CONSIDER THE SOURCE

AIR & WASTE MANAGEMENT ASSOCIATION

OBJECTIVES

Students will do the following:

1. Name the most notable natural sources of the criteria pollutants

2. Name the most notable human-generated sources of the criteria pollutants

TOPICS:
Natural and man-made sources of outdoor air pollution

TIME:
1-2 class periods

SUBJECTS:
Science, social studies, language arts, art

MATERIALS:
Magazines
Glue
Poster board
OPTIONAL: See extension suggestions

BACKGROUND INFORMATION

Air has always been subject to pollution from natural sources; natural air pollution has been around for millions of years. It was during the last century that pollution created by humans started to become a major concern. We are most familiar with visible air pollution such as smog; however, many other air pollutants, including some of the most dangerous, are totally invisible.

Most of the gaseous components of air are part of the natural, complex biochemical cycles of elements such as carbon, nitrogen, and sulfur. Although there have been changes in these cycling patterns over geologic time, the changes are usually slow, and natural ecosystems have ways of keeping the many parts of the system in balance. The problem comes when the activities of people introduce large quantities of additional compounds into the atmosphere. This can disrupt the normal biochemical cycles, affecting earth ecosystems in many ways. The most serious air quality concerns are these additional, often harmful, pollutants that humans add to the air.

Natural Sources of Outdoor Air Pollution

Both particulate matter and gases are released into the earth's atmosphere by volcanoes and by forest fires and grass fires ignited by lightning strikes. Strong winds can lift particles from the surfaces of the oceans and land and can carry them through the air. The process of organic decay can also release certain gases into the atmosphere.

When a volcano erupts, ash (particulate matter) and gases are propelled high into the earth's atmosphere. The strong upward force can cause intermixing between the troposphere and the stratosphere, the two lowest layers of the atmosphere. Materials that reach the upper troposphere and the stratosphere can affect all areas of the earth and can persist for years. One effect of upper atmospheric debris is the blocking and scattering of radiation from the sun. The debris from a large Indonesian volcanic eruption in 1815 (Krakatoa) created a drop in global temperature that led to what has been called "the year without a summer."

Forest fires and grass fires caused by lightning strikes are a part of the earth's natural forces and are important factors in the life cycles of many plants and animals. Although they lack the vertical force of volcanoes, major fires can spread ash and smoke over thousands of square miles, and they contribute to the atmospheric

load of carbon dioxide. Forest and grass fires also cause pollution by redistributing any industrial pollutants that have been deposited on the plants. This sort of relay effect can help transport pollutants thousands of miles from their sources.

Human-Generated Sources of Outdoor Air Pollution

In our industrialized society, we enjoy many modern conveniences in the course of our everyday lives. We drive cars, travel in planes, heat and cool our homes and offices, and use a variety of products (including furniture, clothing, medications, and cleaning products) made of synthetic materials. We often take these conveniences for granted and don't think about their contribution to air quality problems. Yet they do contribute to air pollution.

Human-generated sources of air pollutants include both mobile and stationary sources. Mobile sources include automobiles, trucks, buses, planes, boats, tractors, and trains. Examples of stationary sources are factories, refineries, and power plants. Sources can also be classified as either point or area (non-point) sources. A point source refers to a specific, fixed source that is emitting (or has the potential to emit) a pollutant. A smokestack or a storage tank would be classified as a point source. The term "area source" refers to a group of small sources located close together that individually might not be much of a problem, but together they can adversely affect air quality. A community of homes using wood stoves would be an area source.

Mobile sources—especially automobiles—contribute more than half of all air pollution in the United States and up to 90 percent of the carbon monoxide found in urban areas. These automobiles, trucks, buses, trains, boats, tractors, and planes emit both criteria pollutants and non-criteria pollutants, including hazardous air pollutants (HAPs). It is important to note that both on-the-road and off-the-road vehicles contribute to air pollution. While emissions of automobiles are fairly well controlled, that is not always the case for off-the-road vehicles.

Automobile engines burn gasoline and, in the process, produce large amounts of carbon monoxide, as well as some nitrogen oxides and hydrocarbons. Before the transition to lead-free gasoline, they used to emit large amounts of lead into the ambient air.

Trucks, buses, tractors, some boats, and trains are usually powered by diesel engines. The burning of diesel fuel produces large amounts of nitrogen oxides. Jet planes use jet fuel, the burning of which results in large amounts of nitrogen oxides emissions and lesser amounts of carbon monoxide and unburned hydrocarbons.

Because modern transportation is important to the economic growth of a nation, it is impractical to do away with these mobile sources of air pollutants. However, modern air pollution control devices, alternative fuels, and life-style changes (such as walking, bicycling, using public transportation and carpooling) can help reduce pollutant emissions from mobile sources.

Stationary sources contribute the other 50% or so of air pollutants. In industrialized nations there can be hundreds of thousands of stationary sources of air pollutants. These sources range from large individual sources to groups of smaller sources, and include power plants, chemical plants, oil refineries, manufacturing facilities, printers, dry-cleaning establishments, and houses with fireplaces and wood stoves. Collectively, these stationary sources emit both criteria pollutants and non-criteria pollutants, such as HAPs.

Pollutant emissions from stationary sources come primarily from one of two activities: (1) the combustion (burning) of fuel to generate heat or power, and (2) industrial processes that release pollutants. Electric power plants that burn fossil fuels such as coal and oil produce almost 75 percent of all sulfur dioxide emissions in the United States. Chemical manufacturing facilities are responsible for a significant portion of the HAP and volatile organic compound emissions.

Within a stationary source, there can be many emission points for pollutants. Air pollutants can be emitted from process equipment, process vents, storage tanks, process wastewater handling and treatment areas, loading and unloading facilities, and damaged or worn-out equipment. Process vents are openings where substances (usually gases) are "vented" to the atmosphere. Storage tanks (even covered ones) tend to leak vapors into the atmosphere. If wastewaters contain volatile chemicals (substances that evaporate easily), those chemicals will be released from the wastewater when it comes in contact with the air. Emissions can leak from equipment in a variety of situations, including during the loading and unloading of chemicals into storage or transportation containers. (You've probably noticed the visible fumes escaping as an automobile gas tank is being filled). They can also leak from equipment valves, flanges, and pumps.

Because many of these stationary sources produce useful consumer products, create jobs for citizens, and provide necessary services, it would be impractical to eliminate all of them. We can—and are trying to—use pollution prevention and pollution control to minimize the amount of pollutants generated and emitted into our ambient air.

This lesson contains a table that shows the most common sources (mobile and stationary) of the six criteria pollutants.

Procedure

I. Setting The Stage

A. This activity relates to Objective 1. Students will learn the natural sources of air pollution.

Third-, fourth-, and fifth-graders

B. Using the master provided, make either an overhead transparency or handout copies of "Natural Sources of Air Pollution."

C. Let the students volunteer descriptions of those sources and write them on the board or on a chart.

II. Activity. Human-Generated Sources of Air Pollution

A. This activity relates to Objective 2. Students will learn about the human-generated sources of air pollution.

Third-, fourth-, and fifth-graders

B. Have the students spend a few days observing their town for signs of human-generated sources of air pollution. Ask them to record what they see and bring their list to class for a class discussion. (Using the master provided, make overhead transparencies or handouts of the man-made sources of air pollution and use them if you need to.)

Third-graders

C. Explain the concepts of mobile sources and stationary sources.

1. Make a copy of "Something's In The Air" for every student.

2. Divide the class into groups of 3 or 4 students. Have a contest to see which group can identify the most mobile and stationary sources of air pollution in the handout. (Don't forget that the chimneys in the houses can emit smoke, as can the car and truck, even though the emissions are not shown on the picture.)

D. Have students cut out pictures of man-made sources of air pollution. Use the pictures to make a giant collage. Label each source as stationary or mobile. If you cannot find enough magazine pictures, have students list sources, categorize them, and then draw and label them on paper.

Fourth-graders

E. Review the concepts of mobile and stationary sources, and explain the concepts of point sources and area sources.

F. Divide the class into 4 or 8 groups. Assign each group one of the following: mobile sources, stationary sources, point sources, and area sources. Have them depict (either through drawings or pictures cut out of magazines) each type of source.

Fifth-graders

G. See step E under Fourth-graders.

H. See step F under Fourth-graders.

I. Have the students brainstorm emission points. Discuss their ideas and have them research those ideas.

III. Follow-Up

A. Have students play a game of "Name the Sources."

1. Divide the class into teams of 3 or 4 players.

2. Give each team a sheet with two columns—one labeled "Natural Sources" and the other labeled "Man-made Sources." Have them place the sheet face-down on the desk.

3. When you say "go," the students have 5 minutes to list natural and man-made sources of outdoor air pollution. (Younger children may need help with spelling—or, to avoid having other teams hear you spelling answers, just tell students to spell the sources the way they sound.)

4. At the end of the five minutes, collect the sheets, and on the board list the sources that each team has named. The team with the most correct, non-duplicate answers, wins.

IV. Extension

A. Have the students create a mural or series of posters about man-made and natural sources of air pollution.

B. Show a video of a volcanic eruption (Mt. St. Helens, Hawaii, Indonesia, Philippines, etc.). Discuss the types of pollutants that are emitted.

C. Have the students draw pictures of natural sources of pollution and man-made sources of air pollution. Divide the students into groups. Give each group a set of pictures that they did not draw and let them try to identify the pictures.

D. Divide the class into groups and have them draw pictures of mobile and stationary pollution sources or natural and man-made pollution sources. Have the students make a mobile with their pictures. (Students can hang their pictures from a wire coat hanger.)

RESOURCES

Environmental Resource Guide—Air Quality , Grades 6-8. Pittsburgh: Air & Waste Management Association, 1991.

National Wildlife Federation. *Ranger Rick's Naturescope: Pollution.* Washington, DC, 1990.

Project Learning Tree. *Environmental Education Activity Guide.* American Forest Foundation: Washington, DC, 1993.

Project AIMS. *Our Wonderful World.* AIMS Education Foundation: Fresno, CA, 1987.

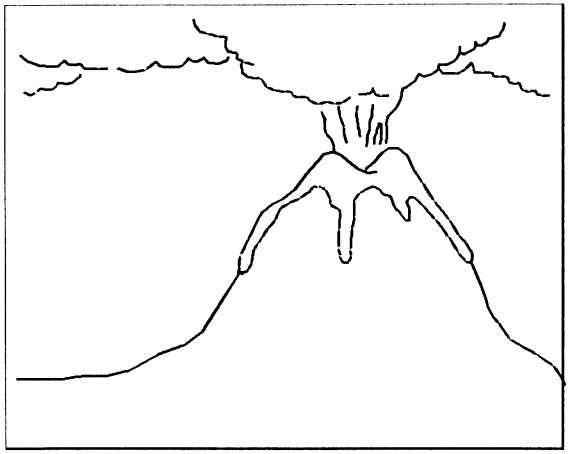
The Common Air Pollutants (Criteria Air Pollutants and VOCs)

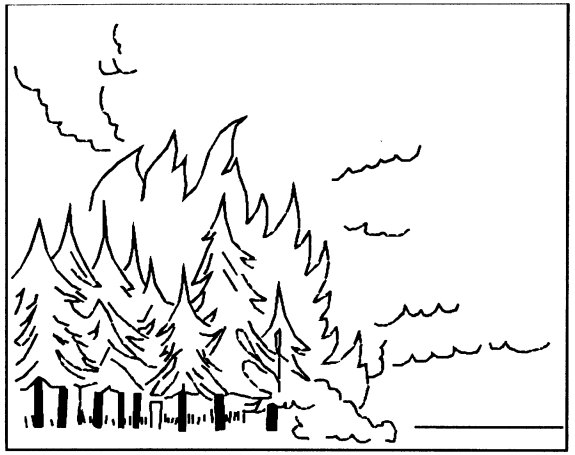
Name	Source	Health Effects	Environmental Effects	Property Damage
Ground-level ozone (principal component of smog)	Chemical reaction of VOCs and NO_x. Cars emit large amounts of both VOCs and NO_x.	Breathing problems Reduced lung function Asthma Eye irritation Stuffy nose Reduced resistance to colds and other infections May speed up aging of lung tissue	Damage to plants and trees (ozone) Reduced visibility (smog)	Chemical reaction of VOCs and NOx. Cars emit large amounts of both VOCs and NOx.
Nitrogen Dioxide (NO_2), one of the NO_x	Burning of gasoline, natural gas, coal, oil, etc. Cars, which burn gasoline, are an important source.	Lung damage Illnesses of breathing passages and lungs (respiratory system)	Ingredient of acid rain, which can damage plants, can kill fish in streams and lakes, and can reduce visibility	Eats away concrete, metal, and sone used on buildings, statues, monuments, etc.
Carbon Monoxide (CO)	Burning of gasoline, wood, natural gas, coal, oil, etc.	Reduces ability of blood to bring oxygen to body cells and tissue, which need oxygen to work. CO may be particularly hazardous to people who have heart of circulatory (blood vessel) problems and people who have damaged lungs or breathing passages. Causes headache, dizziness, nausea, drowsiness, and sometimes death		
Particulate Matter less than 10 micrometers in diameter (PM_{10}); dust, smoke, soot, etc.	Burning of wood, diesel fuel, and other fuels Industrial plants Agriculture (plowing, burning off fields) Unpaved roads Construction Mining, quarrying Street sand	Nose and throat irritation Lung damage Bronchitis Early death Asthma	Haze that reduces visibility Dust on leaves can prevent plants from carrying out photosynthesis	Ashes, soot, smoke, and dust can dirty and discolor structures and other property, including clothes and furniture
Sulfur Dioxide (SO_2)	Burning of diesel and other fuel, especially high-sulfur coal Industrial processes (production of paper, metal, etc.)	Respiratory damage Eye irritation Burning of skin Asthma Early death	Ingredient of acid rain, which can damage plants and can damage or kill aquatic life in streams and lakes	As acid rain, may eat away concrete and stone structures
Lead (Pb)	Leaded gasoline Paint Smelters (metal refineries) Manufacture of lead storage	Brain and other nervous-system damage, especially in children Cancer in animals Digestive and other health problems Kidney damage	Can harm wildlife	Can contaminate soil

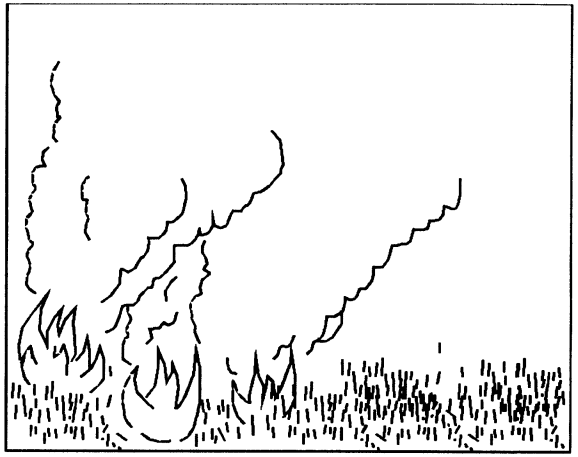
The Common Air Pollutants (Criteria Air Pollutants and VOCs) Cont'd.

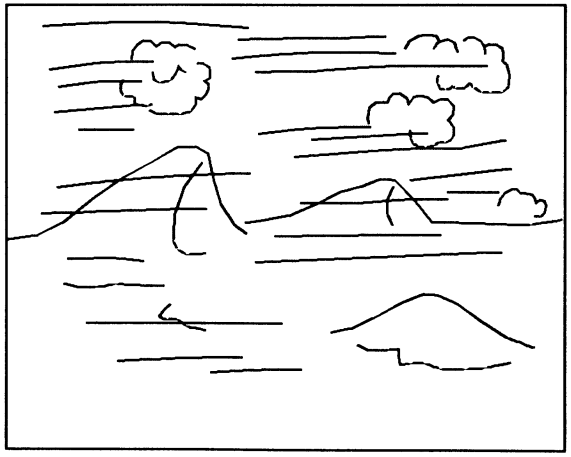
Name	Source	Health Effects	Environmental Effects	Property Damage
Volatile Organic Compounds (VOCs). VOCs contain carbon, the basic chemical element found in living things. Carbon-containing chemicals are called "organic." Volatile chemicals escape into the air easily. Many VOCs are also hazardous air pollutants (HAPs), which can cause very serious illnesses. While VOCs are not criteria pollutants, they are included in this list because of their role in smog formation.	Released form burning of fuel (gasoline, oil, wood, coal, natural gas, etc.) Solvents Paints Glues Cars, which burn gasoline, are an important source.	Cancer (some, but not all VOCs) Dizziness, headache, nausea Specific VOCs may affect the digestive system, kidneys, liver, eyes, or skin	Contribute to ozone/ smog formation Damage to plants	May have unpleasant odors.

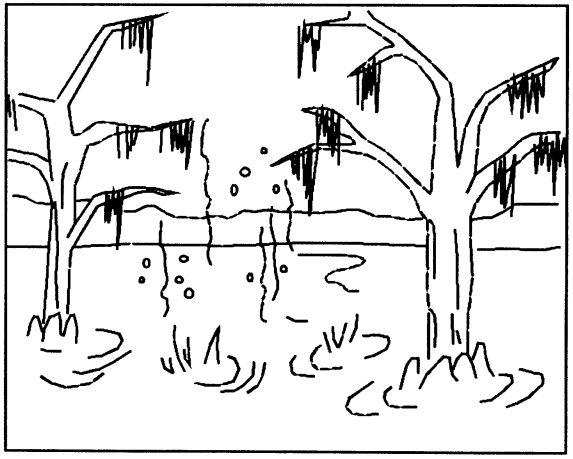
Natural Sources of Air Pollutants



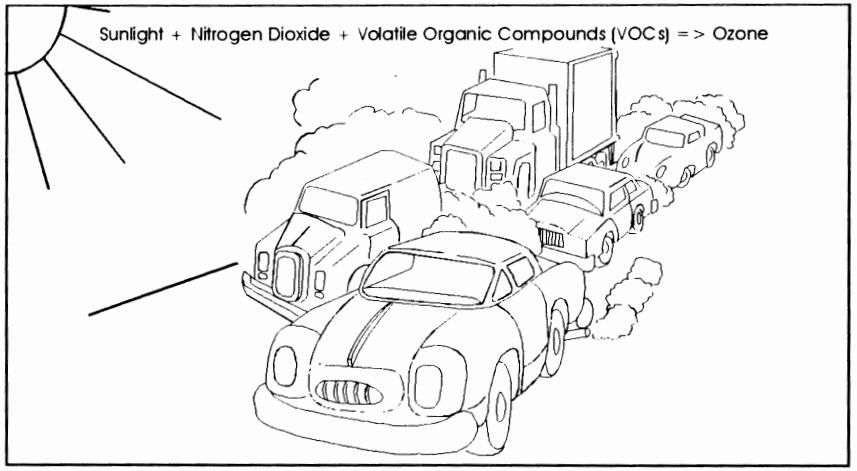


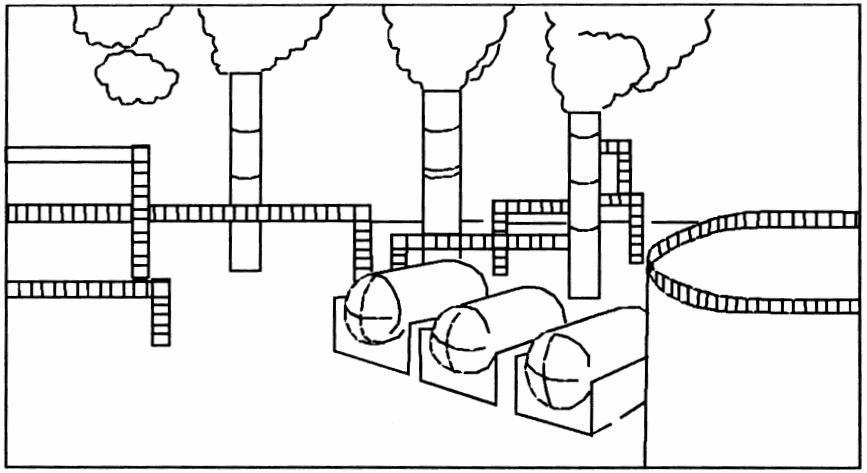


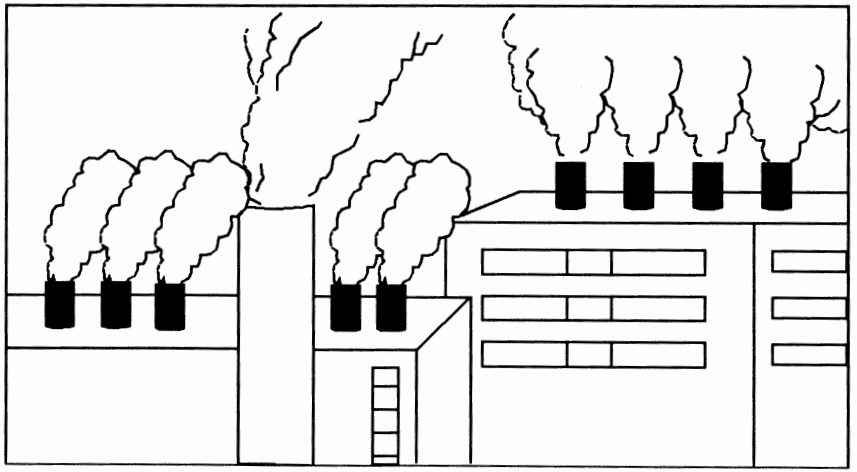




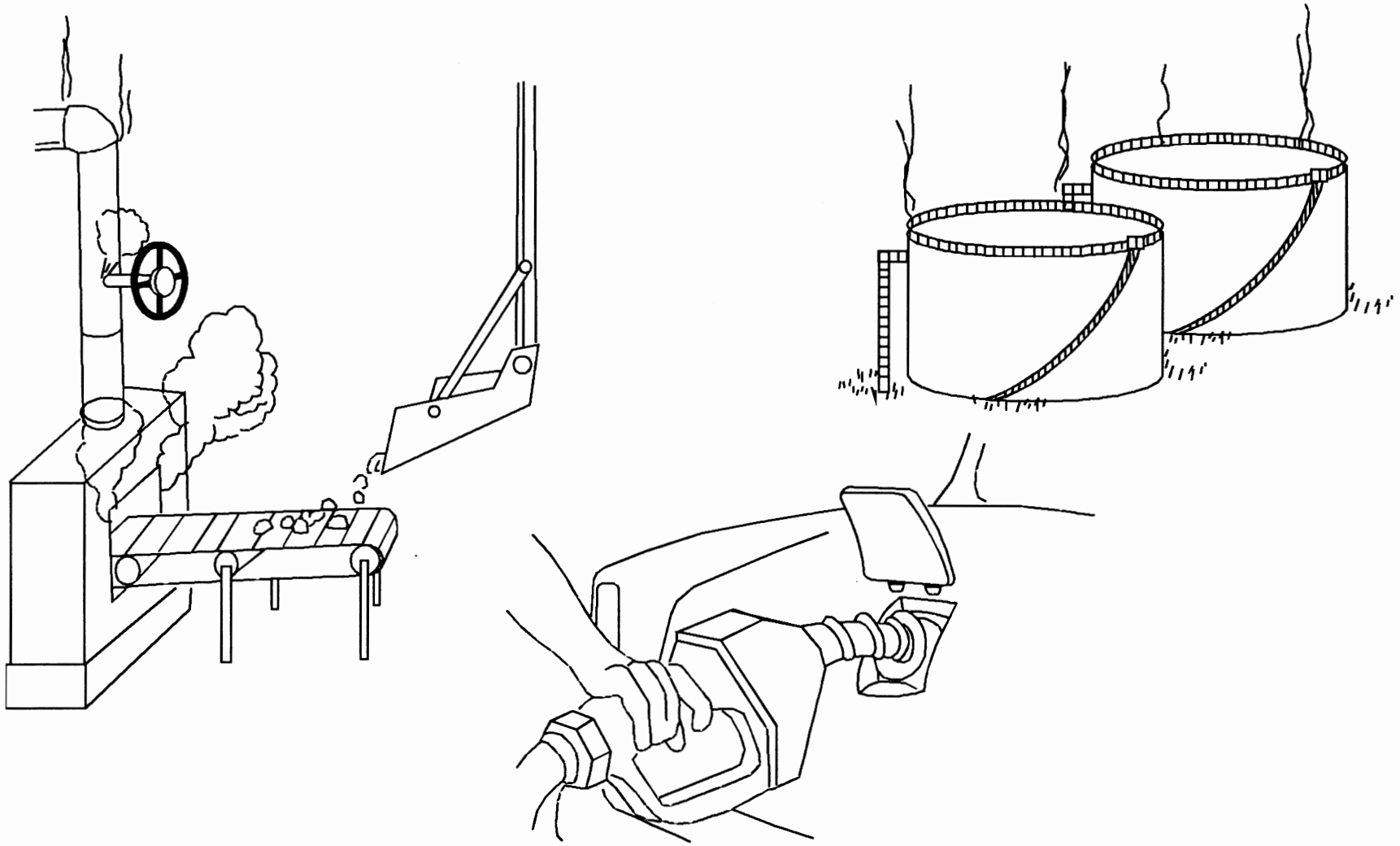
Human-Generated Sources of Air Pollutants







Emission Points Within A Source



Natural Sources Human-Generated Sources

What's In The Air?