

# THE DIRTY HALF DOZEN



AIR & WASTE MANAGEMENT  
ASSOCIATION

## OBJECTIVES

The student will do the following:

1. List six major air pollutants.
2. Identify the major sources of each of the six pollutants.
3. Identify the major effects of each of the six pollutants.
4. List three ways to reduce air pollution.

### SUBJECT:

Science

### TIME:

2 class periods

### MATERIALS:

photographs or other depictions of air pollution  
transparency (master included)  
overhead projector  
wipe-off marker (optional)  
student sheets (included)

## BACKGROUND INFORMATION

In the United States (U.S.), the Clean Air Act of 1970 strengthened earlier laws. It required that air quality standards be established, set up guidelines for achieving them, and gave the federal government more responsibility and power in protecting air quality. In the same year, the U.S. Congress created the Environmental Protection Agency (EPA) to be in charge of the federal government's environmental programs. EPA was given responsibility for implementing the Clean Air Act, regulating air pollution, and enforcing the law.

The Clean Air Act required EPA to set air quality standards so that even people most sensitive to air pollution (usually the very young, the very old, and the sick) would not suffer adverse health effects from pollution levels in the ambient air (the air around us) if the standards were met. National Ambient Air Quality Standards were set for substances identified as "criteria pollutants"—common, widespread pollutants shown by research to be harmful to human health and to general public welfare. ("Welfare" includes crops, livestock, vegetation, buildings, and visibility.) Carbon monoxide, lead, nitrogen oxides, photochemical oxidants (such as ozone), particulate matter, and sulfur dioxide are the criteria pollutants. The 1990 Clean Air Act Amendments add further criteria pollutant restrictions. For example, most areas in the country must attain particulate matter standards by 1994; and to combat acid rain, large reductions in sulfur dioxide and nitrogen oxide emissions are included.

In Canada, the Clean Air Act of 1971 empowers Environment Canada to set (1) national ambient air quality objectives, (2) national emission standards, and (3) national emission guidelines. Canadian ambient air objectives have been set by Environment Canada for sulfur dioxide, suspended particulates, carbon monoxide, ozone, and nitrogen dioxide. The provincial governments set the enforceable standards for these pollutants. In 1988, the Canadian Environmental Protection Act (CEPA) was passed; the 1971 Clean Air Act is included in the CEPA.

Many efforts are underway to reduce air pollution. Air pollution control devices are being installed in factories, power plants, vehicles, and even wood stoves to trap pollutants before they get into the air. Use of cleaner-burning fuels and more advanced combustion technology are other ways pollution is reduced. Other efforts include encouraging people to use cars less and to conserve electricity, which will reduce the amount of fuel we burn and at the same time reduce the amount of pollutants we put into the atmosphere. Pollution prevention efforts also include using fewer harmful materials in business and industry and/or using less harmful materials.

## PROCEDURE

### I. Setting the stage

- A. Show the class magazine photographs, slides, or other pictures of air pollution. Ask them about their own observations of air pollution in their community or in places they have visited.
- B. Tell the students that this lesson will introduce them to six major air pollutants, their sources, and their effects. List the lesson's objectives.

### II. Activity

- A. Remind the students that the atmosphere is necessary for plants, animals, and people to live. There is only a thin layer of air that we can breathe surrounding the earth; it is roughly comparable in extent to the peeling on an apple. Natural air pollution caused by volcanoes, forest fires, and other natural occurrences has always existed. Naturally produced pollutants are present in greater amounts than pollutants of human origin. Because they are dispersed over such huge areas and because many are less harmful than those resulting from human activities, however, natural pollutants do not present as serious a problem as man-made air pollutants do.

There are so many people using large quantities of fuel (to produce electricity and power vehicles) and engaging in high levels of industrial activity, that the resulting air pollution is a serious problem. Not only are some of these pollutants very harmful, but the activities producing them are often carried out in urban areas, increasing their concentration in places where many people live and work. We have no control over natural pollutants, but we can control man-made pollutants. As humans produce even more pollutants, control and reduction of them becomes increasingly important.

1. Introduce the term pollutant and identify air pollutants as chemicals or materials that change the air so that its use is impaired in some way. Tell the students that many air pollutants come from burning coal, oil, wood, and other fuels. We use these fuels to run factories, cars, and power plants that generate the electricity we use to heat and light our homes.
  2. Ask the students if they can name any air pollutants. They may be able to identify several natural and/or man-made pollutants.
- B. Present the following information on each of the six major air pollutants. Share with the students that these pollutants are "criteria pollutants" and are regulated with federal laws by Environmental Protection Agency in the United States and by Environment Canada in Canada. Use a transparency made from the provided master ("MAJOR MAN-MADE AIR POLLUTANTS") to give visual support for the students to take notes.
    1. Carbon monoxide is a colorless, odorless gas emitted when vehicles burn fuel. It is also given off by kerosene or wood stoves used to heat homes. The effects of carbon monoxide include headaches, reduced mental alertness, and heart damage. It may even cause death by reducing the oxygen-carrying capacity of red blood cells.

2. Lead was more of a problem a few years ago when all cars used gasoline with lead additives. When leaded gasoline is burned, lead is released into the air. Some industrial processes also result in lead air pollution. When people or animals breathe lead over a period of time, it accumulates in their bodies and can cause brain or kidney damage. Today most cars use unleaded gasoline, but there is still much leaded gasoline being sold, and lead continues to be a major pollutant, especially in cities. The production of leaded gasoline is being phased out by law.
  3. Nitrogen oxides are produced naturally by bacteria in soil and play an important role in plant growth. However, nitrogen oxides that enter the air through exhaust from vehicles and some power plants can be harmful. They can combine with water to make acid rain, react in the air to produce ozone and other pollutants, or are harmful by themselves as a gas in the air. (See [6] below for more information on acid deposition.)
  4. Ozone is formed during the interaction of nitrogen oxides, gaseous hydrocarbons, and sunlight. If the air over a city does not move, pollutants become trapped close to the earth's surface, reacting and producing smog and ozone, which can lead to breathing problems. High ozone levels also harm plants, including trees and crop plants, and cause the accelerated deterioration of materials such as rubber and fabrics.
  5. Particulate matter consists of soot, dust, tiny droplets of liquid, and other materials. It is sent up into the air primarily by the burning of coal, diesel fuel, and wood. Particulates gradually settle back to earth and can cause people to cough, get sore throats, or develop other more serious breathing problems. They can affect animals and plants. Pollution from particulate matter also causes discoloration of buildings and other structures. The smaller the particulates, the more easily they can travel deep into the lungs, causing more harm. Regulations now focus on small particulates.
  6. Sulfur oxides are emitted by power plants and factories that burn coal for fuel. Sulfur dioxide is the main sulfur oxide pollutant. It can harm human and animal lungs, as well as all kinds of plants. Sulfur dioxide is a main contributor to acid deposition. It reacts with oxygen in the air to become sulfur trioxide, which then reacts with water in the air to form sulfuric acid. Acid rain can harm animal populations in lakes and rivers as well as trees and other plants by damaging leaves and root systems. It can deteriorate metal and stone on buildings and statues. Acid-forming dry particles can also fall to earth. The effects of acid deposition are not only local; they can also occur hundreds of miles away from the sources of sulfur dioxide (or other contributors).
- C. Give each student a copy of the student sheet, "MATCHING MAJOR AIR POLLUTANTS WITH THEIR SOURCES AND EFFECTS" (included). Have the students complete the student sheet with information given on the transparency. (If you prefer, you may make transparencies from the student sheet masters rather than reproducing copies for each student. If you use transparencies, ask the students to identify the sources and effects of each pollutant; use a wipe-off marker to circle the correct symbols.) Answers are as follows:

Carbon Monoxide - Sources: cars, wood stoves; Effects: less oxygen in blood, reduced mental alertness, heart damage.

Lead - Sources: electric power plants, cars, metal refineries; Effects: brain damage, contaminated crops and livestock.

Nitrogen Oxides - Sources: cars, coal-burning stoves, electric power plants; Effects: lung damage, damaged forests, smog.

Ozone - Source: vehicles (formed mainly from pollutants in exhaust), other sources of ozone-forming fumes (such as gas stations, paints, etc.); Effects: eye irritation, respiratory tract problems, lung damage, damaged vegetation, smog.

Particulate Matter - Sources: diesel engines, windblown dust, wood stoves; Effects: lung damage, eye irritation, damaged crops, reduced visibility, discolored buildings and statues.

Sulfur Dioxide - Sources: electric power plants, coal-burning stoves, refineries; Effects: eye irritation, lung damage, harmed aquatic organisms, damaged forests, deteriorated buildings and statues. (The environmental effects are largely due to acid deposition.)

### III. Follow-Up

- A. Have the students list the six criteria air pollutants discussed in this activity, identifying the major sources and effects of each one.
- B. Have the students name three ways to reduce air pollution. Examples include reducing the use of automobiles and other vehicles, using cleaner-burning fuel and/or pollution control devices, and reducing the amount of electricity we use.
- C. Divide the students into groups of three or four students each. Have each group create a poster portraying an anti-air pollution message.

### IV. Extension

- A. Have the students write their government's environmental agency (either EPA or Environment Canada) to request information on major air quality legislation, including major changes in recent years.
- B. Have a representative from a local industry talk to the class about methods used by the industry to reduce or prevent air pollution.
- C. Have interested students research the killer smog in London in December 1952 which resulted in the deaths of over 4,000 people. (There were also other deadly air pollution episodes in London, as well as some in the United States.)

## RESOURCES

Air Pollution Control Association. Dictionary of Air Pollution Terms. (Address: P.O. Box 2861, Pittsburgh, PA 15320.)

Duckworth, C. "The Big Bad Six." Ranger Rick. National Wildlife Federation. Washington: n.p., September 1987.

Keep America Beautiful, Inc. Pollution Pointers for Elementary Students. (Address: 9 West Broad Street, Stamford, CT 06902, 203-323-8987.)

Motor Vehicle Manufacturers Association. Saving Energy! (stock no. 22). (Address: MVMA, ATTN: Communication Department, 300 New Center Building, Bartlesville, OK 74004.)

Schultz, R.F. "Solids in the Air." Environmental Experiments from Edison. Southfield, MI: Thomas Alva Edison Foundation, 1982.

### MAJOR MAN-MADE AIR POLLUTANTS

Pollutant	Description	Sources	Effects
Carbon monoxide (CO)	<ul style="list-style-type: none"> <li>• colorless, odorless gas</li> </ul>	<ul style="list-style-type: none"> <li>• vehicles burning gasoline</li> <li>• indoor sources include kerosene- or wood-burning stoves</li> </ul>	<ul style="list-style-type: none"> <li>• headaches, reduced mental alertness, death</li> <li>• heart damage</li> </ul>
Lead (Pb)	<ul style="list-style-type: none"> <li>• metallic element</li> </ul>	<ul style="list-style-type: none"> <li>• vehicles burning leaded gasoline</li> <li>• metal refineries</li> </ul>	<ul style="list-style-type: none"> <li>• brain and kidney damage</li> <li>• contaminated crops and livestock</li> </ul>
Nitrogen oxides (NO <sub>x</sub> )	<ul style="list-style-type: none"> <li>• several gaseous compounds made up of nitrogen and oxygen</li> </ul>	<ul style="list-style-type: none"> <li>• vehicles</li> <li>• power plants burning fossil fuels</li> <li>• coal-burning stoves</li> </ul>	<ul style="list-style-type: none"> <li>• lung damage</li> <li>• react in atmosphere to form acid rain</li> <li>• deteriorate buildings and statues</li> <li>• damage forests</li> <li>• form ozone &amp; other pollutants (smog)</li> </ul>
Ozone (O <sub>3</sub> )	<ul style="list-style-type: none"> <li>• gaseous pollutant</li> </ul>	<ul style="list-style-type: none"> <li>• vehicle exhaust and certain other fumes</li> <li>• formed from other air pollutants in the presence of sunlight</li> </ul>	<ul style="list-style-type: none"> <li>• lung damage</li> <li>• eye irritation</li> <li>• respiratory tract problems</li> <li>• damages vegetation</li> <li>• smog</li> </ul>
Particulate matter	<ul style="list-style-type: none"> <li>• very small particles of soot, dust, or other matter, including tiny droplets of liquids</li> </ul>	<ul style="list-style-type: none"> <li>• diesel engines</li> <li>• power plants</li> <li>• industries</li> <li>• windblown dust</li> <li>• wood stoves</li> </ul>	<ul style="list-style-type: none"> <li>• lung damage</li> <li>• eye irritation</li> <li>• damages crops</li> <li>• reduces visibility</li> <li>• discolors buildings and statues</li> </ul>
Sulfur dioxide (SO <sub>2</sub> )	<ul style="list-style-type: none"> <li>• gaseous compound made up of sulfur and oxygen</li> </ul>	<ul style="list-style-type: none"> <li>• coal-burning power plants &amp; industries</li> <li>• coal-burning stoves</li> <li>• refineries</li> </ul>	<ul style="list-style-type: none"> <li>• eye irritation</li> <li>• lung damage</li> <li>• kills aquatic life</li> <li>• reacts in atmosphere to form acid rain</li> <li>• damages forests</li> <li>• deteriorates buildings &amp; statues</li> </ul>

### MATCHING MAJOR AIR POLLUTANTS WITH THEIR SOURCES AND EFFECTS

Directions: Circle the symbols for the sources and effects of the given pollutant.

Pollutant: *CARBON MONOXIDE*

Sources:



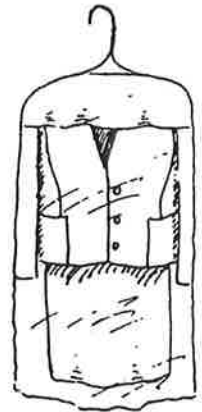
cars



wood stoves



windblown dust

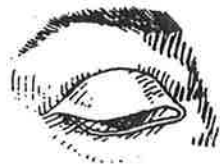


dry cleaners

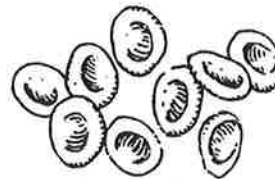
Effects:



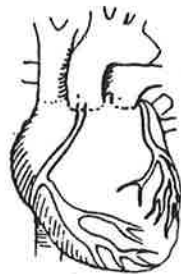
global warming



reduced mental alertness



less oxygen in blood



heart damage



corroded buildings, statues

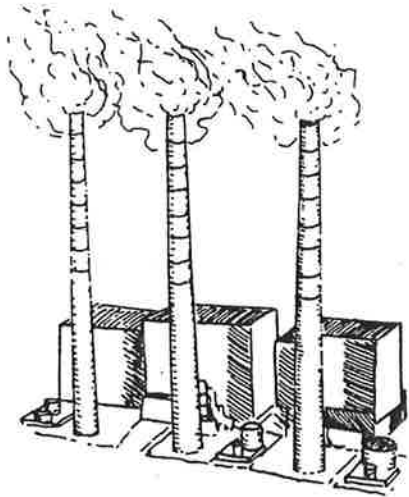


smog

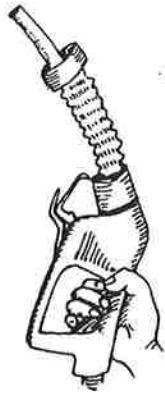
**MATCHING MAJOR AIR POLLUTANTS  
WITH THEIR SOURCES AND EFFECTS**  
(continued)

Pollutant: **LEAD**

Sources:



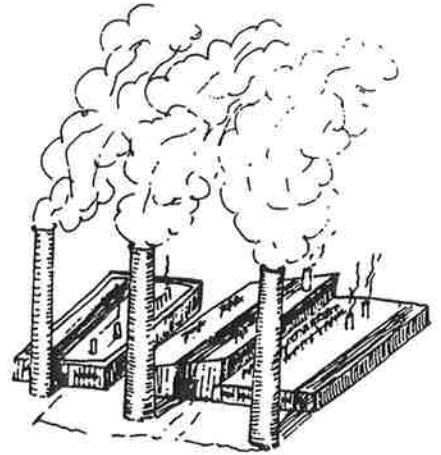
electric power plants



gas stations



cars



metal refineries

Effects:



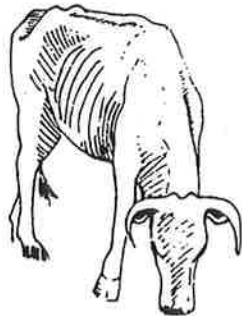
less oxygen in blood



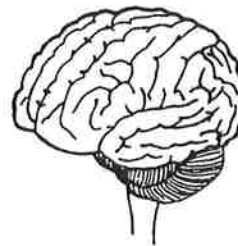
eye irritation



smog



contaminated livestock



brain damage



contaminated crops

**MATCHING MAJOR AIR POLLUTANTS  
WITH THEIR SOURCES AND EFFECTS**  
(continued)

Pollutant: *NITROGEN OXIDES*

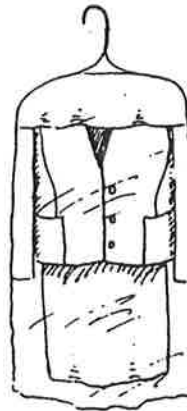
Sources:



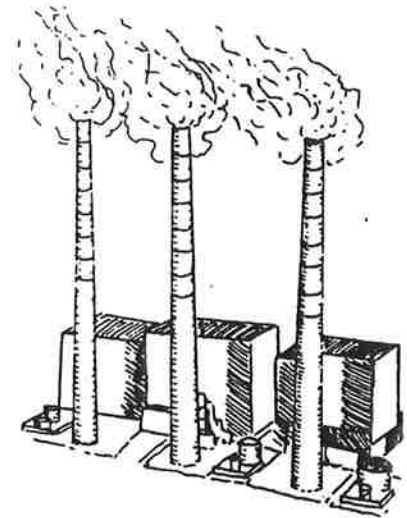
cars



coal-burning stoves



dry cleaners



electric power plants

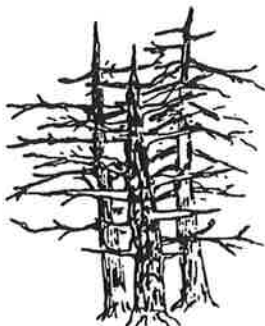
Effects:



less oxygen  
in blood



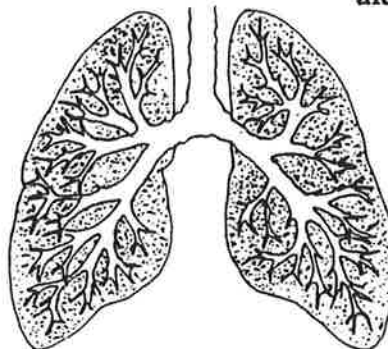
reduced mental  
alertness



damaged  
forests



corroded  
buildings, statues



lung damage



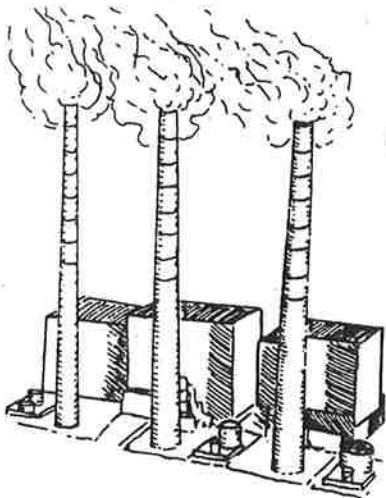
smog



**MATCHING MAJOR AIR POLLUTANTS  
WITH THEIR SOURCES AND EFFECTS**  
(continued)

Pollutant: *OZONE*

Sources:



electric power plants



gas stations



wood stoves

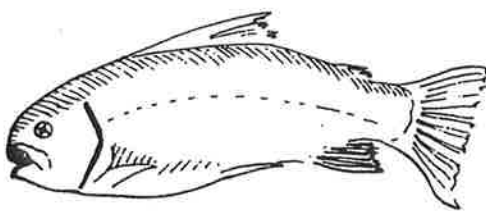


cars

Effects:



eye irritation



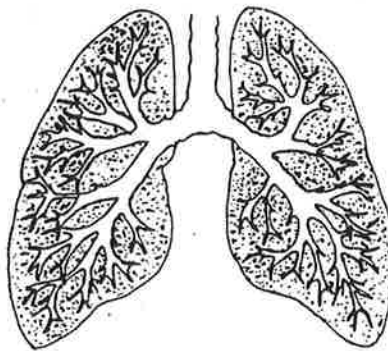
dead aquatic life



respiratory tract problems



smog



lung damage



contaminated crops

**MATCHING MAJOR AIR POLLUTANTS  
WITH THEIR SOURCES AND EFFECTS**  
(continued)

Pollutant: *PARTICULATE MATTER*

Sources:



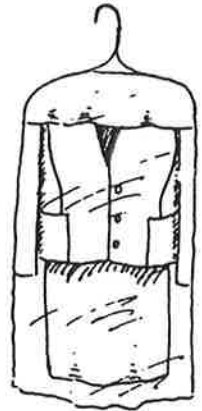
diesel engines



windblown dust

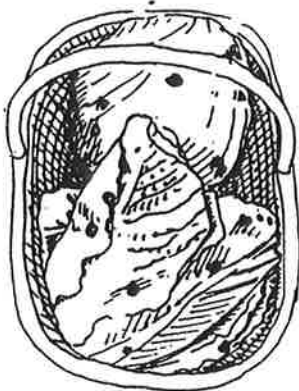


wood stoves



dry cleaners

Effects:



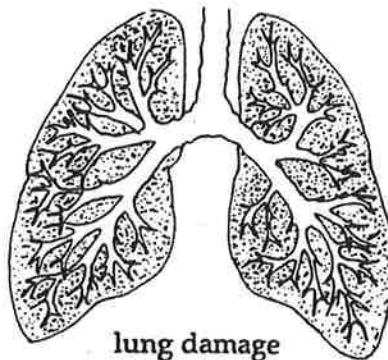
damaged  
crops



brain damage



corroded  
buildings, statues



lung damage



eye irritation

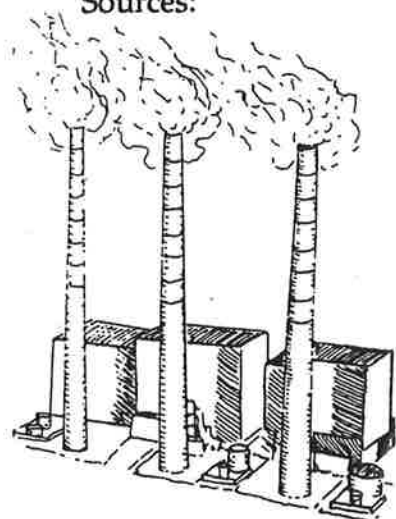


reduced  
visibility

**MATCHING MAJOR AIR POLLUTANTS  
WITH THEIR SOURCES AND EFFECTS**  
(continued)

Pollutant: *SULFUR DIOXIDE*

Sources:



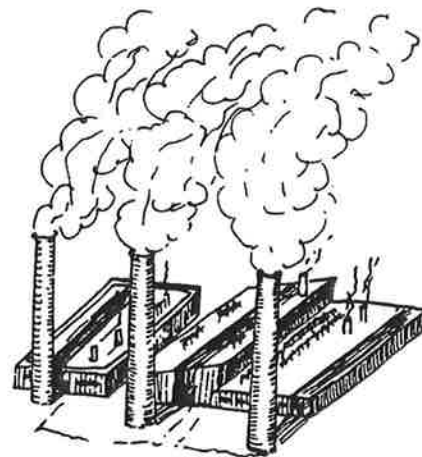
electric power plants



coal-burning stoves



gas stations

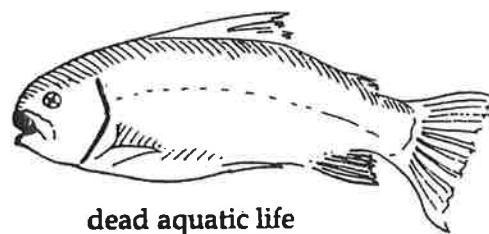


refineries

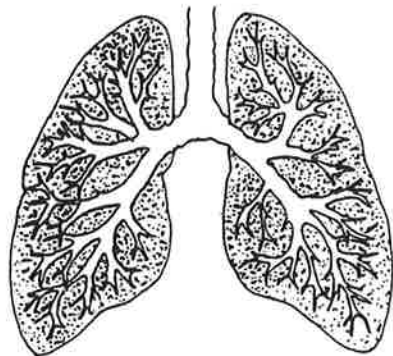
Effects:



eye irritation



dead aquatic life



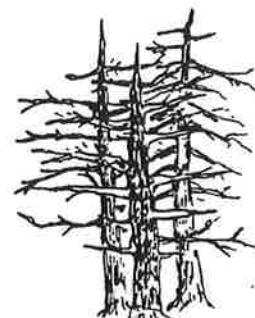
lung damage



corroded buildings, statues



smog



damaged forests