellent	Soap and water
Moth repellent	Proper storage and laundering of clothing
Oil based paint	Water based paint
Oil stain remover	White chalk (rubbed into stain before laundering)
Paintbrush softener	Vinegar (hot)
Refrigerator odor remover	Baking soda
Roach repellent	Roach trap or “hotel”
Rug cleaner	Club soda
Rust remover	Lemon juice and salt and sunlight
Shoe polish	Banana peel
Slug repellent	Diatomaceous earth
Spot remover	Club soda; lemon juice; salt
Water mark remover	Toothpaste
Window cleaner	Vinegar (in warm water)
Wine stain remover	Salt

Handle with care even when using less hazardous household products!

Safer Subs - Alternatives for Potentially Hazardous Household Products

Use This Safer Substitute	For this Potentially Hazardous Product
Baby oil	Hand cleaner for paint/grease
Baking soda	Bathtub/tile cleanser; refrigerator deodorizer; general household cleaner
Banana peel	Shoe polish
Cinnamon and cloves	Air freshener
Club soda	Rug cleaner; spot remover
Cream of tartar and lemon juice	Ink spot remover
Diatomaceous earth	Slug repellent
Grated onion	Burn mark remover
Lemon juice and salt and sunlight	Rust remover
Lemon oil and mineral oil	Furniture polish
Plunger	Drain cleaner
Proper storage and laundering of clothing	Moth repellent
Roach trap or “hotel”	Roach repellent
Salt	Coffee cup stain cleaner; spot remover; decal remover
Soap and water	Remove insects on plants
Toothpaste	Water mark remover
Vinegar	Bathtub/tile cleanser; drain cleaner; paintbrush softener; window cleaner; decal remover
Water based paint	Oil based paint
White chalk	Oil stain remover

SS **BAKING SODA; VINEGAR AND WATER** SS	SS **GRATED ONION** SS	SS **SALT (MOIST)** SS
SS **WHITE VINEGAR** SS	SS **PLUNGER; BAKING SODA AND HOT WATER; VINEGAR AND HOT WATER** SS	SS **LEMON OIL (OR JUICE) AND MINERAL OIL** SS
SS **BAKING SODA** SS	SS **BABY OIL** SS	SS **CREAM OF TARTAR AND LEMON JUICE AND COLD WATER** SS

HP **PAINT BRUSH SOFTENER** HP	HP **INK SPOT REMOVER** HP	HP **HAND CLEANSER FOR PAINT/GREASE** HP
HP **GENERAL HOUSEHOLD CLEANER** HP	HP **FURNITURE POLISH** HP	HP **DRAIN CLEANER** HP
HP **AIR FRESHENER** HP	HP **BATHTUB AND TILE CLEANER** HP	HP **BURN MARK REMOVER** HP

HP **REFRIGERATOR ODOR REMOVER** HP	HP **SHOE POLISH** HP	HP **RUST REMOVER** HP
HP **MOTH REPELLENT** HP	HP **OIL BASED PAINT** HP	HP **OIL STAIN REMOVER** HP
HP **RUG CLEANER** HP	HP **ROACH REPELLENT** HP	HP **INSECTS ON PLANTS** HP

HP **COFFEE CUP STAIN CLEANER** HP	HP **DECAL REMOVER** HP	HP **SLUG REPELLENT** HP
HP **SPOT REMOVER** HP	HP **WATER MARK REMOVER** HP	HP **WINDOW CLEANER** HP
HP **WINE STAIN REMOVER** HP	HP **CINNAMON AND CLOVES (SIMMERED)** HP	

SS **BANANA PEEL** SS	SS **DIATOMACEOUS EARTH** SS	SS **CLUB SODA; LEMON JUICE; SALT** SS
SS **TOOTHPASTE** SS	SS **VINEGAR (IN WARM WATER)** SS	SS **SALT** SS

Hazards In My Home?

Subjects: Science, Health, Home Economics, Industrial Arts, Consumer Education

Grades: 6-9

Teaching Time: One to Two Class Periods

Focus: Household Hazardous Waste, Hazard Warnings, Hazardous Substance Characteristics

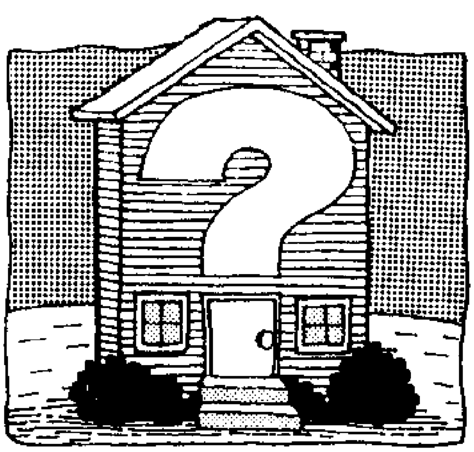
Rationale

Many common household products are hazardous. Using and disposing of such products safely requires a knowledge of the different identifying characteristics of hazardous substances.

Learning Objective

Students will:

- Learn the basic characteristics that identify materials and wastes as hazardous:
  - Ignitable (or flammable)
  - Corrosive (or irritant)
  - Reactive (or irritant)
  - Toxic (or poisonous)
- Identify commonly used household products that are hazardous to human and/or animal health and the environment if not used and disposed of safely.



Teacher Background

People have become concerned about the health effects of hazardous materials stored, used, or disposed of in their houses and communities. Consumers generally have little information about the long-term effects of chemicals contained in common home and garden products and are unfamiliar with the information provided on the label. Many products and chemicals that were once considered “harmless” have now been linked to health problems, due to exposure over long periods. These health effects can be as mild as fatigue and headaches or as serious as cancer. Often products act synergistically (the action of two or more substances, organs, or organisms to achieve an effect of which each is individually incapable) with other substances in the environment, particularly air pollutants.

In the past, hazardous substances have been characterized and labeled in a variety of ways. Even now, there is no completely consistent characterization scheme that is used by all government regulations. The Household Hazardous Waste Wheel appearing in this activity uses the word “Irritant,” which is not a part of the legal definitions used by Washington State to describe and label products. Substances that are irritants could be either “Corrosive" or ”Reactive," or both. However, for the purposes of this activity, reactive and irritant can mean the same thing.

Similarly, the words “Ignitable” and “Flammable” are often used interchangeably, although depending on the locale, they may or may not have different chemical and/or legal meanings. Although this is a bit confusing, it very much reflects the reality of household hazardous substances and their labeling as it exists today.

Materials

Student Materials

- Five Household Hazardous Waste Wheels (See Resources)
- "Inventory of Potentially Hazardous Household Products" (Use the forms on pp. 314.)

Teacher Materials

- Overheads: "Hazardous Substance Warnings," p. 297, and"Hazardous Substance Characteristics," p. 299.
- Examples of hazardous household substances: drain cleaners, insect foggers, polishes. Make sure the containers are empty. (Do not empty container just for this activity.) Bring the label, or tape lids shut and wrap the entire container in a clear plastic bag and tie the top.

Pre & Post Test Questions

1. What are two potentially hazardous products that could be found in each of the following areas of your home?
   - Bathroom (toilet bowl cleaner, certain household cleansers, laundry soaps)
   - Kitchen (furniture polishes, oven cleaner)
   - Garage/basement (pesticides, flea powders, paints)
2. What are four characteristics that identify a material as hazardous? What are the hazards that these products have? Can a product have more than one hazard?

3. What are three "warning" words for hazardous substances?

Learning Procedure

First Day

1 List the "Pre & Post Test Questions" on the board. Have students brainstorm answers to these questions. Write down student responses to these questions.

2 Show the overhead "Hazardous Substance Characteristics." Discuss what qualities makes something hazardous. (Harmful to human or animal health; harmful to the environment) **Ask:** "What is waste?" (Something not needed anymore, or an unwanted by-product from the manufacture of an item)

3 Show the overhead "Hazardous Substance Warnings." **Ask:** "What makes some substances more dangerous than others?" (The amount required to cause harm and how hazardous it is.)

4 Break the class up into five groups. Give each group a Household Hazardous Waste Wheel. Using the wheel, tell the groups to prepare a report for class presentation. Assign each group three products from the list generated in Step 1. Each report should cover:

- The hazard characteristics
- The type of product (automotive, household, etc.)
- The proper disposal choice (recycle, use up, etc.) Since the wheel is designed for nationwide use, you may want to give specific disposal options in your county.
- A safer substitute

Have each group give their report.

5 Distribute the "Inventory of Potentially Hazardous Household Products." Tell students they will use this form to find out what hazardous products they have in their homes and how these products are labeled to warn the consumer. This can be given as an overnight or longer assignment. Stress that these products are potentially hazardous and that caution should be taken while doing the inventory. Tell the students to ask their parents for assistance. Have students make sure items are labeled correctly and are on shelves out of children's reach. Put *Mr. Yuk* stickers on.
You may find parents that do not want their children doing the hazardous product inventory. A signature space has been provided on the inventory for parents to indicate they do not wish to have their child participate.

6 **Important.** Discuss and make sure students understand the provisions of the warnings on the first page of the "Inventory of Potentially Hazardous Household Products." Using the example products you bring to class, show how to fill out the inventory.

Second Day

Discuss some or all of the following questions after the students have completed and turned in their surveys. You may wish to prepare a tally sheet that combines all the results (pp. 317). Students whose parents requested they not do the inventory can tally combined results and present them to the class.

- Which items were found most frequently?
- Where were most of the products found?
- What are the best places to store potentially hazardous products? Did you find any products being stored unsafely?
- What was the most common warning on the labels? Did similar products have similar warnings?
- Which products had directions for safe disposal?
- Did any of the products mention the health effects that the product could have?
- Were any products found that did not have adequate warnings, or that were unlabeled?

Extended Learning

1 Using the Household Hazardous Waste Wheel, have students fill out the alternatives section of the inventory.

2 Show the video Household Hazardous Wastes: A Little Goes A Long Way. (See Resources)

3 Write an article for the school or community newspaper about some common household hazardous materials. Describe the warnings, some alternatives, and safe disposal practices.

4 Prepare safety sheets and post them in your home where hazardous materials are stored.

Resources

Household Hazardous Waste Wheel. Environmental Hazards Management Institute, 1991. (Five per classroom)

Video Tape: Household Hazardous Waste: a Little Goes A Long Way. Washington State Department of Ecology. 1987. 18 min., color. (Available for loan)

Check your local health department for materials specific to your area.

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Dykeman, Claire, et al. Sleuth: Educational Activities on the Disposal of Household Hazardous Waste. Seattle: Toxicant Program, Report No. 10. Water Quality Division, Municipality of Metropolitan Seattle (Metro), August 1982.

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Ontario Waste Management Corporation. Hazardous Waste Education Resource Kit. Toronto, 1985.

Robertson, David K., et al. "Liquid Household Hazardous Wastes in the United States: Identification, Disposal, and Management Plan." Environmental Management. 1988, Vol. 11, No. 6, pp. 735-742.

Name ____________________________ Date ____________ Period ___________

Inventory of Potentially Hazardous Household Products

This activity is an inventory. You are going to hunt around your house, basement, and garage to find out which of these products you have. Ask your parents to assist you with this activity.

Caution: Do not disturb or spill these products. Some of them might be harmful. Wash your hands carefully after you handle any container that might be leaking. (Not all household products are hazardous.)

1. Check off items you find. Add others that you find that are not on the list.
2. Write down where you find the product (under sink in kitchen, etc.). List both the room and exact location.
3. Read the labels of the products. Write down any warnings (hazards and characteristics) that are on the labels. Have parents collect unwanted items for collection day.

Do you have?	**Where is it stored?**	**Warnings**	**Hazard Characteristics**	**Alternative (Do In Class)**
HOUSE ___Oven cleaner				
___Drain cleaner				
___Toilet cleaner				
___Disinfectants				
___Rug or uphol-stery cleaners				
___Floor or furniture polish				
___Bleach or cleaners with bleach				
___Photographic chemicals				

________________________ *Please excuse my child from doing the inventory*

Do you have?	Where is it stored?	Warnings	Hazard Characteristics	Alternative (Do In Class)
___Silver polish				
___Pool chemicals				
___Mothballs				
___Powder or abrasive cleaners				
___Ammonia or cleaners with ammonia				
___Spot removers				
PAINTS ___Enamel or oil based paints				
___Latex or water based paints				
___Rust paint				
___Thinners and turpentine				
___Furniture strippers				
___Stain or finish				
AUTO ___Antifreeze				
___Used oil				

Do you have?	Where is it stored?	Warnings	Hazard Characteristics	Alternative (Do In Class)
___Brake fluid				
___Transmission fluid				
___Batteries				
___Gasoline				
PESTICIDES				
___Herbicides (weed killers)				
___Rat and mouse poison				
___Roach and ant killer				
___Flea collars and sprays				
___House plant insecticides				
___Fungicides				
___Slug bait				
___Other garden pesticides				
OTHER				

Tally Sheet - Household Hazardous Products

Product	Warning Label			Hazard Characteristic				
Type	Caution	Warning	Danger	Ignitable	Corrosive	Reactive	Toxic	Other
AUTOMOTIVE								
1.								
2.								
3.								
4.								
5.								
6.								
7. Others								
HOUSEHOLD								
1.								
2.								
3.								
4.								
5.								
6.								
7. Others								
PESTICIDES								
1.								
2.								
3.								
4.								
5.								
6.								
7. Others								

Tally Sheet - Household Hazardous Products

Product	Warning Label			Hazard Characteristic				
Type	Caution	Warning	Danger	Ignitable	Corrosive	Reactive	Toxic	Other
PAINTS								
1.								
2.								
3.								
4.								
5.								
6.								
7.								
OTHERS								
1.								
2.								
3.								
4.								
5.								
6.								
7.								
MISCELLANEOUS								

Hazardous Substance Toxicity Chart

Warning Word	Toxicity*	Examples
CAUTION OR WARNING	Moderately to very Toxic Lethal dose: A teaspoon to a pint	Ammonia Most paints Floor polishes Antifreeze Bleach Some fertilizers Many pesticides
DANGER	Extremely Toxic, Flammable or Corrosive Lethal dose: A taste to a teaspoon	Rat poison Mercury batteries Some pesticides and weed killers Paint thinner Drain opener Some oven cleaners
POISON	Highly Toxic	

*Robert E. Gosselin et al., Clinical Toxicology of Commercial Products, Baltimore: Williams and Wilkins, 1984, pp. 1-2.

Read The Label

Subjects: Science, Health, Social Studies, Home Economics

Grades: 7 - 10

Teaching Time: Two Class Periods and One Homework Assignment

Focus: Household Hazardous Products

Rationale

Some of the most common and frequently used household products contain hazardous chemicals. Using and disposing of such products wisely begins with knowing which products pose a problem - by reading labels.

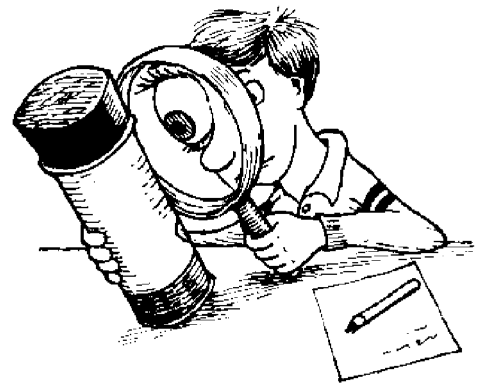
Learning Objective

Students will:

- Understand that the same substances that make a product useful can also make that product potentially hazardous.
- Understand that labels on household products contain important information on how to use, store, and dispose of products safely.

Teacher Background

People have become concerned about the health effects of hazardous materials stored, used, or disposed of in their homes and communities. Consumers generally have little information about the long-term effects of chemicals contained in common home and garden products. Many products and chemicals once considered "harmless" have now been linked to health problems, due to exposure over long periods. These health effects can be as mild as fatigue and headaches or as serious as cancer. Often products combine with other substances in the environment, creating a reaction which is more hazardous than the individual chemical's effects.



A substance that is classified as hazardous is required to bear labeling with warning statements and safety information if it is packaged for, or intended for, use in or around the home. The U.S. Consumer Product Safety Commission has established specific labeling requirements; however, labels required for various hazardous substances differ. This, in addition to the considerable amount of label information required, can make it very difficult to determine how to use, store, and dispose of a product safely.

Materials

Examples of

- Potentially hazardous household products such as drain opener, spray oven cleaner, paint, car care products, scented liquid furniture polish, aerosol air freshener, or pesticides. Make sure the containers are empty. (Do not empty container just for this activity.) Bring the label, or tape lids shut and wrap the entire container in a clear plastic bag and tie the top.

Student Handouts

- "What's In Your House?" pp. 324
- "Read the Label - Product Worksheet"
- "Household Hazardous Products Test " (Optional)

Teacher Overheads

- "Hazardous Substance Toxicity Chart" (p. 319)
- "Hazardous Substance Characteristics" (p. 299)

Pre & Post Test Questions

See the handout "Household Hazardous Products Test."

Learning Procedure

Day One

1 **Ask:** "What does the word "toxic" mean?" (poisonous) Hold up a container of liquid drain opener or garden pesticide. **Ask:** "Is this toxic?" "What's the safest way to find out?" (Read the label)
"What other household products might be toxic or hazardous?"
"What does hazardous mean?" "What qualities would make something hazardous?"
"How does the label on a product give us information on potential hazards?"

2 Show the overhead, "Hazardous Substance Characteristics," p. 299. Explain to the students that the characteristics on the overhead are used to describe hazardous waste and that additional terms such as "generates pressure" are required on product labels. Using different hazardous household products as examples, identify the other characteristics of hazardous materials. (corrosive, reactive, ignitable)
Circulate the household products (safely prepared) and ask students to discuss which hazardous properties each product has. **Ask:** "Do any products have more than one kind of hazard?" "Are there any words on the label that you do not know the meaning of?"

3 Tell students that many people are unaware that such common products may be hazardous. Consequently, these products are often used or disposed of unsafely. The same substances that make a product a good cleaner or solvent by dissolving dirt, grease, or other unwanted solids can also act to dissolve your skin or the surface of your lungs, etc.
Tell students that poisonings can occur not only by eating or drinking but also by breathing and skin absorption.

Tell students that direct or prolonged exposure to hazardous materials may damage human health in a variety of ways. Depending on individual sensitivity, a person may develop a headache, experience nausea or lightheadedness, or have difficulty breathing. Many other symptoms are also possible.

Some hazardous materials are associated with long-term effects that may not be noticeable for years - for example cancer, birth defects, or gene mutation. Chronic health effects are not usually on warning labels and are often unknown.

4 **Ask:** "What on a product's label tells us that the product may be hazardous?" "What key words should we look for?"
Show the overhead "Hazardous Substance Toxicity Chart," p. 319. Tell students that these words apply mostly to the degree of toxicity of the substance, but that they may also refer to how serious the consequences of mishandling are. Review the key words with students. Ask the students to think of a memory aid (mnemonic) to help them remember the order of toxicity.

- CAUTION OR WARNING - Use the product with care; low to high toxicity.
- DANGER - Signals that exposure or unsafe use may cause injury, illness, or death; high or extreme toxicity.

5 Distribute copies of the five-page handout "What's In Your House," pp. 324. Allowing 15 to 20 minutes, have students read and complete the five worksheets. The worksheets deal with:

- Drain openers/oven cleaners
- Furniture polish
- Air fresheners
- Pesticides
- Solvents

Discuss and review student responses.

6 **Homework Assignment.** Distribute two copies of the "Read The Label" worksheet p. 328, to each student. Have students examine, in their home, labels from at least two products with hazardous properties. Tell students to fill out worksheets and prepare to participate in classroom discussion about their findings.

Day Two

Start the discussion with the following items:

1. Necessary Precautions: Some of the precautions that products had. Did the labels mention any health hazard from prolonged use?
2. Warning Symbols: What, if any, warning symbols were used? Were the warning symbols clear?
3. First Aid Measures: What kind of first aid measures were printed on the labels? Were the instructions clear?
4. Ingredients: What are "active ingredients"? (The ingredients that make the product both useful and potentially harmful.) What are "inert ingredients"? (Substances that "carry" the active ingredient and are also potentially harmful.) What are the amounts of the different kinds of ingredients? Why are some amounts larger than others? (Active ingredients are present in small amounts due to their potency.) Does the label list what the inert ingredients are? Why is it important to know the names of chemicals? (To be able to tell a doctor or other health professional the kind of poison, etc.)
5. Directions for Use, Storage, and Disposal: What were some of the precautions listed in the directions for use? Did the label give any suggestions for storage? For disposal?
6. Ask your class, working in small groups, to design and create labels for hazardous materials of their choice. To get them started, ask:
   - What information should a hazardous product label list?
   - How should the information be displayed?

Extended Learning

1 Find out if your city or county government has a poison information center. Call the Department of Ecology Recycle Hotline, 1-800-RECYCLE, about a specific chemical substance listed on a product.

2 Have students present to the class hazardous material labels they created.

Acknowledgment

Parts of this activity were adapted from Toxics In My Home? You Bet!: Curriculum on Household Toxics for Grades 7-8. Golden Empire Health Planning Center, Sacramento, CA, 1982.

Resources

"Household Hazardous Waste Wheel." Environmental Hazards Management Institute. 1987.

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What's In Your House?

Drain Openers - often contain a substance called sodium hydroxide. Another name for this is lye. It is very corrosive to body tissue and can cause burns. The degree of the burn depends on the amount of chemical exposure and the person's sensitivity to it. Drain openers are designed to eat away the materials clogging your drain. The material is generally made of organic matter—much like your skin. They should be used with extreme care. To avoid the release of toxic fumes, drain openers should never be mixed with another brand or with bleach. Most accidents involve children with burns of the mouth, face, esophagus, and upper digestive pathways.

Oven Cleaners - most oven cleaners contain lye, much like drain openers. Some oven cleaners are in aerosol spray form. Aerosol sprays are particularly dangerous because the very fine mist spreads over a large area of the room and can land on skin, eyes, and sensitive lung tissue. While skin can regenerate itself, this is not true of the lungs.

What type of signal words and/or other precautions do you think should be listed on these products? Give your reasons.

Furniture Polish - may contain pretty scents and colors that are attractive to children who can be seriously injured by drinking them. Polishes come in different forms, and different chemicals are used to help apply the polish onto the furniture.

Some kerosene-like substances are present in some polishes. When ingested, they enter the lungs and saturate them so that the lungs cannot function. There is no way to rid the body of the poison or to reverse its effect.

The health dangers most often occurring with furniture polishes are from ingestion and inhalation of fumes—especially from the aerosols. The aerosol spray propellants may decompose to harmful gases when in contact with a heated surface.

Another common danger is the polish getting into sensitive parts of the body, especially the eyes.

Most polishes are flammable and can ignite when applied by someone who is smoking.

What type of signal word and/or other precautions do you think should be listed on this product? Give your reasons.

Air Fresheners - usually act in one of three ways: (1) masking or counteracting one odor with another; (2) coating the nasal passages with an oily film; or (3) diminishing the sense of smell with a nerve-deadening agent. Tampering with our sense of smell can be dangerous because olfaction (smelling) is one of our best human defenses against fire, toxic gases, and decayed or spoiled foods.

Many air "fresheners" simply contaminate the air with another foreign substance and have no freshening effect at all.

Some of the chemicals found in aerosol air fresheners can be extremely dangerous to internal tissues and organs.

Aerosols can become powerful bombs when exposed to heat, external pressure, or puncture. They are also a major source of air pollution in the home, particularly when used in small closed rooms such as the bathroom.

What type of signal word and/or other precautions do you think should be listed on this product? Give your reasons.

Pesticides - are poisons. Some of them remain in the environment for long periods and resist natural means of breakdown and decomposition. Some are formulated to rapidly breakdown. Some pesticides may destroy beneficial as well as harmful insects and can also harm plants, birds, fish, squirrels, and other wildlife.

Chemical pesticides are a convenient way to get rid of or control unwanted insects or other pests, small mammals, weeds, or fungus growths. Convenience, however, comes at a high price. The price was realized by an 8 1/2 month old infant who had been suffering from a cough for a few weeks and then died five days after her room had been sprayed by an exterminator.

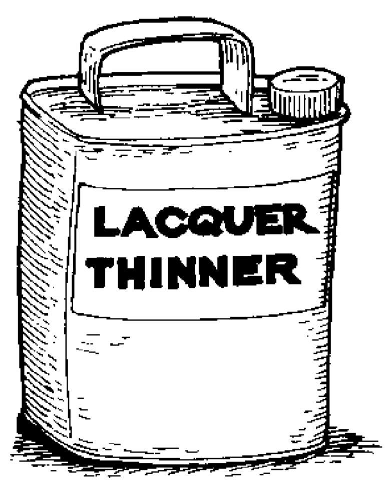
In California alone, it is estimated that each year about 14,000 incidents of pesticide exposure result in requests for medical assistance. Most of these are nonoccupational exposures involving children in the home or garden.

Pesticides can injure the user if consumed, absorbed through the skin, or inhaled. Pesticide poisoning often resembles, and is mistaken for, the flu. Symptoms may include headaches, nausea, dizziness, aches, etc. Some pesticides have also been associated with more damaging effects such as cancer or birth defects.

Authorities believe that many pesticides (over 50 percent) have not been adequately tested for their ability to cause cancer or birth defects.

What type of signal word and/or other precautions do you think should be listed on this product? Give your reasons.

Solvents - are substances that dissolve other substances. The most familiar and universal of solvents is water. Water dissolves minerals and carries them in sap to the upper reaches of plants. In cooking, it dissolves sugar and salt. Nonwater-based solvents are called organic solvents—so called because chemicals like them (i.e., those based on carbon) form the structure of living things. Most solvents are organic and capable of causing injury if not used properly.



Some solvents enter the body through skin contact because they dissolve oily materials (skin oils, for instance) so easily. Inhalation can have an irritant effect on mucous membrane and can cause nausea, headaches, muscular weakness, drowsiness, and impaired motor response (leading to a loss of coordination that contributes to increased accidents). One of the prime organ targets of solvents is the liver—the organ that removes poisonous chemicals from the body and aids in food digestion. The liver can be severely damaged by solvents that destroy liver cells. One symptom of liver disease is jaundice—a yellowing of the skin and eyes.

The eyes are a major target area of solvents. People who refuse to wear goggles place themselves at risk of injury when handling solvents. Solvents can be splashed or reach the eyes by scratching an itch or pushing away some hair. This is especially dangerous if the victim is wearing soft contact lenses, which can absorb the chemicals and hold them against the eyes until the lenses are removed. The length of exposure can cause considerable eye damage or irritation.

Solvents dry easily but the vapors still linger in the air and are breathed unless there is plenty of fresh air and good ventilation.

What type of signal word and/or other precautions do you think should be listed on this product? Give your reasons.

Name ______________________________ Class____________________
Product______________________________

Read The Label - Product Worksheet

Directions: Tell your parents about your assignment and ask for their assistance. Carefully read the label on the container and answer the following questions:

1. What is the name of the product?

2. What are its uses?

3. What are its active ingredients? Give their percentages, if any.

4. What are the product's inactive or inert ingredients? Give their percentages.

5. Does this product have any hazard or warning word or symbol? If so, what is it and what does it mean?

6. List any directions that help protect people's health.

7. Does this label offer any first-aid directions? If so, what are they?

8. Briefly describe, from the label, directions for use and directions for storage.

9. Describe, from the label, directions for container disposal.

10. What other helpful information is listed on the label?

11. What information do you think should be on the label that is not there?

12. Would you buy and use this product again? Give reasons?

13. Does this product have any environmental warnings? If so, what are they? Could your disposal choice be a threat to the environment?

Name ____________________________ Class_________________

Household Hazardous Products Test

1. List the four basic characteristics of hazardous substances.

2. Give three examples of potentially hazardous household products.

3. List three signal words that indicate a product's level of hazard, in the order of toxicity from lowest to highest.

4. Give two reasons why people buy potentially hazardous household products.

5. Give the name and health effect of one chemical found in a home or garden product.

6. Identify two ways potentially hazardous household products can be used unsafely.

7. List three unsafe disposal methods for household hazardous wastes.

8. Name two organizations that may be able to give you information on sensible disposal of potentially hazardous household products.

9. List two potentially hazardous household products and their safer substitutes.

TRUE OR FALSE

10. ____ Toxic means poisonous.
11. ____ Poisonings occur only through eating or drinking harmful substances.
12. ____ Some pesticides destroy beneficial as well as harmful insects.
13. ____ Putting household wastes down a storm drain is a good idea because storm drains are connected to sewage treatment plants.
14. ____ Used motor oil can be recycled.
15. ____ Solvents can pass through the skin and be absorbed in the bloodstream.

What Goes Around Comes Around

Subjects: Science, Social Studies
Grades: 7-12
Time: Three or Four Class Periods
Focus: Household Hazardous Waste, Ground Water Quality, Bioaccumulation, Ecology, Persistent Chemicals, Impermeable, Aquifers, Microlayers, Sewage Treatment, Sludge, Leachate

Rationale

Household hazardous wastes, if improperly disposed of, threaten public health and the environment.

Learning Objective

Students will:

- Understand the environmental consequences, particularly the effects on water, of a variety of household hazardous waste disposal methods.
- Learn where persistent household hazardous wastes go when they are thrown out.

Teacher Background

Hazardous substances can enter our environment in a wide variety of ways. Because the subject is so large, this activity is primarily informational in nature.

Refer to the Glossary for definitions of any unfamiliar terms.

Materials

Teacher/Classroom Materials

- Examples of commonly used household hazardous products, such as motor oil, a garden pesticide, or paint thinner
- Protective gloves (optional)
- Brochure Protecting Our Ground Water (see Bibliography)
- Overheads "Routes To The Environment" (p. 342) and "Bioaccumulation" (p. 341)

Student Handouts

- "Where Will It End Up" worksheet
- Disposal option information sheets (These sheets are on separate pages for easy distribution of a particular option.)

Pre & Post Test Questions

1. Why are persistent hazardous substances of particular concern in waste management?

2. What is bioaccumulation?

3. What are four different hazardous waste disposal options? (Give an example of a product that should be disposed of using each option.)

4. How can we reduce the amount of household hazardous waste we produce?

Learning Procedure

1 Bring to class one or two examples of some common types of household or school hazardous substances. Motor oil, pesticides, and paint thinner are good examples of products that are known to be persistent and long lasting in the environment. Handle these products with care. As a precaution, notify the school and/or parent if you intend to bring these products to class. You may wish to bring empty containers only. Restrict student handling of these products. Wearing gloves for protection will emphasize the hazardous nature of these products.

2 Explain that some combinations of hazardous chemicals degrade (break down) quickly into safe, naturally occurring substances. Explain that in this activity we are primarily concerned with persistent hazardous chemical combinations - those that remain unchanged in the environment for long periods, or chemicals that combine with natural substances in such a way as to pose a hazard to humans and other living organisms. Show the overhead "Bioaccumulation" and discuss the concept with students.

3 **Ask:** "What should we do with these products when we are through with them?" "What are the different ways we might dispose of them?" (Recycle, flush down the drain, put in the garbage can, burn in the back yard, pour out on the ground or pavement.)
Tell students that some disposal options are no longer legally available, but for the purposes of this activity, we will want to think about what happens to substances when they are disposed of in various ways.

Discuss with students any directions for disposal that the labels on the products give. For example, most motor oil containers suggest recycling.

4 Discuss with students that part of the study of ecology is the examination and understanding of connections. Tell students that the class will now consider how each of the possible ways we might use to dispose of household hazardous waste could be connected to our food and water supplies.

5 Tell students they are now going to consider where wastes go. Show the overhead "Routes To The Environment" and display/distribute the pamphlet Protecting Our Ground Water. Point out to the class the various ways a chemical can travel through the environment from our homes.

6 Divide the students into groups or pairs and assign a different disposal method to each group.

- Incineration
- Storm drain, ditch, hole in the ground
- Sink/toilet
- Garbage can
- Household hazardous waste community collection

Have each group brainstorm for several minutes on where substances disposed of by their designated disposal method might end up. You may wish to assign a different hazardous product to each group. Questions that each group can ask themselves are:

- If we dispose of the product by this method, what might happen?
- Is there any way that wildlife might be harmed?
- Is there any way this product could get into our drinking water?
- Is there any way this product could get into our food?

Tell the groups to consult the brochure Protecting Our Ground Water and use the "Where Will It End Up" chart to write down their ideas.

7 Have the groups share their ideas with the rest of the class. After each group presents its ideas, discuss with the class the information contained in disposal option sheets that are included with this activity. You may wish to pass these out to the class. If you prefer, do a different disposal option each day. Ask the class to vote on the best disposal choice for each product. Show the video Household Hazardous Waste: A Little Goes a Long Way. (See Resources)

8 After all the options have been covered, review with the class where persistent household hazardous waste goes. **Ask:** "What can we do to reduce the amount of household hazardous waste we produce, in other words eliminate or reduce the waste before it becomes a problem for us and the environment?" Have students brainstorm ways that we can prevent persistent hazardous substances from harming the environment. Have them think of solutions they themselves might do, such as:

- Don't buy products containing hazardous materials. Learn to read product labels. See the activity "Read The Label," p. 321.
- Use safer substitutes. See the activity "Safer Subs," p. 301.
- Use up what you have or, if it is not a banned chemical, find someone who can use it.
- Take it to a hazardous household waste collection program or a recycling center that handles hazardous substances.

Tell students that they can get information about participating in a collection program by calling their local health department or by calling the Department of Ecology's Recycling Hotline, 1-800-RECYCLE.

Extended Learning

Give the class some more examples of potentially hazardous household products (safely prepared) or use examples from the activity "Hazards In My Home?" on p. 311 and ask them to decide the best way to deal with each.

Acknowledgment

Much of the information in this activity is taken from the activity guide Sleuth: Educational Activities on the Disposal of Hazardous Waste, published by the Municipality of Metropolitan Seattle (Metro). We wish to thank Dave Galvin for his permission to use this excellent resource.

Resources

Household Hazardous Waste Wheel, Environmental Hazards Management Institute, 1991.

Video Tape: Household Hazardous Waste: A Little Goes a Long Way. Washington State Department of Ecology. 1987. 18 min., color.

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Product Disposal Recommendations
Incineration

If you burn your household hazardous wastes, what happens? This depends on the type of chemical in the waste being burned. A pressurized aerosol can could explode and cause injury. Burning paints could leave a residue of heavy metals which is toxic. Burning rags soaked with cleaning fluid might simply vaporize the liquid into the air. This would disperse it and thus make its concentration very low.

Burning plastic containers or certain solvents could release potentially harmful fumes like hydrogen cyanide or chlorine bearing compounds that are harmful if inhaled. Some of the chlorine bearing compounds do not break down easily and last a long time. Over a period of time, these compounds can accumulate to levels that are harmful to the atmosphere.

Burning household hazardous waste is illegal in a homeowner’s woodstove, burning barrel or fireplace. It is also illegal to burn garbage, plastic, rubber products, paint, waste petroleum products, or painted or treated wood.

In addition, the burning of household hazardous substances by individuals is never complete. This means that waste is illegal if small particles from paper or cloth are released into the air. These particles, which can carry toxic substances, may settle and form a very thin layer called a microlayer on different surfaces, such as plant leaves. The toxic substances in the layers can interfere with vital biological processes. Microlayers can also form on the surface of water. Because microlayers form at the place called an interface (where two different states of matter meet such as liquid and gas or solid and liquid) it is much more likely that toxic substances will become concentrated in these microlayers.

Finally, human beings can breathe small particles into their lungs and absorb the toxic substances into the bloodstream. (Our lungs are an interface with the atmosphere).

Storm Drain, Ditch, Hole in the Ground

If you pour household hazardous waste in a storm drain, in a ditch, or in a hole in your backyard, there's a good chance the waste will end up in a nearby stream, river, or lake. Let's figure out exactly where your waste might go.

First, the storm drain—The square metal grates at the sides or curbs of streets are called storm drains or catch basins. When it begins to rain, the first drops soak into the ground, but once the soil is saturated or if it's covered by cement, the rain runs into these storm drains. They drain anything soluble on your driveway, backyard, or street into the storm sewer system.

Once there, this runoff water enters pipes which carry it to larger pipes or "trunk lines" buried under the ground. These pipes empty the water into the nearest drywell or waterway: a creek, river, or lake. So if you pour used motor oil down the storm drain in the street in front of your house, it very well may end up on the feathers of ducks or the gills of fish in a nearby lake.

In some areas, the storm drain joins sanitary sewer pipes and the runoff water goes to a sewage treatment plant. This is called a combined sewer system. In this case, the water containing your hazardous waste will be treated. Some sewage plants have only a single treatment stage which will not eliminate most hazardous wastes. Other sewage plants have secondary treatment plants that eliminate many more, but not all, hazardous wastes. However, these are very expensive. What kind of systems do you have in your city?

Next, the ditch or your backyard—In some areas there are no storm drains. Once the soil is saturated, rainwater runs overland to the nearest ditch or gully and downhill to the nearest waterway. If you disposed of a household hazardous waste - say a pesticide - in your backyard or applied it on your yard, and it rained hard the next day, the rain would carry the substance overland along the ditches to a waterway or down into the ground water.

"Ground water," "water table," "aquifer," "artesian well," and "springs" are names which describe where water is and what water does underground. Water drains or soaks into the ground until it hits an impermeable (difficult to penetrate) layer. The water then collects in the spaces between sand, gravel, or rock particles. Underground areas where ground water collects are called aquifers. Some aquifers replenish lakes or streams. Others are enclosed by layers of rock and do not move. Wells are drilled into both kinds of aquifers, those that flow and those like pockets. Aquifers around the country are becoming contaminated at an alarming rate, threatening drinking water supplies.

Of all the water available in our state, only a small amount is actually available for drinking purposes. From where does your drinking water come?

Sink/Toilet

When you pour the substance down the sink or flush it down the toilet, where does it go? It goes either to the municipal sewage treatment system or into a septic system.

The sewage system is a network of underground pipes that collects liquid waste from each house, store, office, factory, and building and brings it together into huge pipes called trunk lines. These trunk lines carry enormous volumes of waste.

Not all that long ago, sewage used to be dumped directly into rivers, lakes, sounds, and oceans. What problems did this create?

Now, most cities and towns have municipal sewage treatment plants to clean up sewage before it is pumped into Puget Sound or a nearby river.

At the sewage treatment plant, the water is treated with chlorine or ultraviolet light to kill any disease-causing organisms in the raw sewage. Much of the solid material and some of the heavy metals are also removed by allowing them to settle out of solution. Common heavy metals are lead, zinc, mercury, and cadmium. Exposure to heavy metals, in any other amount than small concentrations, can be harmful to human and environmental health.

Some of the toxics in the sewage biodegrade, while others, including some of the heavy metals, settle out in a residue called sludge. Sludge is sometimes disposed of in a landfill but is usually applied as a fertilizer to forest land. Some hazardous chemicals can be absorbed by plants, and these plants, in turn, are eaten by animals and the chemicals can accumulate and concentrate to dangerous levels. This process is called bioaccumulation. The Environmental Protection Agency has set standards for the level of toxicants in sludge that may be used on farm or garden soils producing food. As a substance moves from one organism to another, through being eaten or absorption, the substance is said to move through a food chain. Each link in the chain may accumulate the hazardous substance in higher concentrations. Human beings are often at the top of a food chain, which means the food we eat has had a chance to bioaccumulate many times.

If you poured a persistent hazardous waste down the sink, which food chains could these hazards become part of?

Today, we are only starting to recognize and understand the environmental damage caused by household hazardous waste. There is no doubt that treatment removes or makes less harmful some of the toxic substances found in sewage. Some hazards, however, are not removed and are pumped into rivers and into Puget Sound.

If your house is not connected to a sewer system, it is probably connected to a septic tank. Many gallons of water and sewage go through these septic system each day. (For example, most toilets use five to seven gallons for every flush.)

Bacteria break down much of the waste entering a septic system. However, if you pour or flush hazardous waste into a septic system, the waste can kill this helpful bacteria and can contaminate the septic tank sludge or septic system’s drain field soil. The sludge, pumped every four or five years from the septic tank, is disposed of either at a sewage treatment plant in a septage lagoon or in a sludge landfill (basically a hole in the ground). The septic system can last many years if the sludge tank is pumped out periodically. If the system is not pumped regularly, the bacterial action may stop, allowing harmful substances into the ground water; or the drain field may get blocked, causing the system to back up.

The suspected cancer-causing chemical trichloroethylene (a powerful solvent and degreaser) has leached from septic tank drain fields in several places in the country to contaminate local wells.

This compound, used in the past as a cleaner for septic tanks, is the suspected source.[1] Chlorinated compounds make good cleaning agents, but they are persistent, toxic, and mobile. Bacteria that can break down nonchlorinated substances cannot biodegrade these compounds, which pass through such systems into the drain field and ultimately may end up in drinking water sources.

1 Metro Toxicant Program Report No. 1E, Water Quality Division, Seattle, 1982.

Garbage Can

For many people, after they put their trash in the garbage can, they probably don't think about it any more. The garbage truck comes by every week and takes it away. But now that you've been studying garbage, maybe you'll think about it more.

What happens to your garbage after it's picked up? Where does it go?

In some areas, the garbage truck takes your trash to a transfer station. From there, it is hauled by large trucks to a landfill.

What happens to garbage after it reaches the landfill? What happens to hazardous waste if you put it in the garbage?

Trash in landfills used to be burned to reduce the volume. This produced a relatively nontoxic ash, but sent hazardous emissions into the air. Consequently, open burning was stopped and replaced by compaction and burial of waste. The waste at a landfill is heavily compacted. As a result, almost any container will break and its contents spill. Now the problem is leachate.

At the landfill, rainwater and any liquids in the waste soak through the garbage. Soluble (dissolvable in water) hazardous materials may be washed down with them. This liquid mixture is called leachate. Leachate will go down through the soil until it reaches an impermeable layer (a layer it cannot go through), or it will flow downhill over the surface. Leachate can contaminate ground water and surface waters. Landfills constructed today must have a protective lining, a leachate collection system, and a ground water monitoring system. However, many of our existing landfills were established prior to these requirements.

So if you throw household hazardous waste in the garbage can, the waste's persistent components may end up in the soil, groundwater or surface water near your local landfill.

Household Hazardous Waste Collection

Many counties in the state of Washington now sponsor household hazardous waste collection programs or permanent, staffed collection sites. Spokane and Island counties, as do other counties, rely almost exclusively on ground water for all county water needs and are particularly concerned about safely collecting household hazardous wastes in order to keep them out of local landfills and out of drinking water.

During a county collection program, people can bring in, generally at no cost, household hazardous materials. In cooperation with private hazardous waste management companies, county workers record and pack hazardous waste in drums for shipment.

Some of the material can eventually be rendered safe by hazardous waste management companies using various chemical, physical, and/or biological techniques. Some can be recycled (e.g., motor oil and solvent). Some must be shipped, at a high cost, out of state for disposal in a hazardous waste landfill or high temperature incinerator. Washington State currently has no hazardous waste landfill or incinerator.

If you participate in a county program and take your household hazardous waste to a collection site, your waste will be safely handled. It will be transported for treatment, long-term storage, or disposal in an out-of-state hazardous waste landfill or incinerator.

Where Will It End Up
Household Hazardous Waste Disposal Choices

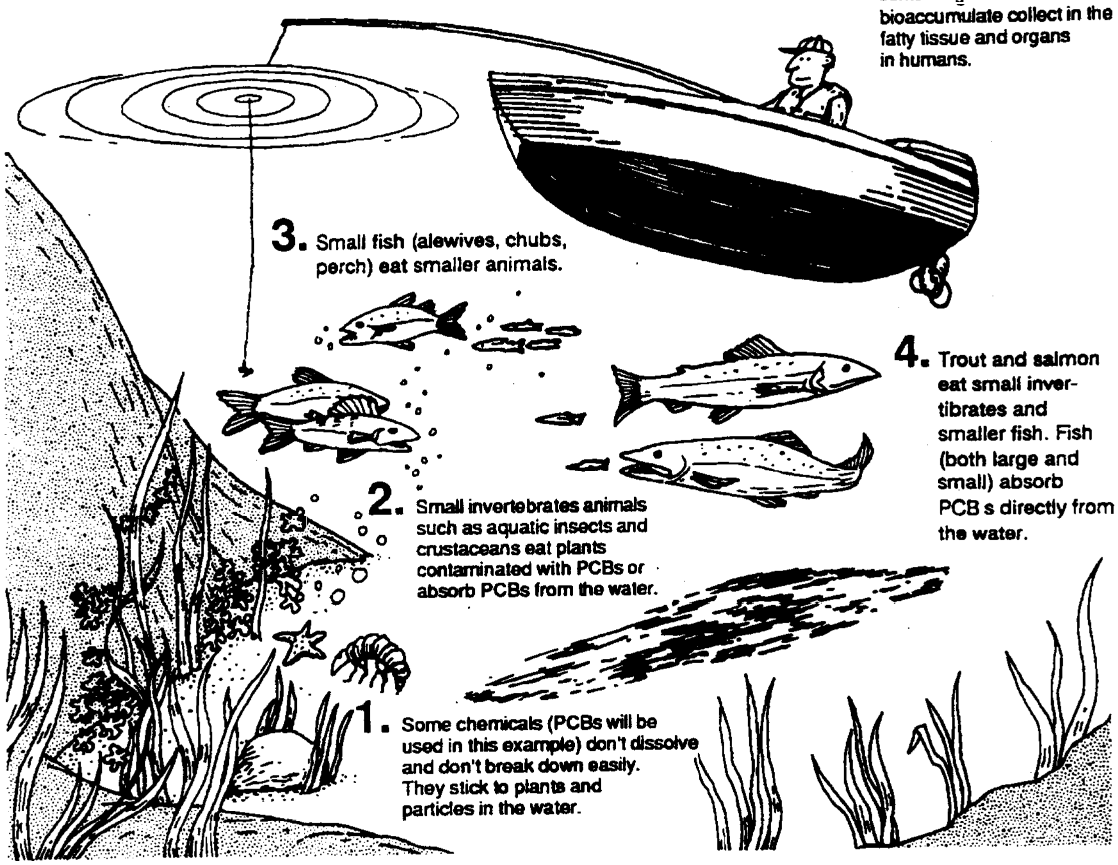
Incineration, Storm Drain/Ditch/Hole in Ground, Sink/Toilet, Garbage Can, Household Hazardous Waste Community Collection

Disposal Choice ___________________

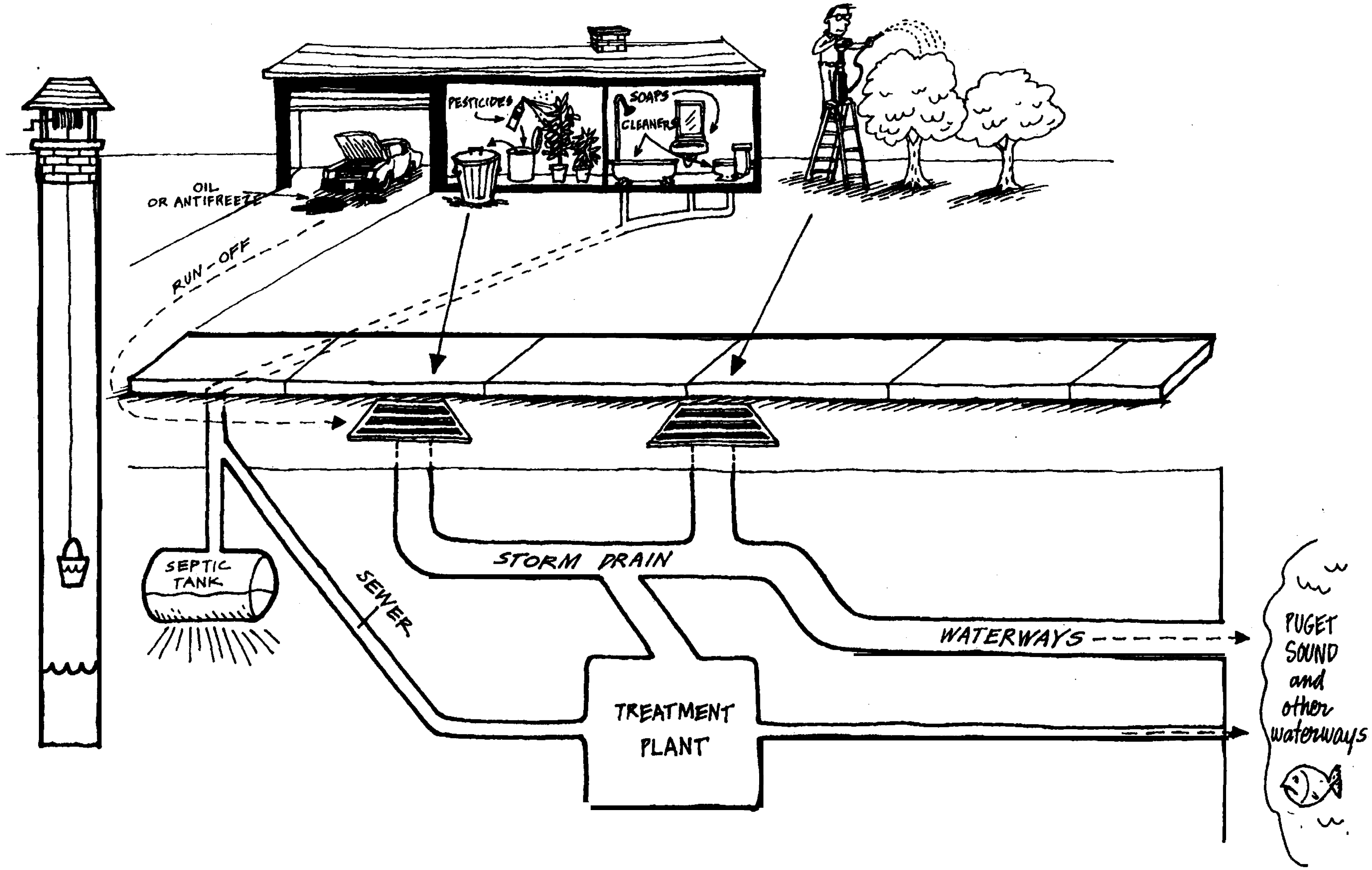
Product	Air	Water	Wildlife	Land	Other
1. Paint Thinner					
2. Motor Oil					
3. Weed Killers					
4. Aerosols					
5.					
6.					

List as many possibilities as you can. If the disposal option can lead to pollution in the water, say what kinds of water (streams, ground water, etc.).

Bioaccumulation



Routes To The Environment



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Glossary

absorption - A process in which one material (the absorbent) takes up and retains another (the absorbate) with the formation of a homogenous mixture having the attributes of a solution. Chemical reaction may accompany or follow absorption.

acetone - A solvent and thinner for paint, varnish, and lacquer, also used to clean and dry parts of precision equipment. Very flammable and volatile liquid. Explosive. Moderately toxic if inhaled.

acid rain - Rain that forms when certain pollutants, such as sulfur dioxide and oxides of nitrogen, mix with water vapor. It is acidic and falls to the earth as snow, rain, and fog.

air impairment - Unhealthy levels of air pollutants necessitating burn bans. Local air quality authorities may declare air impairments based on monitored levels of pollution and weather forecasts.

Air Quality Index (AQI) - Also known as the Pollution Standards Index. This is a scale (0-500) developed by the government to measure how much air pollution is in the air. It is often used in weather reports.

alloy - A homogenous mixture of two or more metals.

aluminum - A silvery nonferrous metal found in the ore bauxite. It is used in making hard, light, corrosion-resistant materials.

alveoli - Tiny air sacs in the lungs where the exchange of gases with the bloodstream takes place.

ambient air - The surrounding air (excluding indoor air).

antidote - A remedy that counters the effects of a poison.

aquifer - A porous layer of rock that carries a usable supply of ground water.

area source - A pollution source not confined to one point, but spread out in a large geographical area. Area sources include automobiles, wood stoves and small businesses.

bauxite - The claylike ore from which most aluminum is made.

biodegradable - The property of a substance that allows it to be broken down by microorganisms into simple, stable compounds such as carbon dioxide and water.

bioaccumulation - The process in which certain substances, like pesticides or heavy metals, work their way into a river or lake, move up the food chain, and are eaten by aquatic organisms, which in turn are eaten by birds, mammals, or humans. The substances become more and more concentrated in tissues and internal organs as they move up the chain.

bottom ash - The ash residue (unburnables) remaining on the grates or in the combustion chamber of the incineration or energy recovery facility.

BTU - British Thermal Unit. A measurement of heat: the amount of heat needed to raise the temperature of one pound of water 1 degree Fahrenheit.

calorie - The amount of heat energy needed to raise the temperature of one gram of water by 1 degree Centigrade at standard atmospheric pressure.

capillary attraction - The attractive force between two unlike molecules that causes a liquid to rise.

capillary water zone - That soil zone in which underground water is held above the water table by capillary attraction.

carbon dioxide (CO2) - A colorless, odorless gas given off by animals and humans, and used by plants. It is also created when fossil fuels burn.

carbon monoxide (CO) - A colorless, poisonous gas formed when carbon-containing fuel is not burned completely. Sources include vehicle emissions, industry and wood burning. Related to respiratory and heart disease.

catalytic converter - A device in cars that reduces air pollution by changing harmful pollutants into water and carbon dioxide.

caustic - Capable of corroding, burning, dissolving, or otherwise eating away by chemical action.

caustic soda - (See SODIUM HYDROXIDE)

chemistry - Science of the composition, structure, properties, and reactions of matter.

chlorine - Used in the manufacture of many chemicals, as a disinfectant for swimming pools, hot tubs, etc., in shrink-proofing wool, and in drinking water purification. A pungent and very reactive gas. Has been used as a military poison in chemical warfare. Very dangerous in contact with ammonia, turpentine, ether, and some other chemicals.

chlorinated - (1) Containing chlorine atoms as part of the chemical structure, as in chlorinated hydrocarbons or chlorinated solvents. (2) Addition of chlorine to drinking water to kill infectious bacteria or to oxidize undesirable compounds.

chlorofluorocarbons (CFCs) - A family of gases used as coolants for refrigeration and air conditioning, solvents, blowing agents for foam insulation and various other purposes. They are the chief agent responsible for the depletion of the high altitude ozone layer that protects us from the sun's ultraviolet rays.

clitellum - The thickened, glandular, saddlelike portion of the body wall of earthworms.

commercial waste - Waste from all nonresidential sources.

commodity - A commercial article, produced specifically for sale and profit.

compost - As a noun, the humuslike organic product generated from composting. As a verb, to decay.

composting - The microbial degredation of organic matter into a useful product.

conservation - The preservation and protection of natural resources from loss or waste.

consumer - A person who buys goods or services for his own needs and not for resale or production of other goods for resale.

contaminate - To adversely affect the quality of air, water, or soil by contact or mixture with a substance.

corrode - To eat into or wear away gradually, as by rusting, or by the action of chemicals.

corrosive - A chemical agent that reacts with or attacks the surface of a material causing it to deteriorate or wear away.

criteria pollutants - A category of pollutants identified by EPA for which standards for protecting human health have been set. Includes carbon monoxide, nitrogen dioxide, sulfur dioxide, ozone, particulate matter and lead.

cycle - To circle, return, or occur again.

decibel - A unit of the intensity of sound. A measurement of 50 dB is considered to be moderate, 80 dB loud. At intensities over 100, sound becomes intolerable.

decompose - To decay, rot, come apart, change form, break down into simpler components.

dioxin - A commonly used name for the tetra chloro form of a family of compounds, basically dibenzo-para-dioxins. Tests on laboratory animals indicate them to be among the most toxic man-made chemicals known. Have been found to be contaminants in some commercial products.

disinfectant - A physical process or chemical that kills pathogenic (disease-causing) organisms in water. Chlorine is often used to disinfect sewage treatment effluent, drinking water supplies, wells, and swimming pools.

disposal - The discharge, deposit, injection, dumping, incineration, leaking or placing of any waste into or on any land, air, or water.

drop box - Facility used to collect self-hauled waste or recyclable separated materials from individuals and businesses.

dump - To throw away garbage or solid waste.

dumps - Now illegal, dumps were open, unsanitary disposal sites used prior to sanitary landfills.

ecology - The interrelationships between organisms and their environment.

ecosystem - A system made up of a community of animals, plants, and bacteria and the physical and chemical environment with which it is interrelated.

emission check program - A program of the Air Quality Program that tests motor vehicles to ensure that all factory installed emission control systems are working properly. The emission check program identifies the most polluting vehicles and requires the proper repair of these vehicles.

emission inventory - A data bank of air pollution statistics, identifying the type, size and location of various pollution sources. Categories include point sources and area sources.

energy - The capacity to perform work or produce a change from existing conditions.

energy recovery - The recovery of energy in a usable form from mass burning or refuse-derived fuel incineration, pyrolysis, or any other means of using heat of combustion of waste.

energy recovery facility - A plant that generates energy by burning waste.

environment - All the conditions, circumstances, and influences affecting the development or existence of organisms.

EPA - Environmental Protection Agency, a federal agency responsible for environmental concerns.

Federal Clean Air Act - The first major legislation to target air pollution. First passed in 1963, with subsequent revisions in 1970, 1977, and 1990.

ferrous metals - Iron and alloys containing iron, generally magnetic.

flammable - Easily started on fire, capable of burning rapidly.

fly ash - Noncombustible residual particles from the combustion process, carried by smoke, air, and flue gas. In correct procedures, fly ash is prevented from escaping from the incinerator by air pollution control devices like scrubbers or precipitators.

functional standards - Criteria for solid waste handling expressed in terms of expected performance.

garbage - All waste considered worthless and thrown away.

glass - Any of a large class of materials that solidify from a molten state without crystallization, and are generally transparent or translucent. A recyclable and durable material.

global warming - A predicted increase in climatic temperature due to increased carbon dioxide levels from cars, power plants, and industry.

greenhouse effect - Heat trapped in the atmosphere by carbon dioxide and other gases. Altered weather patterns and rising sea levels may result.

Gross National Product (GNP) - The total market value of all the goods and services produced by a nation during a specified period.

ground water - The supply of fresh water found beneath the earth's surface, in cracks and crevices in stone, and in spaces between pieces of gravel and grains of sand. Usually in aquifers, which supply wells and springs.

hazardous (dangerous) waste - Those wastes which cause special problems because they are poisonous, explosive, corrosive of metal or skin, harbor disease-causing microorganisms, are radioactive, or are dangerous for any other reason(s).

household hazardous waste - Waste substances from a home that have any hazardous characteristics.

hydrocarbons - Toxic compounds found in fossil fuels that contain carbon and hydrogen. Some are capable of causing cancer. A type of volatile organic compound.

impermeable - Not permitting water or another fluid to pass through.

incineration (solid waste) - Reducing the volume of solid wastes by use of an enclosed device using controlled flame combustion.

incinerator - A furnace, boiler, kiln, etc. for burning wastes under controlled conditions.

ingestion - To take into the body, usually by swallowing.

inorganic - Composed of matter that is not animal or vegetable not having the organized structure of living things.

interface - A shared boundary, at which one substance, component, or system comes into contact with another.

inversion - An atmospheric condition in which a layer of warm air traps a layer of cooler air next to the ground, trapping pollutants near the ground and preventing the air from dispersing.

ions - Particles that have a positive or negative charge due to having an unequal number of protons and electrons.

irritant - A substance that causes pain, inflammation, annoyance, or soreness upon contact or when breathed.

landfill - A disposal facility at which solid waste is placed on or in land. (See SANITARY LANDFILL)

leachate - Liquid that has percolated through solid waste and/or been generated by decomposition of solid waste. Contains dissolved, extracted, or suspended materials. This liquid may contaminate ground or surface water, and is especially a problem in areas of high rainfall and porous, sandy-gravelly soil.

lead (Pb) - A heavy gray metal found in gasoline, paints, plumbing, etc. Exposure can affect the nervous system.

litter - Waste materials carelessly discarded in an inappropriate place. Litter is waste out of place.

manifest - A list of cargo hauled on a truck, airplane, ship, etc.

methane - A colorless, odorless, flammable gaseous hydrocarbon present in natural gas and formed by the decomposition of carbonaceous matter. Can be used as a fuel.

mnemonic - A formula, rhyme, jingle, or another device used as an aid to memorize something.

mobile source - A moving source of air pollution, such as cars and trucks.

monomer - (1) A simple molecule which is capable of combining with a number of other molecules into a long chain to form a polymer.

mutation - An inheritable alteration of the genes or chromosomes of an organism.

National Ambient Air Quality Standards (NAAQS) - Primary and secondary standards set at a national level for criteria pollutants. The purpose of these standards is to protect human health.

natural resources - A material source of wealth, occurring in nature, such as timber, fresh water, wildlife, or a mineral deposit.

nitrogen cycle - The continuous cyclic progression of chemical reactions in which atmospheric and other nitrogen sources are compounded, dissolved in precipitation, deposited in soil, assimilated and metabolized by bacteria and plants, consumed by animals, and returned to the atmosphere by organic decomposition.

nitrogen oxides - Gases produced by high temperature combustion in cars, industry and power plants furnaces. One of the major components of acid rain and smog.

nonattainment area - An area designated by EPA in which National Ambient Air Quality Standards are exceeded.

nonferrous metals - Metals and alloys which contain no iron, such as aluminum, copper, brass, and their alloys.

nonrenewable resources - Natural materials which, for one reason or another (scarcity, the great length of time required for their formation, their rapid depletion rate, etc.) are considered to be finite and exhaustible.

nonreturnable - A container that is not accepted by the retailer or supplier for refilling.

opacity - A relative measurement of how much a view is blocked by smoke. It is expressed as a percentage. State law limits opacity from wood stoves and fireplaces to 20%.

open burning - The combustion of material of any kind in an open fire or in an outdoor container (such as a burn barrel), except for agricultural and silvicultural fires.

Operating Permit Program (Title V) - A renewable permit program for industrial and commercial sources of air pollution. The program is required by federal law. It lists in one document all the requirements concerning air emissions that apply to any source that is subject to the program.

organic - Living or once living material.

organic gardening - Gardening with fertilizers consisting only of naturally occurring animal and/or plant material, with no use of man-made chemicals or pesticides.

oxides of nitrogen - See nitrogen oxides.

oxygenated gas - Gasoline that has an added ingredient, either ethanol or methyl-tertiary-butyl ether (MTBE), that increases the amount of oxygen in the fuel blend. This increased oxygen makes the combustion process more complete, reducing carbon monoxide emissions.

ozone (O_3) - A poisonous, bluish gas form of oxygen, which is the result of chemical reactions between volatile organic compounds and nitrogen oxides. Destroys crops and impairs breathing.

ozone layer - The layer of the upper atmosphere in which a relative concentration of ozone absorbs a significant amount of in-coming potentially hazardous ultraviolet radiation.

packaging - A commodity's wrapping, sealing, or container often designed to attract purchasers as well as to protect a product.

paper - A thin material made of cellulose fiber pulp, derived mainly from wood. Paper can be recycled many times before its fibers become too short for reuse.

particulate matter (PM_{10}) - Airborne particles resulting from wood stove burning, outdoor burning, road dust and industry, which can get in lungs and impair the respiratory system.

pest - A nuisance plant or animal that is capable of interfering with the living environment.

pesticide - Any substance used to kill nuisance organisms.

petroleum - A naturally occurring flammable liquid solution of hydrocarbons of organic origin used to make such products as natural gas, gasoline, lubricating oils, and plastic.

pH - A scale numbered from 0 (acidic) to 14 (alkaline) used to measure the degree of acidity or alkalinity in a substance. Acid rain has a pH of less than 5.6.

plastic - Any of a large class of complex organic compounds formed by polymerization; capable of being molded or cast into various shapes and films.

plume - Visible smoke emitted from smoke stacks or chimneys.

point source - Identifiable pollution sources such as large industries that emit significant levels of air pollutants in a particular geographic location.

pollution - Contamination of air, soil, or water by the discharge of wastes or other harmful substances.

polymers - A large molecule containing a chain of chemically linked subunits called monomers.

pollution - The contamination of soil, water, or the atmosphere by the discharge of wastes or other harmful materials.

potency - The strength or concentration of a substance.

propellant - A substance added to an aerosol formulation that assists in the ejection of the product from the container.

rationale - A statement or explanation of fundamental reasons.

reactive - Tending to participate in reactions. (See REACTION)

reaction - The mutual action of substances undergoing chemical change, and the state resulting from such changes.

recycle - The collection and reprocessing of manufactured materials for reuse either in the same form or as part of a different product.

recycling center - A site where manufactured materials are collected and resold for reprocessing. Types of recycling centers include: 1. Buy-back: a center where the recycler pays for materials. 2. Donation: a center where the recycler accepts donated materials. 3. Drop-off: an unattended donation station.

reduction, waste - Reducing the amount of waste by careful buying, less wasteful practices, or reusing materials.

refuse-derived fuel - A solid fuel obtained from municipal solid waste that has been processed to improve its combustion characteristics.

renewable resource - Natural resource which can be renewed or regenerated by natural ecological cycles or sound management practices, such as trees and water.

resin - Any of a class of solid or semisolid organic products, natural or man-made, with no definite melting point, generally of high molecular weight.

resource recovery - A general term used to describe the extraction of economically usable materials or energy from wastes.

respiratory system - A body's system for breathing, including the nose, throat, and lungs.

reuse - To extend the life of an item by cleaning it and using it again as is, repairing or modifying it, or by creating new uses for it.

sanitary landfill - A specially engineered site for disposing of nonhazardous solid waste on land. The site is constructed so that it will reduce hazards to public health and safety. Under federal law, a sanitary landfill must have an impermeable lower liner to block the movement of leachate into ground water, a leachate collection system, gravel layers permitting the control of methane, and other features. Waste is spread in layers, compacted to the smallest practical volume, and covered at the end of each operating day.

saturated - Completely filled, loaded to capacity.

SIP - State Implementation Plan, a plan the state adopts to ensure that state air quality objectives are met.

sludge - Any semisolid, heavy waste deposit, sediment, or mass that precipitates in a sewage system, septic tank, or municipal sewage treatment operation.

smog - A term originally coined to mean a combination of smoke and fog. Now used commonly to refer to pollution in the air caused by hydrocarbon and oxides of nitrogen in the presence of sunlight (low level ozone).

sodium hydroxide - (lye/caustic soda) A corrosive chemical, irritating to eyes, skin, and mucous membranes used in making soap and detergents, synthetic textiles, paper, aluminum, and in refining vegetable oil.

solid waste - Regularly collected wastes from households, institutions, agriculture, industry, and commercial establishments. May contain liquid and nonliquid substances which may be hazardous.

solid waste management - The systematic administration of activities which provide for the collection, source separation, storage, transportation, transfer, processing, treatment, and disposal of solid waste.

solution - A mixture in which the components are uniformly dissolved (homogenous), do not separate on standing, cannot be separated by filtration.

source separation - The separation of different kinds of solid waste at the place where the waste originates. Sorting out recyclable materials from nonrecyclables in business, household, or school waste.

stationary source - An industrial smoke stack or other non-moving source of air pollution.

stratosphere - The atmospheric layer which lies over the troposphere and is 25 miles from the surface of the Earth.

surface water - All water naturally open to the atmosphere: lakes, rivers, ponds, streams, reservoirs, other inland waters, and saltwater bays, sounds, estuaries, etc.

sulfur dioxide (SO_2) - A gas or liquid resulting from the burning of sulfur-containing fuel. May cause breathing problems.

suspension - A nonhomogenous mixture that separates into layers if allowed to stand, and is either translucent or opaque.

synergy (synergism) - That property of an association or combination in which the total effect, production, or action of the components working together exceeds that of the sum of the individual ingredients or members working independently.

thermodynamics - The science concerned with the relations between different forms of energy, and the conversion of one into another.

throwaway - A disposable waste item, not designed for reuse or recycling.

toluene - Used in gasoline blending, and in the manufacture of paints and solvents, plastic toys and model airplanes, explosives (TNT), saccharin, and other products. Flammable and a dangerous fire risk. Explosive. Toxic by inhalation or absorption through the skin.

toxic - Harmful, destructive, or deadly. Poisonous.

toxic air pollutants - Compounds which may induce cancer and/or other health problems at extremely low concentrations.

toxicant - A poison.

toxicity (acute) - The ability of a substance to cause poisonous effects soon after a single exposure or dose.

toxicity (chronic) - The capacity of a substance to cause long-term adverse effects upon human health.

transfer station - A permanent intermediate collection facility used by individuals and private or municipal haulers to transfer solid waste into a larger transfer vehicle for transport to another handling facility or to an ultimate disposal site. Transfer stations may include recycling facilities.

troposphere - The layer of atmosphere closest to the Earth's surface containing the air we breathe. It is about 10 miles thick.

unsecured load - Any material liable to fall or blow from a moving vehicle and become a hazard, litter, or debris upon a roadway.

vermicompost - Mixture of partially decomposed organic waste, bedding, worm castings, cocoons, worms, and other associated organisms.

vinyl acetate - A chemical used in latex paint, safety glass interlayers, paper coating, adhesives, and other uses. Very flammable and a dangerous fire risk. Toxic by inhalation and ingestion.

volatile organic compounds (VOCs) - Unstable or carbon-based compounds that, when combined with nitrogen oxides, will produce ozone.

volume - The capacity of a container: how much something can hold.

wildlife - Wild animals living in an undomesticated natural state.

worm castings - Worm manure: undigested material, soil, and bacteria deposited by worms.

worm cocoon - Structure formed by the clitellum which houses embryonic worms until hatching.

Appendix

Washington State Air Quality: A Status Report

Though Washington State continues to grapple with population growth and related air pollution problems, many areas showed an improvement in air quality during 1995. These improvements are expected to continue, based on trends from data collected over the last 25 years. Below is a look at current, historical and future trends in air quality in Washington State and what's being done to prevent and control air pollution

How do we measure progress in air quality?

Ecology and seven local air pollution control authorities around the state monitor for three pollutants which are of most concern in Washington: carbon monoxide, ozone and very small particulate matter (PM_{10}). Ongoing monitoring provides data which help determine the status of our air quality, identify the areas with the worst air pollution, identify where health risks may exist, and determine if strategies for controlling pollutants in various areas of the state are working.

Thirteen areas in Washington where air quality is monitored are "nonattainment areas" – areas designated by the U.S. Environmental Protection Agency as not meeting the federal health-based standards for one or more of these pollutants. The population, geography, and meteorology of each of these areas influence what air pollutant is a problem, what the *major sources are,* and what strategies are likely to succeed in controlling pollution. For example, population and the resulting traffic are the primary sources of carbon monoxide pollution in the Puget Sound area, while windblown dust is a major contributor to the PM_{10} problem in eastern Washington.

What are the health impacts?

Health impacts for individuals exposed to carbon monoxide, ozone and PM_{10} range from minimal effects to short-term reduction in lung functions to cancer and respiratory problems. Air pollution has the greatest impact on individuals experiencing cardiovascular or respiratory disease, children and the elderly in addition to its health impacts, air pollution causes problems with visibility, odors and deposition.

How is data collected?

Ecology's air monitoring network is established with the intent of finding out how bad the air is in areas of the state with the worst air quality. The number and location of air monitors may change each year based on changing conditions in an area. This is done to ensure that data are collected in areas of the state with high levels of pollutants. The highest pollutant levels in monitored areas were compared over time to determine air quality trends in each area.

What progress have we made?

Our progress in reducing air pollution is clear Data from air quality monitors show that levels of carbon monoxide, ozone and PM_{10} are improving markedly in many areas across the state. Of the 13 nonattainment areas, 11 are now monitoring air quality that meets federal standards. The Spokane PM_{10} area and the Spokane carbon monoxide area are the two lingering problem areas.

Todays strategies for addressing air pollution are significantly different from some of the first strategies implemented 25 years ago. At that time, the main focus of air pollution controls was industry. Through the 1970s and '80s, air pollution from industry was reduced by more than 90 percent due to increased awareness, regulation and technological advances. As businesses took steps to prevent and reduce their emissions of air pollutants, it became clear that the major sources of air pollution were shifting to individuals and their lifestyle choices. Current control strategies and our progress in cleaning up the air are summarized below:

- **Carbon monoxide:** Carbon monoxide has been one of our state's biggest problems in terms of air pollution. In 1977, for example, carbon monoxide levels exceeded the standard 403 times in Spokane alone. In 1995, carbon monoxide levels exceeded the standard 5 times – and continued progress is expected.

  Data collected from 1975 onward show a clear and dramatic downward trend in carbon monoxide pollution, due in part to programs such as vehicle emission inspection, oxygenated gasoline andcommute trip reduction, as well as tighter new car performance standards.

- **Ozone:** Since 1975, ozone levels have remained fairly consistent – hovering very close to the federal standard in spite of population increases and the accompanying increase in motor vehicle use. At its worst in 1978, ozone exceeded the standard 23 times in the Puget Sound area. In 1995, ozone levels did not exceed the standard. Progress in reducing ozone pollution is due in part to vehicle emission inspection, gasoline vapor recovery and federal motor vehicle and motor vehicle fuel programs.

  However, because ozone is weather-related (hot, sunny days are required for ozone to be formed from a combination of hydrocarbons and nitrogen oxides), ozone trends are erratic.

- **PM_{10}:** In 1985, PM_{10} levels exceeded the standard 43 times, with observations above the standard occurring in Puget Sound, Yakima and Spokane. In contrast, PM_{10} levels did not exceed the standard in 1995. However, trends show a continuing PM_{10} problem in Spokane and the Tri-Cities and Wallula areas. PM_{10} remains a pollutant of concern here due largely to wood stove use and outdoor burning in the central Washington area, and to the unpredictability and lack of controls for windblown dust in eastern Washington. Despite this, PM_{10} levels are on the downturn. Strategies being implemented to address the problem include programs to limit wood stove use and outdoor burning, road paving, and controls on major industrial sources.

The future: Challenges ahead

Continuing growth in Washington means more development, more people . . . and more potential for pollution. Largely due to population growth and increased use of cars, the actions and choices of individuals have much more impact on air quality to&y than ever before. Today, the leading source of air pollution is motor vehicles, followed by wood stoves, industry and outdoor burning. In the face of these challenges, our goal for the future is to maintain acceptable levels of air quality. As carbon monoxide, ozone and PM_{10} are brought under control, we will begin investigating and addressing any remaining pollutants that could pose threats to human health and the environment.

For more information

For more information on air quality trends and what you can do to prevent and control air pollution, please contact Pat Bailey Norman at the Department of Ecology at (360) 407-6841.

The Department of Ecology is an equal opportunity agency and does not discriminate on the basis of race, creed color, disability, age, religion, national origin, sex, marital status, disabled veteran's status, Vietnam Era veteran's status or sexual orientation.

If you have special accommodation needs or require this document in alternative format, please contact Pat Bailey Norman at (360) 407-6841 (voice) or (360) 407-6006 (TDD only).

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Focus

Redesignating Nonattainment Areas

Background

Areas that have experienced persistent air quality problems have been designated by the U.S. Environmental Protection Agency (EPA) as nonattainment areas. Each nonattainment area is declared for a specific pollutant. Nonattainment areas for different pollutants may overlap each other or share common boundaries. The federal Clean Air Act requires additional air pollution controls in these areas.

Several of the nonattainment areas in Washington now appear to be meeting the federal health-based standards for outdoor air quality. This apparent compliance with the federal standards does not automatically bring an area's nonattainment designation to an end. The federal Clean Air Act requires the state to follow an extensive process to prove that the nonattainment designation should be removed. The basic federal requirements are:

- The national outdoor air quality standards have been attained.
- EPA has approved the State Implementation Plan for bringing the area into attainment.
- The state must prove to EPA that the improved air quality is due to permanent and enforceable reductions in pollutant emissions.
- EPA has approved a state/local maintenance plan, including a contingency plan, that will keep the area's air quality within the standards.

Meeting the standards

To be considered for redesignation, a nonattainment area must not violate the following national outdoor air quality standards:

- **Fine particulate matter and ground level ozone:** No more than an average of one exceedence of the standard per year in a consecutive three-year period.
- **Carbon monoxide:** No more than one exceedence of the standard each year during a two year period. (No averaging is allowed; there can't be two exceedences one year and none the next.)

These data must be the result of actual monitoring. Ecology must demonstrate the monitoring equipment was located in places likely to experience the highest concentrations of the pollutant. EPA also requires a computer modelling analysis to show that monitoring did occur in high concentration areas and to support Ecology's case that the standard has been met.

The nonattainment area plan

Ecology must complete and obtain EPA approval of the State Implementation Plan for the nonattainment area. Ecology must complete the federal planning process before fully addressing other redesignation requirements.

April 1996

F-AIR-94-01

"Real" pollution reductions

Ecology must prove that the air quality improvements are permanent and *enforceable. They* must not be attributable to unusually favorable weather conditions or such factors as economic downturns that resulted in less traffic and industrial activity.

Maintenance plan

For an area to be redesignated, EPA must approve **a** maintenance plan. Ecology must outline the measures that will be used to keep the area's air quality within the federal standard for 10 years after redesignation. Circumstances will dictate whether fewer, the same or additional control measures will be required. The plan must describe measures that will be taken to correct violations of the air quality standards, if they occur. Ecology may submit the maintenance plan at the same time it petitions for redesignation.

Other requirements

Inventory

Ecology and local air quality agencies must prepare an inventory showing the sources of emissions and how much pollution they generate. Sources are things such as vehicles, wood stoves and commercial or industrial facilities that generate air pollution. Ecology must identify the maximum amount of emissions that can be allowed without violating the air quality standards.

Maintenance demonstration

Using a computer model, Ecology must demonstrate to EPA's satisfaction that the maintenance plan will keep air quality within the federal standards for 10 years, even if the number of pollution sources increases.

Monitoring

The state must continue its monitoring program. Ecology must submit a monitoring plan that will effectively show whether the federal standards are being maintained. The plan must allow for special studies in case traffic or other air pollution source patterns change. These studies could lead to new permanent monitoring sites if high pollution concentration areas change.

Verification

Ecology must submit its plan for verifying that the air quality standards are being maintained and enforced. This verification scheme must keep track of the maintenance plan. This can include updates to the inventory or the assumptions and inputs used for modelling.

Conclusion

The federal procedure for removing an area's nonattainment designation is detailed and extensive. The task of fully meeting these requirements and obtaining redesignation can be expected to take approximately two years for each area. Ecology and the local air quality agencies are working to gain redesignation in all areas that are meeting the outdoor air quality standards.

For more information

Doug Schneider **(360) 407-6874**
Unit Supervisor for nonattainment area planning

If you have special accommodation needs or require this document in alternative format, please contact Tami Dahlgren, Department of Ecology, (360) 407-6830 (voice); or (360) 407-6006 (TDD only).

Sources of Information about Air Pollution in Washington State

1.	**Olympic Air Pollution Control Authority** *(Clallam, Grays Harbor, Jefferson, Mason, Pacific, Thurston Counties)* 909 Sleater-Kinney Road SE, Suite 1 Lacey WA 98503-1128 Charles E. Peace, Executive Director *Telephone:* (360) 438-8768 or 1-800-422-5623 *Fax:* (360) 491-6308; *E-mail:* oapca@wln.com Internet: http://www.wln.com/~oapca	**2.**	**Department of Ecology Northwest Regional Office** *(San Juan County)* 3190-160th Avenue SE, Bellevue, WA 98008-5452 *Telephone:* (425) 649-7000 *Fax:* (425) 649-7098, *TDD:* (425) 649-4259
3.	**Northwest Air Pollution Authority** *(Island, Skagit, Whatcom Counties)* 1600 South Second Street Mount Vernon, WA 98273-5202 Terry Nyman, Air Pollution Control Officer *Telephone:* (360) 428-1617 *Telephone:* 1-800-622-4627 (*Island & Whatcom*) *Fax:* (360) 428-1620; *E-mail:* nwapa@pacificrim.net Internet: http://www.pacificrim.net/~nwapa	**4.**	**Puget Sound Air Pollution Control Agency** *(King, Kitsap, Pierce, Snohomish Counties)* 110 Union Street, Suite 500 Seattle, WA 98101-2038 Dennis J. McLerran, Air Pollution Control Officer *Telephone:* (206) 343-8800 or 1-800-552-3565 1-800-595-4341 *(Burn Ban Recording)* *Fax:* (206) 343-7522; *E-mail:* psapca@wolfenet.com Internet: http://www.psapca.org
5.	**Southwest Air Pollution Control Authority** *(Clark, Cowlitz, Lewis, Skamania, Wahkiakum Counties)* 1308 NE 134th Street Vancouver, WA 98685-2747 Robert D. Elliott, Executive Director *Telephone:* (360) 574-3058 or 1-800-633-0709 *Fax:* (360) 576-0925; *E-mail:* swapca@worldaccessnet.com Internet: http://www.swapca.org	**6.**	**Department of Ecology Central Regional Office** *(Chelan, Douglas, Kittitas, Klickitat, Okanogan Counties)* 15 West Yakima Avenue, Suite #200 Yakima, WA 98902-3401 *Telephone:* (509) 575-2490 *Fax:* (509) 575-2809, *TDD:* (509) 454-7673
7.	**Yakima Regional Clean Air Authority** 6 South 2nd Street, Room 1016 Yakima, WA 98901 Les Ornelas, Director *Telephone:* (509) 574-1410 or 1-800-540-6950 *Fax:* (509) 574-1411; *E-mail:* les@yrcaa.org (please also cc: tom@yrcaa.org and gar@yrcaa.org on e-mail inquiries)	**8.**	**Department of Ecology Eastern Regional Office** *(Adams, Asotin, Columbia, Ferry, Franklin, Garfield, Grant, Lincoln, Pend Oreille, Stevens, Walla Walla, Whitman Counties)* 4601 N. Monroe Street, Suite 202 Spokane, WA 99205-1295 *Telephone:* (509) 456-2926 *Fax:* (509) 456-6175, *TDD:* (509) 458-2055
9.	**Spokane County Air Pollution Control Authority** W 1101 College Ave, Suite 403 Spokane, WA 99201 Eric Skelton, Director *Telephone:* (509) 456-4727 *Fax:* (509) 459-6828; *E-mail:* scapca@iea.com	**10.**	**Benton County Clean Air Authority** 650 George Washington Way, Richland, WA 99352 Dave Lauer, Director Telephone: (509) 943-3396 Fax: (509) 943-0505 or 943-2232; *E-mail:* bccaa@3-cities.com Telephone: (509) 946-4489 *(Burn Ban Recording)* Internet: http://www.cbvcp.com/bccaa

Other Sources of Information about Air Pollution in Washington State

Washington State Department of Ecology
Air Quality Program
PO Box 47600, Olympia, WA 98504-7600
Telephone: (360) 407-6800
Fax: (360) 407-6802, *TDD:* (360) 407-6006
Internet: http://www.wa.gov/ecology/air/airhome.html

Pulp Mills, Aluminum Smelters
Department of Ecology - Industrial Section
PO Box 47600, Olympia, WA 98504-7600
Telephone: (360) 407-6916
Fax: (360) 407-6902

Department of Ecology Southwest Regional Office
PO Box 47775
Olympia, WA 98504-7775
Telephone: (360) 407-6300
Fax: (360) 407-6305, *TDD:* (360) 407-6006

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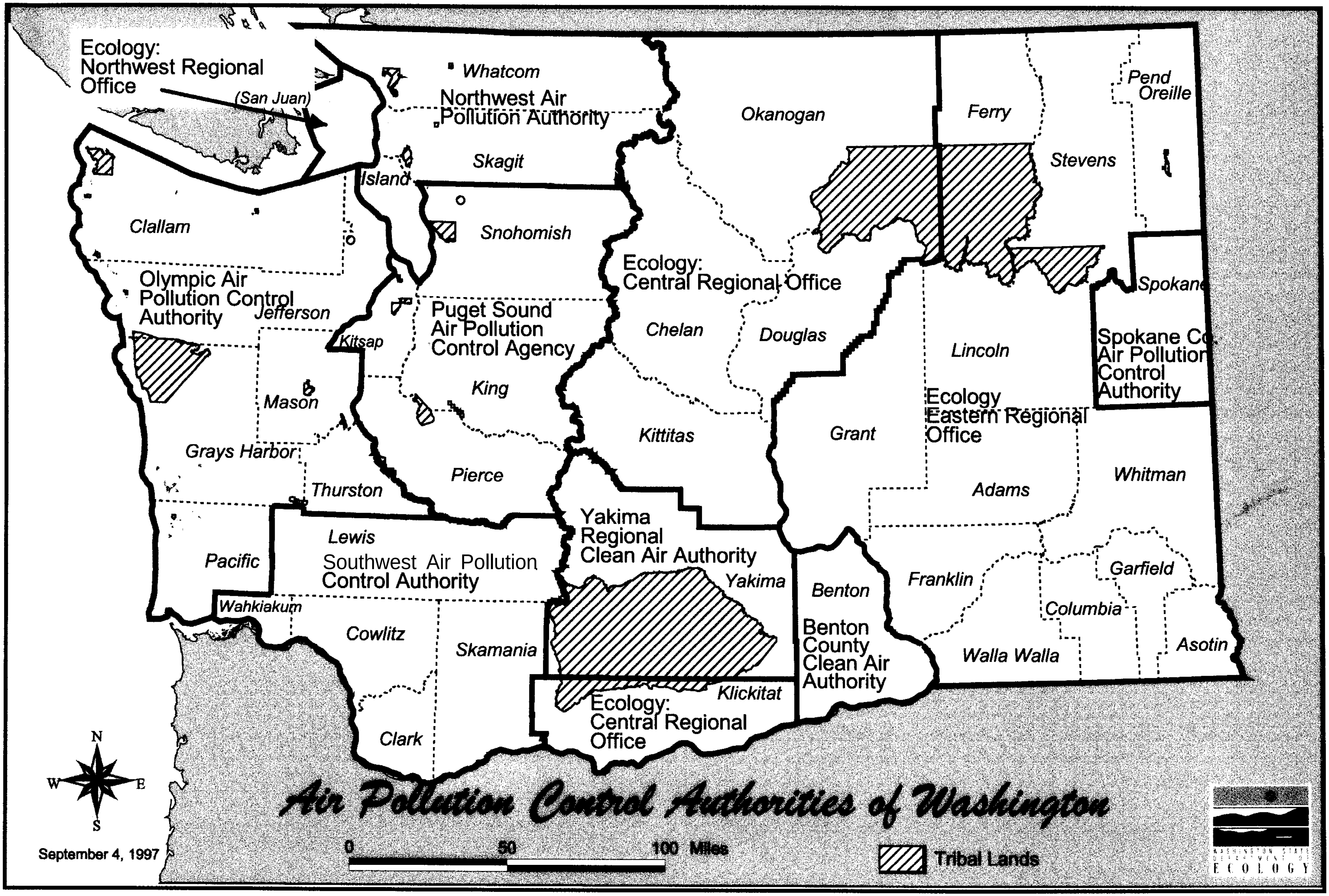

Ecology: Northwest Regional Office
(San Juan)
Whatcom
Northwest Air Pollution Authority
Skagit
Island
Okanogan
Ferry
Pend Oreille
Stevens
Clallam
Snohomish
Ecology: Central Regional Office
Olympic Air Pollution Control Authority
Jefferson
Puget Sound Air Pollution Control Agency
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ECOLOGY

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Focus

Major Air Pollutants

Carbon Monoxide

Background

You can't see it. You can't smell it, But more carbon monoxide gas dirties the air in Washington than any other pollutant. Carbon monoxide can cause headaches and drowsiness. It kills at very high concentrations. When you inhale carbon monoxide it takes the place of oxygen in the blood. The result: your body doesn't get enough oxygen.

Carbon monoxide is a by-product of all kinds of burning: motor vehicle engines, factory boilers, wood stoves and open burning. Motor vehicle exhaust is the leading source of carbon monoxide pollution. The number of motor vehicles in use and the miles traveled have been increasing faster than Washington's population.

Washington's urban carbon monoxide problem

The federal Environmental Protection Agency has declared four parts of Washington as areas where the concentrations of carbon monoxide in the air exceeds the national health-based standard. These locations are:

- The urban areas of western King, Pierce and Snohomish counties;
- Vancouver and souther Clark County;
- Spokane and its surrounding urban area;
- The Yakima-Union Gap area.

Motor vehicles account for at least half of the carbon monoxide pollution in all four areas. Most of the rest comes from wood stoves and fireplaces, industries, and outdoor burning, including forest slash fires and residential and commercial open burning.

Health effects

Carbon monoxide attaches to the red pigment, hemoglobin, which carries oxygen to body tissues. It then interferes with the hemoglobin's ability to supply tissues with the oxygen they need to function. Individuals most sensitive to carbon monoxide exposure are heart patients, people with lung problems and people with blood problems such as anemia.

Symptoms of carbon monoxide exposure may be increased length and frequency of episodes of chest pain for those with heart or other circulatory problems. Other people may experience headaches, dizziness, lack of concentration, fever or nausea. Mood swings, irritability or behavioral changes can also be symptoms of relatively low exposures to carbon monoxide. Higher exposures can result in aggressiveness, unconsciousness and death.

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Controlling carbon monoxide

The Clean Air Washington Act of 1991 provides new and better tools to control carbon monoxide pollution:

- **Vehicle inspections. The** current vehicle emissions testing programs in the Seattle and Spokane areas will expand to include more of Spokane and King counties and extend to parts of Snohomish, Pierce and Clark counties. Diesel vehicles will be tested too.
- **Oxygenated gasoline. Starting** November 1,1992, state regulations require that gasoline sold during the winter have more oxygen in the formula. This will ensure more complete combustion, which will reduce carbon monoxide emissions.
- **Reducing solo commuting.** Major employers in the largest counties will be required to reduce drive-alone commuting by their employees.
- **Transportation planning.** Transportation programs and projects must not make air pollution worse in areas with air pollution problems.
- **Wood stoves.** Tighter emission standards will apply to wood stoves sold in Washington. These standards will result in more efficient wood burning, which in turn will produce less carbon monoxide and other pollutants.
- **Industrial regulation.** Major industries will have to obtain operating permits, which must be updated and renewed every five years. In addition, the state must review and update the pollution control technology standards for carbon monoxide and other industrial pollutants on a five year cycle.
- **Outdoor burning.** Outdoor burning is being phased out in the urbanized parts of Washington.

For more information

Tami *Dahlgren* Outreach Specialist (360) 407-6830

If you have special accommodation needs or require this document in alternative format, please contact Ecology's Air Quality Program at (360) 407-6830 (voice) or (360) 407-6006 (TDD only).

Washington State Department of Ecology
P.O. Box 47600
Olympia WA 98504-7600

Focus

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Major Air Pollutants

Nitrogen Oxides

Background

Nitrogen oxides are gases composed of nitrogen and oxygen. Nitrogen dioxide (NO_2) is a public health concern. It is a suffocating brownish-colored gas and a strong oxidizing agent. It reacts easily with water vapor to form acid rain. Nitrogen oxide (NO) is more common but relatively less harmful However, nitrogen oxides emitted into the air are converted to nitrogen dioxide by photochemical reactions promoted by sunlight, and,eventually cause ozone (or smog) when combined with other air pollutants.

The main sources of nitrogen oxides are motor vehicles, power plants, industry, and solid waste and outdoor burning. Natural sources include volcanoes and forest fires.

Washington's nitrogen oxide problem

Washington does not exceed federal health-based standards for nitrogen oxides. However, nitrogen oxides are a major contributor to ozone pollution. The federal Environmental Protection Agency declared two areas of Washington state as locations where the concentration of ozone in the air exceeds the national health-based standard. More than half of Washington's residents live in these two areas. These areas are:

- Parts of Snohomish, King and Pierce counties, and
- Southern Clark County.

Health effects

Nitrogen oxide is not very toxic, but is rapidly converted to nitrogen dioxide which is toxic. At high concentrations, nitrogen dioxide can cause disturbance in the

- central nervous system,
- circulatory system, and
- enzymesystem.

Nitrogen dioxide can penetrate to the most remote portions of the respiratory tract because of its low solubility in water. At high concentrations it can be fatal. At lower concentrations it can irritate the lungs and lower the body's resistance to respiratory infections such as influenza, pneumonia and bronchitis.

As mentioned above, nitrogen oxides united with hydrocarbons and other volatile organic compounds form ozone or smog. Ozone can pose serious health problems. It can inflame and irritate breathing passages, reduce resistance to other illnesses and cause coughing and wheezing. For further information on ozone, see Ecology's Focus sheet FA-91-128.

Other effects of nitrogen oxides

In addition to their effects on human health, nitrogen oxides, through their role in producing ozone, also damage other organisms and materials. They can reduce the size of plants and produce leaf spotting. They also change the color of clothing dyes, cause fabrics to lose strength and corrode some metals.

Nitrogen oxides also produce a brown haze that impairs visibility. Ecology evaluates the potential of new sources to harm visibility and applies stringent emission limits to protect our state's scenic resources. Some federal lands (national parks and wilderness areas) have visibility standards that Ecology helps enforce.

In addition, nitrogen oxides contribute to acid rain. Washington has alpine lakes throughout the Cascade range that are sensitive to acid rain.

Controlling nitrogen oxides

The Clean Air Washington Act of 1991 tackles the air pollution problem in Washington State on many levels. The strategies of the Act to decrease the amount of nitrogen oxides and ozone in the air around us include:

- Reduction of traffic and the use of single-occupancy vehicles,
- **Reductions in slash and agricultural burning,**
- Permit program for industrial facilities, and
- Research into, and use of, alternative fuels.

More information

Ecology has prepared fact sheets on each major element of Clean Air Washington, as well as major pollutants, These are available from the Washington State Department of Ecology, PO Box 47600, Olympia, WA 98504-7600, or call:

Tami Dahlgren Outreach Specialist *(360) 407-6830*

If you have special accommodation needs or require this document in alternative format, please call Ecology's Air Quality Program at (360) 407-6830 (voice); or (360) 407-6006 (TDD only).

Washington State Department of Ecology
P.O. Box 47600
Olympia WA 98504-7600

Focus

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Major Air Pollutants

Ozone

Background

Ozone is a key component of smog. Ozone at ground level is different from the "good" ozone in the upper atmosphere that protects us from the sun's harmful rays. Ground level concentrations pose a risk to human, animal and plant life.

Ground level ozone comes from the interaction of ultraviolet rays from sunlight on emissions from motor vehicles, industry, solvents and gasoline fumes. It is formed on warm sunny days when two kinds of pollutants mix in the air: gases or vapors of chemicals called volatile organic compounds and nitrogen oxides. Most ozone pollution occurs in late spring, summer and early fall, when the days are longer and there's enough sunlight to heat the chemicals.

Western Washington's ozone problem

More than half of Washington's residents live in areas of the state where the level of ozone in the air exceeds the federal health-based standard. These areas include all of King and Pierce counties, part of Snohomish County and southern Clark County.

The central Puget Sound region did meet the standard in 1985, but by 1988 the area's growth in population and motor vehicle use overwhelmed efforts to keep ozone in check.

Ozone's sources

Most of the air pollutants that form ozone come from many small sources spread over a wide area. Nearly two-thirds of these emissions come from motor vehicles. In addition, vehicle usage is growing two to three times faster than the rate of increase of Washington's population Land use, development and transportation patterns in these areas have fostered continued reliance on the private automobile for basic transportation.

Industry is a smaller contributor to the ozone problem than motor vehicles, but is still a significant source. The commercial, industrial and residential use of solvents add to ozone pollution Dry cleaners, gas stations, auto body paint shops, cleaning of mechanical and electronic parts, outdoor burning and house painting are examples of activities that commonly generate air pollutants that form ozone.

Health effects

Even though ozone is a form of oxygen it can pose serious health problems. Ozone can irritate and inflame the breathing passages in the lungs, throat, nose and sinuses. It can reduce resistance to infections, colds and other diseases. It can cause harmful changes in breathing passages, reduce the lung's working ability and can worsen existing conditions, such as asthma, bronchitis and emphysema.

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Ozone can cause cough, wheezing, chest tightness, dry throat, headache or nausea. People exposed to ozone can experience a tired feeling, shortness of breath or pain during deep breaths. Those at greatest risk are those who exercise heavily during periods of peak ozone concentrations, children, the elderly and those with existing lung or immune system problems.

Ozone's wide-ranging effects

Breezes often blow pollution form the big cities toward rural areas and the mountains. By the time this "urban air" arrives, the ozone can reach its highest concentrations. In fact, the Department of Ecology's ozone monitoring program has recorded its highest readings in the Cascade foothills. People downwind from urban areas during clear weather can be exposed to unhealthful concentrations of ozone in the air.

Ozone can also harm vegetation. The downwind areas that experience high ozone concentrations include some of Western Washington's agricultural areas. The U.S. Forest Service and the National Park Service report that ozone has damaged trees, moss and lichens in Mt. Rainier National Park and in Cascade forests and wilderness areas.

Materials damage attributed to ozone includes cracking of rubber products, weakening of textiles, changes in dyes and premature cracking of paint.

Controlling ozone

The Clean Air Washington Act of 1991 tackles the air pollution problem in Washington State on many levels. The Act requires us to decrease the amount of ozone in the air around us by:

- Motor vehicle inspections,
- **Reduction of traffic and the use of single-occupancy vehicles,**
- Research into and use of alternative fuels, and
- Permit program for industrial facilities.

In addition to the Clean Air Washington Act activities, Ecology and local air pollution control agencies have been pursuing strategies to control nitrogen oxides and volatile organic compounds, the main ingredients of ozone. These strategies include:

- **Gasoline vapor control,**
- Regulation of volatile organic compounds and toxic chemicals, and
- Review of permit applications of potential major air pollution sources.

For more information

Ecology has prepared fact sheets on each element of Clean Air Washington, as well as major pollutants. These are available from the Washington State Department of Ecology, PO Box 47600, Olympia, WA 98504-7600, or call:

Tami Dahlgren	Outreach Specialist	*(360) 407-6830*

If you have special accommodation needs, please call Ecology's Air Quality Program at (360) *407-6830* (voice); or (360) 407-6006 (TDD).

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Focus

Major Air Pollutants

Particulate Matter

Background

Particulate matter is particles of soot, dust and unburned fuel suspended in the air. The smaller particles, less than 10 microns, are a public health concern. Thousands of these tiny particles would fit on the period at the end of this sentence. Visible smoke is largely composed of these tiny particles. The particles cannot always be seen, since they are so small, but enough can still be present to threaten health.

Particulate matter is a product of many things: soil erosion, road dust, industrial wood waste boilers, wood stoves, slash fires, land clearing fires, agricultural burning and backyard burning. The federal government regulates particulate matter less than 10 microns in diameter as one of six major air pollutants for which health-based air quality standards have been set.

Health effects of particulate matter

Particulate matter larger than 10 microns in diameter collects in the upper respiratory system (throat and nose) and is eliminated by sneezing, coughing, spitting, or the digestive system. Smaller particulate matter is a much more serious health threat.

Your body cannot keep the smaller particulates out of your lungs. Tiny particles collect in the most remote portions of the lungs, called alveoli – the tiny air sacs where oxygen enters the blood stream.

Once in your body, the tiny particulate matter can cause structural and chemical changes deep in the lungs. These small particles can damage the alveoli and act as carriers for other toxic or carcinogenic materials. Damage can result in scarring, which reduces the ability of the lung to absorb oxygen Chronic diseases, such as emphysema, chronic bronchitis, cancer and cardiovascular complications of lung damage have been associated with exposure to fine particles. Death rates from these diseases in U.S. and European cities, have increased during pollution episodes which included increased levels of fine particles. Local studies have also shown a relationship between levels of particulate matter and lung capacity and hospitalization of asthmatic children. The levels affecting these children were below current health standards.

Pre-adolescent children, the elderly and people with pm-existing respiratory diseases are the most susceptible to health problems from particulate matter.

In addition to these health effects, particulate matter can cause damage to materials and can cause deposits on land and in water.

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Controlling particulate matter

The Clean Air Washington Act of 1991 tackles the particulate matter problem in Washington State on many levels. The Act requires us to decrease the amount of small particulate matter in the air around us through the following:

- A permit program for industrial facilities,
- Stricter wood stove regulations,
- Restricted backyard and land clearing fires,
- Reduction in slash burning and agricultural burning,
- Decreased traffic and decreased use of single-occupancy vehicles, and
- A permitting system to minimize unnecessary agricultural burning.

You can help decrease particulate air pollution by composting yard waste instead of burning it; using a form of heat other than wood heat or making sure your wood stove is burning cleanly; obeying all burn ban days; and using your car less. For more information on these topics, contact Ecology (see below).

Particulate matter standard may change

The federal and state governments have set a health-based limit for particulate matters, called a standard. This standard is set for particulate matter that is 10 microns in diameter and smaller (the period at the end of this sentence is about 500 microns in size). When monitoring data show that levels of particulate matter have exceeded the standard, various control measures are required, such as curtailing the use of wood stoves in some areas.

Increasingly, research is linking the smallest particles (those under 2.5 microns in diameter) to adverse health effects. Because of this research, the standard is being reviewed by the U.S. Environmental Protection Agency to ensure that public health is adequately protected. If a new standard addressing $PM_{2.5}$ is adopted, it may result in tougher restrictions on wood stoves, outdoor burning and industrial sources.

For more information

Ecology has prepared fact sheets on each major element of Clean Air Washington, as well as major pollutants. These are available from the Washington State Department of Ecology, PO Box 47600, Olympia, WA 98504-7600, or call the following Ecology staff:

Ann Butler	Southwest Regional Office	(360) 664-8965
Christine Sund	Eastern Regional Office	(509) 454-7845
Christine Sund	Central Regional Office	(509) 454-7845
Larry Altose	Northwest Regional Office	(360) 649-7192
Tami Dahlgren	Ecology Headquarters	(360) 407-6830

If you have special accommodation needs or require this document in alternative format, please call Tami Dahlgren at (360) 407-6830 (voice) or call (360) 407-6006 (TDD).

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Focus

Major Air Pollutants

Sulfur Dioxide

Background

Sulfur dioxide is a colorless liquid or gas with a very strong odor. It is one of the six air pollutants regulated by health-based standards of the federal government. Sulfur dioxide is produced by the combustion of fossil fuels at electrical power plants; industrial processes, such as copper smelting and pulp mills; and combustion in motor vehicle engines. Sulfur dioxide is most toxic when combined with small particles and moisture. The conversion of sulfur dioxide to sulfate particles is also considered a significant problem.

Sulfur dioxide in Washington State

Sulfur dioxide levels in Washington State have declined over the past ten years, probably due to the closure of the ASARCO smelter in Tacoma. However, the threat remains and violations of state standards are occasionally recorded near large industrial facilities. The coal-fired power plant near Centralia is a major contributor of sulfur dioxide in the state. Acid rain is a likely outcome should sulfur dioxide levels in Washington State increase.

Health effects

The major health concerns associated with high exposures to sulfur dioxide include effects on breathing and lung illnesses, changes in the lung's ability to defend itself, aggravation of existing respiratory and cardiovascular disease and death.

The people most sensitive to sulfur dioxide include asthmatics and individuals with chronic lung disease (such as bronchitis and emphysema) or cardiovascular disease, and people with allergies. Children and the elderly may also be sensitive. In persons with asthma, the clinical symptoms of brief exposure to low concentrations of sulfur dioxide are shortness of breath, wheezing and coughing.

People chronically exposed to sulfur dioxide have a higher incidence of persistent cough, shortness of breath, bronchitis, fatigue and colds of long duration. Research suggests that the federal standard is not protective of human health.

Other effects of sulfur dioxide

- Sulfur dioxide is one of the ingredients in the formation of acid rain. Acid rain acidifies lakes which destroys aquatic life and makes soil more acid. It can also damage building materials, cloth and metals.
- Sulfur dioxide can lead to decreased visibility because it causes a whitish haze.
- Sulfur dioxide can damage trees and agricultural crops. Some of these effects apparently occur at levels below the federal standard.

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Controlling sulfur dioxide

The Clean Air Washington Act of 1991 tackles the air pollution problem in Washington State on many levels. The strategies of the Act to decrease the amount of sulfur dioxide in the air around us include:

- **Permit program for industrial facilities, and**
- Reduction of traffic and the use of single-occupancy vehicles.

More information

Ecology has prepared fact sheets on each element of Clean Air Washington, as well as major pollutants. These are available from the Washington State Department of Ecology, PO Box 47600, Olympia, WA 98504-7600, or call:

Tami Dahlgren	Outreach Specialist	*(360) 407-6830*

If you have special accommodation needs, please call Ecology's Air Quality Program at (360) *407-6830* (voice); or (360) 407-6006 (TDD only).

Washington State Department of Ecology
P.O. Box 47600
Olympia WA 98504-7600

Focus

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Major Air Pollutants

Volatile Organic Compounds

Background

Volatile organic compounds (VOCs) are vapors released by cleaning fluids, degreasing agents, gasoline, paints and other widely used products. They include hydrocarbons, some toxic chemicals (diethyl sulfate, tetramethyl lead) and some carcinogens (benzene, vinyl chloride), They contain carbon and hydrogen and other elements, including oxygen, nitrogen, sulfur, chlorine and fluorine. They are in gaseous form at normal atmospheric conditions.

Volatile organic compounds in Washington State

The federal Environmental Protection Agency has found two areas of Washington State where the concentration of ozone (caused by nitrogen oxides and volatile organic compounds) in the air exceeds the national health-based standard. More than half of Washington's residents live in these two areas. These areas are:

- Parts of Snohomish, King and Pierce counties, and
- Southern Clark County.

Health effects

As a group. volatile organic compounds are a concern because they interact with nitrogen oxides in the presence of sunlight to form ozone and other smog.

Ozone can pose serious health problems. It can inflame and irritate breathing passages, reduce resistance to other illnesses and cause coughing and wheezing, headaches and nausea. People who are exposed to ozone can experience a tired feeling, shortness of breath or pain during deep breaths. (See Ecology's Focus sheet on nitrogen oxides, FA-92-30 and Ozone FA-91-128).

Individually some volatile organic compounds are toxic chemicals. They are irritants and neurotoxins that can cause headaches and the inability to concentrate. Some of the important toxic volatile organic compounds are:

- Toluene, a common component of printing inks, paints and solvents, can affect the nervous system. It is emitted into the outside air from such businesses as plastic wrapper printing facilities and painting operations.
- Trichloroethylene, a solvent commonly used to clean and degrease metal aircraft and other mechanical parts, is a probable human carcinogen.
- Perchloroethylene, a cleaning agent used by dry cleaners, is a probable carcinogen.

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Other effects

In addition to their effect on human health, volatile organic compounds, through their role in producing ozone, also damage other organisms and materials. Ozone can reduce the size of plants and cause leaf spotting. It can change the color of clothing dyes, cause fabrics to lose strength and corrode some metals.

Both the National Park Service and the U.S. Forest Service have expressed concerns regarding existing levels of ozone in the Cascade Mountains and the possible effects to the national parks and wilderness areas.

Controlling volatile organic compounds

The Clean Air Washington Act of 1991 tackles the air pollution problem in Washington State on many levels. The Act requires us to decrease the amount of volatile organic compounds and ozone in the air around us by:

- **Reductions of traffic and the use of single-occupancy vehicles,**
- Permit program for industrial facilities,
- Research into and use of alternative fuels, and
- **Permitting programs to reduce outdoor burning.**

In addition, Ecology and local air pollution control agencies have been pursuing strategies to control nitrogen oxides and volatile organic compounds.

For more information

Ecology has prepared fact sheets on each major element of Clean Air Washington, as well as major pollutants. These are available from the Washington State Department of Ecology, PO Box 47600, Olympia, WA 98504-7600, or call:

Tami Dahlgren	Outreach Specialist	*(360) 407-6830*

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Olympia WA 98504-7600

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Clean Air Washington

The Clean Air Washington Act of 1991 sets a comprehensive new course toward cleaner air throughout the state.

Agricultural Burning

Background

The Clean Air Washington Act addresses air pollution from many sources. Programs have been put into place to reduce pollution from motor vehicles, industrial sources and wood stoves as well as outdoor burning.

The problem

Farmers use fire to dispose of the stubble, or "straw" left in the field after harvest and to dispose of trees when an orchard is "pushed up" for replanting. Burning is also used to control weeds and plant diseases. For certain crops--most notably grass seed--farmers use fire to stimulate the yield. An estimated 3,000 to 5,000 agricultural fires are set each year in Washington, with up to 600,000 acres thought to be burned. While often only a few hours in duration, these fires produce substantial amounts of smoke, containing small particles. These small particles can be inhaled deep into the lungs and lodge there, causing structural and chemical damage.

Agricultural burning, in combination with other types of outdoor burning, accounts for more than 10 percent of Washington's annual air pollution and a much higher percentage of eastern Washington's air pollution. Ecology, local air pollution control agencies and other environmental and health organizations receive hundreds of complaints each year regarding health problems and impaired visibility associated with agricultural burning.

In order to reduce air pollution from agricultural burning, a special advisory committee made up of members of the agricultural community and others worked for over two years to write a regulation. The goal of this regulation is to eliminate unnecessary burning without overly restricting the agricultural industry.

In addition, the Agricultural Burning Practices and Research Task Force, comprised of agricultural experts, regulators and medical representatives, is charged with setting fees, recommending research priorities and establishing best management practices.

When to get a permit

By law, permits are required for all farm burning except orchard prunings; natural vegetation along fencelines, irrigation or drainage ditches; or natural vegetation blown by the wind (i.e. tumbleweeds). In areas where the state administers the program, permits will be required for agricultural burning totalling 10 acres or more per year. The same is true where the state has delegated the program to a conservation district, county or fire district. (The program may differ slightly in areas under the jurisdiction of local air pollution control authorities.)

The fee for a permit is a maximum of $2.50 per acre. It could be lower in some years in some locations depending upon research and administrative needs. In 1995 the fee was set at $2.00 per acre. The fee pays for research into alternatives to burning and local permit program administrative costs.

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Best Management Practices

The Agricultural Burning Practices and Research Task Force developed best management practices (BMPs) for each major category of agricultural crops. BMPs help in determining when burning is necessary and when it is not. The permit application will ask questions that can be answered by referring to the BMPs. BMPs may be changed periodically to reflect changes in the industry and research results. For more information about BMPs contact Pat McGuire, Department of Ecology, (509) 456-3121.

Getting a permit to burn on the farm

In many areas, the agricultural burning permitting program will be administered by a local air pollution control agency, the county, a fire protection agency or the local conservation district. In areas where no local agency opts to run the program, the state Department of Ecology will issue permits. For more information about how to get a permit, call:

Central Washington:

Donna Smith, Yakima — l-800-501-01 14 or (509) 454-7660

Eastern Washington

Pat McGuire, Spokane — l-800-406-5322 or (509) 456-3121

Or call your local air pollution control authority:

Eastern Washington:

In Spokane County, call the Spokane County Air Pollution Control Authority at (509) 456-4727.

In Benton County, call the Benton County Clean Air Authority at (509) 946-0865.

In Yakima County, call the Yakima County Clean Air Authority at (509) 575-4116.

Western Washington:

In King, Kitsap, Pierce, and Snohomish counties call the Puget Sound Air Pollution Control Agency at (206) 689-4053.

In Island, Skagit and Whatcom counties call the Northwest Air Pollution Authority at (206) 428-1617.

In Clallam, Grays Harbor, Jefferson, Mason, Pacific, and Thurston counties call the Olympic Air Pollution Control Authority at (206) 438-8768.

In Clark, Cowlitz, Lewis, Skamania, Wahkiakum counties call the Southwest Air Pollution Control Authority at (206) 574-3058.

If you have special accommodation needs or require this document in an alternative format, please contact Tami Dahlgren at (360) 407-6830 (voice) or (360) 407-6006 (TDD only).

Clean Air Washington

WASHINGTON STATE DEPARTMENT OF ECOLOGY

The Clean Air Washington Act of 1991 sets a comprehensive new course toward cleaner air throughout the state.

Forest Slash Fires

Slash burning

Timber land managers use slash burning to dispose of logging residue after trees are harvested. Current law requires forest land managers to obtain a burning permit. The Department of Natural Resources (DNR) and Ecology monitor weather conditions so that fires are set when smoke will blow away from population centers and scenic areas. The permits require fir control and containment measures.

Slash fires can smolder for days and release substantial amounts of smoke. In some cases, individual slash fires release more pollution in several hours than some large industrial plants do in a year. Each year in Washington, logging operations set more than 1,000 slash burns, burning more than 800,000 tons of wood, on more than 50,000 acres.

DNR has practices that minimize slash burning. Since 1980, DNR has reduced slash burning on its lands by over 90%. Slash is now burned on less than five percent of the acres harvested each year, significantly below the industry average.

The Problem

Slash burning is only one of many kinds of outdoor burning. Outdoor burning also includes leaf and yard waste burning and controlled burning of farm fields. Outdoor fires account for more than 10 percent of Washington's annual air pollution:

- 255,000 tons of carbon monoxide;
- 20,000 tons of volatile organic compounds, which contribute to ozone pollution;
- 26,000 tons of p articu late m atter; as well as
- toxic air pollutants.

These fires are burned in the drier months, resulting in higher emissions at those times. This magnifies the effects of outdoor burning beyond its 12 percent share of total state air pollution. Air quality levels can exceed federal health standards in areas affected by outdoor burning, especially from larger fires, or when dispersion of smoke by wind or rain is poor. Particulate pollution -tiny particles suspended in the air -from outdoor burning contributes to the smoke haze that obscures Washington's scenery. This harms a visual resource that is vital to the state's tourism industry.

What Clean Air Washington does

- Reduces slash burn emissions through a phased approach, based on 1985-89 averages:
  - 20 percent by the year 1995; and
  - 50 percent by the year 2001.
- Directs DNR to develop and implement a plan to achieve the reductions, beginning in July 1992.

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- Declares that the emission reduction requirements apply to all forest land — including federal — in Washington.
- Directs DNR to encourage alternative disposal methods in the following priority:
  - production of less slash;
  - better use of slash;
  - disposal without burning; and
  - slash burning.
- Requires DNR to establish a slash burning permit fee to cover the cost of permit system administration and enforcement.
- Declares that slash burning shall not damage public health or the environment.
- Requires DNR to coordinate the issuance of slash burning permits with local air quality authority rules. DNR may not permit slash burning during an air pollution episode or an air quality impairment.

For more information

Ecology has prepared fact sheets on each major element of Clean Air Washington. Any or all of these are available from the Washington State Department of Ecology, PO Box 47600, Olympia, WA 98504-7600, or call:

Tami Dahlgren Outreach Specialist *(360) 407-6830*

If you have special accommodation needs or require this document in alternative format, please contact Ecology's Air Quality Program, (360) 407-6830 (voice); or (360) 407-6006 (TDD only).

Washington State Department of Ecology
PO Box 47600
Olympia, Washington 98504-7600

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Focus

The Clean Air Washington Act of 1991 set a comprehensive new course toward cleaner air throughout the state.

Open Burning

What is open burning?

People use outdoor fires for many purposes. Home owners burn leaves. Firefighters learn and practice their skills with training fires. Contractors burn debris at demolition and construction sites. And, of course, people use fire as a part of outdoor recreation for cookouts and campfires.

The types of burning listed above are classified as "open burning," which is one of three kinds of outdoor burning. The others are agricultural and silvicultural (forest land) burning. Open burning is the combustion of material of any kind in an open fire or in an outdoor container (such as a burn barrel) except agricultural and silvicultural fires. These fires have different permitting systems. Other exceptions to this rule are ceremonial fires, recreational fires, and special cases where ecosystems are dependent on fire.

The problem

Outdoor burning releases carbon monoxide, particulate matter, and volatile organic compounds into the air. Carbon monoxide is a gas that interferes with the body's ability to absorb oxygen. It can cause headaches, drowsiness, and even death at high concentrations. Particulate matter is made up of tiny particles of soot, dust, and unburned fuel suspended in the air. Visible smoke is largely composed of these particles. Chronic diseases such as emphysema, asthma, chronic bronchitis and cancer have been linked to exposure to fine particulate matter. Volatile organic compounds contribute to the formation of ozone pollution. Ozone can irritate and inflame the breathing passages in the lungs, throat, nose, and sinuses. It can cause coughing, wheezing, chest tightness, dry throat, headaches, or nausea. Outdoor burning is also known to release toxic air pollutants. Much of this pollution is released during half of the year, making its impact more concentrated.

The Open Burning rule

The Clean Air Washington Act passed by the legislature in 1991 required new regulations for open burning. The purpose of these regulations is to reduce emissions from burning of yard, garden, residential or commercial, demolition/construction, and land clearing debris by using reasonable alternatives. Following state law, the rule bans open burning in areas that do not meet federal health-based air quality standards (nonattainment areas) for pollutants released by open burning. The rule establishes conditions for when burning can occur, and requires permits for burning in areas of the state where burning is still allowed. In addition, it calls for a ban on open burning by the year 2001 in "urban growth" areas and cities with a population of 10,000 or more.

Implementation

Phase-out: The new rule allows for a "phase-out" (instead of an immediate ban) approach in nonattainment areas where alternatives to open burning are not yet available. These areas are still required to meet federal Environmental Protection Agency deadlines for nonattainment areas.

Permit program: The law identifies potential permitters for the open burning program. They include conservation districts, fire protection authorities, counties, Ecology, and local

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air pollution control agencies. Under regulations adopted in 1992, Ecology and local air pollution control agencies will work in cooperation with these groups to develop model permit and response programs to be implemented locally if the local agency chooses. In some cases, local jurisdictions may choose to let the state administer the program.

Reasonable Alternatives: The law requires the state to support and encourage the use of economical and reasonable alternatives to open burning. The rule defines reasonable alternatives as those costing less than $8.50 per cubic yard of waste. As alternatives become available locally, open burning will be banned in some areas.

Prohibited materials

Open burning of the following materials is prohibited by law:

- Garbage
- Asphalt
- Plastics
- Paper
- Metal
- Construction debris
- Rubber products
- Petroleum products
- Dead animals
- Treated wood
- Cardboard
- Any substance other than natural vegetation which, when burned, releases toxic emissions, dense smoke, or obnoxious odors

For more information

Ecology has prepared fact sheets on each major element of the Clean Air Washington Act. These are available from the Washington State Department of Ecology, P.O. Box 47600, Olympia, WA 98504-7600.

Telephone inquiries may be directed to:

Ann Butler
Air Quality Program, Olympia (360) 407-6334

Christine Corrigan
Air Quality Program, Yakima (509) 454-7845

Larry Altose
Air Quality Program, Bellevue (206) 649-7192

If you have special accommodation needs, please contact Tami Dahlgren at (360) 407-6830 (voice); or (360) 407-6006 (TDD only).

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Focus

Open Burning: Prohibited Materials

Background

Until recently, burning was a common way to dispose of trash such as paper, cardboard and junk mail. Although burning of garbage has been prohibited since 1974, some people still consider it an acceptable practice. However, with increasing population growth, burning of any prohibited materials such as garbage or plastic has become recognized as a significant health risk and public nuisance.

Prohibited materials

State law (Chapter 70.94 RCW) banned outdoor burning of certain materials in 1974. Those prohibited materials include:

- Garbage
- Rubber products
- Asphalt
- Any substance that emits dense smoke or obnoxious odors (other than natural vegetation)
- Petroleum products
- Plastics
- Dead animals

In January 1993, rules were adopted adding the following specific materials which are also prohibited:

- Paper
- Treated wood
- Metal
- Cardboard
- Construction debris
- Any substance which when burned releases toxic emissions, dense smoke or obnoxious odors (other than natural vegetation)

The only materials that may be legally burned in an outdoor fire are dry, natural vegetation and, in some cases, clean, dry, untreated, unpainted wood that is not construction debris.

Note: **Regardless of the material, outdoor burning is banned altogether in some areas and is prohibited during certain times of the year in others. Check with your local air pollution control authority or fire protection district.**

Health effects

Medical research has shown that air pollution causes lung damage. The smoke from burning wood and natural vegetation contains more than 100 chemical compounds and three major types of pollutants. These include carbon monoxide, volatile organic compounds and particulate matter. If you burn prohibited materials such as plastics, painted wood or garbage, additional toxic compounds are emitted. These may include dioxin, furans, benzene, formaldehyde and polycyclic aromatic hydrocarbons. Many of these chemicals are known carcinogens.

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These toxic chemicals attach themselves to small particles in the smoke. The health risks associated with inhaling small particulate matter are made worse when the particles are carrying a load of toxic molecules. These small particles go deep into the lungs.

Burn barrels

Burn barrels should not be used, even for burning natural vegetation. The design of burn barrels restricts the flow of oxygen to the fire, resulting in excessive amounts of smoke. In addition, these fires are a hazard because embers can smolder and drift long after the flames have died.

Open burning of natural vegetation

The 1991 Clean Air Washington Act protects air quality in Washington. One way it does this is by requiring new regulations for open burning. Following state law, the regulation bans open burning in areas that do not meet federal health-based air quality standards (nonattainment areas) for pollutants released by open burning (particulate matter and carbon monoxide). The rule establishes conditions for when burning can occur, and requires permits for burning in areas of the state where burning is still allowed. In addition, it calls for a ban on open burning by the year 2001 in "urban growth" areas and cities with 10,000 or more residents.

Alternatives to burning

Consider chipping large prunings and mulching or composting your food and garden waste. Recycle paper, plastic, glass, aluminum and metal. For information on recycling call 1-800-RECYCLE or your county's solid waste division. For waste that can't be recycled, use a garbage collection service or haul to the local landfill. Disposing in a landfill is not an ideal alternative; the best way to handle the problem of garbage is to create less of it. Buy durable products rather than disposable ones and look for recycled products and packaging.

For more' information

For open burning rules in eastern Washington, call tollfree l-800-5723973. For more information on prohibited materials or open burning, contact the following Ecology staff:

In eastern Washington:

Christine Sund **(509) 454-7845**
Central Regional Office

In western Washington, contact your local air pollution control agency.

If you have special accommodation needs, please call Christine Sund at (509) 454-7845 (voice), or Tami Dahlgren at (360) 407-6830 (voice); or call (360) 407-6206 (TDD).

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Focus

Outdoor Burning
Legislative Changes

In 1995 the Washington State Legislature passed Engrossed Substitute House Bill 1080, which changed the air pollution requirements for open or residential burning and agricultural burning.

Open burning changes

Open burning is residential or land clearing burning of vegetative material. The legislature removed the requirement for residential burning permits in rural areas of any county with fewer than 50,000 people living in unincorporated areas. The rural area of a county is defined as being outside the urban growth area determined under Growth Management Act planning, or the unincorporated area of a county which does not plan under the Growth Management Act.

Where are open burning permits required?

Residential burning:

Permits for residential burning are still required in urban areas of all counties, and in rural areas of the following counties:

Clark	King	Kitsap
Pierce	Snohomish	Spokane
Thurston	Whatcom	Yakima

Land clearing burning:

Permits for land clearing burning are still required in all counties

Agricultural burning changes

The legislature removed the requirement for permits and fees for burning of orchard prunings, organic debris along fence lines or irrigation or drainage ditches, and organic debris blown by wind. However, burning of these materials remains prohibited during air pollution episodes or any stage of impaired air quality.

Next steps

The Department of Ecology will need to revise the state's open and agricultural burning regulations (Chapter 173-425 Washington Administrative Code and Chapter 173-430 Washington Administrative Code) to reflect the changes made by the legislature. Because formal rule-making will take some time, Ecology will be working with local air pollution control agencies during the next few months to develop an interim policy on burning. The interim policy is intended to provide guidance to Ecology, local air pollution control agencies, local governments, and the public on the implementation of the revised law.

August 1995

95-1003-Air

For more information

Jim Crawford (360) 407-6862
Department of Ecology

Stu Clark (360) 407-6873
Department of Ecology

If you have special accommodation needs or require this document in alternative format, please call Tami Dahlgren, Air Quality Program, (360) 407-6830 (voice) or (360) 407-6006 (TDD only).

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Focus

Controlling Wood Smoke Pollution

Background

Washington's wood heat regulation implements the 1991 Legislature's Clean Air Washington Act. The 1991 legislation restricts indoor burning and emphasizes education and enforcement to control wood stove pollution.

Pollution from Wood Smoke

Nearly half of Washington's households have wood burning devices. During the past 15 years the number of wood stoves, fireplaces, pellet stoves, and fireplace inserts in Washington State has grown rapidly. Wood burning units can emit hundreds of times more pollution than other forms of heat such as natural gas, electricity, or oil.

Heating with wood accounts for about 12 percent of Washington's air pollution on an annual basis. The impact of this pollution is much larger for two reasons:

- Virtually all of it is released during winter months. It takes just half the year for wood smoke to become Washington's third leading source of air pollution.
- A common feature of Washington's winter climate is stagnant air. Wood smoke does not disperse under such conditions. It is trapped near the ground and accumulates in the neighborhood air.

Seven areas in Washington exceed federal health standards for particulate air pollution. Particulate is the fine matter that makes up smoke and soot.

Wood Smoke and Health

The smoke from wood burning devices can cause serious health problems. Breathing air containing wood smoke contributes to cardiovascular problems; lung diseases like asthma, emphysema, pneumonia and bronchitis; irritation of the lungs, throat, sinuses and eyes; headaches; and allergic reactions. Those with the greatest health risk from wood smoke include infants and children, pregnant women and people with lung and heart diseases.

There are hundreds of chemical compounds in wood smoke, including many that are irritating and potentially cancer causing. Wood smoke pollutants include nitrogen oxides, carbon monoxide, organic gases and particulate matter. University of Washington studies show decreased lung function and increased respiratory disease in both healthy and asthmatic children exposed to wood smoke in some Seattle neighborhoods.

Particulate matter may be the most insidious component of wood smoke pollution. Most of the particles are so small that when inhaled they get past the hairlike cilia that protect the air passages of the lungs. The tiny particles are called PM_{10}. They are less than one one-hundredth of a millimeter across. They lodge in the deepest part of the lungs, where the blood takes on oxygen The particles can cause structural and biochemical changes, including scarring of the tissue. Many of the particles are toxic. Death rates in several U.S. cities have been shown to increase with higher levels of PM_{10} in the air.

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Washington's Wood Smoke Control Program

The 1991 Legislature established a program to help protect the public from wood smoke pollution, especially in residential areas. The Clean Air Washington Act of 1991 tightened emission standards for new wood stoves and other solid **fuel** burning devices.

The current program

- **Bans installation of uncertified stoves after January 1,1992.**
- **Requires non-wood heat sources after July 1,1992 in new** or substantially remodeled construction in urban areas or areas that don't meet federal air quality standards for particulates. This is so that wood is not the sole source of adequate heat.
- **Wood fuel must have a moisture content of 20 percent or less.** Wood that is split, then dried for at least a year, usually meets this requirement. (For a free plan to build a wood storage shed, see Ecology publication M-62, 'Woodshed Design.")
- **Prohibited materials.** Garbage, treated wood, particle board, plastics, rubber, animal carcasses, asphalt products, paint, chemicals or any substance which normally emits dense smoke or obnoxious odors may not be burned in a wood stove or fireplace.
- **Smoke density is restricted. The** maximum smoke plume opacity (how much you can't see through the smoke) is 20%, except six minutes stoking time per hour, and **20** minutes every four hours for fire starting. This is to ensure that people give enough air to their fires to promote efficient fires and less pollution.
- **Tighter emission standards for new certified stoves and fireplace inserts sold at retail in Washington. Stack** emissions of new certified models are limited to:
  - 4.5 grams of particulates per hour for non-catalytic models.
  - **2.5** grams per hour for catalytic models (stoves with catalytic converters built in).
  - Stoves with at least a 35-to-1 air/fuel ratio are "non-affected;" they burn relatively cleanly already (almost all are pellet stoves) and do not require certification to be sold in Washington
  - Look for the EPA Emission Certification label, or check Ecology's list of certified stoves (available at no cost by calling l-800-523-4636).
- **Local bum bans are called when wood smoke pollution is measured at unsafe levels. This is a two stage plan**
  - Stage 2: The use of all uncertified wood heating devices-including fireplaces-is prohibited **when** pollution approaches unhealthful levels (an average of 75 micrograms of fine particulates per cubic meter of air over 24 hours, or an average eight parts per million of carbon monoxide over eight hours). Certified and non-affected stoves may be operated.
  - Stage 2: All wood heating-including certified and non-affected devices-is prohibited when pollution reaches a higher threshold (a 24hour average of 105 micrograms of fine particulates per cubic meter of air).

  Homes with no other source of adequate heat are exempt from these bans. Adequate heat means a system that can maintain a temperature of 70 degrees Fahrenheit three feet off the floor, when the heater is operating as designed.
- **$30 fee on the sale of new wood stoves and fireplaces. This supports state and local** air pollution control agency wood stove education and enforcement programs.

Changes still to come under Clean Air Washington

- **Sets emission standards for new masonary and** factory built fireplaces.

After January 1,1997, all fireplaces offered for sale in Washington must meet certification standards comparable to the 1990 wood stove standards. Masonry fireplaces must also meet design standards that achieve similar emission reductions. The State Building Code Council will devise fireplace construction standards and testing methods to meet this emission requirement.

State Air Pollution Episodes

The Department of Ecology's four step Air Pollution Episode Plan no longer affects indoor burning at the first step, or Forecast level. If an Episode reaches the Alert, Warning or Emergency level, Ecology can curtail the use of wood heat. The Alert level has not been called since 1981 and this applied only to downtown Tacoma. The Warning and Emergency levels have never been put into effect.

Only outdoor burning is banned under the Forecast level of a State Air Pollution Episode. Indoor burning may only be curtailed locally under the two stage program described above, based on instrument measurements of air quality.

Uncertified Stove Bans as a Contingency Measure

The 1991 legislation authorizes a local air quality authority or Ecology to prohibit the use of uncertified stoves if:

- the U.S. Environmental Protection Agency finds and shows in writing that an area has **failed to make reasonable progress in meeting federal health-based air quality**

Low income persons, certified and most pellet stoves, and fireplaces would be exempt from the ban

Tips for Cleaner Burning

The most complete and effective way to reduce wood smoke pollution is to use another form of heat. If you must use wood, or choose to do so when local rules permit, the following recommendations can help diminish the emissions from your wood stove, fireplace or fireplace insert:

- Only burn dry, seasoned wood. Be sure your firewood has been split and dried for at least one year.
- Never burn wet, painted, stained or treated wood, color newsprint, plastic, garbage, diapers or magazines. Items such as these produce high amounts of odor, smoke and toxic fumes.
- Store your firewood under cover. A shed or shelter is best. If you use a plastic tarp, allow ventilation to prevent condensation. Easy plans for a shelter can be requested over the Information Line: 1-800-523-4636.
- Burn small, hot fires. This helps the wood burn completely and cleanly.
- Never allow the fire to smolder. Smoldering fires are the worst polluters because they burn at a temperature too low for efficient combustion. The result is more smoke – unburned wood going up the chimney, wasted.
- Do not damper too much. Allow enough air for the wood to burn fully, without smoldering. Never try to keep the "fire" going overnight by cutting back the air supply. This wastes wood, produces much smoke and creosote and produces little heat.
- Step outside and look at the plume from your chimney. You should see only heat waves. If you can see smoke, your wood is not burning completely. Increase the air supply to your fire.

- Size your wood stove properly. A stove that is too large for the space to be heated will have to be damped down, causing much smoke and wasting wood.
- Do not burn in moderate temperatures. Your stove will tend to overheat your house. You will want to close the dampers to cut back on the heat, which cuts oxygen to the fire, wastes wood and increases pollution.
- Proper stove installation is very important Even the least polluting certified stoves will not function well if the installation does not meet the specification for each model. (This is not the same as safety specifications, which also must be followed.)
- Don't install a wood stove until you've considered other ways to cut heating costs. Insulating and weather stripping can cost less than a stove and will reduce your heating requirements, whether your heat source is wood, oil, gas or electricity. Many cities, counties, housing authorities and utilities offer conservation and weatherization programs in the form of grants, low-interest or interest-free loans, and free weatherization materials and installation
- Don't install an uncertified stove – installation of uncertified stoves is illegal. These stoves are more polluting. They may be banned in some counties after June 30,1995.

For More Information

- **Ecology Wood Smoke Information Line: 1-800-523-4636. You can** leave a message to ask questions and request more written material about Washington's wood smoke program.
- Washington **State Energy Office Hotline:** Specialists can answer your energy questions, including inquiries on wood heat. Many free publications are available, with topics ranging from home insulation and solar water heating to sizing and installing wood stoves. l-800-962-9731.
- Local **Air Pollution Control Authorities:**
  - **Puget Sound Air Pollution Control Agency, serving King, Snohomish, Kitsap and Pierce Counties, 1-800-552-3565, (206) 343-8800. For recorded information on indoor burning restrictions call: 1-800-595-4341.**
  - **Olympic Air Pollution Control Authority, serving Thurston, Clallam, Grays Harbor, Jefferson, Mason and Pacific Counties, (360) 438-8768, 1-800-422-5623. When in the local radio area, tune in 530 AM for indoor burn ban information.**
  - **Southwest Air Pollution Control Authority, serving Clark, Cowlitz, Lewis, Skamania and Wahkiakum Counties, (360) 574-3058, 1-800-633-0709.**
  - **Northwest Air Pollution Authority, serving Skagit, Whatcom and Island Counties, (360) 428-1617, or 1-800-622-4627 (Island and Whatcom counties only).**
  - **Spokane County Air Pollution Control Authority, (509) 456-4727.**
  - **Yakima County Clean Air Authority, (509) 574-1410**
  - **Benton County Clean Air Authority, Richland, (509) 946-4489.**
  - **Ecology's Central Regional Office, serving Chelan, Douglas, Kittitas, Klickitat and Okanogan Counties, (509) 575-2490.**
  - **Ecology's Eastern Regional Office, serving Adams, Asotin, Columbia, Ferry, Franklin, Garfield, Grant, Lincoln, Pend Oreille, Stevens, Walla Walla and Whitman Counties, (509) 456-3114.**

If you have special accommodation needs, please call (360) 407-6832 (voice) or (360) 407-6006 (TDD only).

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Focus

Episodes and Impairments

Overview

Air Pollution Episodes and Air Quality Impairments are programs designed to protect the public from unhealthy levels of air pollution. The state Department of Ecology carries out the Episode program. Local air quality agencies administer Air Impairment programs. In most cases, Episodes restrict only outdoor burning, including residential yard debris fires, burn barrels, land clearing fires, forest slash fires and agricultural burning. Impairments affect outdoor and indoor burning, including fireplaces, wood stoves, fireplace inserts and pellet stoves.

Air Stagnation

Air stagnation is similar to being in a closed room with no ventilation. It is difficult to breathe comfortably until a window is opened, or a fan is turned on.

The air over the state can work the same way. When air movement is limited or becomes "stagnant," air pollutants can become concentrated or "trapped" in certain areas. The air and pollutants cannot move or circulate out of these areas.

Stagnant air conditions usually occur when a large high pressure system settles over the Pacific Northwest. Air movement is restricted as the surface air becomes cooler than the air above. These conditions cause dust, wood smoke, carbon monoxide, sulfur dioxide and other air pollutants to accumulate at increasing levels close to the ground. These conditions most often occur during the late fall and winter.

Air Impairments

Local air quality authorities may declare air impairments based on monitored levels of pollution and weather forecasts. There are two stages of these impairments. All outdoor burning is prohibited during either stage. For indoor burning, there are differences between the two stages:

Stage One

A stage one air impairment is declared when PM-10 particulates (particles less than one one-hundredth of a millimeter across, suspended in the air) are measured at an average of at least 75 micrograms per cubic meter of air over 24 hours, or when carbon monoxide is measured at an average of eight parts per million over eight hours.

- During a stage one air impairment, the use of fireplaces and *uncertified* stoves and fireplace inserts is prohibited unless wood is the only source of adequate heat.

Stage Two

A stage two air impairment is declared when PM-10 particulates are measured at an average of at least 105 micrograms per cubic meter of air over 24 hours.

- During a stage two air impairment, use of *all* wood stoves, fireplaces, fireplace inserts and pellet stoves—certified or not—is prohibited, unless wood is the only source of adequate heat.

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Air Pollution Episode Program

The state Air Pollution Episode Program has four stages which are determined by Ecology depending on pollution levels and current and predicted weather conditions.

Forecast Stage

A Forecast stage is declared by Ecology when meteorological data indicate that stagnant weather conducive to the build-up of air pollutants will persist for at least 24 hours. Forecast stages are generally declared for relatively large areas (statewide, Eastern Washington, Western Washington, or specific counties).

During a Forecast stage:

- All outdoor burning, including slash burning, is prohibited and all existing outdoor fires must be extinguished.
- No new burning permits will be issued.

In previous years the Forecast stage meant a ban on wood **heat** devices. This is no longer the case, due to legislation passed in 1990 and implementing rules adopted in March, 1991.

Alert, Warning and Emergency Stages

The Alert stage of an Air Pollution Episode Program has not been called since 1981 and this applied only to in Downtown Tacoma; the Warning and Emergency stages have never been declared. They would come in response to pollution levels that significantly threaten public health. They can include progressively stringent steps-including wood heat bans, curtailment of motor vehicle use and industrial restrictions or shutdowns-to reduce the emission of pollutants into the air. Ecology-r, at the Emergency level, the Governor-would announce these stages, and the actions to be taken under them, through the media.

Air Stagnation Advisories

The National Weather Service calls Air Stagnation Advisories to warn about stagnant air conditions. Experts at the Weather Service, Ecology and the local air quality agencies share data and consult regularly. Forecast Episodes generally are declared after an Advisory is issued. But the calling of an Air **Stagnation** Advisory does not necessarily mean an Impairment or Episode will follow. Advisories often cover broad regions, sometimes several states, while Episodes and, especially, Impairments relate to local conditions.

For more information

Ecology **Toll Free Wood Smoke Information Line l-800-523-4636: You can** leave a message to ask questions and request more written material about Washington's wood smoke program.

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Clean Air Washington

The Clean Air Washington Act of 1991 sets a comprehensive new course toward cleaner air throughout the state.

Motor Vehicle Emission Check Program

The problem

Motor vehicles are Washington's largest air pollution source, accounting for more than 50 percent of the statewide total, or nearly 1.3 million tons of air pollutants per year. The urban areas of Clark, King, Pierce, Snohomish and Spokane counties exceed the federal health standard for carbon monoxide, largely because of motor vehicle pollution. Motor vehicle emissions in King, Pierce, Snohomish and Clark counties are a major reason why these counties exceed federal ozone pollution standards. At the same time, vehicle use is growing two to three times faster than Washington's rate of population increase, undoing past vehicle emission control accomplishments.

One solution: motor vehicle emission checks

The goal of the vehicle emission check is to ensure that all factory installed emission control systems are working properly. Federal law requires this in areas where carbon monoxide and ozone pollution exceeds federal health standards. The emission check identifies the most polluting vehicles and requires proper repair of these vehicles.

The program applies to vehicles registered in the urban areas of King, Pierce, Snohomish, Spokane and Clark counties.

Every other year vehicles must pass an emission test or spend a given amount in repairs to be re-registered. The inspection fee of $12 is paid in cash at the inspection station. There is no charge for the first re-test of a vehicle that fails the initial test.

What Clean Air Washington has done

- **Allowed the vehicle emission check** program to be enhanced and expanded, as required by federal law.
- **Included** diesel vehicles in the motor vehicle emission check program.
- **Changed the waiver requirement. One hundred** dollars must be spent on repairing **a** pm-1981 vehicle that fails a retest before a waiver can be granted preventing further expense to **a vehicle's owner. For** 1981 and newer vehicles the limit is $150. The waiver does not apply for:
  - vehicles less than five years old;
  - vehicles with less than 50,000 miles (check the vehicle's warranty);
  - vehicles with tampered or removed emission control equipment; or
  - vehicles repaired by someone other than a Department of Ecology Authorized Emission Specialist.
- **Requires** an emission check before a new owner can change registration of that vehicle if purchased from a private party or from outside the state.

May 1995

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- **Requires annual** emission check of all state and local government vehicles in the check areas. It also requires the emission check of state vehicles statewide when 20 or more are kept at the same location.
- **Exempts** new vehicles from emission testing if the vehicle year is the same as or newer than the current calendar year.

For more information

Ecology has prepared fact sheets on each major element of Clean Air Washington. Any or all of these are available from the Washington State Department of Ecology, PO Box 47600, Olympia, WA 98504-7600.

Telephone calls on the vehicle inspection program may be directed to the Vehicle Emission Information Number, l-800-453-4951. For information on other elements of Clean Air Washington please contact:

Sandi Newton **Outreach Specialist** **(360) 407-6826**

If you have special accommodation needs or require this document in alternative format, please call Tami Dahlgren, Air Quality Program (360) 407-6830 (voice); or (360) 407-6006 (TDD only).

Washington State Department of Ecology
PO Box 47600
Olympia, Washington 98504-7600

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Focus

Emission Check Program Areas

The motor vehicle emission check program applies to 1968 and newer gasoline and diesel cars and trucks registered within the areas defined by the ZIP Codes listed below.

For more information:

Call 1-800-453-4951, toll-free, 7 a.m. to 7 p.m. Monday through Friday.

King

Auburn	98001-02, 98063, 98071, 98092
Bellevue	98004-09, 98015
Bothell	98011-12, 98021, 98041
Burien	98166
Des Moines	98198
Federal Way	98003, 98023, 98063, 98093
Hobart	98025
Issaquah	98027
Kenmore	98028
Kent	98031-32, 98035, 98042, 98064
Kirkland	98033-34, 98083
Lake Forest Park	98155
Maple Valley	98038
Medina	98039
Mercer Island	98040
Milton	98354
Pacific	98047
Redmond	98052-53, 98073
Redondo	98054
Renton	98055-59
Seahurst	98062
Seattle Area	98101-199 (Except 98110.)
Tukwila	98188
Woodinville	98072

Pierce County

Du Pont	98327
Fife	98424
Fircrest	98466
Fort Lewis	98433
Frederickson	98446
Gig Harbor	98332, 98335
Graham	98338
Kapowsin	98344
Lakeview	98499
McChord AFB	98438-39
McMillin	98352
Milton	98354
Parkland	98444, 98447
Puyallup	98371-74
Spanaway	98387
Steilacoom	98388
Sumner	98390
Tillicum	98498
Tacoma Area	98401-499

Snohomish County

Bothell	98011-12, 98021, 98041
Edmonds	98020, 98026
Everett	98201-08
Lake Stevens	98258
Lynnwood	98036-37, 98046
Marysville	98270-71
Mill Creek	98012
Mountlake Terrace	98043
Mukilteo	98275
Snohomish	98290-91
Woodinville	98072

(See other side for Clark and Spokane counties.)

July 1994

Clark County

Camas 98607	Washougal 98671
Vancouver Area 98660-68, 98682-86	(Excluding Skamania County portion.)

Spokane County

Airway Heights 99001	Mead 99021
Colbert 99005	Newman Lake 99025
Four Lakes 99014	Otis Orchards 99027
Greenacres 99016	Spokane 99200-299
Liberty Lake 99019	Veradale 99037

For more information:
Call l-800-453-4951, toll-free, 7 a.m. to 7 p.m. Monday through Friday.

If you have special accommodation needs, please contact Sandi Newton, Air Quality Program at (206) 407-6826 (voice) or (206) 407-6206 (TDD only).

(See other side for King, Pierce and ***Snohomish*** counties.)

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Emission Check

You're on the Road to Cleaner Air.

BENEFITS OF WASHINGTON'S EMISSION CHECK PROGRAM

Washington's Motor Vehicle Emission Check Program began in 1982, and has provided significant benefits for the people of our state. Mandated by the federal Clean Air Act for areas that don't meet air quality standards, the program was first established in the Seattle metropolitan area. Three years later, it expanded to the city of Spokane and its outskirts. Beginning June 1,1993, the program will expand to new areas of King, Snohomish and Spokane counties, and will be introduced for the first time to Clark County. The program will become effective August 2, 1993 in South King and Pierce counties.

Summarized below are some of the contributions the emission check program makes to improve air quality, better your health, and enhance vehicle performance.

AIR QUALITY

Q: Does emission testing reduce air pollution?

A: Yes. The most recently available data shows that, per year, carbon monoxide emissions, our state's largest air pollution problem, are reduced by approximately 20% among vehicles inspected by the program. This represents a reduction of 43,000 tons of air pollutants! Because cars and trucks are responsible for approximately 55 percent of the state's total air pollution, emission testing significantly helps to improve air quality

HEALTH

Q: How will the emission check program protect my lungs?

A: Emission testing can help you breathe easier because it helps reduce air pollution. In general. polluted air can make healthy people cough and wheeze, while also creating more severe problems for children, the elderly, and individuals with heart or respiratory trouble.

Carbon monoxide from motor vehicles is the main component of air pollution. It can interfere with your blood's ability to carry oxygen to your brain, heart, and other areas of your body, starving your body of oxygen. Common symptoms of carbon monoxide exposure at levels such as those found in traffic include headaches, drowsiness, dizziness, lapses in concentration, irritability, and nausea.

VEHICLE PERFORMANCE

Q: How **can the testing program improve the performance of my vehicle?**

A: **Emission testing encourages an** ongoing program of preventive maintenance which results in a better performing vehicle. In general, a properly performing emission control system means the following benefits for your car or truck:

- Better **gas mileage.** A vehicle which meets emission standards is more likely to run at or near peak fuel efficiency The fuel savings from an improvement of even one to two miles per gallon can add up over the course of a year. This reduced fuel consumption represents economic, energy, and environmental savings.
- **Enhanced performance.** An emission test for a motor vehicle is similar to checking a person's pulse rate; it's a good, basic way to find out whether the subject is functioning normally Failing to meet emission standards can be an indicator of any number of problems which may be hindering a vehicle's performance. Repairing the problem often will result in improved performance.
- **Longer life span and more reliability.** Many manufacturers and mechanics recommend an emission test along with regular tune-ups for your vehicle. They know that a regularly serviced vehicle has a longer life span and will be more reliable than one which is neglected. Emission testing can be an important part of that service. It can help identify problems before expensive or irreparable damage is done. If your vehicle fails to meet emission standards while still under warranty. repairs to the emission control system are often covered.

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WASHINGTON STATE DEPARTMENT OF ECOLOGY

Emission Check

You're on the Road to Cleaner Air.

VEHICLES, AIR QUALITY, AND YOUR HEALTH

Q: How much do motor vehicles contribute to air pollution?

A: Cars and trucks are the prime source of air pollution in **Washington** state. Motor vehicles are responsible for 55 percent of the state's total air pollution, more than double the amount from all industrial sources. Each year, motor vehicles emit **1.4** million tons of harmful pollutants, more than all other sources combined.

Q: What types of pollutants do gasoline-fueled vehicles release?

A: The "big three" of vehicle pollutants are carbon monoxide (CO), hydrocarbons (HC), and nitrogen dioxide (NO,).

Q: How do the pollutants in vehicle emissions worsen air quality?

A: CO — Carbon monoxide poses the biggest air pollution problem in Washington state. Each year, one million tons of carbon monoxide are released into the air. In areas where air quality dips **below** federal health-based standards for carbon monoxide (nonattainment areas), motor vehicles account for up to 75 percent of the carbon monoxide emissions.

HC **and** NO_3 - Hydrocarbons help make up ozone CO,), a prime ingredient in photochemical smog (not to be confused with the protective "ozone layer."). Nitrogen dioxide, reacts in the atmosphere with hydrocarbons **and sunlight to form *ground-level* ozone. Motor vehicles produce 292,000** tons of **ozone-causing pollutants each year in Washington.**

Q: Do diesel-powered vehicles pollute more than gasoline-powered vehicles?

A: It's easy to think diesel-powered vehicles pollute more than gasoline-powered vehicles because you can see the smoke. However, one doesn't necessarily pollute more than the other. The two types of fuels release different pollutants, so a straightforward comparison can't be made. Diesel-powered vehicles release small particutates or soot, while gasoline-powered vehicles primarily release carbon monoxide. The most important fact is that both types of pollutants worsen air quality and are harmful to your lungs.

Q: Aren't vehicles burning cleaner than before?

A: Yes. However, any air quality gains from cleaner fuels and improved emission control systems have been more than offset by the rapid increase in the number of vehicles on our roads. Total traffic volume in our state continues to grow at a rate faster than our population, and people are driving more miles annually. As a result, more and more pollutants are being poured into our air each year.

Q: How does air pollution affect my health?

A: **Numerous scientific studies have** shown **that the air pollutants contained in motor vehicle emissions are harmful to** humans. **In** general, polluted air can make healthy people cough and wheeze, while also creating more severe problems for young children, the elderly, and individuals with heart or respiratory trouble. Long-term exposure to air pollution has permanent effects on the ability of the lungs to function and can lead to lung disease. More specifically:

- **Carbon monoxide** interferes with your blood's ability to carry oxygen to your brain, heart, and other areas of your body, starving your body of oxygen. It most severely affects pregnant women and those with heart or lung trouble, and can be lethal at high concentrations. More common symptoms at lower carbon monoxide levels, such as those found in traffic, include headaches, drowsiness, dizziness, lapses in concentration, irritability, and nausea.
- Ozone, while not as large a problem as CO in this state, is just as bad for your body. Smoggy air inflames your lung tissues and breathing passages, decreases lung capacity, and causes coughing and **chest pains.**
- People who exercise outdoors are more vulnerable to the effects of air pollution, feeling symptoms at lower pollution levels and suffering a reduced ability to breathe. It's estimated that a daily half-hour run in a polluted urban area exposes an individual to as much carbon monoxide in the blood as smoking about a pack of cigarettes a day.

Q: What's the bottom line on air pollution in Washington?

A: Air pollution causes health problems and lost productivity costing our economy almost $ 1 billion annually. It contributes to 150 cancer cases and 100 deaths each year.

Q: Will emission testing really help reduce air pollution?

A: It will. The program has been proven to cut carbon monoxide emissions by 20 percent from tested vehicles as a group. Since testing can identify the 10 percent of the vehicles on the road that produce as much as half of all vehicle emissions, it makes a significant contribution to improving air quality.

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WASHINGTON STATE DEPARTMENT OF ECOLOGY

Focus

Transportation Demand Management: Commute Trip Reduction

Transportation Demand Management (TDM) programs help solve transportation-related air pollution, energy and congestion problems by promoting changes in driving behavior. TDM in Washington focuses on commute trip reduction efforts. It promotes alternatives to single-occupancy vehicles, such as transit, high-occupancy vehicle lanes, car and van pools, cycling and walking.

Through their Commute Trip Reduction programs, employers can help change commuting behavior by offering such things as flex time, ride matching, telecommuting, alternative work schedules, bicycle parking and lockers, and a "guaranteed ride home" for family emergencies or times when an employee must work late. Employers can offer incentives, including preferential parking and/or lower parking fees for car and van pools, transit passes and other transportation allowances. Disincentives, such as restricted parking or fees for parking can also be used to influence commuting decisions.

Commute Trip Reduction works!

Commute Trip Reduction programs are successfully underway in parts of California, Arizona and Maryland and are being developed and implemented in other states as well.

Commute Trip Reduction programs can work here in Washington, whether the work sites house 100, 3,000 or 13,000 employees:

- **_Boeing Plant, Renton:_ Only 73 percent of the employees commute in single-occupancy vehicles, compared to 87 percent in the surrounding area.**
- **_Swedish Hospital, Seattle:_ 44 percent drive alone, compared to 59 percent at similar locations.**
- **_CH2M Hill, Bellevue:_ 54 percent now drive alone, compared to 82 percent for similar locations.**

What the new law does

Originally proposed as part of Governor Gardner's Clean Air Washington Act (ESHB 1028), this legislation was amended and adopted separately as SSHB 1671. It:

- Creates a task force representing businesses, state and local governments, the general public and transit agencies to establish guidelines for Commute Trip Reduction ordinances, plans and programs, by March 1,1992.
- Directs local governments in Clark, King, Kitsap, Pierce, Snohomish, Spokane, Thurston and Yakima counties (and others, if they wish) to adopt Commute Trip Reduction ordinances and plans by the end of 1992.
- Requires major public and private employers to adopt and implement Commute Trip Reduction programs after local jurisdictions have adopted their plans.
- Defines major employers as having 100 or more workers per site.
- Sets these goals for reductions in the number of trips made by commuters in single-occupancy vehicles: 15 percent by 1995, 25 percent by 1997 and 35 percent by 1999.

June1996

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- Gives credit to firms that have adopted programs of this nature already. Those who can demonstrate they have met the goals may not need to do more.
- Establishes a state technical assistance team, composed of the Energy Office and Ecology and Transportation departments, to provide support for the task force, develop information and training materials and assist employers and local governments.
- Requires Commute Trip Reduction plans for state agencies not subject to local plans, to be developed by the Department of General Administration by summer 1993.
- Employers are required to show a good faith effort in implementing their program. Civil penalties can be levied against willful violators.

More information

For more information on Commute Trip Reduction, contact: Kristine Burton, Washington State Energy Office, 809 Legion Way SE, P.O. Box 43165, Olympia, WA 98504-121 1; (206) 956-2062.

Ecology has prepared fact sheets on each major element of Clean Air Washington. Any or all of these are available from the Washington State Department of Ecology, P.O. Box 47600, Olympia WA 98504-7600, or call

Marcia Geidel	Commute Trip Reduction Coordinator	(360) 407-6857
Tami Dahlgren	Outreach Specialist	*(360) 407-6830*

If you have special accommodation needs or require this document in alternative format, please call Ecology's Air Quality Program at (360) 407-6830 (voice) or (360) 407-6006 (TDD only).

Washington State Department of Ecology
P.O. Box 47600
Olympia WA 98504-7600

PARTNERS For SMART COMMUTING

Facts about Smart Commuting

from the Partners for Smart Commuting

- When you leave your car at home and find another way to get to work – and you convince others to do the same – you help reduce traffic congestion and air pollution, and you save energy.

- Driving causes more of the Pacific Northwest's – and the world's – air pollution than any other activity.

- In the Pacific Northwest, auto exhaust accounts for two to eleven times as much air pollution as forest slash burning and about five times as much air pollution as industry.

- If each car carried two passengers instead of only one, we could save up to 40 million gallons of gas each day.

- When just one commuter leaves the car in the garage and uses another way to get to work for one year, our lungs and planet are spared an average of eighteen pounds of hydrocarbons, 185 pounds of carbon monoxide, and nineteen pounds of nitrogen oxides. *

- For every 25 miles you drive, you add one pound of pollution to the air.

- The United States has only 5 percent of the world's population, but uses 26 percent of all commercial energy.

- Automobiles account for about 30 percent of the nation's total carbon dioxide emissions. Carbon dioxide is the main contributor to the greenhouse effect – the slow warming of the Earth's atmosphere.

- If you drive alone to work and switch to mass transit, carpool or vanpool, you can cut your commute costs by more than half. You eliminate your commute costs if you ride your bike or walk.

* based on round trip mileage of 18 miles per day

(See other side)

Clean Air and Energy-Saving Tips

- Carpool or use public transportation whenever possible.
- Avoid short trips. Link your trips together or try to use a bicycle or walk for short trips. Your car burns more than twice as much gasoline during the first few minutes of operation as it does at other times.
- Inflate your tires properly. Underinflated tires cause drag, which can raise fuel consumption as much as 6 percent.
- Limit the use of your car's air conditioner. It consumes more than a gallon of gasoline for each tankful you burn.
- Use radial tires. They can improve fuel economy by about one mile per gallon.
- When you buy a new car, choose a fuel-efficient model.
- Keep your car properly tuned.
- Have your emissions system inspected regularly.
- Replace your car's air filter every 15,000 miles.
- Drive at a steady speed.
- Slow down when traffic permits. You'll burn less gasoline at 55 mpg than at 65 mpg.
- Avoid idling. Thirty seconds of idling can consume more gasoline than the amount used to start your car.

Clean Air Washington

WASHINGTON STATE DEPARTMENT OF ECOLOGY

The Clean Air Washington Act of 1991 sets a comprehensive new course toward cleaner air throughout the state.

Alternative Motor Vehicle Fuels

The problem

Motor vehicles are Washington's largest air pollution source, accounting for more than 50 percent of the statewide total, or about 1.3 million tons of pollutants per year. The metropolitan areas in Clark, King, Pierce, Snohomish, Spokane, and Yakima counties officially exceed federal health standards for carbon monoxide, mainly because of motor vehicle pollution. Motor vehicle emission account for much of the reason why King, Pierce, Snohomish and southern Clark counties exceed federal ozone pollution standards, too. Compounding the problem is the fact that vehicle use is growing two to three times faster than the rate of increase of Washington's population.

Cleaner fuel and alternative Dower

There are several alternatives to today's gasoline and diesel fuel. These include: compressed natural gas (CNG), propane, methanol, ethanol, reformulated or oxygenated gasoline, liquefied petroleum gas, electricity, and hydrogen. There is, however, no inherently clean fuel. It is important to look at actual emissions from specific vehicles. There are vehicles available now whose emissions are below the federal standards.

Alternative fuel technologies can offer the possibility of lower emissions. To date, alternative fuels are used mainly in large, centrally fueled fleets. This is due, in part, to high costs and a lack of refueling stations and manufacturers.

School districts in Tacoma, Tumwater, Yelm, and West Valley near Spokane run buses on compressed natural gas. The cities of Enumclaw, Kirkland, and Longview use it in their municipal fleets. Compressed natural gas vehicles have been introduced into the King County motor pool. Pierce Transit plans to run its entire fleet on compressed natural gas in ten years.

Propane is used in 46 local government fleets. The North Shore School District, near Seattle, has been operating propane vehicles since 1977.

Clean Air Washington's requirements

- Required Ecology to develop specifications that define clean fuels and clean-fuel vehicles for as many types of fuel as possible by July 1, 1992.
- Requires that at least 30 percent of new vehicles purchased by the state must be "clean-fuel vehicles." This requirement increases five percent every year. Ecology and the Energy Office are looking into recommending a "fuel blind" standard that recommends cleaner vehicles,

rather than specific “clean fuel.” In this way, cars that are now available using standard gasoline, but which have low emissions, can be considered for purchase, as well as vehicles that use “alternative fuels.”

- Establishes a school bus compressed natural gas advisory committee, administered by the Washington State Energy Office, to study the potential benefits, costs, and safety risks of increasing the use of CNG as a fuel for school buses. The committee submitted a report to the legislature in December 1991.
- Directs Ecology, in cooperation with other departments, to report every two years to the legislature on the clean fuel program. This report should include the effect of the program on air quality, recommendations for enhancing the distribution of clean fuels, and how much the private sector and local governments have been using clean fuels and clean-fuel vehicles.
- Requires the Utilities and Transportation commission to identify barriers to the development of CNG refueling stations and to develop policies to remove those obstacles.
- Provides for the use of air pollution control funds for matching grants to local governments that voluntarily decide to switch to clean-fuel vehicles for public transit. These grant monies may also be used to start clean-fuel vehicle mechanic certification programs at vocational-technical institutes.
- Provides funds to Western Washington University for research and development of alternative fuel and solar-powered vehicles.

For more information

Ecology has prepared fact sheets on each major element of Clean Air Washington. Any or all of these are available from the Washington State Department of Ecology, PO Box 47600, Olympia, WA 98504-7600, or call:

Tami Dahlgren, Outreach Specialist (360) 407-6830

If you have special accommodation needs or require this document in alternative format, please call Tami Dahlgren at (360) 407-6830 (voice) or (360) 407-6006 (TDD only).

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Focus

Oxygenated Gasoline

The problem

Motor vehicles are Washington's largest air pollution source, accounting for over 50 percent of the statewide total, or 1.3 million tons of pollutants a year. The metropolitan areas in Clark, King, Pierce, Snohomish and Spokane counties officially exceed federal health-based standards for carbon monoxide, mainly because of motor vehicle pollution. The carbon monoxide problem is especially bad in winter, when cold weather causes cars to be less efficient and stagnant air traps pollution close to the ground.

How does oxygenated gasoline help solve the problem?

Carbon monoxide results from the incomplete combustion of carbon-based fuels, such as gasoline. An important step toward reducing carbon monoxide emissions is the use of "oxygenates" in gasoline. An "oxygenate" is a substance that is added to gasoline to increase the amount of oxygen in the fuel blend. This increased oxygen makes the combustion process more complete, thereby reducing carbon monoxide emissions. Federally permitted oxygenates include ethanol and MTBE (methyl-tertiary-butyl ether).

Gasoline blended with ethanol or MTBE has been used successfully in motor vehicles for several years. Most drivers will not notice any difference in performance or maintenance when using oxygenated gasoline in a properly maintained vehicle.

About the oxygenated gasoline program

Oxygenated gasoline programs began in November 1992 and are required by federal law during the fall and winter in 39 metropolitan areas in the United States, including Everett-Seattle-Tacoma, Spokane and Vancouver. The Department of Ecology estimates that the use of oxygenated gasoline in these areas during the winter months reduces tailpipe carbon monoxide emissions by about 25 percent.

To meet requirements of the federal Clean Air Act, Ecology's oxygenated gasoline regulation:

- Requires the use of oxygenated fuels during colder weather months in areas that do not officially meet federal health standards for carbon monoxide. These areas are in Clark, King, Pierce, Snohomish and Spokane counties.
- Sets time periods when oxygenated fuels are required:
  - November 1 - February 29 in western Washington; and
  - September 1 - February 29 in eastern Washington.
- Requires an average oxygen content of 2.7 percent and a minimum of 2.0 percent in gasoline.
- Requires labeling at service stations using oxygenated gasoline to explain the purpose of oxygenates.

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For more information

If you would like more information on the oxygenated gasoline program, contact your local air pollution control agency listed below:

Puget Sound Air Pollution Control Agency
(King, Kitsap, Pierce, Snohomish Counties)
110 Union St., Ste. 500; Seattle, WA 98102-2038
l-800-453-4951 (Oxygenated gasoline calls only.)
(206) 343-8800 or l-800-552-3565 (All other business,)

Southwest Air Pollution Control Authority
(Clark, Cowlitz, Lewis, Skamania, Wahkiakum Counties)
1308 NE 134th St., Ste. A; Vancouver, WA 986852747
(206) 574-3058 or l-800-633-0709

Spokane County Air Pollution Control Authority
W 1101 College Ave., Ste. 403; Spokane, WA 99201
(509) 456-4727

If you have special accommodation needs, please contact the Air Quality Program, Department of Ecology, at (206) 407-6800 (voice) or (206) 407-6006 (TDD).

Washington State Department of Ecology
P.O. Box 47600
Olympia WA 98504-7600

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Focus

Oxygenated Gasoline

Changes to the Program

Background

The federal Clean Air Act requires oxygenated fuels to be used during colder weather months in areas that do not meet federal health-based standards for carbon monoxide. Beginning in 1992, wintertime use of oxygenated gasoline was required in Clark, King, Pierce, Snohomish and Spokane Counties. Because Clark, King, Pierce and Snohomish counties are now meeting the federal carbon monoxide standard, Ecology is proposing to eliminate the requirement for oxygenated gasoline use in these areas. Local air pollution control agencies are requesting that the Environmental Protection Agency (EPA) redesignate these areas as attainment areas, and have prepared plans for maintaining the air quality standard. Approval of the plans by EPA is expected in 1996. Each plan specifies that oxygenated gasoline may be reintroduced by local regulation if violations of the carbon monoxide standard occur.

The oxygenated gasoline requirement will remain in Spokane County, where oxygenated gasoline is still needed to control carbon monoxide.

How does oxygenated gasoline work?

Carbon monoxide results from the incomplete combustion of carbon-based fuels, such as gasoline. Adding an "oxygenate" to gasoline increases the amount of oxygen in the fuel blend. This makes the combustion process more complete, thereby reducing carbon monoxide emissions. The Department of Ecology estimates that the use of oxygenated gasoline in required areas during the winter months in 1992-93 reduced tailpipe emissions of carbon monoxide by about 25 percent.

Why is oxygenated gasoline no longer needed?

Newer cars are equipped with devices that sense the oxygen level in the fuel mix and add air as needed. As newer cars replace older ones, the fleet is becoming more efficient. In addition, the motor vehicle Emission Check Program tests car emissions and requires the proper repair of those vehicles that emit excessive air pollution. These factors have helped reduce carbon monoxide to levels that meet the federal standard.

Effects of changing the oxygenated gasoline program

Most motorists will not notice the changes in the gasoline. Because oxygenated gasoline decreases fuel efficiency by about two percent in certain vehicles, some vehicle owners may benefit slightly from the removal of the oxygenated gasoline requirement. Others may need to change their fuel filters less frequently.

The proposed changes will likely reduce costs for gasoline blenders and distributors located in the central Puget Sound and Clark County areas. Ecology estimates that eliminating the oxygenated gasoline program in western Washington will save about $39 million per year in the affected counties. These savings are in the reduced mileage, higher maintenance, production and distribution of oxygenated gasoline, and administrative costs associated with the oxygenated gasoline program.

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What happens next?

Following public hearings on the proposed changes to the program, Ecology will summarize and respond to public comments and revise the draft rule as appropriate. The final rule is scheduled for adoption in September 1996, and will become effective one month later.

For more information

Kitty Gillespie *(360) 407-6862*
Department of Ecology

If you have special accommodation needs or require this document in alternative format, please contact Tami Dahlgren at Ecology's Air Quality Program, (360) 407-6830 (voice); or (360) 407-6006 (TDD only).