Air Quality Section

Air Pollution Introduction

The Air Around Us

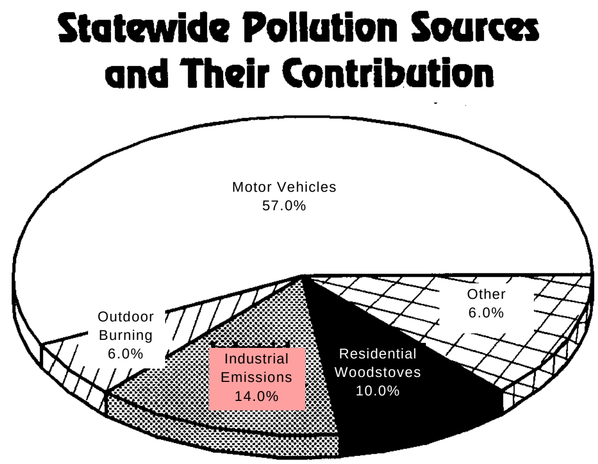
Earth's atmosphere is composed of a mixture of gases, mostly nitrogen (78 percent) and oxygen (21 percent). Argon, carbon monoxide, methane, ozone, sulfur dioxide, carbon dioxide, and carbon monoxide make up the rest of the air. In addition to "pure air," our atmosphere also carries water vapor, solid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

Wintertime Inversion:

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.

Summertime Smog:

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

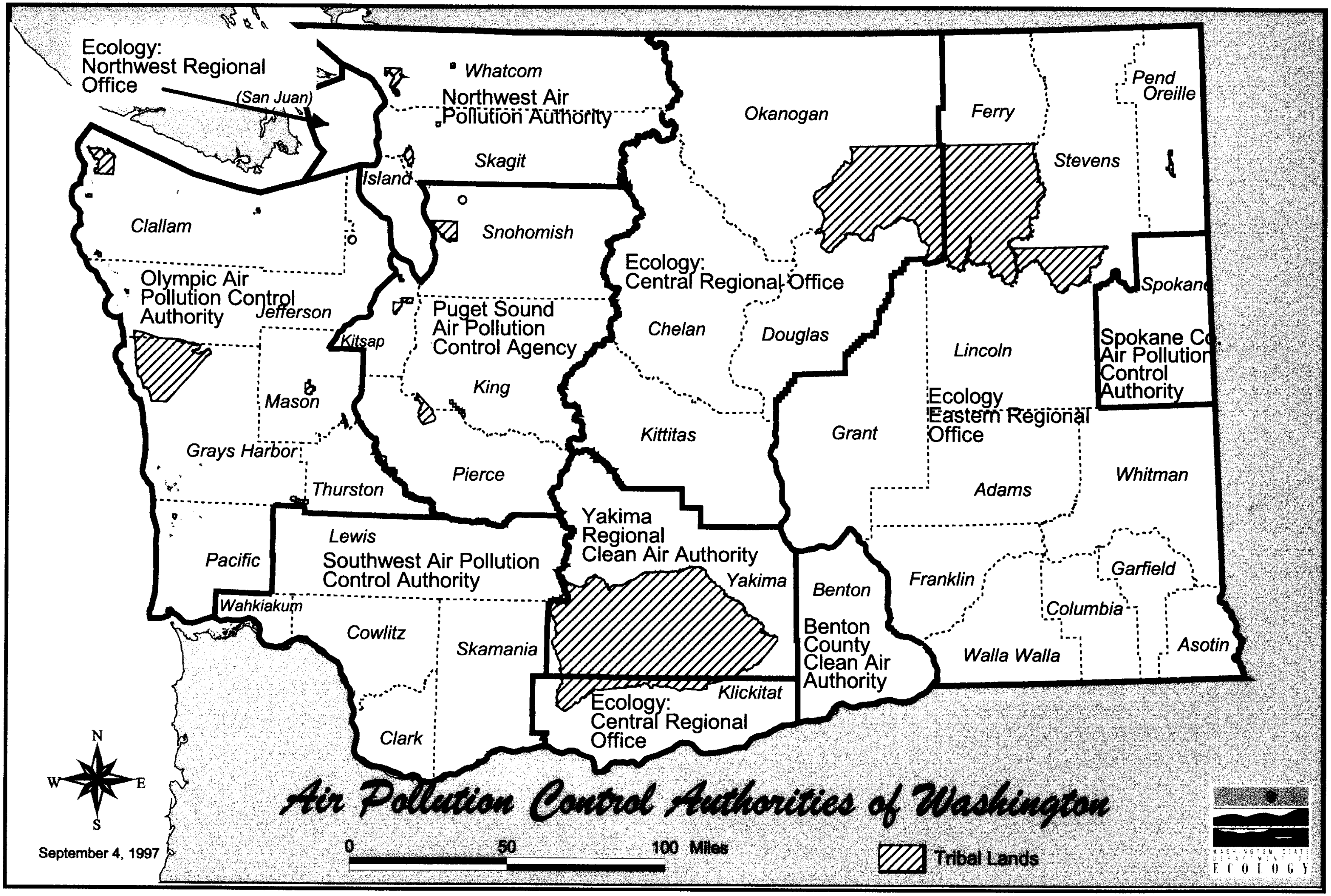
Other Sources of Information about Air Pollution in Washington State

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

If you have special accommodation needs, please contact Ecology's Air Quality Program at (360) 407-6800 (Voice) or (360) 407-6006 (TDD),
Ecology is an Equal Opportunity and Affirmative Action Employer


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
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Jefferson
Kitsap
Puget Sound
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DEPARTMENT OF
ECOLOGY

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.

Doyle, Andrea and Wasserman, Pamela. Earth Matters. Zero Population Growth, Inc., Washington, D.C. 1991.

FAST 1. Foundational Approaches in Science Teaching. The Local Environment. Curriculum Research and Development Group. College of Education. University of Hawaii, Honolulu, Hawaii. 1978

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

Hinrichsen, Don; Lean, Geoffrey; and Markham, Adam. Atlas of the Environment. Prentice Hall Press. New York. 1990.

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

Nature Scope. Pollution: Problems & Solutions. The National Wildlife Federation, Washington, D.C. 1990.

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.

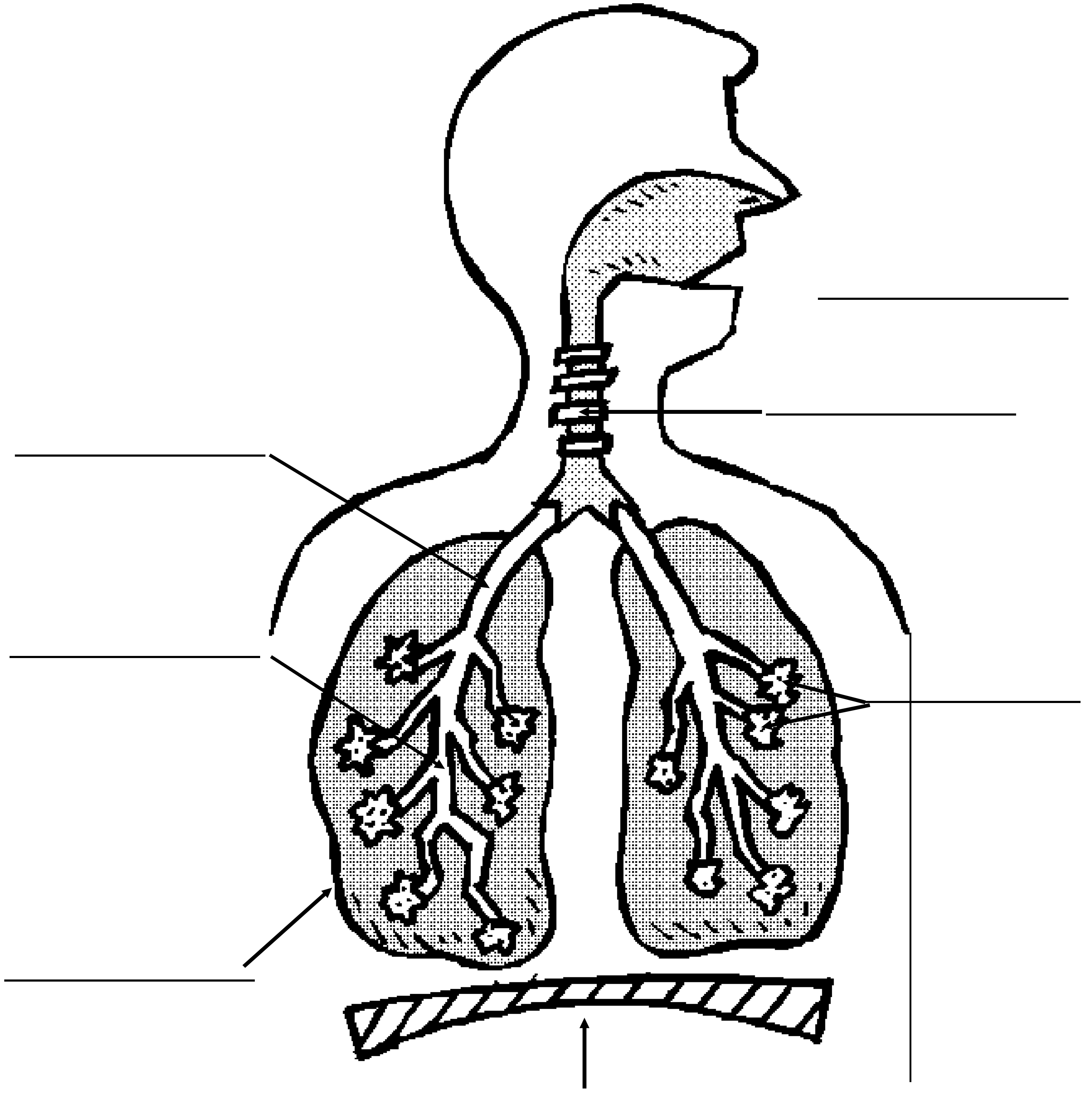
Have them work individually or in pairs to label the various parts of the respiratory system on the diagram, and devise a quiz on the parts. Have them explain to each other how this system works.

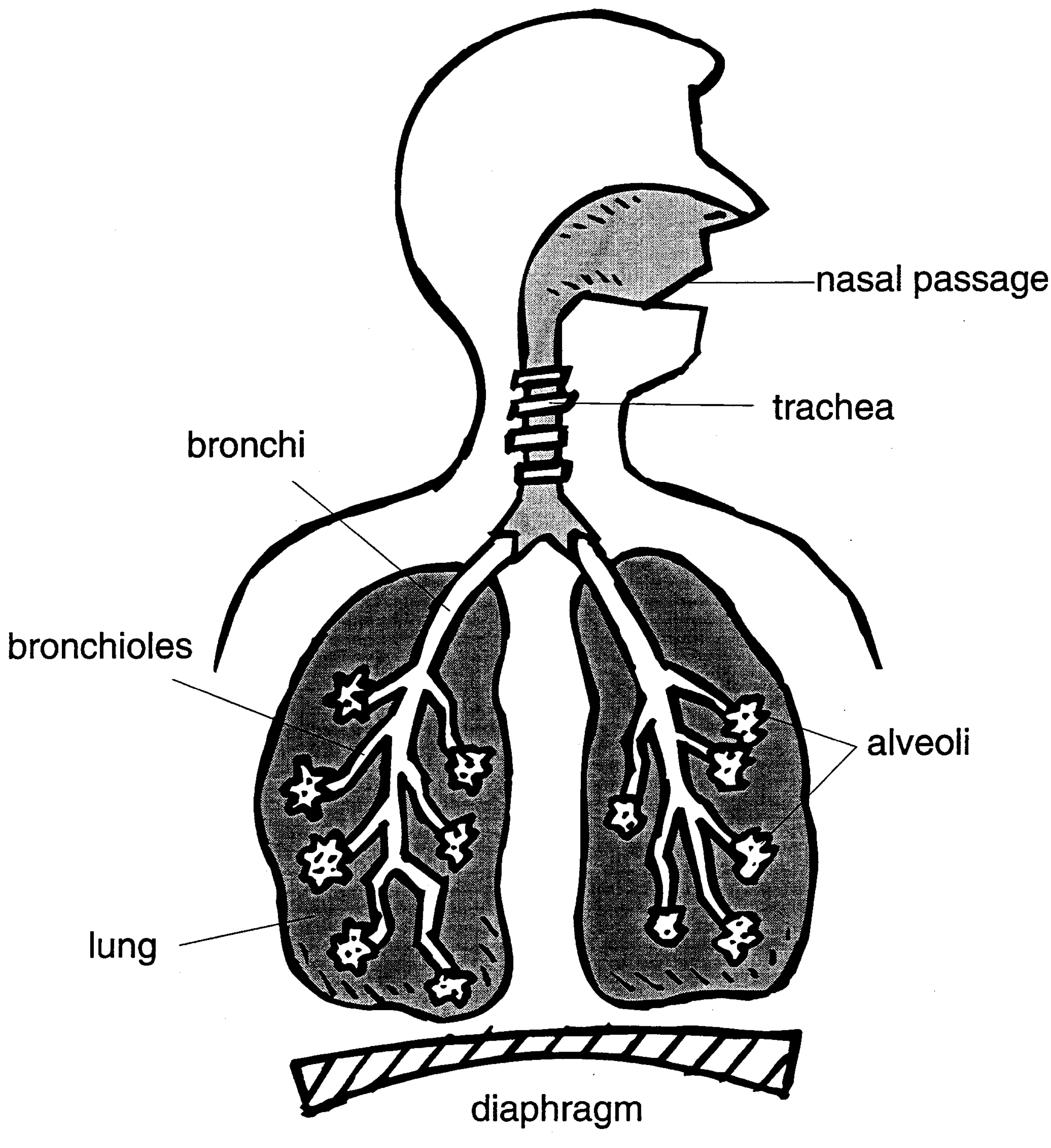
4 Divide students into groups. Each group should set up a filter, funnel, and container, and then add a medium amount of soil to the filter.

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.

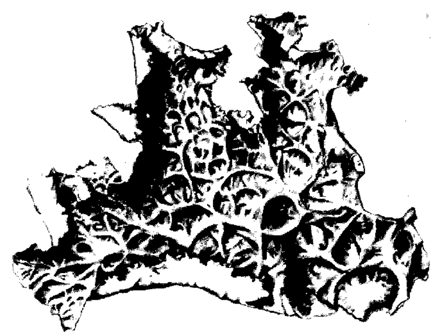
2 Break students into groups and give each group an "urban branch" and a "non-urban branch." Have students look for lichens on each and jot down their findings.

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

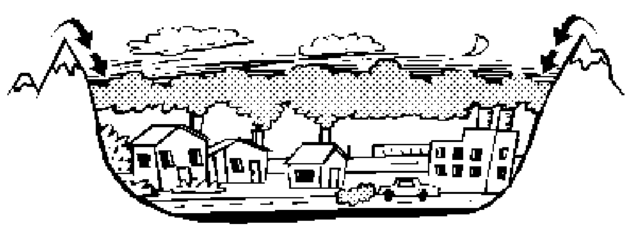
In the winter often there is no wind and no mixing of different layers of air. A layer of warm air can settle over an area and prevent the cooler air below it from rising. This is called a "thermal inversion." This can happen in several ways. On a cold night the ground can get very cold. This cold air 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.)

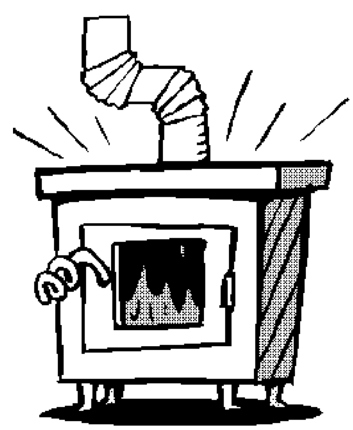
2. What kind of air pollution can you see? (Answers will vary.)

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.

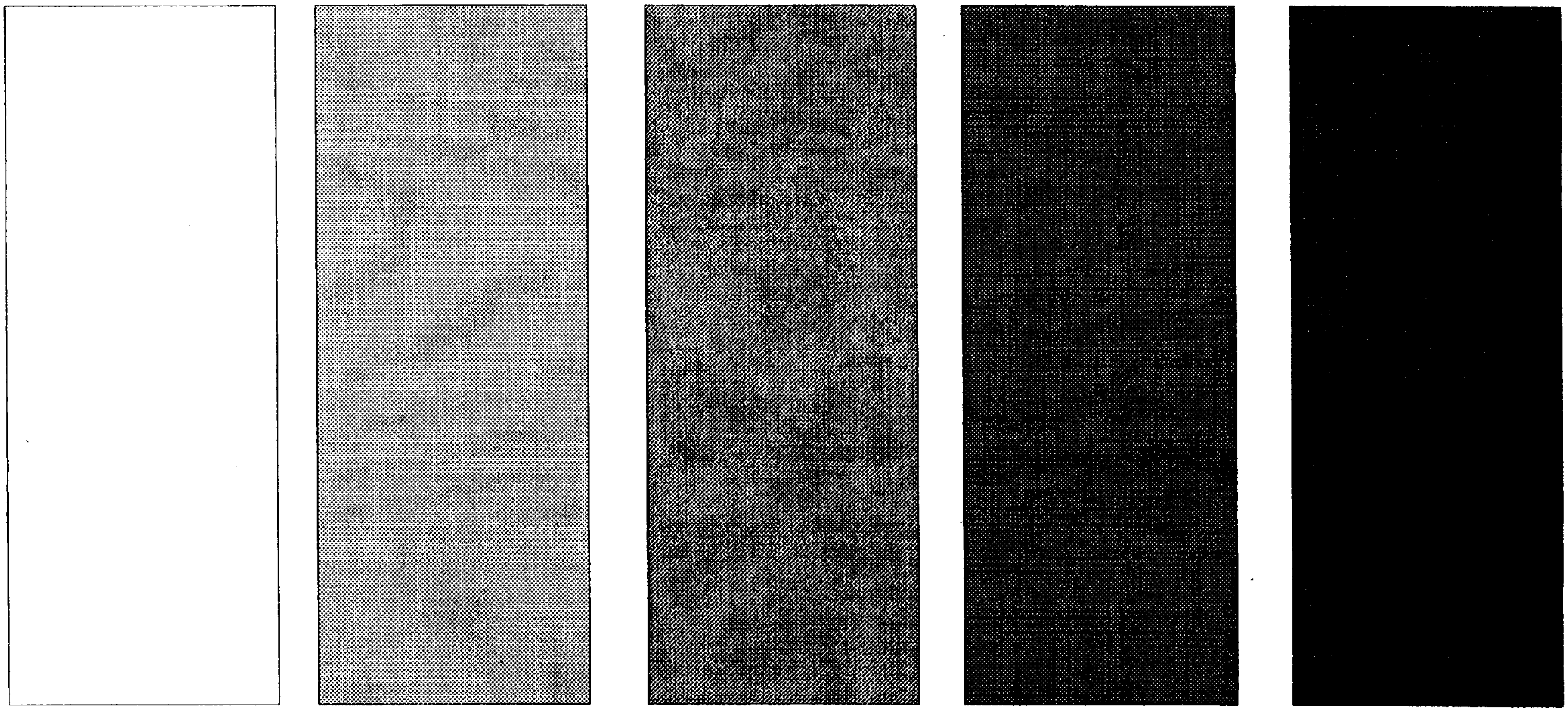
4 Ask students if they know of any air pollution that they can't see or smell. (If they get stuck, you can ask about pollen allergies or carbon monoxide detectors.) Show them the pictures of filters from the particulate matter monitors that collect primarily visible air pollutants. Ask them what part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

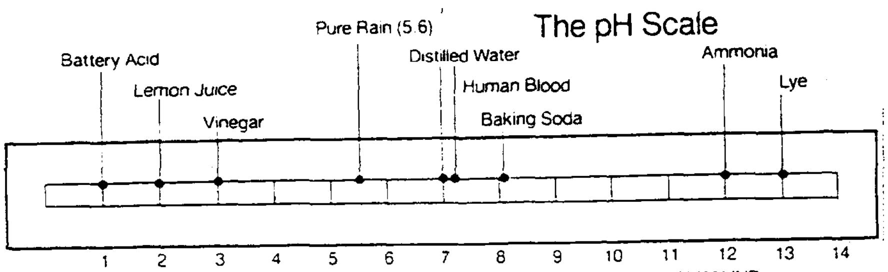
3 Break students into small groups. Each group needs a set of the sample solutions (lemon juice, baking soda, vinegar, and plain distilled water) and pH test paper.

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.

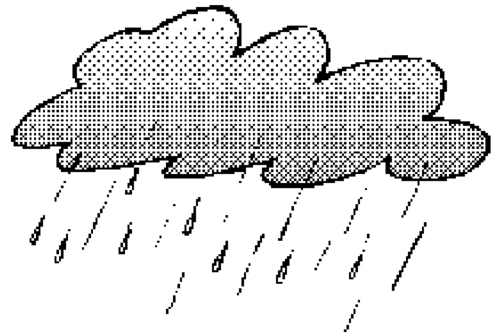
7 Have students break into groups again to test the locally collected samples of rainfall and water. Plot these samples on the pH scale.



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.

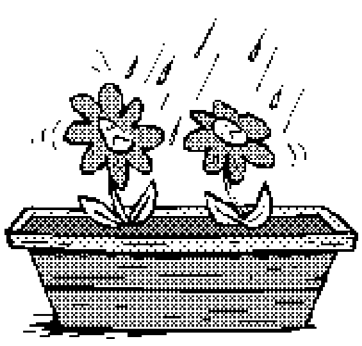
Learning Objective

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:

$$H_2O + SO_2 \text{———} H_2SO_3$$

$$H_2O + SO_3 \text{———} H_2SO_4$$

$$H_2O + 2\ NO_2 \text{———} HNO_3 + HNO_2$$

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.

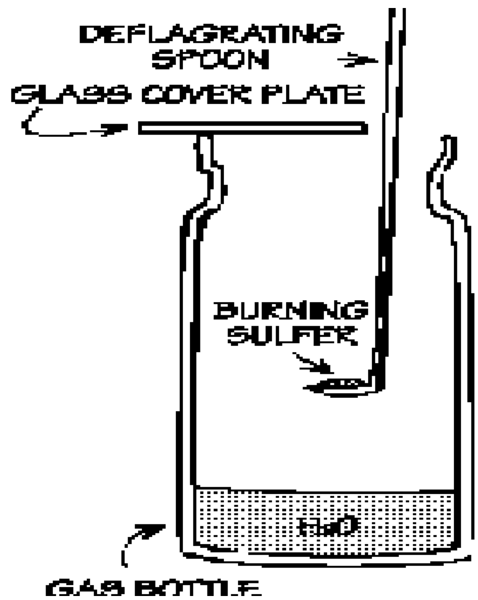
Red litmus paper____________________.

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?

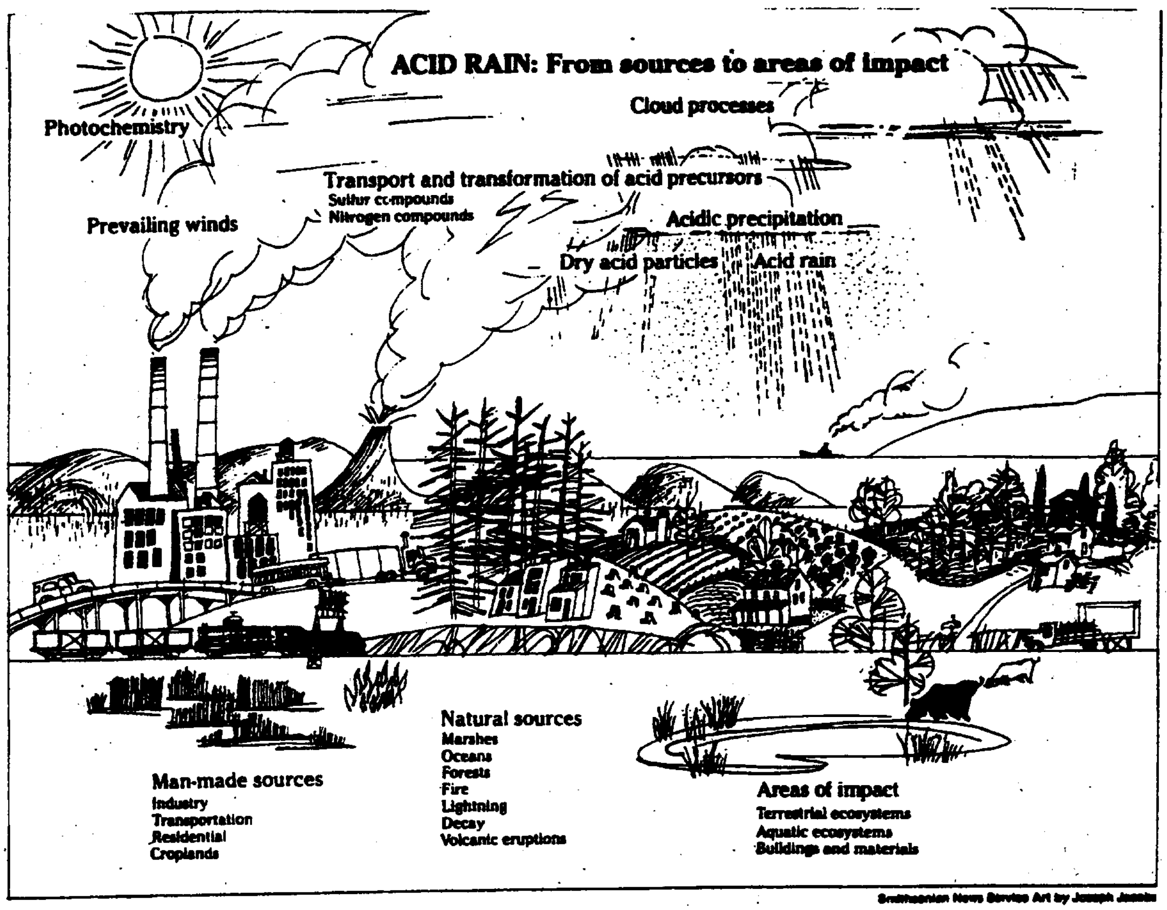
2. How was the acidity of the water affected by the gas produced from the burning of the sulfur?

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?



Smithsonian News Service Art by Joseph Jacobs

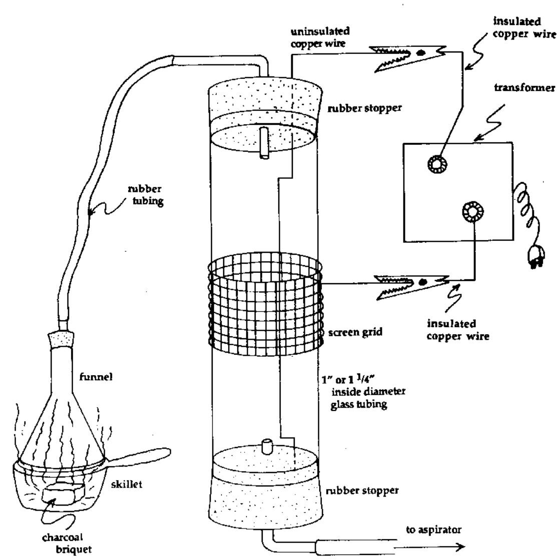
Simply Shocking

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

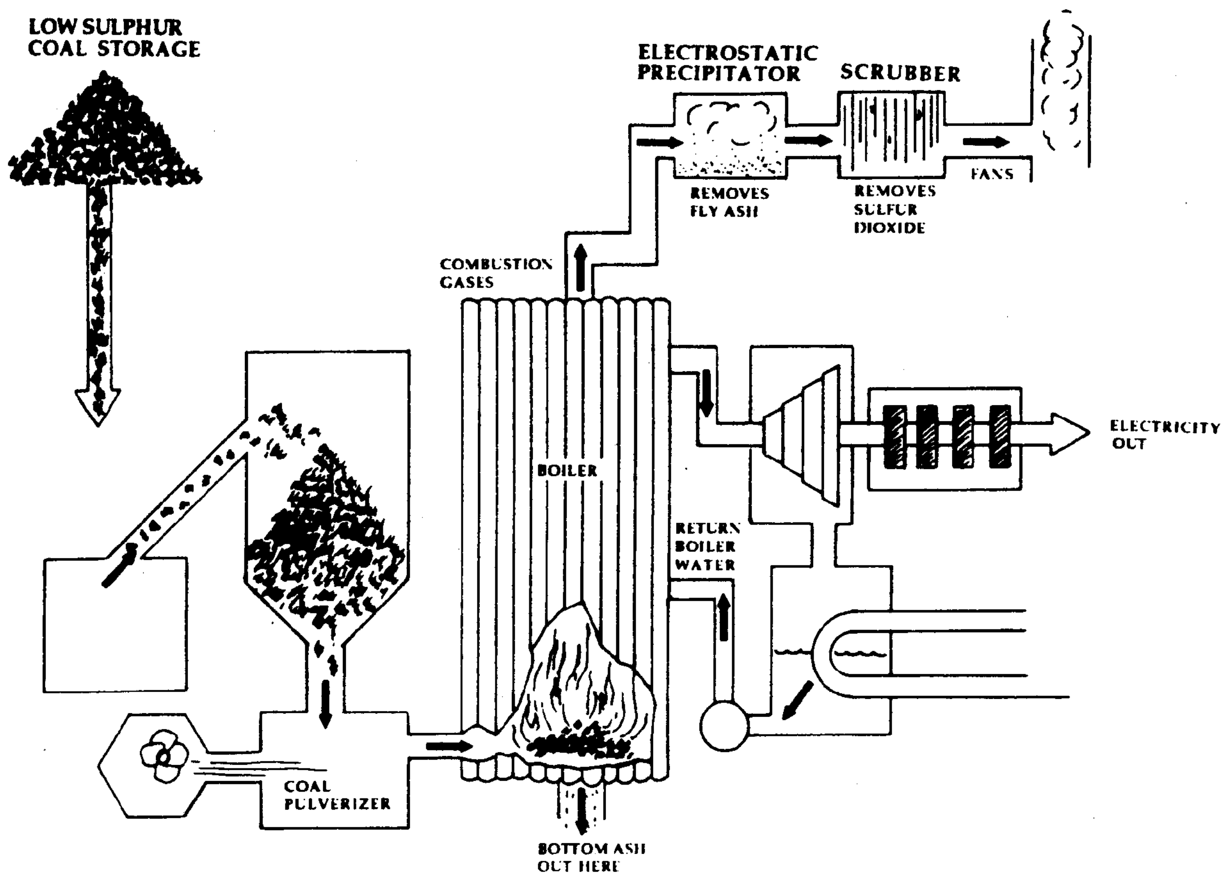
Adapted with permission from the Air and Waste Management Assocation Environmental Guide (ERG) - Air Quality, Grades 6-8, copyright 1991; Air & Waste Management Association, Pittsburgh, PA 15222.

Resources

Chem Ed. 1979 Conference Report. Ontario: University of Waterloo, 1979.

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

Williams, Thomas F. Polluted Air -- A Social Challenge. National Tuberculosis Association, January 1985.



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)

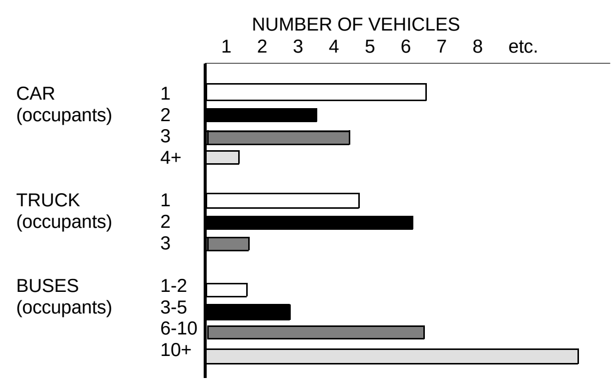
2. What effects would lowering this percentage have on traffic and pollution? (There would be fewer cars on the road, and less pollution in the air.)

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

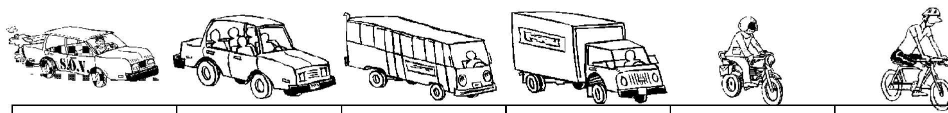
Use tally marks for single occupant vehicles (𝍸); record high occupant vehicles (cars, buses, commercial trucks, motorcycles, and bicycles) with the estimated number of occupants (2, 3, 2, 9, etc.).

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

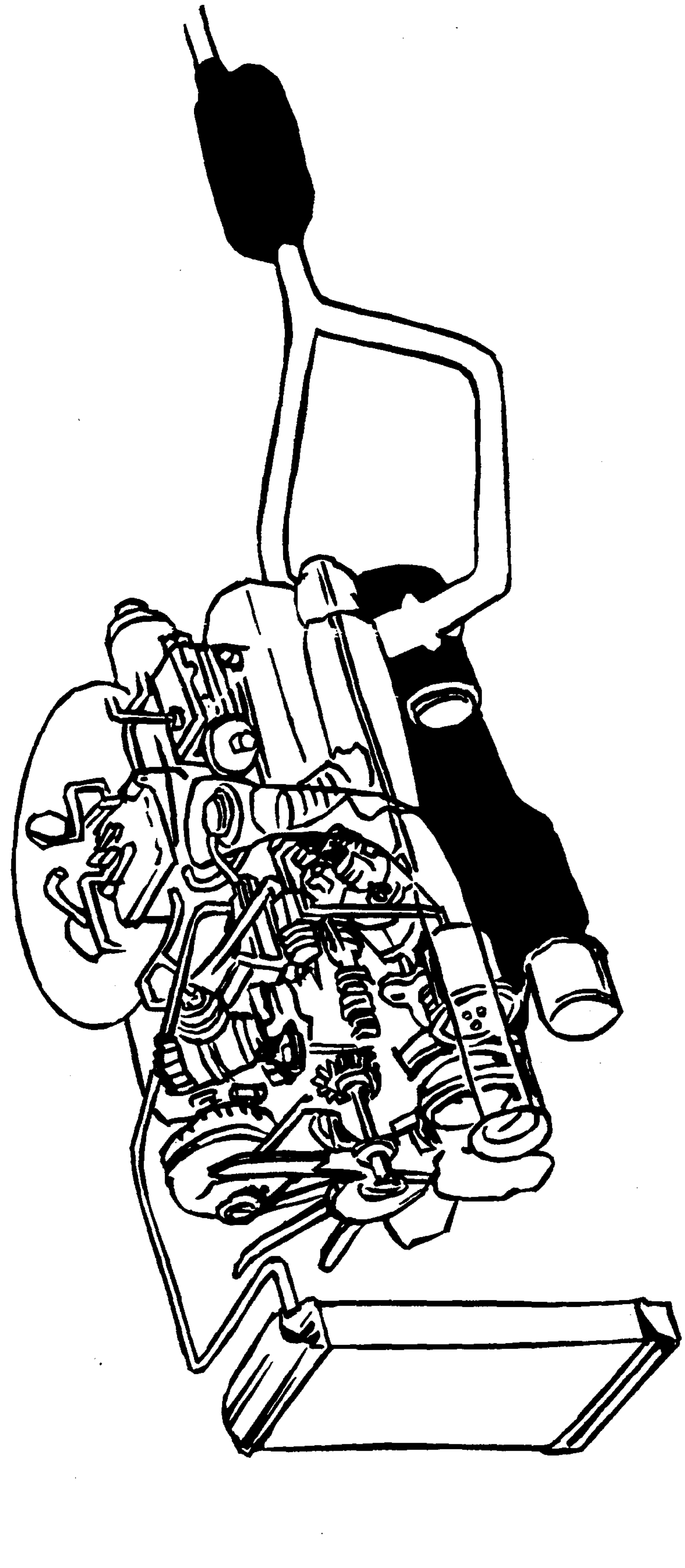


Table 5-2

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 *(choose one)*	Mode of Travel *(choose one)*	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 *(choose one)*	Mode of Travel *(choose one)*	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?

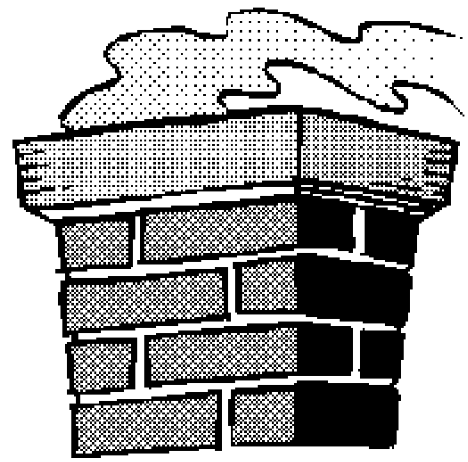
- Compost and chip yard waste. This will give you natural nutrients and mulch for your garden. Leave your lawn clippings in place to help retain moisture.
- Develop a landscape design that leaves trees and native plants in place.

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.

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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).